

Bristol Bay Red King Crab Information

Discussion Paper

April 2022¹

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1 Introduction and Background

In October and December 2021, the North Pacific Fishery Management Council (Council) tasked staff to prepare a discussion paper that provides the best available information on four topics related to Bristol Bay red king crab (BBRKC).² The Council's motions are responsive to an ongoing decline in the BBRKC stock, culminating in the State of Alaska's inability to open a directed fishery for the 2021/2022 season. After review of this paper, the Council may request further analysis, develop alternatives to recommend actions that fall under its authority, or initiate dialogue with other management agencies at its own discretion. No action is required by statute and this document is not part of a mandated program or allocation review.

Staff has reordered the four topics in the final December 2021 motion so that the information presented in this paper flows logically and the background information provided in each section contributes to the understanding of the following sections to the extent possible. The four topics, as ordered in this paper, are described here in the Council's words:

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² The [December 2021 motion](#) appended a fourth topic to the previously passed October motion.

1. Provide the best available information on Bristol Bay red king crab molting/mating annual cycle and how the seasonality of this overlaps with fisheries and the effects these interactions may have.
2. Evaluate boundaries used for the BBRKC survey, stock assessment, PSC limits, and directed fishery.
3. Provide the best available information on bottom contact by pelagic trawl gear and the impact it may have on BBRKC stocks.
4. Summarize mechanisms used in other council managed fisheries to create flexible, responsive spatial management measures for all gear types and how they might be applied to protect BBRKC.

The 2021 NMFS eastern Bering Sea bottom trawl survey (“trawl survey”) results were consistent with a trend of decreasing BBRKC biomass (Zacher et al. 2021). The 2021 mature female abundance estimate was 25% less than in 2019. While the abundance of female red king crab (RKC) has been low in recent years, 2021 was the first year since 1995 that the mature female abundance fell below the established threshold in the State of Alaska’s harvest strategy to allow a directed fishery in Registration Area T (see Figure 3-1). The length-based abundance estimate was 7.9 million mature female RKC in 2021, which is below the threshold of 8.4 million (Zheng et al. 2021). As a result, the directed fishery was closed for the 2021/2022 season.

Estimated mature biomass increased in the mid-1970s and then decreased precipitously in the early 1980s (Figure 1-1). Abundance increased from the mid-1980s until about 2007. Mature females were estimated to be roughly four times more abundant in 2007 than in 1985; mature males were roughly twice as abundant in 2007 than in 1985. Abundance has steadily declined since 2010 (Zacher et al. 2021). The projected mature male biomass in 2021 is less than 50% of the peak value (2002) during the last 40 years. Estimated mature female biomass has been at a low level during the four most recent years. Since 1984, recruitment has only been above the long-term historical average in six years, with the most recent above-average year occurring in 2005 (Zheng et al. 2021).

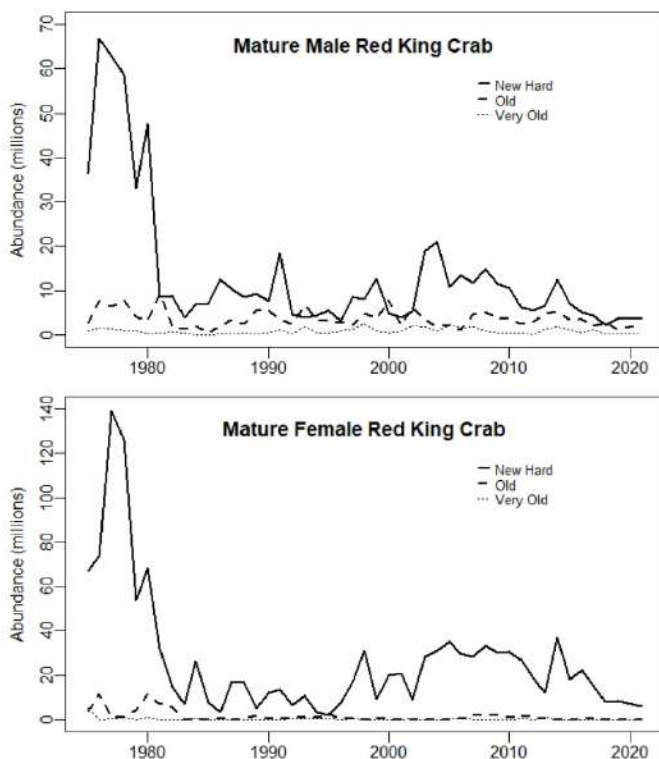


Figure 1-1 Time series of mature male (≥ 120 mm CL) and female (actual maturity) Bristol Bay red king crab abundance by shell condition, 1975-2021 (Zacher et al. 2021).

The Council has recently reviewed several analyses related to the abundance of BBRKC. The Council considered adjusting Bering Sea and Aleutian Islands (BSAI) groundfish trawl PSC limits for BBRKC, snow crab, and Tanner crab in February 2021 (NPFMC 2021a), and an emergency rule request for a northward expansion of the Red King Crab Savings Area (RKCSA) in December 2021 (NPFMC 2021b). The Council did not pursue action following those analyses but has closely monitored the stock and requested this discussion paper as a platform to contemplate actions that might address the fishery and its stakeholders, as bounded by the Council's authority. Whereas previous analyses focused on a specific topic or action alternatives, this paper looks broadly at what information is available on several requested topics. The topic areas include BBRKC biology, stock assessment, interaction with gear from other fisheries and flexible management options.

2 Item 1: BBRKC Molting and Mating

Red king crab (RKC) mate when they enter shallow waters (<50 m) where males grasp females just prior to female molting, after which the eggs are fertilized and extruded on the female's abdomen. Adult females brood thousands of embryos (43,000 to 500,000 eggs) underneath their tail flap for 11 months before they hatch. Hatching generally occurs in April but embryo development can be delayed in cold years (Chilton et al. 2010).³ When embryos are fully developed they hatch as swimming larvae but are susceptible to the movements of tides and currents. Cooler water temperatures slow larval development

³ For example, colder than average bottom temperatures in 2020 may have delayed peak hatch timing to June. This supposition is based on the fact that 2020 bottom temperatures were colder than 2006-2007 bottom temperatures when Chilton et al. (2010) noted that survey stations sampled in May had high numbers of mature females still brooding embryos fertilized the previous season (Fedewa et al. 2020).

rates and can increase mortality due to spending more time in a vulnerable state and increased offshore transport into ecosystem areas where larvae are less likely to mature to juveniles (Loher and Armstrong 2000). After feeding on plant and animal plankton for two to three months and undergoing body changes with each molt, they settle into their benthic life stage. Young-of-the-year crab occur at depths of 50m or less. They are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Between the ages of two and four years there is a decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Podding generally continues until four years of age (about 65 mm carapace length (CL)) when the crab move to deeper water and join adults in the spring migration to shallow water for spawning, and then to deep water for the remainder of the year. Mean age at recruitment into the fishery is 8-9 years (Crab FMP), though “adult phenology” is described as 5-6+ year (Fedewa et al. 2020⁴).

King crab molt multiple times per year through age-3 after which molting is annual. At larger sizes, king crab (especially males), may skip molt as growth slows. Females grow more slowly and do not become as large as males. In Bristol Bay, 50% maturity is attained by males at 120 mm CL and by females at 90 mm CL (about 7 years). Within days to weeks after molting, RKC shells begin to harden. RKC are particularly vulnerable during their molting phase where it takes 74.2 days for the carapace to reach 90% of maximum hardness (Stevens, 2009). During this time, RKC are at increased risk of predation and harm from contact with fishing gear. Molting crab are not feeding so they do not enter baited pots.

Specific to BBRKC, the best information available to the analysts indicates that the mating season primarily occurs from January to March for primiparous (individuals bearing first offspring) RKC females and from April to June for multiparous RKC females. Mating occurs at the same time as molting for mature females. Molting times for mature males are not as well described as for mature females. Mature males are thought to molt once during the March to May period, whereas juvenile crab may molt several times per year as they grow and can molt at different times during a year. Large juveniles generally molt during the spring. Overall, the molting period for BBRKC ranges from January to June (Pers Comm J. Zheng, ADFG; see also Table 2a in Fedewa et al. 2020).

Larval advection is an important process for recruitment in benthic invertebrates as the supply of settlement-competent larvae to a given area typically depends upon larval hatch that occurs elsewhere. For species with long larval pelagic duration, substantial transport distances may occur before reaching the settling stage (Shanks 2009). As such, variable rates of connectivity and retention can result in large-scale population trends. Recent studies have assessed how predicted settlement success varied through changes in larval pelagic duration and oceanographic circulation patterns, demonstrating that shorter advective distance was associated with warmer conditions, causing higher rates of local retention relative to cold conditions (Daly et al. 2018 & 2020). This is contrary to earlier models which presumed that most larvae hatched in southwest Bristol Bay were advected offshore away from good habitat whereas larvae hatched in central and nearshore Bristol Bay were retained in or advected to good habitat along the Alaska Peninsula. These results suggest that contemporary spatial distributions can supply settlement-competent larvae to nurseries along the Alaska Peninsula and that, under certain conditions, larvae may reach the Pribilof Islands when hatched from southwest Bristol Bay. Larvae released from regions other than the western Unimak area did not reach the Pribilof Islands in the Daly et al. (2020) study, suggesting disconnection of the Pribilof Islands from the present-day Bristol Bay red king crab population.

Recruitment variability is not fully understood for Bering Sea crab stocks. The nearshore area in southwest Bristol Bay was hypothesized as having historically (i.e., prior to 1980) been the most important spawning ground for BBRKC. More recently the nearshore grounds north of Unimak Island and the Black Hills have been hypothesized as the population's most important hatching ground for

⁴ A useful summary of red king crab biology and the Bristol Bay ecosystem is provided in the most recent [Ecosystem and Socioeconomic Profile of BBRKC](#) (Fedewa et al. 2020).

supplying recruits to the population because the predicted location of settling post-larvae after dispersal corresponds with favorable nearshore benthic habitat (Armstrong et al. 1986; Armstrong et al. 1993; Evans et al. 2012; Haynes 1974; Hebard 1959; Hsu 1987; Loher 2001). Additional areas of BBRKC preferred habitat are in the RKCSA and the Nearshore Bristol Bay Trawl Closure Area (NBBTCA), which was created to protect juvenile RKC. These closures were first established under emergency rules in 1995 (60 FR 4866) and then implemented under BSAI Groundfish FMP Amendment 37, effective in 1997 (61 FR 65985). The Secretarial Review Draft of the EA/RIR for Amendment 37 notes that the 1996 RKCSA closure, adopted by NMFS's inseason authority to run from January 1 through March 31, was extended through June 15 "to protect red king crab during the molting and mating period" (NPFMC 1996). The RKCSA is currently in effect year-round, but the Agency's rationale at the time was a documented acknowledgement of the molt/mate season as it was then understood.

RKC distributions vary over both seasonal and interannual time scales due to ontogeny (speed of development from egg to adult), seasonal reproductive cycles, and variable environmental factors (Zacher et al. 2018). Decadal-scale temperature trends can also lead to shifts in distribution of benthic species, including RKC (Mueter and Litzow 2008). The Bering Sea oscillates between warm and cold temperature regimes, largely driven by sea ice extent (Stabeno et al. 2012). In cold years, with greater sea ice extent and later ice retreat in the spring, a pool of cold bottom water ($< 2^{\circ}\text{C}$; called the "cold pool") persists in the southeastern Bering Sea throughout the summer and into fall until vertical mixing occurs (Stabeno et al. 2012). In contrast, the cold pool is farther north in warm years, and bottom waters in the southeastern Bering Sea are several degrees warmer (Mueter and Litzow 2008; Stabeno et al. 2012). Cold and warm years can affect both the recruitment success for BBRKC and the area to which they recruit. Northerly shifts in stock distribution are generally associated with both warmer temperatures and high Pacific Decadal Oscillation values during the summer (Loher and Armstrong, 2005; Zheng and Kruse, 2006). Fall distributions during the BBRKC fishery tend to contract to the center of Bristol Bay during warm years (Zacher et al. 2018). The effect of variable recruitment areas and seasonal distribution may influence which crab are available to the parts of the eastern Bering Sea summer trawl survey that are used in the stock assessment (see Section 3, "Boundaries"). A tagging study on the winter movements of BBRKC is currently underway and is described in Section 3 (see Figure 3-8).

3 Item 2: BBRKC Boundaries

The Council requested an evaluation of four specific boundaries that pertain to BBRKC. Those are the boundaries that define: (1) the sampling areas used in the NMFS summer eastern Bering Sea trawl survey, (2) the areas used to develop the BBRKC stock assessment, (3) the area within which groundfish trawl bycatch accrues to the Zone 1 red king crab PSC limit, and (4) the ADFG registration area that bounds the directed fishery for BBRKC (Area T). Depending on the management or assessment purpose that is being pursued, these boundaries might be synonymous or slightly offset due to the ADFG/NMFS co-management of crab and the difference in ADFG statistical areas and NMFS reporting areas (see Appendix 1).⁵

This paper uses map overlays where possible to describe how boundaries are used, where there is consistency across purposes, and what adjustments are made when there is not consistency.⁶ Because the

⁵ Appendix 1 shows the EBS trawl survey grid stations overlaid on ADFG statistical areas. The survey grid is 20 nm x 20 nm squares. ADFG areas are based on latitude and longitude, thus their size/area change lightly with latitude. ADFG areas are roughly 30 nm x 30 nm in the Bering Sea.

⁶ This paper is responsive to [SSC comments from February 2021](#): "Stock areas used in the assessment do not align with the crab PSC management areas. The implication is that crab caught as bycatch from outside of the stock area (area used in the stock assessment) would accrue towards the PSC limit but would not explicitly be included in total removals in the assessment. These amounts are likely small and are likely more of an issue for BBRKC than Tanner

RKC PSC limit boundary (Zone 1) is part of this Council request, this section is the place where staff have included historical data on PSC, PSC rates, and groundfish basis catch.

The context for this Council request is the coincidence of lower survey abundance data for red king crab in the Bristol Bay stock assessment area, the State of Alaska's inability to open a directed BBRKC fishery for the 2021/2022 season, and preliminary survey evidence that red king crab are moving north into areas that are not included in the BBRKC assessment and directed fishery management.

The purpose of this section is strictly informational and does not presuppose that the Council is looking to recommend changes to boundary lines – the direct authority over which lies with other management entities with the exception of the Zone 1 PSC boundary. For example, the State of Alaska has authority over directed fishery management boundaries; any changes to Registration Area T would require action by the State. The Crab FMP currently adopts the State management areas and stock definitions used in the BBRKC assessment. Even though the Crab FMP gives authority to the State, it should be noted that Federal regulations describe where BBRKC individual fishing quota can be harvested ([§ 680 Table 1](#)). Having consulted with NMFS and NOAA OLE staff, the analysts' current understanding is that if the State establishes different boundary lines but the Federal government does not modify regulations then BBRKC IFQ could not be retained outside of the area currently defined for the rationalized fishery.

This section also describes various Council-established boundaries that are not listed in the Council's motion but affect where and/or when various types of groundfish trawl fishing may occur. Those include the RKCSA, the Red King Crab Savings Subarea (RKCSS; also known as the "10-minute strip" on the southern end of the RKCSA), the NBBTCA, and the Northern Bristol Bay Trawl Area (also referred to as the Togiak subarea) that lies within the NBBTCA but is open to trawling for part of the spring.

Finally, this section informs the Council about timely cooperative crab tagging research on the location of RKC outside of the time-window of the EBS Trawl Survey. That work will supplement the crab and groundfish-bycatch fishery data that currently augment the survey to better understand seasonal stock distribution.

3.1 Survey and Assessment Boundaries

The NMFS EBS trawl survey has been conducted annually since 1968. Haul-level data for BBRKC are available back to 1975, which is the point at which the assessment model originates. The trawl survey is used to collect data on the distribution and abundance of RKC.⁷ Surveyed mature female abundance and effective spawning biomass are used for stock assessment, setting Zone 1 trawl PSC limits (described below), and the State of Alaska's determination of a directed BBRKC fishery. In general, the assessment is based on data from Area T.

The BBRKC stock assessment incorporates data from the trawl survey as it overlaps Area T, retained and discarded catch in the Area T directed fishery, and crab PSC in Bering Sea groundfish fisheries. Figure 3-1 overlays the trawl survey grid on ADFG Area T, showing 2021 survey estimates of RKC. The inclusion of crab PSC data from groundfish fisheries in the assessment is complicated by the fact that NMFS reporting areas and ADFG statistical areas are not identical (see Appendix 1). AKFIN has

or snow crab, given the smaller stock area relative to the fishery footprint. To clarify this issue, the SSC recommends a map be added that overlays the stock areas used in the assessment, crab PSC areas, and state management areas."

⁷ There are four identified stocks of red king crab: Bristol Bay, Pribilof Islands, Norton Sound, and Western Aleutian Islands. Stock assessments are done annually for Bristol Bay and Norton Sound, and triennially for Pribilof Islands and Western Aleutian Islands.

provided the assessment authors with approximated crab PSC data occurring within the State management boundary dating back to 1991.

RKC PSC in groundfish fisheries is estimated in two ways: one to inform the stock assessment and the other to monitor the Zone 1 PSC limit. The PSC estimation that is used to monitor the groundfish trawl limit is denominated in the number of crab and is drawn from the NMFS reporting areas that comprise Zone 1. While the Zone 1 PSC limit was established to protect the BBRKC stock, the areas that accrue to the limit are not synonymous with the BBRKC stock area as defined in the assessment (Figure 3-1). The PSC estimation that informs the stock assessment is denominated in weight and is based on catch in ADFG statistical areas, and thus is more aligned with the State's management boundary (Area T); however, this requires a data adjustment for statistical areas on the northern and southern borders of the State area.

When setting the BBRKC harvest limit, the State of Alaska uses both the raw area-swept abundance estimates from the trawl survey and model-based estimates that account for parameters like recruitment, growth, and gear selectivity. Including additional trawl survey stations in the assessment would affect both raw area-swept data and create a new set of model-based estimates.

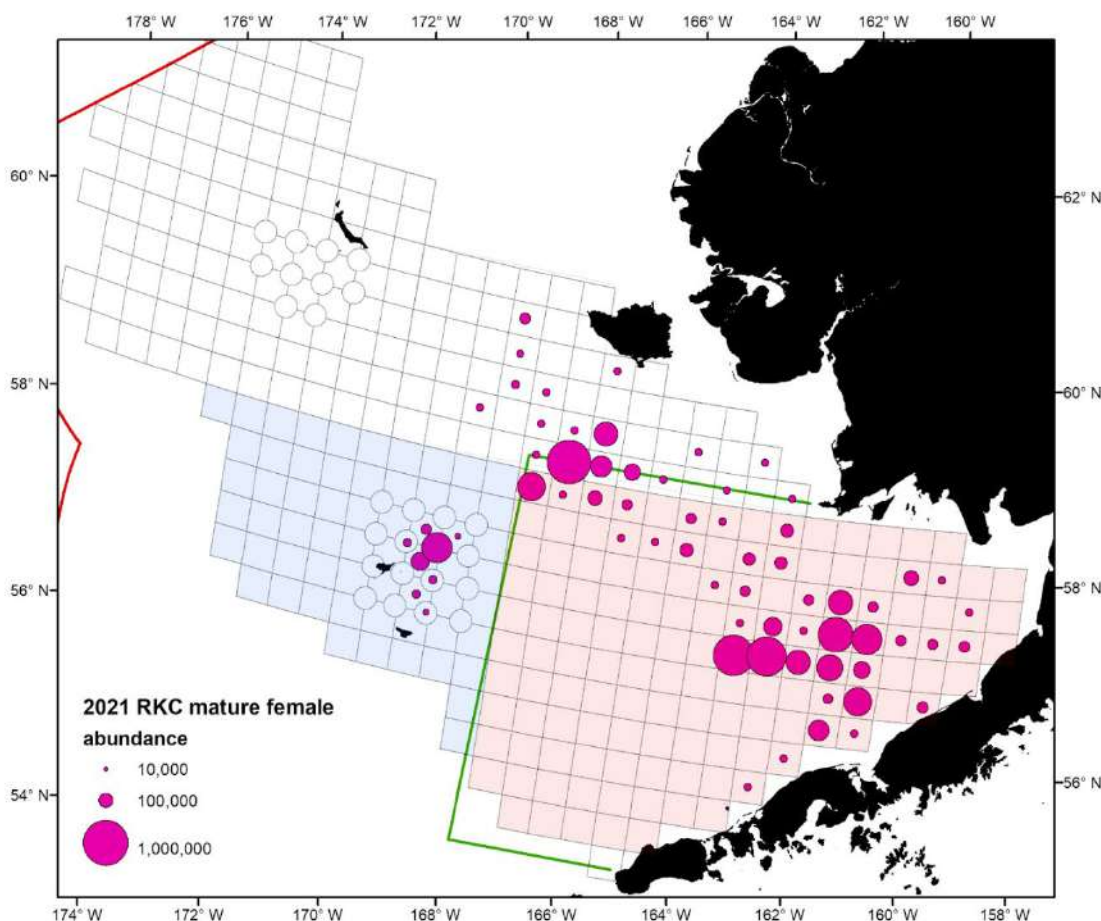


Figure 3-1 Mature female 2021 survey area-swept estimates. Grid corresponds to eastern Bering Sea summer bottom trawl survey stations; green line is the ADFG Bristol Bay management district (Area T). Survey stations included in the BBRKC stock assessment indicated by pink; survey stations included in the Pribilof Islands RKC assessment indicated by blue. Crab in white boxes are classified as “unstratified” and do not get included in any stock assessment. (Source: B. Daly, ADFG. February 2022)

Figure 3-2 illustrates where the pollock trawl fishery has occurred in recent years and overlays that data on where RKC were encountered in the region of the 2021 EBS trawl survey that is used in the BBRKC stock assessment. The analysts focus on the pollock fishery because the Council specifically requested information about the interaction of pelagic gear trawling and RKC, which is further explored in the following section. The survey CPUE data shown in the figure reflect the 2021 trawl survey. Survey CPUE – e.g., high value of 3,307 – is given in units of the estimated number of crab per square nautical mile (total number of crab in a survey haul divided by area swept by the haul). The stock assessment extrapolates survey results over the entire management area to estimate the total abundance of the BBRKC stock, but the figure shown here has no extrapolation.⁸

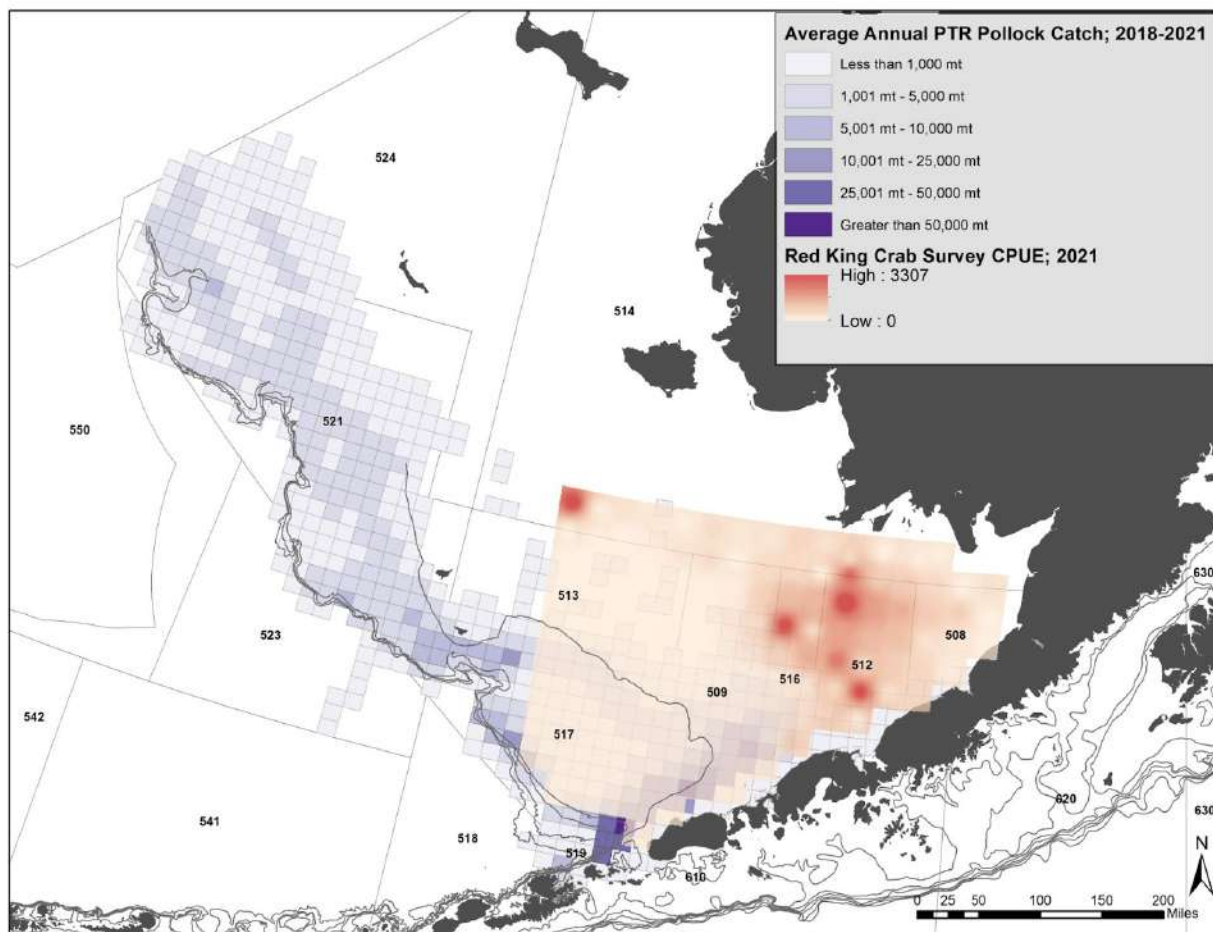


Figure 3-2 2021 EBS trawl survey red king crab CPUE (red scale) overlaid on average annual Bering Sea pelagic trawl pollock catch (by ADFG statistical area; purple scale), 2018-2021 (Source: J. Keaton, NMFS AKRO; NMFS Catch In Areas Database, March 2022)

⁸ NMFS has resurveyed portions of the BBRKC area in certain years to better assess mature female abundance. In 1999, 2000, 2006-2012, and 2021 NMFS resurveyed the northern portion of the survey area about six weeks after the standard survey because a high proportion of females had not yet molted or mated when sampling initially occurred. More large females were found in the resurveys, presumably because mature females were not available to the standard survey (Zheng et al., p.12).

3.2 Red King Crab Distribution

The most recent available survey data suggest that the distribution of RKC could be shifting to the north. [Slides 27-32](#) of an AFSC presentation to the Council's Crab Plan Team given in September 2021 identifies a "Northern District" that lies outside of the area included in the BBRKC assessment (Litzow et al., 2021).

The science on RKC in this area is not settled as to whether those unstratified crab contribute to the Bristol Bay or Norton Sounds stocks. The 2021 surveyed abundance estimates for the Northern District were largely influenced by one survey station (Figure 3-1). Relative to the past, the annual estimate of immature males in the Northern District was the second highest since 1975 and mature females in that area were at a peak. Figure 3-3 shows a marked increase in Northern District mature females in 2021; mature female estimates were up in 2014 as well but the 2021 increase was different because it occurred in the context of lower estimates overall. Legal male abundance in the Northern District was not remarkable but the survey stations with the highest legal male density were towards the north of the area shown in pink in Figure 3-1 (Litzow et al., 2021).

Litzow et al. plot the center of the surveyed stock distribution (centroid) for BBRKC in 2021 compared to all years since 1975 (Slides 31-32, referenced above). The 2021 center of distribution for both males and females of the combined Bristol Bay and Northern District was at or near the most northern latitude observed since 1975, whereas the directed fishery catch center of distribution has remained relatively stable (Figure 3-4). While some evidence suggests population distribution occurs farther north at lower population abundance levels (Figure 3-5), distribution is likely linked to environmental conditions such as temperature, with crab moving north when temperatures are higher (Figure 3-6; Loher and Armstrong 2005). As noted below, finding more crab in the Northern District does not necessarily mean that the crab have migrated there. Chilton et al. (2010) found that colder bottom temperatures (i.e., strong cold pool years) moved the location of larval release closer to shore. Nearshore larval release has been associated with dispersal to the north and release around Amak Island has been associated with dispersal and recruitment in Bristol Bay.

The signal that the center of distribution is farther north could be reflecting any of several different stories: crab in the southern portion of the BBRKC assessment area are doing less well – for whatever reason – or the crab are moving northward in response to environmental factors. The stock could be shifting north because the crab are physically moving, because larvae dispersal is occurring in areas that advect to more northern latitudes, or because the crab in the southern portion of the area are dying and thus are not available to the survey. Figure 3-4 shows that the directed BBRKC fishery has tended to remain in place in terms of latitude, likely due to proximity to ports and processing facilities. The Council may consider whether incorporating additional crab into the assessment – via the inclusion of northern survey stations – might increase local exploitation on the southern end of the stock that is either depleting or fleeing. There are uncertainties about whether the mature female crab surveyed in the Northern District are genetically contributing to the population in the southern portion of the BBRKC management area. From a management perspective, the Council should also consider the fact that these unstratified crab could be a part of one fishery that is rationalized (Bristol Bay) and one that is not (Norton Sound).

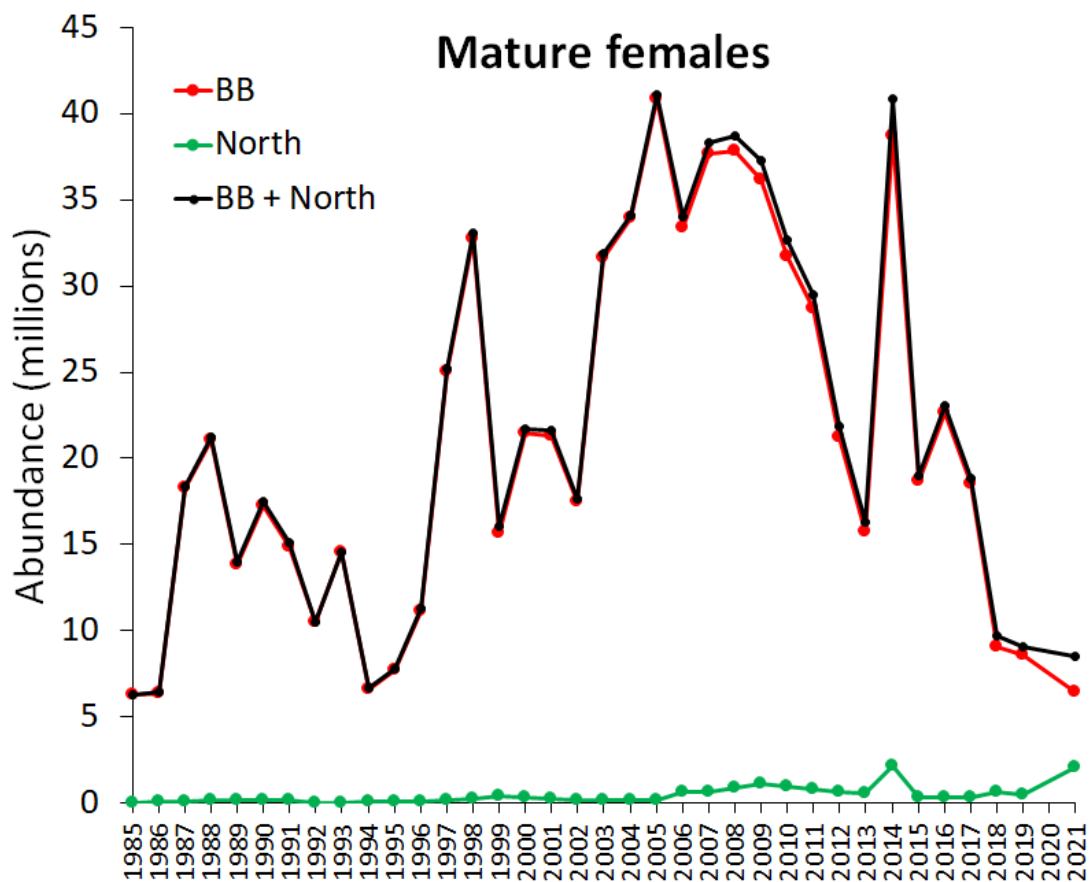


Figure 3-3 Eastern Bering Sea summer bottom trawl survey area-swept abundance estimates for mature females in Bristol Bay, Northern District, and combined from 1975 to 2021.

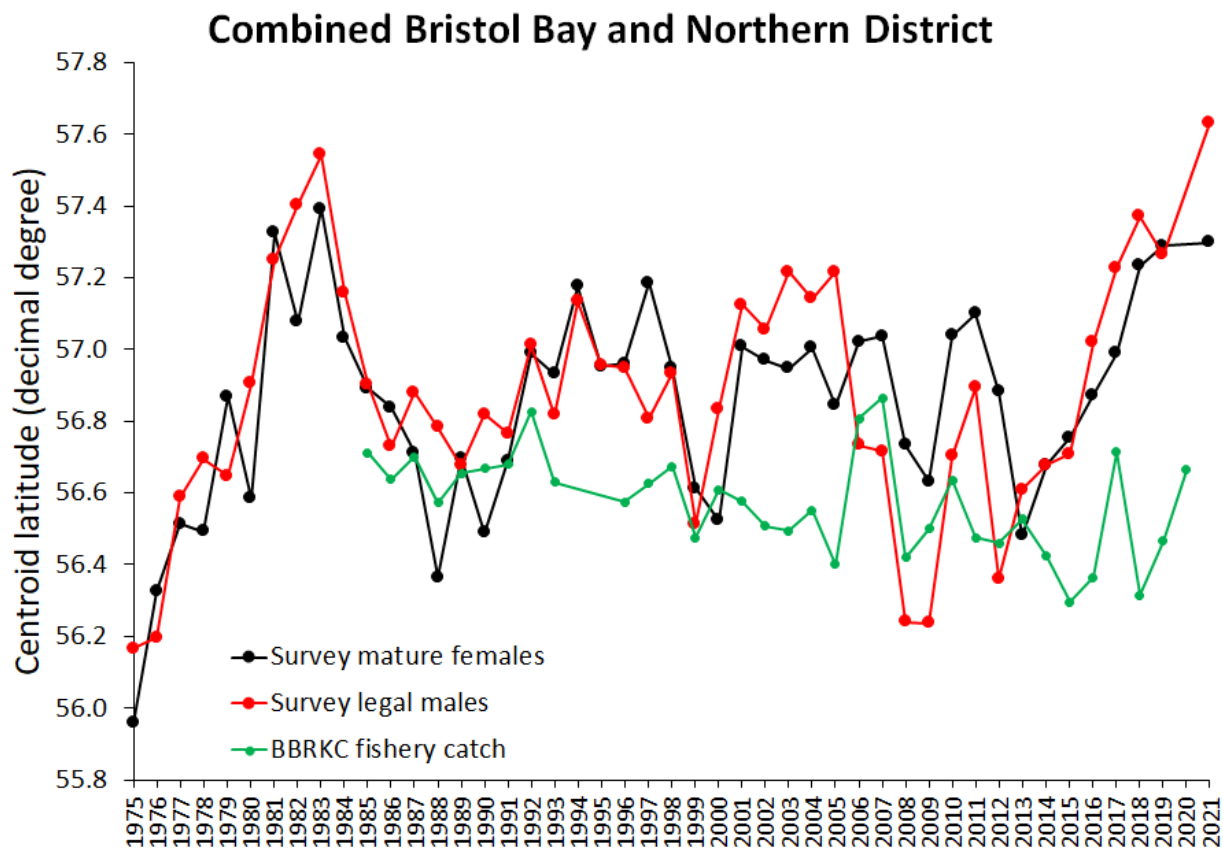


Figure 3-4 Legal male (red line) and mature female (black line) weighted center of distribution latitudes for eastern Bering Sea summer bottom trawl survey data for Bristol Bay and Northern Districts combined. Fishery catch weighted centers of distribution latitudes are shown for comparison (green line).

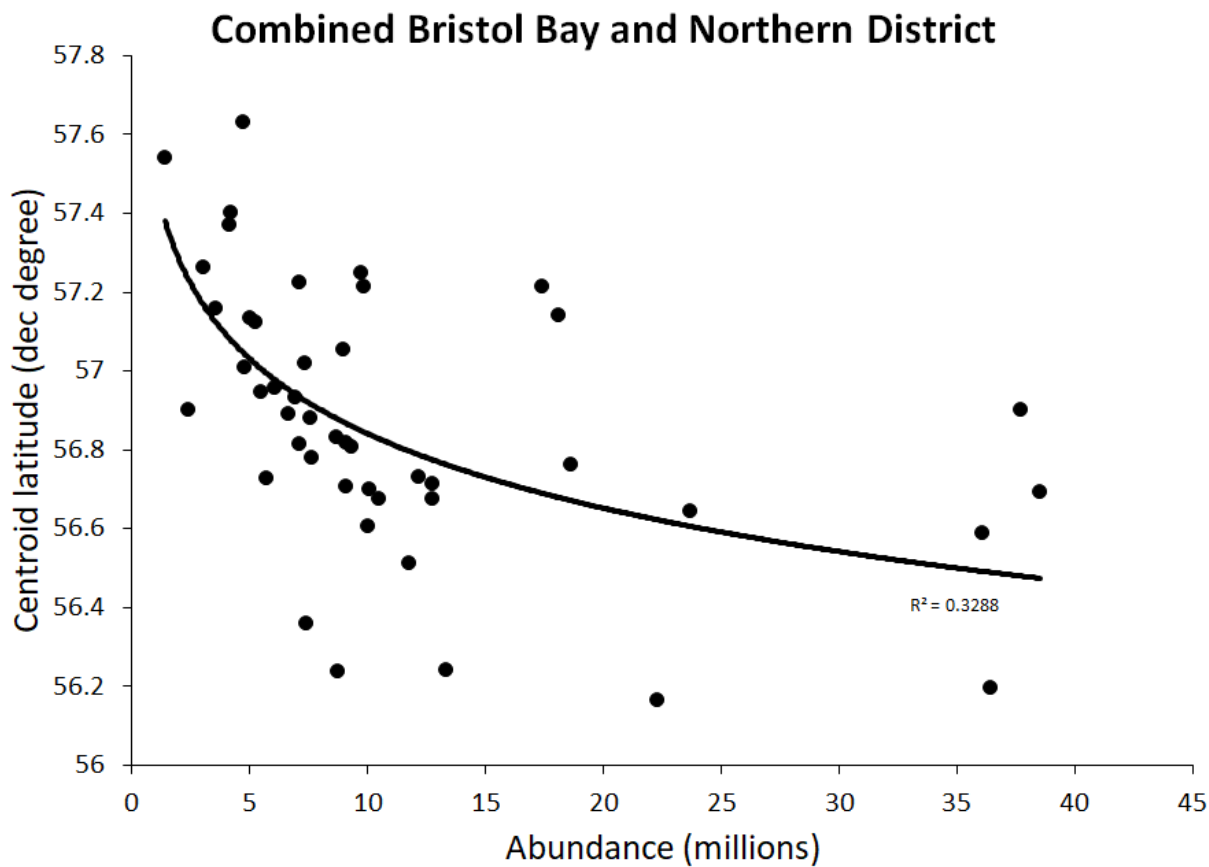


Figure 3-5 Legal male weighted center of distribution latitudes by abundance levels for EBS summer bottom trawl survey data (Bristol Bay and Northern District combined). Each point represents one year of trawl survey data.

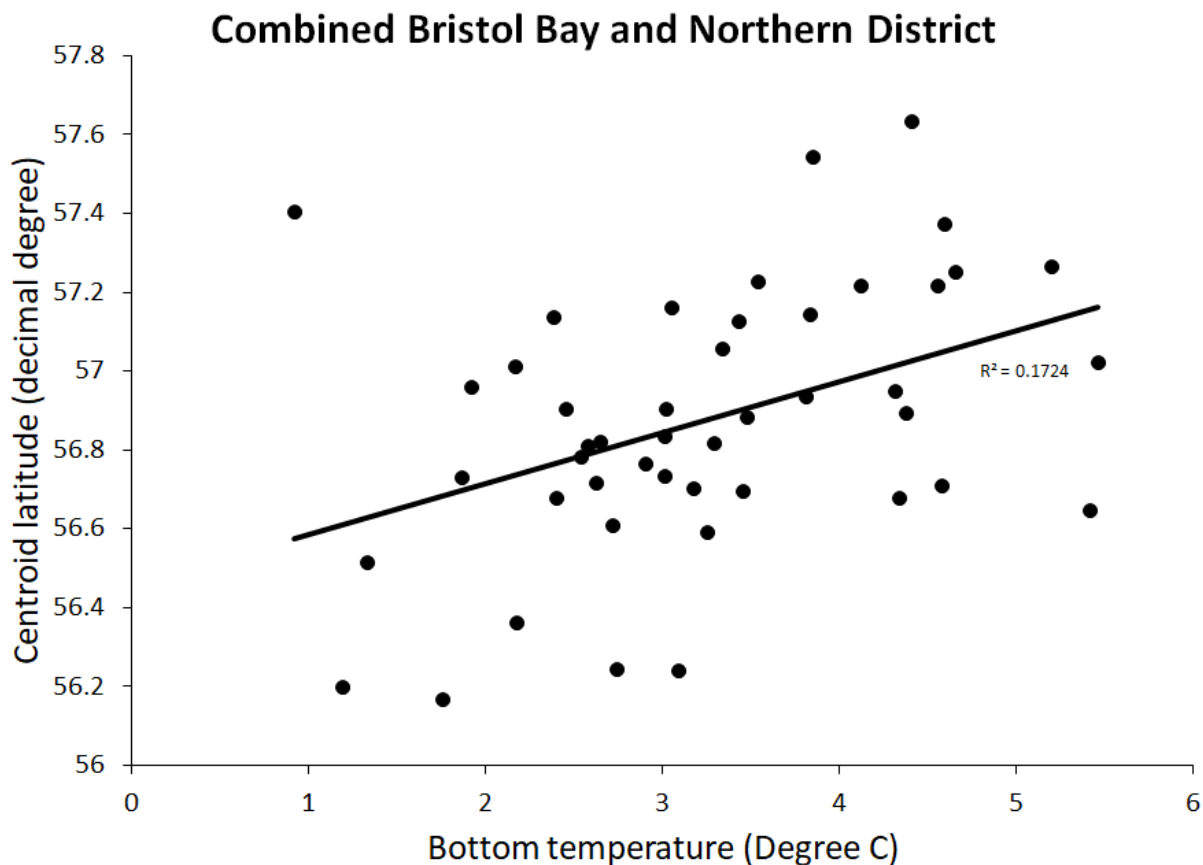


Figure 3-6 Legal male weighted center of distribution latitudes by mean summer bottom temperature for EBS summer bottom trawl survey data (Bristol Bay and Northern District combined). Each point represents one year of trawl survey data.

3.3 Other Boundaries

The RKCSA is closed to non-pelagic trawling year-round. The RKCSS is a 10 nm strip on the southern boundary of the RKCSA that NMFS may be open to non-pelagic trawling if a GHL fishery for BBRKC has been established for the crab season leading into that NMFS calendar fishing year.⁹ The RKCSS was originally established to allow for productive rock sole fishing in years when the RKC biomass is sufficient. The subarea is limited by a subapportionment of the total Zone 1 RKC PSC limit that is set annually in harvest specifications and may not exceed 25% of the Zone 1 PSC limit. The RKCSA/SS were fully implemented as year-round areas in 1997 after having been in place as partial-year closures under emergency rule in the prior year (BSAI FMP Amendment 37; 61 FR 65985, Dec. 1996). At its inception, the area closure was designed to protect the stock and habitat during molting and mating periods. The final EA/RIR for Amendment 37, referencing data from 1993 to 1995, stated that the RKCSA would cover 40% of males and 30% of mature females in the BBRKC stock, with the western portion of the area composed almost entirely of males (NPFMC 1996). For the context of this discussion paper, the reader should note that pelagic trawl gear is allowed within the closure areas. As discussed in the following section of this paper, pelagic gear is known to contact the seafloor.

⁹ See BSAI Groundfish FMP Section 3.5.2.1.3 and § 679.22(a)(3) for RKCSA; § 679.21(e)(3)(ii)(B) for RKSSA.

The NBBTCA is closed to all trawling year-round, except for a subarea near Togiak that is open to trawling from April 1 through June 15 each year (Figure 3-7).¹⁰ The rationale for closing this area to trawl gear is the protection of juvenile RKC habitat. The subarea that is open in the spring is prosecuted for flatfish by non-pelagic trawl vessels, as evidenced by the lack of pelagic trawl impacts mapped in Figure 4-1 through Figure 4-3. Under a voluntary agreement with the Togiak community, the non-pelagic trawl sector ceases fishing in the subarea one week earlier than the regulatory closure (June 7) to minimize interactions with halibut.

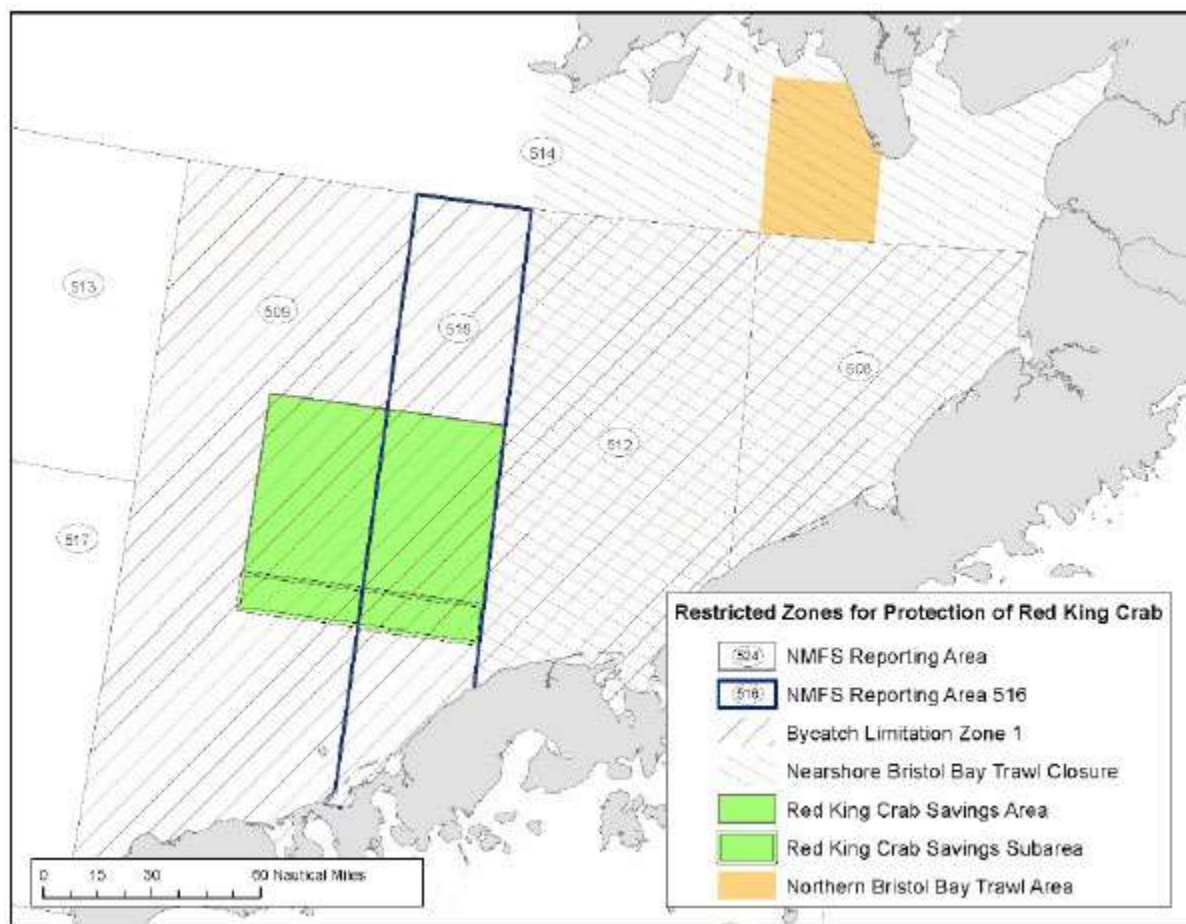


Figure 3-7 Bycatch limitation Zone 1 and trawl closure areas in the Bristol Bay region. NBBTCA includes the areas east of NMFS Area 516. Orange box denotes the “Togiak” area that is open to trawling from April 1-June 15.

Another area designation that affects when certain types of trawling can occur is the Catcher Vessel Operational Area (CVOA).¹¹ Unless directed fishing for CDQ pollock, catcher/processor vessels may not fish in the CVOA during the pollock B Season (June 10 through November 1). The CVOA overlaps Bycatch Limitation Zone 1 by two degrees of longitude (between 165 W and 163 W) and south of 56 N latitude (see [Figure 2 to Part 679](#)). Given that only non-CDQ CP vessels are restricted, this time/area closure does not preclude interactions between trawl gear and RKC.

¹⁰ See FMP Section 3.5.2.1.4 and § 679.22(a)(9).

¹¹ See FMP Section 3.5.2.1.5 and § 679.22(a)(5).

3.4 Zone 1 Red King Crab Trawl PSC Management and Historical Data

Table 3-1 and Table 3-2, below, report the trawl PSC limits and PSC estimates for RKC in Zone 1.¹² The Zone 1 PSC limit for RKC is set in harvest specifications based on criteria established in regulation at § 679.21(e)(1)(i) and is described in Section 3.6.2.1.1 of the BSAI Groundfish FMP (Zone 1 depicted in Figure 3-18 of the FMP, and elsewhere in this paper). The criteria are the estimated abundance of mature females and the effective spawning biomass. The total Zone 1 PSC limit is 197,000 crab if the number of mature females is greater than 8.4 million and the effective spawning biomass is greater than or equal to 55 million lbs. The limit is 97,000 crab if mature females are greater than the 8.4 million threshold and the effective spawning biomass is between 14.5 and 55 million lbs. The limit is 32,000 crab if mature females are below the 8.4 million threshold or effective spawning biomass is less than or equal to 14.5 million lbs. The Zone 1 PSC limit was reduced from 197,000 to 97,000 in 2012 as a result of effective spawning biomass falling below the 55 million lbs. threshold. The number of mature females also went down in 2012, but did not fall below 8.4 million. The Zone 1 PSC limit remained at 97,000 from 2012 until 2022. This year, based on 2021 survey data, the PSC limit is 32,000 crab. Mature female abundance was estimated at 6.432 million crab and effective spawning biomass was estimated at 25.120 million lbs. (87 FR 11641). The reduction in the PSC limit is the result of falling below the mature female abundance threshold of 8.4 million crab.

Each year, the total Zone 1 PSC limit is apportioned to the CDQ PSQ reserve (10.7% of the limit), the Amendment 80 sector (A80), and the BSAI Trawl Limited Access sector (TLAS). CDQ PSQ can be used for directed fishing with any gear type. Part of the total limit that would have been apportioned to A80 is not apportioned to any sector or gear and remains unused; this was part of the designed implementation of the Amendment 80 program. The TLAS limit applies to all trawling by non-A80 vessels, including both pelagic and non-pelagic gear. The TLAS limit is subapportioned to three directed fishery categories for purposes of in-season PSC monitoring and management: yellowfin sole, Pacific cod, and a combined category consisting of pollock, Atka mackerel and “other” species (“other” includes skates, sharks and octopuses). That third fishery category generally encompasses the fishing that occurs with pelagic trawl gear.

When a Zone 1 RKC PSC limit is reached (see Table 3-1), NMFS closes directed fishing with non-pelagic trawl gear for that species category. For example, if TLAS reaches the PSC limit for the Pacific cod directed fishery (2,954 crab in 2021; 975 crab in 2022) then Zone 1 would be closed to non-pelagic trawling in the directed fishery for Pacific cod. Pacific cod could still be retained up to the MRA when fishing with non-pelagic gear in the directed fishery for yellowfin sole. If TLAS reaches the PSC limit for the pollock/Atka/other category (197 crab in 2021; 65 crab in 2022) the directed fishery for that category is closed for non-pelagic trawl gear. This closure may not directly impact where vessels fishing for pollock can fish because pollock vessels use pelagic gear, Atka mackerel are not targeted in Zone 1, and directed fishing for “other species” (skates/shark/octopus) is never open. The pollock fishery is treated differently – i.e., it is already not permitted to use non-pelagic gear and thus it is effectively not subject to non-pelagic trawl closures. This specific handling of the pollock/Atka/other category went into effect under FMP Amendment 57. The Council’s purpose and need for Amendment 57 was focused on bycatch minimization and the action also included PSC limit reductions for halibut, RKC, opilio crab, and Tanner crab.

¹² Though different than a PSC limit, and thus not directly requested as part of this discussion paper, the analysts note a different limit on trawl catch of crab in the BSAI and GOA pollock fisheries. Regulations at 679.7(a)(14)(i) define the BSAI Trawl Gear Performance Standard. This regulation makes it unlawful for a vessel participating in the directed fishery for BSAI pollock to have 20 or more crabs with a carapace width of more than 1.5 inches (38mm) at any particular time. This regulation can be enforced by the NOAA Office of Law Enforcement (OLE).

Comparing Table 3-1 and Table 3-2, it is evident that the Zone 1 PSC limits in place prior to 2022 have not been reached. However, the lower limits in place for 2022 would have been reached in some of the years since 2010, resulting in an area closure for non-pelagic trawl gear. Examples are A80 in all years except 2015 and 2018, CDQ in 2020, and TLAS Pacific cod in 2011. The TLAS pollock/Atka/other category – which best aligns with the Council’s motion as it regards pelagic trawl gear – would not have met the 2022 Zone 1 PSC limit of 65 RKC in any year. Sixty-five animals is a small number of any species in the context of trawling, and it is easy to imagine that this limit could be met but, as noted above, reaching the limit would not directly require vessels targeting pollock to move out of Zone 1.

The groundfish basis weights for the Zone 1 PSC estimates shown in the TLAS Pollock/Atka/Other column of Table 3-2 ranged from 88,000 mt to 513,00 mt during the 2010 through 2021 period, meaning that the number of estimated RKC PSC per ton of groundfish is near to zero. Groundfish basis weight is the denominator used to calculate a PSC rate (number of crab per metric ton of groundfish). In terms of groundfish production in that segment of the TLAS, harvest within Zone 1 averaged roughly 277,000 mt annually for the whole period, and roughly 427,000 mt annually for the five most recent years (range of 343,000 to 513,000 mt). Zone 1 harvest in other fishery categories was lower in volume than the pelagic trawl sector. The A80 sector averaged 84,000 mt of groundfish annually since 2010 (54,000 mt in the five most recent years), and the non-pelagic TLAS category (Pacific cod, yellowfin sole, and other flatfish) averaged 21,000 mt (22,000 mt in the five most recent years). The A80 sector’s PSC rate was around 0.30 to 0.40 RKC per mt of groundfish, and the rate for the non-pelagic portion of the TLAS category was around 0.06 to 0.10 RKC per mt.

Table 3-1 Zone 1 red king crab prohibited species catch limits for trawl gear, 2010-2022

Year	A80 Limit	A80 Not Allocated	CDQ	TLAS Pollock/Atka/Other	TLAS Pacific Cod	TLAS Yellowfin	TLAS Total	Total
2010	98,920	23,204	21,079	400	6,000	47,397	53,797	197,000
2011	93,432	28,692	21,079	400	6,000	47,397	53,797	197,000
2012-2021	43,293	16,839	10,379	197	2,954	23,338	26,489	97,000
2022	14,282	5,555	3,424	65	975	7,700	8,739	32,000

Table 3-2 Zone 1 red king crab prohibited species catch estimates for trawl gear, 2010-2021

Year	A80	CDQ [†]	TLAS Pollock/Atka/Other	TLAS Pacific Cod	TLAS Yellowfin	TLAS Other Flatfish	Total
2010	54,479	779	22	0	0	0	55,280
2011	31,304	3,634	0	1,971	1,366	0	38,276
2012	24,164	2,605	3	0	102	123	26,996
2013	22,537	2,425	15	0	69	140	25,186
2014	26,586	1,457	0	85	92	0	28,220
2015	12,615	62	0	51	6	20	12,754
2016	21,442	430	6	547	842	58	23,325
2017	27,143	3,722	39	280	3,626	245	35,055
2018	9,799	1,936	14	199	778	12	12,739
2019	20,775	2,051	18	466	1,604	119	25,033
2020	32,474	6,301	9	175	3,034	762	42,755
2021	16,397	1,867	17	25	892	0	19,198

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC.

[†] CDQ red king crab PSC is reported for trawl gear only.

Note: "TLAS Other Flatfish" shows PSC that occurred on trips (CV) or hauls (CP) where the target assigned by NMFS CAS based on predominant species caught does not fit the three categories for which a PSC limit is apportioned (e.g., rock sole, flathead sole, plaice). These CAS "targets" likely occur in the directed fishery for yellowfin sole. Accruing this crab PSC to an apportioned limit has not previously been an issue due to the large gap between historical TLAS yellowfin sole PSC limits and use, but with lower limits in effect in 2022 NMFS could reasonably accrue this PSC to the yellowfin sole category. NMFS would use its knowledge of the fishery and the activity of the vessels on which PSC occurred to accrue PSC accurately.

The amount of PSC that can be taken by non-pelagic trawl gear in the Red King Crab Savings Subarea (RKCSS; shown in Figure 3-7) is restricted by a limit set annually in harvest specifications that cannot exceed 25% of the total Zone 1 limit (§ 679.21(e)(3)(ii)(B)(2)). From 2012 through 2021, for example, this meant that non-pelagic gear could not take more than 24,250 RKC in the RKCSS (limit set at 25% of 97,000). However, when the BBRKC stock is insufficient for the State of Alaska to establish a GHL fishery in the previous year NMFS and the Council will not specify a PSC limit for the RKCSS and thus NMFS closes the subarea to directed fishing with non-pelagic gear. This is the case for 2022.¹³

For comparison to trawl bycatch of RKC in Zone 1, Table 3-3 reports estimated crab discard mortality in the directed fishery for BBRKC that takes place in State Registration Area T. ADFG estimates total discards by summing estimated catch of females and males based on fishing effort multiplied by sex-specific observer catch-per-unit-effort (CPUE) data. All female catch is discarded and male discards are estimated as the remainder after subtracting retained catch from total male catch. Most discarded males are of sublegal size, though some legal-size males are discarded due to shell condition or if they are very close to the legal size threshold. Estimated discard mortality is calculated by applying a 20% "handling mortality rate" to total discards.¹⁴ Reliable discard estimates are available back to 2005 when the fishery was rationalized and observer data improved. The table shows that total discards are greater than retained catch in most years, but not all. On average, retained catch was about 80% of the number of discarded crab, though the annual range varied from 42% (2018) to 185% (2012). In the three most recently reported years when there were fewer crab retained (2018-2020), discards outweighed retained catch by a greater margin, perhaps reflecting that the fishery was sorting through a higher relative proportion of sublegal males.

¹³ See final rule for implementing 2022/23 BSAI harvest specifications: [Table 15 in 87 FR 11626, March 3, 2022](#).

¹⁴ The 20% handling mortality rate for red king crab within the directed fishery is lower than mortality rates applied to red king crab caught in the Tanner crab fishery (25%), fixed-gear fisheries (50%), and trawl fisheries (80%).

Table 3-3 Estimated discards, discard mortality, and retained catch (number of animals) in the directed BBRKC fishery, 2005-2020 (Source: B. Daly, ADFG. March 2022. Pers. Comm.)

	Female discards	Male discards	Total discards	Discard mortality	Male catch (retained)
2005	1,682,031	3,181,024	4,863,056	972,611	2,763,147
2006	221,623	1,572,174	1,793,797	358,759	2,502,786
2007	731,651	3,498,460	4,230,111	846,022	3,162,287
2008	662,313	3,772,206	4,434,519	886,904	3,066,286
2009	350,730	3,118,571	3,469,302	693,860	2,556,645
2010	470,492	2,321,052	2,791,545	558,309	2,409,952
2011	118,511	1,338,976	1,457,486	291,497	1,298,023
2012	46,511	590,033	636,545	127,309	1,175,752
2013	409,457	908,106	1,317,563	263,513	1,272,273
2014	275,901	1,704,433	1,980,333	396,067	1,525,581
2015	801,260	1,107,517	1,908,777	381,755	1,526,974
2016	432,824	946,875	1,379,699	275,940	1,281,194
2017	233,063	730,783	963,846	192,769	997,214
2018	591,898	910,903	1,502,801	300,560	629,907
2019	151,967	813,686	965,653	193,131	548,516
2020	64,575	662,986	727,561	145,512	455,262
Average	452,800	1,698,612	2,151,412	430,282	1,698,237
Median	380,094	1,223,246	1,648,299	329,660	1,411,802

3.5 Stock Distribution: Logbook and Tagging Studies

The Alaska Fisheries Science Center, ADF&G, and the Bering Sea Fisheries Research Foundation (BSFRF) have collaborated to develop and test tagging techniques for BBRKC that will contribute to the understanding of stock distribution and movement patterns outside the summer trawl survey period. These methods have included the use of pop-up satellite tags, traditional spaghetti tags¹⁵ and acoustic tags. Each tagging method has different strengths in terms of cost, deployment duration, recovery method, and tag retention through the molt. Initial efforts focused on mature males, examining crab movement from summer into fall, when the directed crab fishery begins. Tagging results are currently being analyzed and prepared for publication. Thus far, results for males show similar patterns in fall distribution compared with fishery-derived data. One published study of fishery data utilized logbooks to track legal males in the fall months of 2005 through 2016 (Zacher et al., 2018). The purpose of the logbook study, and winter tagging studies that are ongoing, is to fill the information gap on where RKC are distributed outside of the summer survey season. Zacher et al. found that, on average, roughly 60% of commercially caught BBRKC were harvested in areas that are closed to all trawling (e.g., NBBTCA) or non-pelagic trawling (RKCSA) but that percentage fluctuated based on temperature regime. RKC were found farther south, towards the Alaska Peninsula, in cold years but tended to cluster in the middle of Bristol Bay in warm years. The study authors noted that “it is difficult to evaluate the placement of no-trawl zones, because most crab bycatch occurs in trawl fisheries during winter when crab distributions are unknown.”

More recent tagging efforts have focused on the winter and early spring when BBRKC distributions are less well understood. The winter/spring period is of particular interest because of increased expected interactions with trawl fisheries at the same time that crab are mating and molting. In November 2021,

¹⁵ “Spaghetti tags” are a piece of tough plastic that is attached to an animal. The tag has an identification code that a person can report when the tag is retrieved.

pop-up satellite tags were placed on both mature male and female RKC in Bristol Bay. Tags released from male crab in January 2022 and will release from females later in spring 2022, which is set to approximate the timing of larval hatch and mating. The timing on both releases is required to ensure tags release before crabs molt and either before/after sea ice is expected in Bristol Bay. Figure 3-8 shows the movement of male crab from fall into winter based on the first pop-up satellite tag results from the ADFG/NMFS/BSFRF study.

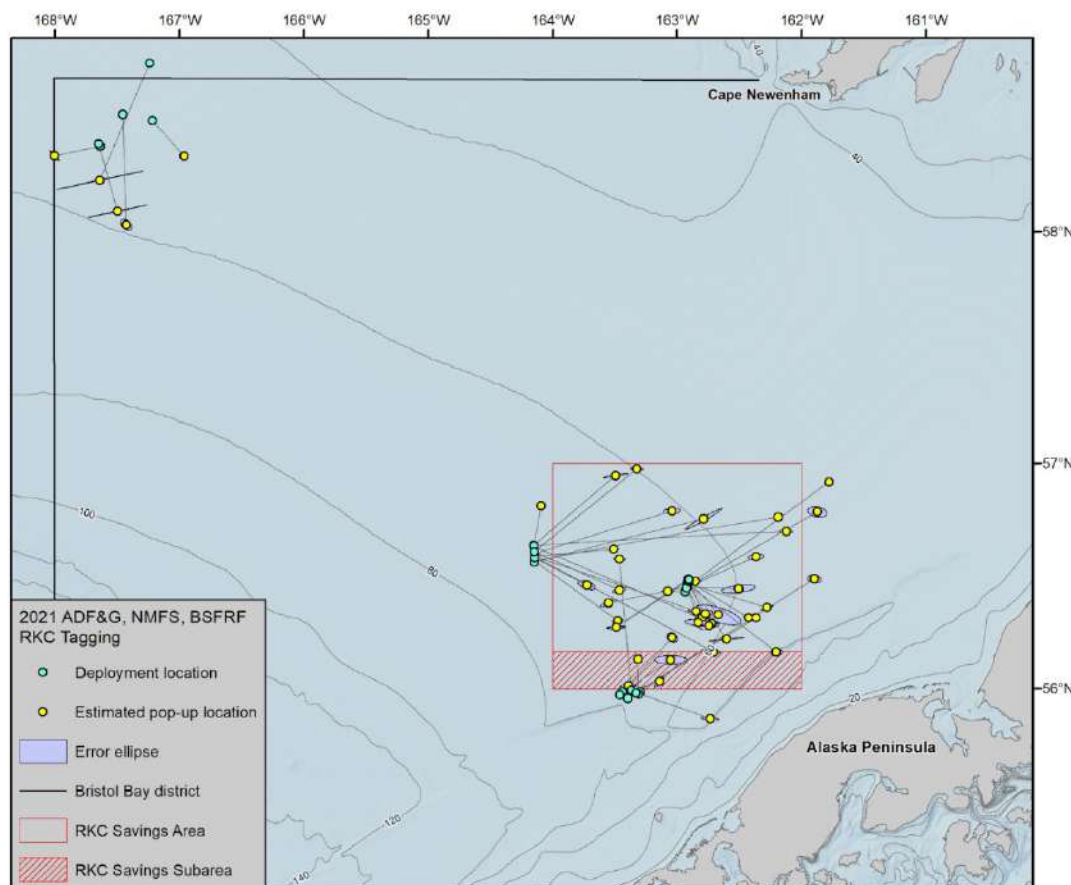


Figure 3-8 Fall-to-winter 2021/22 male red king crab tagging results in Bristol Bay (Source: B. Daly, ADFG. March 2022. Pers. Comm.)

4 Item 3: Bottom Contact by Pelagic Trawl Gear

The Council asked staff to provide the best available information on bottom contact by pelagic trawl (PTR) gear and the impact it may have on the BBRKC stock.¹⁶ This is a complex topic on which the best available science continues to progress. For the following discussion, the analysts stipulate two facts that

¹⁶ “Pelagic trawl” gear is defined in regulation (679.2) as a trawl that has no discs, bobbins or rollers, which are elements of non-pelagic trawls that elevate gear off the seafloor. Pelagic trawls cannot have chafe protection gear attached to the footrope or other lines. The physical aspects of the gear, as is noted by onboard observers or enforcement officers, is what determines whether a vessel may directed fish for pollock or trawl in areas closed to non-pelagic gear (e.g., RKCSA). The term “pelagic” is sometimes used informally to describe the midwater pollock target in NMFS Catch Accounting System (CAS) data as it relates to catch/bycatch estimation. This paper strictly adheres to the definition of pelagic that describes the physical gear, thus the data included reflects all pollock trawling regardless of whether classified in CAS as midwater or bottom pollock targets.

are known to fishery participants and are documented in work reviewed by the SSC: pelagic trawl gear contacts the seafloor, and pelagic trawling is synonymous with the pollock fishery.¹⁷ The fact that pollock trawls in the eastern Bering Sea contact the seafloor is not surprising given that the area is relatively shallow, flat, and has the type of substrates that trawl gear can generally withstand – as compared to areas off the shelf, around the Aleutian Islands, or in the Gulf of Alaska. Also, trawl operators may fish close to the bottom of the water column at times to minimize bycatch of salmon species that are higher up or to increase pollock catch rates if the target fish are near the bottom, thus reducing the total towing time required to meet the harvest target.

The Council's request entails two questions that are highly related but not identical. The first question – where and how often pelagic trawl gear is contacting the seafloor in the Bering Sea – can be, and has been, studied empirically. That work builds upon earlier estimates that were based on the conventional wisdom of gear designers and vessel operators; much of that work was done in service of the Essential Fish Habitat (EFH) EIS which itself has undergone iterative reviews and refinements for several decades. Nevertheless, PTR is the most complex gear for which to estimate bottom contact and event-level data are in relatively short supply. As a result, the best efforts to quantify area-wide bottom contact are model-based, using contact parameters that are estimated for types of fishing events that are being described at increasingly specific levels as work progresses. The second question – what impact pelagic gear contacting the seafloor has on BBRKC – requires a connection to be made between gear-on-bottom and both the benthic habitat of RKC and bycatch (observed and unobserved). That connection is the crux of the issue and will not be fully answered here. The best available information can accurately capture where PTR has occurred since 2003 but the ability to draw a conclusion about stock impacts would require the knowledge of where RKC were during the trawl season and the shell condition of those crab as it relates to the molt/mate cycle.

The analysts wish to make clear that the direct and indirect impacts of PTR, or trawl gear in general, is not presumed to be the sole driver of the decline in the BBRKC stock that has been ongoing since around 2007 (Figure 1-1) and has recently come to a head with the closure of the 2021/22 directed fishery. Trawling that contacts the seafloor is assuredly one of the factors that challenge the BBRKC stock; other factors to account for include directed crab fishing, the effect of other groundfish gear types, and BBRKC stock dynamics as influenced by the changing ecosystem. Ecosystem factors and their effects, as currently understood, were described in the two previous sections of this document (see also Fedewa et al. 2020).

The end of this section acknowledges that other modes of fishing could impact BBRKC and the stock area (Section 4.5), but this paper is largely focused on pelagic trawling to be responsive to the Council's request. A more expansive look at the effects of fishing would be found in the Council's EFH review documents, where cumulative fishing effort across all gear types is mapped while accounting for dynamic changes in the ocean environment (the most recent update on this work is found in Olson et al. 2022; [Feb. 2022 SSC Agenda Item D5](#)).

¹⁷ From 2010 through 2021, 99.98% of groundfish caught with pelagic trawl gear was in the pollock “target” fishery as classified by NMFS Catch Accounting System. Catch by the pelagic gear sector in other targets – Atka mackerel, Pacific cod, rockfish, flathead sole, rock sole, and yellowfin sole – accounted for only 3,725 out of roughly 15.2 million metric tons over the entire period. Those instances in the CAS likely result from outlier events or perhaps test fishing.

The Gear Limitations section of regulations (679.24(b)(4)) specifies that non-pelagic trawl gear may not be used to engage in directed fishing for pollock in the BSAI. The amount of time that a trawl footrope may be in contact with the seabed is restricted in any pelagic-trawl-only portion of the Gulf of Alaska (no more than 10% of any tow), but no such limitation is specified for the BSAI.

4.1 Estimated Bottom Contact

In responding to the Council's request, this paper presents novel outputs that were produced using the data that underlie the Fishing Effects (FE) model, though in a different application. The FE model uses spatially-explicit data (gear tracks) dating back to 2003 to estimate cumulative impacts on benthic habitat while accounting for the nature of the seafloor substrate and its ability to regenerate (Smeltz et al., 2019). FE utilizes parameters that translate gear tracks to estimated bottom contact; these parameters have been reviewed by the SSC, most recently in February 2022 (see Appendix 2 in Olson et al. 2022). Here, the same Vessel Monitoring System (VMS) pelagic trawl tracks that inform FE are plotted to give the best possible accounting for where pelagic trawl gear contacts the seafloor in the Bristol Bay region. The reader should note that estimated bottom contact is not directly equivalent to RKC bycatch or impacts on the ability of BBRKC to reproduce and recruit into the fishery.

Figure 4-1 through Figure 4-4 were produced by the Fisheries, Aquatic Sciences & Technology (FAST) Lab at Alaska Pacific University (APU).¹⁸ Figures FR1 through FR3 depict the nominal area swept by PTR gear as modified by the bottom contact parameters that are used in the FE model, described below the figures. The base unit of measure is the monthly area swept per 5-kilometer grid cell, which has been averaged across years (Figure 4-1) or across seasons annually (Figure 4-2 and Figure 4-3). Estimated PTR bottom contact is cumulative. For instance, a hypothetical grid cell that registers 25 km² of swept area does not indicate that every square kilometer in the cell was subject to bottom contact by PTR; rather, that cell would indicate that cumulative total estimated bottom contact on a monthly basis amounted to more than 25 km². A grid cell that registers 20 km² of swept area also does not indicate that 80% of the grid cell was contacted; in many cases, vessel tracks are overlapping.

Figures Figure 4-2 and Figure 4-3 depict 19-year seasonal averages for what is, approximately, the pollock A and B seasons. Figure 4-2 includes January through May and Figure 4-3 includes June through November. The darker color scale in those figures relative to Figure 4-1 is a function of averaging seasonal totals versus monthly totals. FR1 plots the 19-year average of all months' (Jan-Nov) total swept area from 2003-2021 (e.g. 11 monthly averages over 19 years). Figure 4-2 and Figure 4-3 take the seasonal value of swept area in each year and average those values across years – in other words, each Jan-May or June-Nov time period is a unit that is then averaged over 2003-2021. The reader should focus on the story that the maps tell about where the pollock fishery occurs seasonally, in the context of other information known about the BBRKC stock, rather than the absolute values depicted.

A selection of year/month-specific maps using the same methodology is attached as Appendix 2. Though more intensive to interpret due to the number of months in the analyzed period, those maps allow the interested reader to see past the effect of averaging across years or seasons over a period of many years.

Figure 4-4 shows estimated PTR bottom contact by area (directed BBRKC fishery area, PSC Zone 1, RKCSA, and RKCSS) in relation to the BSAI pollock seasons. Seasonal bottom contact data are of interest because RKC are understood to be molting and mating during the A Season, though their specific location relative to the PTR fishery is uncertain. The time step for each plotted point on the x-axis is one month so, whereas the first three figures show monthly or seasonal averages compressed over years, Figure 4-4 allows the reader to look at swept-area estimates for individual months in isolation. In most years, the peak of estimated swept-area occurs at the beginning of each season (left hand side of grey/white vertical bands); this accords with a general understanding of when the pollock fishery is most heavily prosecuted.

¹⁸ F. Restrepo, APU FAST Lab. March 2022. Personal Communication.

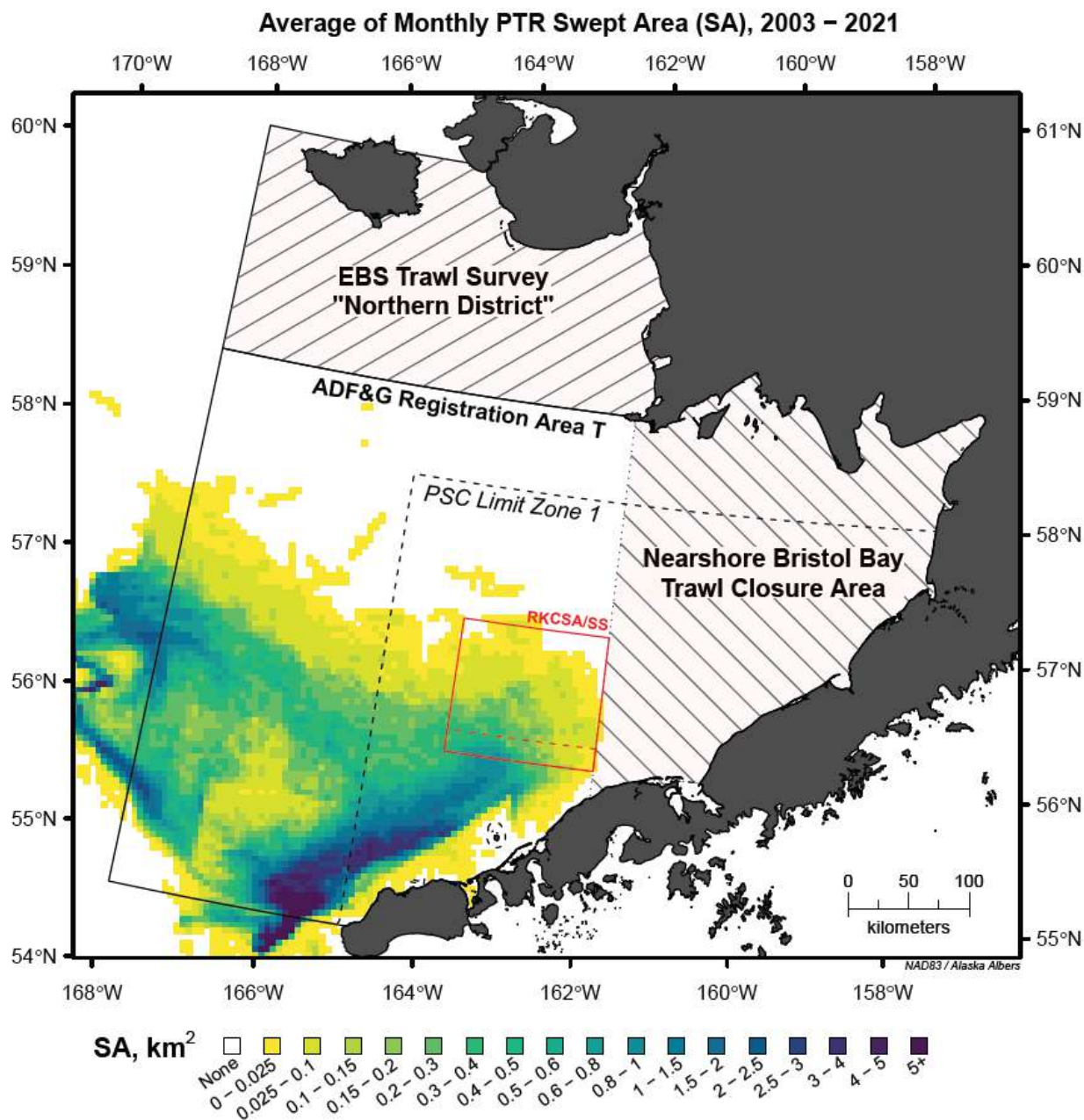


Figure 4-1 Estimated pelagic trawl swept area (SA) in the eastern Bering Sea. 5 km grid cells represent SA by month, averaged across all pollock fishery months (Jan-Nov) in available years, 2003-2021. (Source: APU FAST Lab)

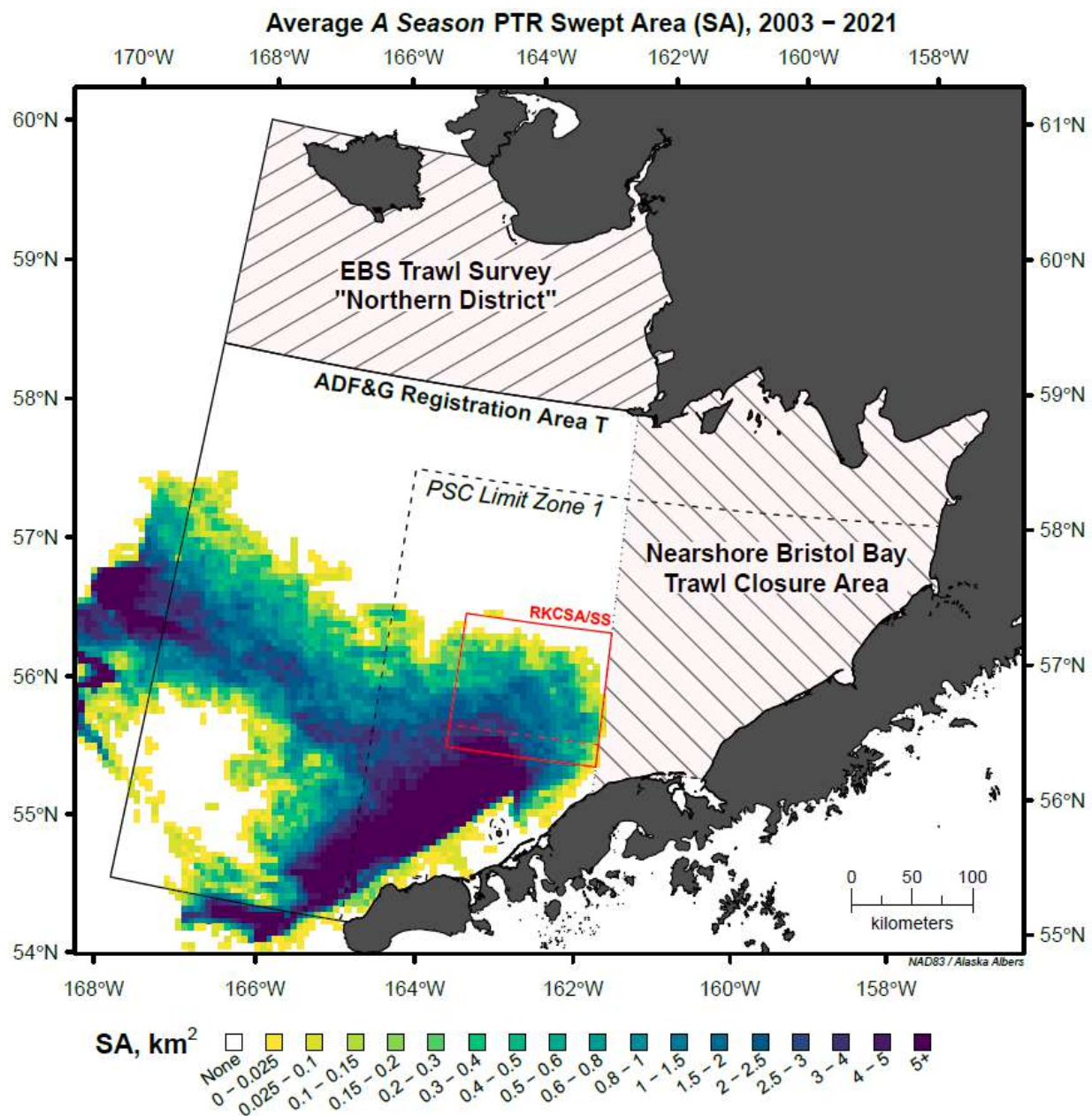


Figure 4-2 Estimated pelagic trawl swept area (SA) in the eastern Bering Sea. 5 km grid cells represent SA by pollock “A season” (Jan-May), averaged across all available years, 2003-2021. (Source: APU FAST Lab)

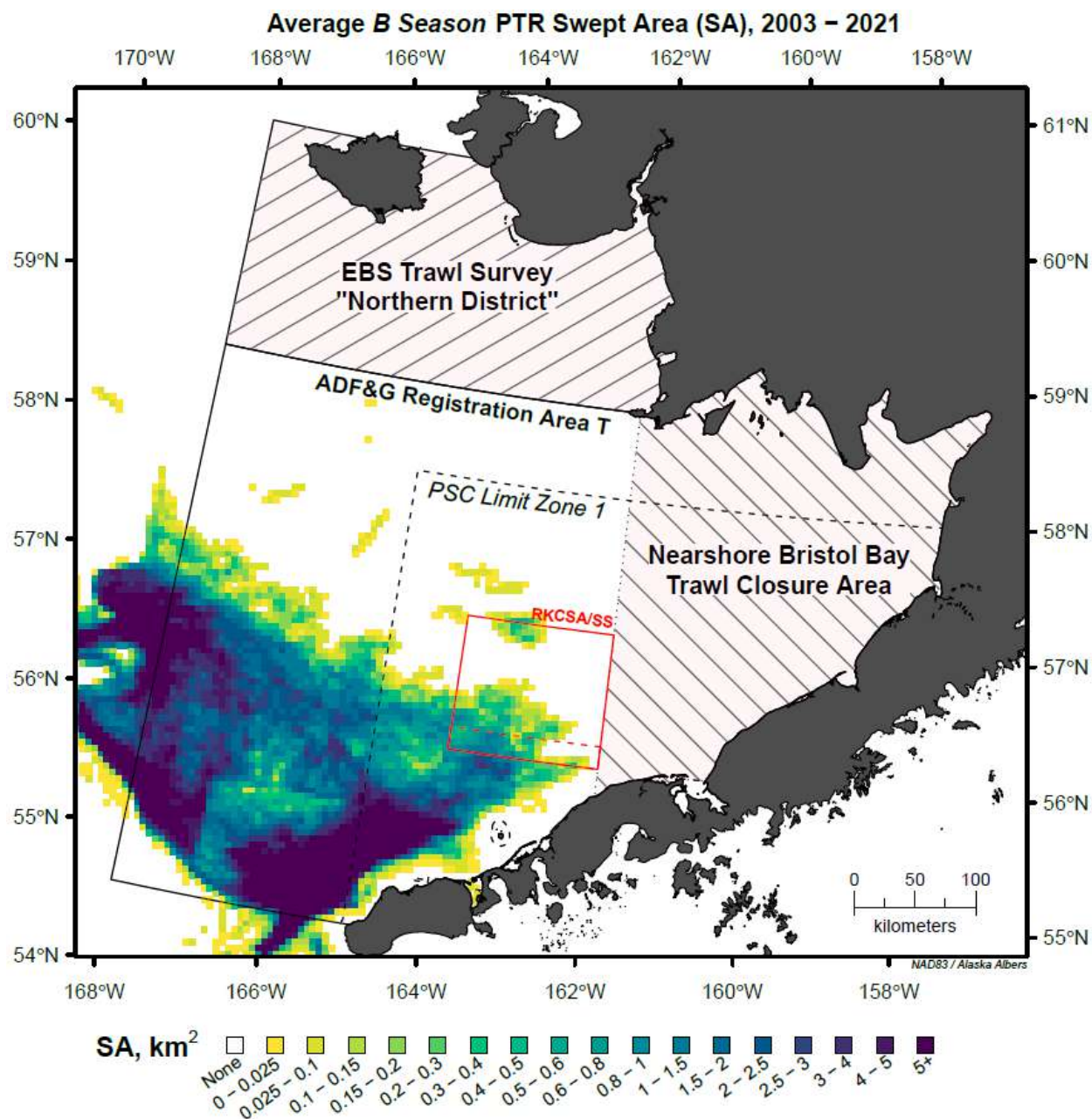


Figure 4-3 Estimated pelagic trawl swept area (SA) in the eastern Bering Sea. 5 km grid cells represent SA by pollock “B season” (June–Nov), averaged across all available years, 2003–2021. (Source: APU FAST Lab)

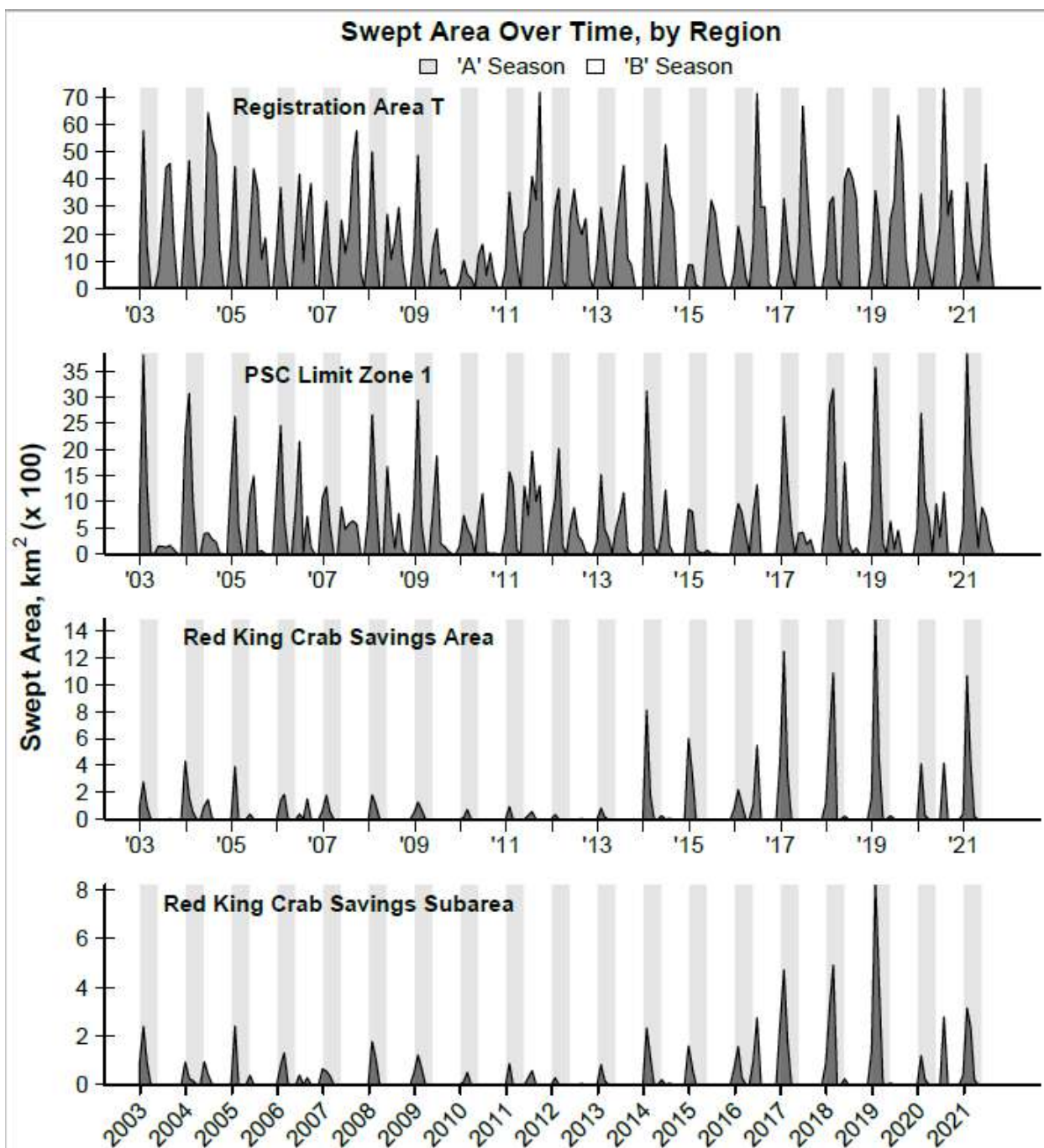


Figure 4-4 Estimated pelagic trawl swept area within four management areas of interest, by month (x-axis), 2003-2021. Grey and white vertical bands represent the pollock “A season” (Jan-May) and “B season” (June-Nov). Note the difference in y-axis scale across the four areas. (Source: APU FAST Lab)

The bottom contact for each trawl tow used to estimate fishing intensity in the FE model itself is calculated by multiplying the distance fished by an estimate of the width of trawl/seafloor contact. Contact width estimates used in these plots break down individual pelagic trawl events by fishery, the target assigned by NMFS Catch Accounting System (CAS) – e.g., midwater-pollock versus bottom-pollock/all others – FMP area, season (A/B), vessel type (CP/CV), vessel length (partly as a proxy for horsepower or other towing characteristics), and ocean depth in the grid cell where the tow occurred. Both

trawl width during operation (nominal width) and the proportion of that width in contact with the seafloor (contact adjustment) vary across fishing situations. Maximum trawl width was derived based on direct input from gear manufacturers. Nominal widths were calculated as a proportion of maximum trawl width for each vessel class and then further adjusted for event-level effects that can affect net spreading – e.g., depth, season, and day vs. night. Finally, the adjusted nominal width is multiplied by the contact adjustment that is indexed for trawl height values estimated from fishing depths and seafloor depths as recorded in vessel logs.

The contact adjustment for a Bering Sea pelagic trawl CV tow is drawn from a range spanning 0.2 to 0.6 with a median of 0.4. In other words, actual bottom contact would be estimated at a value between 20% and 60% of the raw area swept, where raw area swept is a function of tow length and adjusted nominal width. The contact adjustment for pelagic CPs is drawn from a higher range. During the A Season the contact adjustment for CPs is drawn from 0.7 to 0.9, reflecting an assumption that pelagic gear is on bottom at least 70% of the time. During the B Season the range is from 0.8 to 1.0.

The adjustment parameters were developed by the FE model authors in consultation with trawl fleet representatives prior to the model's use in the 2016 Essential Fish Habitat (EFH) analysis. Contact adjustments do not assume that the on-bottom trawl path is the entire width of the trawl's wing-tip spread. In the absence of direct measurement of contact width during fishing operations, the investigators estimated the bottom-contacting proportion of the net by augmenting industry knowledge with data on bycatch of benthic species at different times in the year (as correlates to the depth of area-fished) and trawl height (distance between the headrope and the ocean depth, reported by observers). Bycatch presence and trawl height reports are imprecise measures of the proportion of pelagic trawl widths contacting the seafloor, but it was noted that bycatch increased and trawl height decreased from the A season to the B season and as ocean depth increased. The investigators noted several reasons that nominal width might vary with fishing depth, seasons, or times, and thus result in a higher or lower bottom contact estimate – holding trawl height and fishing depth the same. Trawl nets being fished deeper require longer lines so the cables do not restrict the width as much as they would if the net is fishing closer to the sea surface. Fishing in harsher conditions (e.g., A season) may also put more tension on cables and thus restrict spreading. Also, vessels fishing at night might be more likely to keep the net off the bottom and thus would use less line and allow for less spread.

Another source of the distinction in bottom contact percentages estimated for CVs and CPs came from the proportion of tows where the trawl height was at a level where contact with the seafloor was low, medium, or highly probable based on the estimates of the normal vertical operating opening of the pelagic trawl nets used in each fleet. In other words, CPs had a greater percentage of tows where the distance between the headrope and the seafloor was such that bottom contact had a greater probability (C. Rose. Personal communication, Jan. 2022).

4.2 Related Research: Ecosystem Indicators

Alaska Fisheries Science Center researchers have reached out to the authors of this paper to note that data products similar to the swept-area estimates shown above could support the development of a fishing effects indicator for inclusion in the Bristol Bay RKC Ecosystem and Socioeconomic Profile (ESP).¹⁹ The most recent BBRKC ESP – September 2020 – is available as [Appendix E to the BBRKC SAFE Report](#). The ESP is a useful reader reference for summary information on the relevant ecosystem conditions, stock dynamics, fishery participation, production, and market values.

A quantification of the spatiotemporal overlap of RKC populations and fishing gear could provide an indicator that highlights potential RKC vulnerabilities and communicates stock-specific concerns to

¹⁹ E. Fedewa. 2022. Personal communication.

managers and stakeholders. Future refinement of a fishing effects indicator could, for example, assess the impact of multiple gear types, and utilize ongoing BBRKC satellite tagging efforts to characterize spatial overlap between winter fisheries and BBRKC distributions during the molt-mate season.

4.3 Related Research: Bottom Contact for Pelagic Trawl Gear

This subsection briefly summarizes two master's thesis projects conducted at Alaska Pacific University's FAST Lab.

Zagorski (2016) addresses the pollock industry's ability to develop trawl gear that complies with regulations prohibiting the use of the elevating discs, bobbins and rollers that are common in non-pelagic trawls while efficiently capturing pollock near the seafloor, avoiding salmon, crab, and halibut, and minimizing adverse impacts on benthic habitats. The author cites previous work noting that adult pollock aggregate on or near the seafloor – particularly during the daytime – that pelagic trawls are not optimal for capturing pollock near the seafloor, and that variable seafloor contact increases the potential for benthic impacts. The North Pacific Research Board (NPRB)-funded field research partnered FAST Lab with NOAA and AFSC to quantify the benthic impact of six modified footrope configurations: one that complies with pelagic gear regulations and five that do not. Raised footropes were achieved using floating line material (as opposed to chains) and a range of spacing, weights, and bobbins. Results were gathered with bottom contact sensors on the footrope, cameras, and imaging sonar to assess measures of benthic impact like trawl tracks and downed sea whips. The study found that modified footropes were effective at elevating the groundgear resulting in reduced impact of pelagic gear on benthic organisms. Some of the tested modifications could be implemented under current regulations while others (e.g., bobbins) would require changes. Additional work would be required to understand whether these modifications would be effective for capturing target species while avoiding bycatch (e.g., non-pollock groundfish, halibut, and crab). The final report for this project entitled “Assessment of the benthic impacts of raised groundgear for the eastern Bering Sea pollock fishery” was submitted to the NPRB in August 2016.²⁰

King (2019) evaluated methods to quantify the footrope-seabed interactions of pelagic trawls. Building on the Zagorski (2016) work, this effort focused on developing technological and analytical tools to gather event-level information on bottom contact and seafloor clearance of pelagic trawls. During a NMFS-AFSC conservation engineering research charter, contact and clearance data were gathered at 1 or 5 second intervals by multiple accelerometer-based tilt sensors placed at 5 points across the footrope span. The investigators found that (1) bottom contact was less than expected by the vessel master, (2) contact was highly variable along and across the tow path even when the vessel operator was attempting to keep the gear “hard on the bottom” for the purpose of the experiment, and (3) the center of the footrope had higher clearance (less contact) than the inner and outer wings. This study shows that a technological solution to collect more granular data and estimate bottom contact of the footrope is possible but there are complications that remain to be resolved. Namely, the tilt sensors must be attached and removed from the gear during set and haul back to avoid damage to the sensors and the net thereby limiting their broad use during commercial operations. The analyses employed in this study are currently being refined for submission to a peer-reviewed journal. In general, this work demonstrates that if practical for broad deployment, bottom contact sensors could enhance assessments of fishing impact on benthic habitat and species by providing within-tow data on ground contact and clearance including its variability. Currently, estimates of contact are made at the gear-level (i.e. proportion of nominal swept area by gear type) and rely on assumptions based on key, isolated studies and perceptions of fishery participants. The state of knowledge on bottom contact is such that gains can be made even if the technology is deployed without full fleet coverage or precision estimates. One substantial advancement that could be made is better

²⁰ Rose C.S., Harris B., Zagorski S., Hammond C., Sethi S. and McEntire S. 2016. Assessment of benthic impacts of raised footrope for the Eastern Bering Sea pollock fishery. NPRB Project 1319 Final Report. 60pp.

understanding the variability of bottom contact within and between tows. As noted in the description of the gear parameters used in the Fishing Effects model and the PTR area-swept estimates provided in this paper, bottom contact estimates are based on adjustment parameters that cover a broad range of fishing events that fall within a certain category (e.g., CP/CV, target, season, vessel size). As noted throughout this discussion paper, estimated bottom contact is a key component of quantifying fishing impacts on the benthos but estimated contact is not synonymous with the amount of impact to crab or the level of adversity posed.

4.4 Unobserved Crab Mortality from Trawl Gear

Fishing activities lead to crab mortality in ways that are not directly observed. This includes both post-release mortality of discarded crab (which is estimated through a discard mortality rate) and crab that are never captured by fishing gear but die due to gear interactions or sustained damages that cause delayed mortality. The potential for unobserved mortality of crabs that encounter bottom trawls but are not captured has long been a concern for the management of groundfish fisheries in the Bering Sea (Witherell and Pautzke, 1997; Witherell and Woodby, 2005). Unobserved mortality is not accounted for in crab stock assessments and is not accrued towards trawl PSC limits.

Rose (1999) – in a paper studying the injury rates of RKC that passed under non-pelagic trawl footropes – provided the following introductory statement: “The inability to accurately estimate unaccounted mortality does not preclude its consideration in management and fishing decisions. Unfortunately, the lack of information on unaccounted mortality means that those participating in such decisions have to combine and weigh a mixture of related knowledge, opinions, and suppositions to substitute for conclusive facts. This can be a source of considerable dispute and reservations about the ultimate decisions.” A short overview of research on unobserved crab mortality by non-pelagic gear is provided later in this subsection. Since the time of that writing, the Council has taken action to address crab mortality by raising non-pelagic trawl gear off the seafloor in a variety of ways. However, those tools are not available under the pelagic gear specifications in Federal regulation that apply to all Bering Sea pollock trawls. Unobserved mortality impacts for pelagic gear remain in the realm of informed supposition based on related knowledge.

The topic of unobserved mortality was most recently addressed in a Council analysis when crab PSC limits for trawl fisheries were reviewed in February 2021 prior to taking no action (see Section 3.4.6 and Appendix 4 in NPFMC 2021a). The [SSC’s February 2021 report](#) noted that including any future estimation of unobserved crab mortality (from both groundfish and directed crab fishing) in a stock assessment would require extensive evaluation to understand how the assessment’s parameters for factors like catchability, natural mortality and reference points would be affected. The SSC noted that “unobserved mortality is a source of both assessed and unassessed uncertainty throughout the history of the assessments (e.g., currently attributed to natural mortality), and that the ABC/TAC buffers in place are an appropriate process to account for sources of uncertainty that cannot be explicitly described in the assessment.” Finally, the SSC supported further research on the topic by industry and NMFS and encouraged consideration of this source of uncertainty when setting harvest buffers.

The trawl PSC limit analysis (NPFMC 2021a) identified improving the understanding of the seasonal and spatial distribution of crab, crab bycatch, and crab in various shell conditions as important pieces to a better understanding of the unobserved impact of gear interactions. The PTR area-swept maps provided in this paper – Figure 4-1 through Figure 4-4 – do not allow for an estimation of unobserved mortality – just as they do not allow for an enhanced estimation of observed mortality – because they are not mapped onto seasonal crab distribution and shell condition. Nevertheless, as noted above relative to a potential ESR indicator, this new work advances the effort by showing where PTR is likely contacting the seafloor in the Bristol Bay region during the pollock A and B seasons.

Appendix 4 to the trawl PSC limit analysis (NPFMC 2021a) includes a sensitivity analysis conducted by the BBRKC stock assessment author in response to the Crab Plan Team's request to better understand potential stock impacts from theoretical unobserved fishing mortality levels. The author recreated the preferred 2020 stock assessment model but increased the input level of trawl and fixed-gear bycatch biomass by amounts ranging from 100% to 1,000%. The author found that the model's terminal mature male biomass (MMB) and OFL levels did not change much if bycatch biomass was doubled or increased by a lesser amount (decrease < 3% of MMB compared to no change in bycatch). Increasing the bycatch biomass by 500% reduced the model's terminal MMB to decrease by 14% or more, with the author noting that the change could be much larger in some years throughout the model's run.

Published studies on the impacts of trawl gear on crab have generally focused on non-pelagic gear, including studies in the Bering Sea and in the shrimp fishery off the east coast of Canada. Studies have utilized bottom and wing recapture nets to collect impacted crab that would not have ended up in the trawl net, cameras to visualize crab that were avoiding the trawl net, and even submersible camera-equipped vehicle dives to compare damage to crabs before and after trawling in an area. The obvious limitation of referencing studies of non-pelagic gear is that the studies were assessing mortality reduction tools that are not permitted the pelagic trawls that are specified in regulations for the Bering Sea pollock fishery.

Rose (1999) cites an earlier study (Donaldson 1990) as a "preliminary estimate" of the rate of unobserved crab injuries, wherein RKC were tethered to the seafloor, a trawl net was towed over the area, and divers attempted to recover the crab. Of 169 crab, 21% were captured in the net, 46% were recovered by the divers, and 33% could not be located. While only two of the 78 recovered crabs were injured, Rose noted the ambiguity posed by the fate of the unrecovered crabs relative to the sample size. An unpublished video study (Rose 1995) found that sweep diameter was the main factor in whether crab could escape over the sweep (note that sweeps were not elevated during this period). The study was not able to determine the frequency, nature, or severity of injuries to crabs that went under the sweep. The Rose (1999) study in Bristol Bay used a recapture net to assess injury rates to crab that pass under different types of footrope. Eight experimental tows yielded injury rates of between 5% and 10% of the recaptured crab.

Subsequent work by Rose et al. (2013) provided estimates of the unobserved mortality rates of crabs swept over by trawl gear common to bottom trawl fisheries in the Bering Sea. This research demonstrated that mortality rates varied by crab species (red king, Tanner, and snow) but depended mainly on that part of the trawl system crab encountered. Additionally, reduction of crab mortality rates by altering specific gear designs showed that gear modifications, such as raised sweeps, can mitigate unobserved mortality. The finding was that mortality was much higher for crab that passed under the footrope (particularly the wing section) than for crab that were struck by the sweeps that herd flatfish. One supposition was that effective herding can reduce overall crab mortality because it reduces the amount of footrope-swept area needed to catch the same number of flatfish. This study used an assessment method²¹ onboard the vessel to predict the delayed mortality of recaptured crab that would have been impacted by the trawl but not captured by normal fishing. The study also evaluated crab caught in a control net where they did not encounter the trawl gear (footrope, sweeps) to adjust observed mortality rates for the effects of capture and handling. The study results were that the experimental trawls produced more mortalities of RKC than either snow or tanner crab, which was expected due to their larger, less flat body shape. The raw mortality rate for RKC that passed under the footrope wing was the highest, at 32%. The study concluded that RKC estimated unobserved mortality rates, adjusted for the area swept by each trawl component (i.e., footrope center, wing, and sweep) were reduced to 6% when sweeps were elevated, which is now required for BSAI non-pelagic trawls.

²¹ Reflex Action Mortality Predictor (RAMP); see Davis and Ottmar (2006) and Stoner et al. (2008).

The remote-video study of shrimp trawl interactions with snow crab off St. Mary's Bay in southeastern Canada only assessed areas swept by the trawl footrope (Dawe et al. 2007). The study did not collect a large sample of direct post-trawl observations but did not report any dead crab in the trawl corridor or crab with carapace damage. The authors note that the study area has a soft mud substrate and that a similar early study (Schwinghamer et al. 1998) did observe dead crab in a dense sand substrate on the northern Grand Bank. The study did not find a reduced density of snow crab in the trawled bays after trawling occurred. However, the study concluded that intensive trawling could increase crab leg-loss by about 10%.

A trawl-mounted video study in the same part of Canada looked at how snow crab physically reacted to shrimp bottom trawls (Nguyen et al. 2014). This study was also limited to the footrope portion of the trawl, and concluded that about 54% of observable crab interacted with the footgear (e.g., elevating discs, spacers, or chains). The majority of video-observed crabs actively responded to the approaching trawl and tried to escape. The study was unable to estimate the severity or likelihood of mortality after passing under footgear. This study, and references to herding in Rose et al. (2013), highlights the relevance of crab shell condition to susceptibility to unobserved trawl mortality. In a time/area where crab are likely to be in a soft-shell condition and less mobile, unobserved mortality rates could be higher than the ranges estimated in the studies available.

The primary reason for the decline in the BBRKC stock, if there is one, is not clearly understood. While there are likely many interacting factors including crab movement and environmental shifts (including shifts identified prior to the BBRKC decline in the late 1970s), some researchers have highlighted unobserved trawl mortality – historically if not currently (Dew and McConnaughey 2005; Dew 2010). Those researchers contend that the BBRKC brood stock had a high site fidelity to an area in southwest Bristol Bay that was the region's first no-trawl zone, known as the Bristol Bay Pot Sanctuary, but that subsequent management measures allowing trawl gear in that area resulted in high unobserved mortality. Further, relatively low numbers of trawl BBRKC bycatch today could be the result of historical mortality. Researchers with different views note that BBRKC crab abundance declined precipitously before trawl gear was permitted in the Pot Sanctuary (i.e., prior to 1982; see Witherell and Pautzke, 1997). While it is not possible to make a definitive conclusion and whether or not one believes that trawling was the principal cause of the BBRKC stock decline dating to the late 1970s, it remains possible that trawling could have impacted RKC rebuilding over the decades since then.²²

4.5 Bottom Contact by Other Gear Types

Though it is not part of the Council's direct request, this paper briefly acknowledges that types of gear other than pelagic trawls contact the seafloor and may affect BBRKC in ways that are not captured by observed crab bycatch mortality data. The nominal gear width values in the gear parameter table of Olson et al. (2022) provides a measure by which to compare gears. However, similar to the information presented about PTR, those parameters are intended for the study of habitat disturbance and do not tell the reader anything about the time/area collocation of these gear types and BBRKC.

The nominal gear widths for trawls in the BSAI and GOA range from 50 m to 259 m. BSAI pelagic trawls ranged from 50 m to 175 m and BSAI non-pelagic trawls ranged from 90 m to 259 m. GOA pelagic trawls ranged from 50 m to 100m and GOA non-pelagic trawls ranged from 55 m to 193 m. Certain categories of non-pelagic trawling have bottom contact adjustments of 1.0 (assumed bottom contact) but others, where trawl sweeps are raised and fishing gear is elevated by bobbins, have contact adjustments as low as 0.27 (27% of nominal area swept being contacted).

²² J. Zheng (ADFG). 2022. Personal Communication.

By comparison, the nominal widths used in the FE model for pot gear and hook-and-line gear is listed at 5.6 and 6 meters, respectively. The benthic impacts of fishing gears other than trawl and dredges (i.e., scallop gear) has been less studied. When updating the gear parameter table in 2022, Olson et al. cited a hook-and-line longline study from Australia (Welsford et al. 2014) and a sablefish longline-pot study from British Columbia, Canada (Doherty et al. 2017). The hook-and-line study identified line shear and hooking that could impact structure-forming invertebrates. Such impacts might relate to crab as they rely on structure for safety after molting. The average lateral line movement in Welsford et al. was 6.2 meters, and virtually all lateral movement occurred during deployment or retrieval. The documentation behind the FE gear parameter table noted that lateral line movement can result from currents or from captured fish. Bycatch of sessile benthos (e.g., sponges, corals) are sometimes observed in the Alaska longline fishery so it is known that seafloor interactions do occur. The longline-pot study (Doherty) noted that hauling speed and direction, combined with environmental factors like depth, slope, and current affects a pot's footprint. The BC pot study was assessing conical pots that are significantly smaller than most Bering Sea crab pots but similar to smaller groundfish pots (e.g., sablefish). Doherty estimated the mean bottom-contact area for a 54-inch pot at 53m², or roughly 36 times its static footprint of 1.47 x 1.47 meters. The longline-pots were observed to drag for between 0.4 and 5.9 minutes when hauling. For comparison, Doherty et al. specifically cites Alaska king crab pots as having a roughly 2.4 x 2.4 meter size. The analysts note that the effect of pot dragging would greatly depend on hauling conditions and also note that less dragging would be expected for pots that are not connected to one another by a groundline.

Alaska weathervane scallops are fished with towed dredges that directly impact the seafloor. There is only one scallop area in the Bering Sea; it is relatively small and lies directly north of Unimak Island, which places it inside the boundaries of interest in this paper (i.e., ADFG Area T, trawl PSC limit Zone 1, and the parts of the summer trawl survey that are included in the BBRKC stock assessment. The Bering Sea scallop area has not been widely fished in recent years due to a parasite that emerged during the 2014/15 season. A small amount of scallop fishing occurs occasionally but only as part of the parasite and stock monitoring efforts that the scallop cooperative undertakes. No scallop fishing occurred in the area in the 2020/21 season due to the quality impacts of the parasite, high fuel costs, and the logistical impacts of COVID-19. The primary scallop vessel that had fished the area in past years is reported to be geared for other fisheries.²³

5 Item 4: Flexible Spatial Management Measures

Fishing for groundfish by U.S. vessels in the U.S. Exclusive Economic Zone (EEZ) of the BSAI is managed by NMFS according to the FMP for the Groundfish Fishery of the Bering Sea and Aleutian Islands Management Area (BSAI FMP). The BSAI FMP was prepared by the Council under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801, et seq.) (Magnuson-Stevens Act), and is implemented by regulations governing the U.S. groundfish fisheries at 50 CFR part 679.

The FMP for the Commercial King and Tanner Crab Fisheries (Crab FMP) in the BSAI was approved by the Secretary of Commerce on June 2, 1989. The FMP establishes a state/federal cooperative management regime that defers crab management to the State of Alaska with federal oversight. State regulations are subject to the provisions of the FMP, including its goals and objectives, the Magnuson-Stevens Act National Standards, and other applicable federal laws.

Various management measures have been implemented in the Bering Sea to protect RKC. These measures consist of PSC limits and area closures, such as the RKCSA and the NBBTCA. In the December motion, the Council asked for an exploration of available flexible spatial management

²³ Sources for this paragraph: Scallop FMP Figures 3 & 4 (pp.29-30), and R. Woodruff, ADFG (2021).

measures that may benefit BBRKC. The analysts examined management options within Alaska, as well as from other regions. The options examined fell into three primary categories: inseason management, incentive approaches, and time and area closures. The following discussion will consider each of these categories and offer examples of possible strategies under each. The analysts also offer several examples of management considerations that might benefit BBRKC but are not “spatial” in nature.

5.1 Inseason Management

Federal regulations provide NMFS with the authority to make inseason management adjustments for directed groundfish fishing (679.25(a)). Inseason adjustments can include season closures, extensions or openings in all or part of a management area; modification of the allowable gear in all or part of a management area; adjustment to TAC or PSC limits; or interim closures of statistical areas to directed fishing for specific groundfish species. The authority for these actions is reiterated in BSAI Groundfish FMP Section 3.8.1 "Flexible Management Authority -- Inseason Adjustments". The FMP text makes clear that inseason interventions by NMFS are a necessary tool to manage groundfish harvest or PSC limits that were specified based on the best available information at the time but may be subject to changes in the state of the fishery or a prohibited species that become known from events within the fishery as it proceeds or from new scientific survey data. If a groundfish harvest or PSC limit was set too high or too low prior to the fishery commencing, then prescribed closures could lead to conservation concerns or forgone economic benefits. The FMP states: "The Council finds that inseason adjustments are accomplished most effectively by management personnel who are monitoring the fishery and communicating with those in the fishing industry who would be directly affected by such adjustments." The FMP lists the types of information that NMFS must consider in determining whether an inseason adjustment is required.

That said, the FMP goes on to acknowledge that NMFS managers are constrained in their choice of management response in several ways. First, data on catch/bycatch rates might not be timely enough to implement effective closures or to determine whether a rate-spike is reflecting natural variability or "dirty fishing". Second, NMFS is subject to procedural requirements to consider "least restrictive" measures and then -- in most cases -- go through the process of publishing notice of proposed adjustments in the Federal Register with a comment period. And third, when applicable, NMFS must coordinate inseason adjustments with the State of Alaska to assure uniformity of management in State and Federal waters. In recognition of some of the limitations of NMFS's ability to take inseason action on bycatch, the FMP allows for the Secretary of Commerce -- after consultation with the Council -- to implement measures that provide incentives to individual vessels to reduce PSC, with the intended effect of increasing the opportunity to harvest groundfish TACs before PSC limits are reached (BSAI Groundfish FMP Section 3.6.4).

5.2 Incentive Approaches

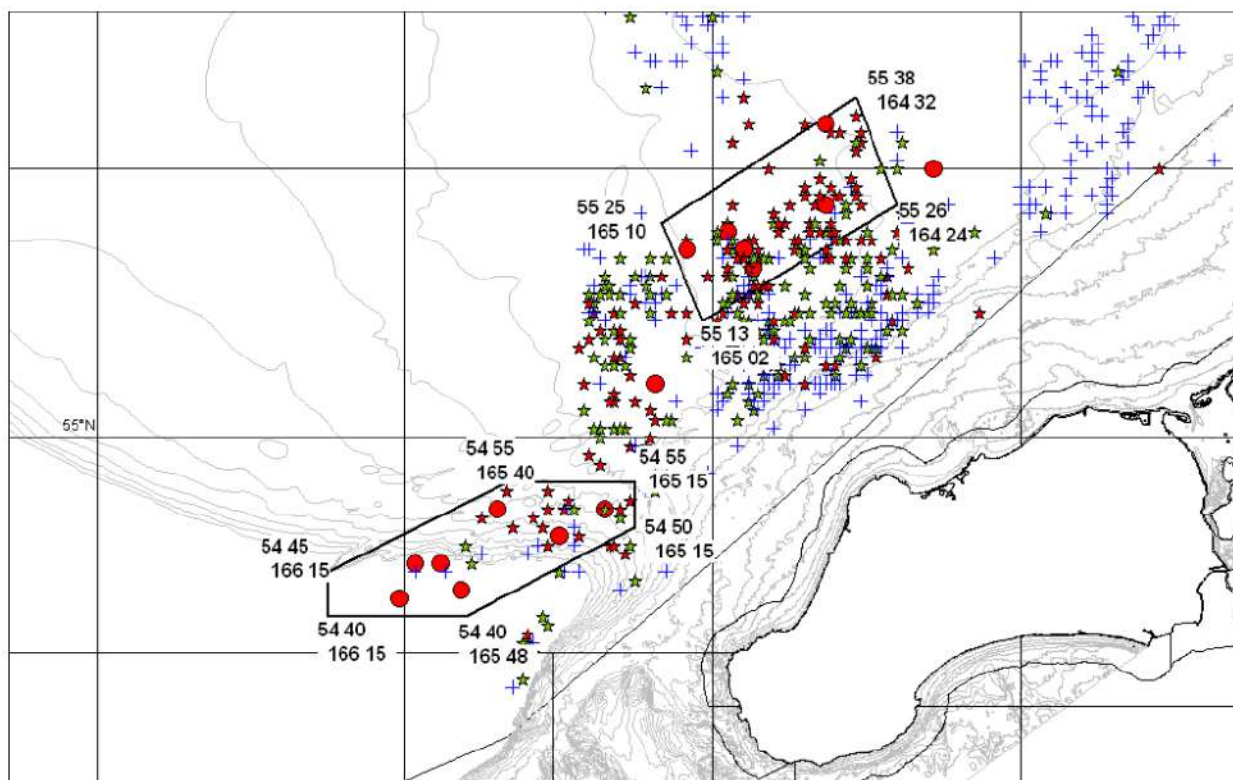
One example of an incentive approach in the BSAI, albeit with a complex history that is not likely to be duplicated, is the management of salmon bycatch in the BSAI pollock trawl fishery. Chinook and chum salmon bycatch in the pollock fishery was managed by triggered area and/or time closures that predate the Congressional implementation of the American Fisheries Act (AFA). In 2001 and 2002 AFA participants began voluntarily implementing a flexible management approach to chum and Chinook salmon bycatch, respectively, known as the "rolling hotspot system" (RHS, described below). Participants utilized RHS to reduce the likelihood that area closures would be triggered, having noted that CDQ pollock fishing -- which was not subject to the same area restrictions -- was finding clean fishing in times/areas for which non-CDQ vessels were often finding themselves barred. In 2006 and 2007 exempted fishing permits issued by NMFS allowed RHS participants to fish in the triggered-closure areas. Starting in 2008, NMFS has approved Inter-Cooperative Agreements (ICA) that exempt RHS participants from chum/Chinook closure areas.

The purpose of the RHS exemption (Amendment 84) was to reduce bycatch through the RHS while other management measures were being developed. Through subsequent actions (Amendments 91 and 110), triggered closure areas were effectively replaced by Incentive Plan Agreements (IPA) under which participating cooperative members utilize real-time third-party spatial catch/bycatch data management and internal accountability measures to minimize bycatch with dynamic tools while remaining under various forms of an overall PSC cap on Chinook salmon. IPA participation, which currently covers the entire AFA fleet, alleviates the need for static spatial boundaries based on historical survey and fishery data that can be difficult to manage responsively. A triggered closure area for chum salmon still exists as a back-stop but, because the pollock fleet entirely operates under IPAs, closed areas are not currently the foundation of salmon bycatch minimization.

The RHS works by monitoring bycatch rates at the AFA-cooperative or vessel level and comparing them to a base rate. Basing performance on a rate is meant to incentivize bycatch avoidance at all levels relative to a PSC cap. Poor performers may be restricted in their fishing options and internally penalized, while all vessels benefit from timely information on areas with high bycatch rates so that they can fish productively under the cap (or their allocation of the cap). Fishing cooperatives may impose temporary area closures on their members. The efficacy of the program is reviewed annually by the Council. Figure 5-1 shows an example of a pollock cooperative's salmon bycatch monitoring that was presented to the Alaska House of Representatives Fisheries Committee in March 2017.

The Council will want to consider the extent to which a dynamic hotspot strategy could apply to RKC as it applies to salmon. Crab may not move throughout the ocean or commingle with target species in the same way that salmon do but the relative lack of knowledge about crab distribution throughout the year – and their susceptibility to bycatch mortality, i.e., molting and mating – might resemble the uncertainty that a trawl captain has when setting a net under a salmon cap or cooperative performance standard. A potential weakness of this approach lies in the incentives. The Zone 1 trawl PSC limit does not close the pollock fleet out of fishing areas. Given the low number of observed RKC bycatch in the pollock fishery (see Table 3-2), the incentive to implement a hotspot strategy through cooperatives might stem from social pressure more so than from the potential loss of directed fishing opportunities. While recent historical BBRKC PSC in the pollock fishery can be called “very low”, the limit in harvest specs is also quite low – less than 100 crab. That is a reachable cap under any circumstances, and so it is conceivable that the pollock fleet would be willing to invest in additional measures if they believe those measures to be both necessary and effective.

The premise of a dynamic hotspot strategy is that static area closures can be sticky (difficult to change) and ineffective/inefficient if the closure set in regulation becomes out of step with the current state of the stock distribution. If event-level bycatch encounter rates are sufficiently uncertain, real-time data become very valuable and vessel operators pay more attention to predicting and interpreting bycatch than they pay to a closure area on a map.



Note: “Sea State” refers to a pollock cooperative’s third-party data manager.

Figure 5-1 Example of rolling hot spot monitoring: “High bycatch areas identified by Sea State” – from pollock industry presentation to Alaska House of Representatives Fisheries Committee, 3/9/2017. (Source: http://www.akleg.gov/basis/get_documents.asp?session=30&docid=13337)

Other incentive-based measures to minimize effects on bycatch species in Alaska tend to be structured around annual hard caps where performance to a low level of bycatch in one year provides an insurance-like buffer in the following year. One example of this is the Chinook salmon PSC limit for non-pollock and Rockfish Program trawl vessels in the GOA. The incentive to achieve a certain standard is closely linked to the economic penalty of having a season shortened or a PSC limit reduced. As noted above, the BS crab PSC limit for pelagic trawling does not directly entail a similar penalty. Moreover, the pelagic trawl sector’s subapportionment of Zone 1 crab PSC is set in harvest specifications and can be modified by NMFS under inseason authority; it is not a hard cap set in regulations and/or the FMP. Finally, while the effect of these GOA incentive structures is expected to be dynamic responses by the groundfish fleet – as left to their own individual or cooperative decisions – there is nothing about them that directly incentivizes spatial responses. A vessel operator could fish under this incentive-structured hard cap without changing where they fish, generally. In that sense, if the Council is hoping to keep certain gear types out of areas – with the areas themselves being the dynamic aspect – then this sort of example may miss the mark.

In the U.S. Pacific region, the Pacific Council and NMFS took steps to transition contour-based area closures protecting salmon from static zones to “routine inseason management tools” based on triggered thresholds. The offshore whiting fishery (CPs and motherships) uses a third-party data manager to disseminate catch and bycatch data at a fine spatial scale. Similar to the RHS program in Alaska, vessels voluntarily move away from bycatch and alert other vessels. Council action was required to institute spatial flexibility and transform bycatch hard caps to soft caps with reserves that can only be accessed when vessels participate in co-management through a Salmon Mitigation Plan process. One key to making this transition acceptable was providing publicly accessible data on catch and salmon bycatch in

the whiting fishery (through PACFIN/PSMFC), as opposed to providing public information retrospectively through end-of-year reports.

Existing examples of incentive-based approaches to change fishing behavior that rely on real-time communication can be thought of as partnership approaches. As a category, they rely on collaboration, iteration, and trust. In most cases, it seems, the effectiveness of these programs depends on the existence of bycatch caps or triggered area closures that would restrict the fishery that needs to minimize bycatch. An example that turns the Bristol Bay fish/shellfish bycatch relationship on its head is the Atlantic scallop fishery off the U.S. east coast. The Atlantic Scallop FMP includes gear modifications and time/area closures to try to mitigate flatfish bycatch – specifically of yellowtail and windowpane flounder – in scallop dredges. In addition to bycatch limits and time/area closures, the scallop fishery partnered for several years with UMass-Dartmouth’s School for Marine Science and Technology (SMAST) to develop a bycatch avoidance plan. The plan involved distributing flatfish and scallop survey data to the fleet prior to the fishery and then facilitating real-time communication to avoid flounder hotspots.

5.3 Time and Area Closures

Permanent Area Closures

Several permanent area closures already exist in the Bering Sea aimed at protecting RKC, such as the RKCSA to protect mature adult BBRKC and the NBBTCA to protect juvenile BBRKC habitat (December 16, 1996, 61 FR 65985). While the Council asked for flexible spatial management strategies and permanent area closures are by no means flexible, the Council may consider examining existing closure areas and deciding whether these areas should remain in the correct location, whether they should be moved, or if new closure areas are warranted.

Permanent closures are commonly used across U.S. regions to protect habitat or recovering stocks. Closures might apply to all fishing, certain gears, or vessels of a certain size. Closure areas might have exceptions. For example, the many closure areas of the New England region’s Northeast Multispecies (groundfish) FMP – a trawl gear fishery – include “access areas” that allow the scallop fishery to access the scallop resource during specified seasons. The permanent closures are described [here](#). The Western Pacific region is dominated by Marine National Monuments (under the Antiquities Act) and coral refuges, marine mammal protection areas, and permanent closures that apply only to certain gears or vessel sizes (under the Magnuson-Stevens Act). A map illustrating these closed areas is found [here](#).

Seasonal Closures

Unlike permanent closures, seasonal closures seek to protect vulnerable species at strategic times during the year. Seasonal closures can be instituted for a variety of reasons including avoidance of times and areas with high bycatch, to prevent interference with recreational and subsistence practices, and to protect species during important biological times. Permanent area closures for RKC based on areas of high abundance of mature adult RKC and important habitat for juvenile RKC have already been instituted, therefore the analysts have focused this section on examples of seasonal closures to protect species during important biological times.

In Alaska, Area 516 of Zone 1 is closed to trawl gear from March 15 through June 15 (50 CFR 679.22(a)(2)). The seasonal extension of the closed area is intended to provide additional protection to RKC, especially females during molting and mating when their shells are soft and more vulnerable to damage by trawl gear. This measure is based on a 1988 scientific survey of RKC distribution, which indicates a significant movement of RKC, especially mature female animals into this area (May 4, 1989, 54 FR 19199).

In New England, the New England Northeast Multispecies FMP includes areas that are seasonally closed to protect groundfish. Those closures also prohibit fishing by non-groundfish gears that are capable of catching groundfish – i.e., scallop dredges. Examples include the Winter Massachusetts Bay Spawning Protection Area (Nov-Jan), the Spring Massachusetts Bay Spawning Protection Area (April 15-30), and the Gulf of Maine Cod Spawning Protection Area (April-June). Full details on those seasonal closures and exception categories are available [here](#).

The analysts also offer an example of seasonal management that, while not a closure, does take into account biologically important times for a vulnerable species. Ensuring a steady supply of prey for a recovering population is important for a variety of reasons, especially for adult females with dependent young. For Steller sea lions winter is an especially demanding metabolic period and obtaining an adequate supply of food is critical to ensuring successful pregnancies. In order to maintain a consistent amount of prey, seasonal apportionments of important prey species such as Atka Mackerel and Pacific cod were created (May 8, 2003, 68 FR 203).

One might consider triggered-closures to be a subset of seasonal closures (although sometimes a season can be the remainder of the calendar year). In Alaska, hard cap PSC limits could be considered triggered closures. A management area could be closed to all fishing by a certain gear type or for a certain directed fishery. Examples include Chinook salmon PSC limits in the Gulf of Alaska pollock and non-pollock trawl fisheries (the pollock PSC limit is apportioned by management subarea), or the closure of BBRKC Zone 1 to non-pelagic trawl gear for certain directed fisheries. Non-trawl fisheries can be closed based on observed takes of protected seabird species. South of the Main Hawaiian Islands, there is a Southern Exclusion Zone that prohibits “deep-set” longline fishing after a certain number of interactions with False Killer Whales is met. The Western Pacific also has hard caps for interactions with sea turtles, seabirds, and Oceanic Whitetip sharks that trigger area closures. Some of those triggered area closures apply only to a certain part of the fishery, analogous to a gear type; for example, sea turtle interactions close the “shallow-set” component of the longline fishery.

In discussion of seasonal closures, it may also be worth consideration of seasonal openings. Seasonal openings can strike a balance between protection of one species while allowing full prosecution of fisheries during times when disturbance and bycatch would be at a minimum. An example in Alaska of a seasonal opening is in the NBBTCA where a portion of the closure area is open to trawling from April 1st to June 15th (December 16, 1996, 61 FR 65986). Harvest information indicates that allowing trawling in this area yields high catches of flatfish and low bycatch of other species. The April 1 to June 15 time period is allowed as a way to reduce bycatch rates of halibut, which move into the nearshore area in June. Sea ice generally prevents fishing operations in northern Bristol Bay before April 1.

Effective seasonal closure areas for BBRKC, would likely be most effective if applied to mature BBRKC females during molting and mating. A seasonal closure area could be based on summer trawl survey results that would indicate where large groupings of mature females are located. The weakness of that approach is the disconnect between the survey period, the fisheries, and molt/mate period. A different approach might use data on catch/bycatch in the first few weeks of a fishery to place a closure area. That approach may lack timeliness and could still subject crab in need of protection to a period of heavy fishing with gear that contacts the bottom. A third approach would be to set a fixed seasonal closure area using historical data on where mature females occurred. That approach would essentially be repeating the process that led to the RKCSA (which itself was a seasonal closure at first) and would also require an improved understanding of where crab are during the relevant fishing seasons and during molt/mate periods. As noted elsewhere in this paper, fixed-area closures are difficult to change once implemented, and they are not particularly responsive to stock distribution changes that might be predictable but occur on a slow scale (e.g., related to temperature regime shifts like the decadal oscillation) or that might be less predictable (e.g., the less well understood effects of climate change).

Rotational Area Closures

Rotational closures are area closures that shift spatially dependent on input data or predetermined criteria. These closures target specific vulnerable species, generally for a specific demographic of the population. One example of a rotational area closure is for Atlantic scallops, where juvenile scallops are protected with rotational closures in the Northeast and Midatlantic U.S. regions. Based on data from both NMFS and industry-led surveys, abundance, distribution and size of scallops are mapped in the Northeast Atlantic. Areas of predominantly smaller scallops are closed to directed fishing for scallop in order to allow these scallops the time to grow into a commercially valuable size. These closures are focused on protecting the scallop stock by restricting the scallop fishery itself rather than restricting other fisheries that may impact scallops.

If a similar strategy were used in the BS for BBRKC, the results of the BSAI NMFS Trawl Survey could be used to identify areas of vulnerable populations, which for BBRKC would likely be mature adult females. Additionally, efforts could be made to develop an industry-led survey that could improve the type and resolution of data collected on the spatial distribution of RKC in data deficient times of year, such as Fall/Winter. A winter survey would be particularly beneficial if sampling protocols were capable of finding molting crab, which do not typically enter pots and can be missed or damaged by trawl survey gear.

A different approach to rotational closure is to close an entire management area in alternating time periods – e.g., single or multiple years. Since 1978 the State of Hawaii has used rotational closures of one to two years in the Waikiki-Diamond Head Fishery Management Area (FMA) on Oahu, Hawaii to protect coral reef fish stocks. The effects were studied in 2006 (Williams et al.) and found that time-rotational closures were not effective, whereas stocks did improve in a neighboring permanent closure even though reefs were being overtaken by alien algae in both areas. The success of a species protected by a rotational closure likely has much to do with its life history characteristics and non-fishing impacts on the habitat (e.g., recreation tourism, which is not an issue in the Bering Sea).

Temperature Closures

Temperature closures can go into effect when temperature thresholds are surpassed and conditions are unsafe for certain species. These closures can go into effect to protect species when air or water temperatures are outside of normal thermal thresholds. Several examples of temperature closures are described below.

The first example was implemented by the Texas Parks and Wildlife Department and resulted in a [temporary closure](#) to saltwater fishing along parts of the Texas coast due to freezing weather conditions. In addition to killing game fish in shallow bay waters, a hard freeze can also cause surviving fish to congregate in a few deeper areas where they become sluggish and prone to capture, which was the main justification for implementing the closure. The second example occurred in Yellowstone National Park, when the park [closed fishing](#) to anglers, in order to protect fish that were experiencing unprecedented heat exposure and low river levels.

Another example of dynamic temperature-based fishery management is the TurtleWatch tool, created by Pacific Island Fisheries Science Center and available through NOAA OceanWatch.²⁴ No fishery closures are enacted through TurtleWatch but an up-to-date map tool is provided online that helps fishermen avoid ESA-listed loggerhead sea turtles. Most interactions with loggerheads occur during the longline swordfish fishery north of the Hawaiian Islands during the first three months of the year. The map provides a sea surface temperature contour in terms of latitude and longitude that shows areas to avoid. The warmer end

²⁴ See <https://www.fisheries.noaa.gov/resource/map/turtlewatch>; and <https://oceanwatch.pifsc.noaa.gov/turtlewatch.html>.

of the band indicates the southern boundary of the turtles' preferred temperature habitat (65.5°F) and the cooler end of the band (63.5°F) marks the northern edge of the temperature range in which more than half of observed fishery interactions have occurred. The data that inform the turtles' preferred habitat were gathered through capture-tag-release studies.

In Alaska, it is known that when air temperatures are very low, snow crab can instantly freeze and lose legs when hauled on deck. For crab that are brought on deck as bycatch, even though they are technically still alive and can regrow legs, this loss of legs would likely increase discard mortality rates. Not much is known about how freezing air temperatures affect RKC. The Alaska Bering Sea Crabbers (ABSC) industry group informed the analysts that they have submitted a preliminary proposal to NOAA's Bycatch Reduction Engineering Program (BREP) to place water temperature sensors on crab pots (as well as some more sophisticated data loggers that record water salinity and pH). The goal of the study is to do statistical analysis of retained and discarded crab under certain conditions; presumably, air temperatures could be recorded for each pot haul as part of the study protocol if viability is being assessed on deck.

5.4 Non-Spatial Management Considerations

The Council motion was specific in its request that options for flexible spatial management measures be examined. In exploring available options, the analysts noted management options that did not fit in the realm of spatial management but may be of interest to Council. The analysts did not do an in-depth analysis of these options; a brief summary is provided for each method.

Gear Modifications or Changes

Floating pots – Studies have been conducted on the feasibility of using floating pots to reduce bycatch of crab species. Studies conducted for cod fisheries have shown that floating pots greatly reduce bycatch of crab species and in some cases increased catch of targeted cod (Furevik et al. 2008. Marcella et al. 2016, Ovegard et al. 2011).

Slinky pots – Slinky pots are a lightweight, collapsible mesh pot that is easily stacked onboard vessels and is primarily used in Alaska waters to reduce depredation by marine mammals. Bycatch of crab in slinky pots has yet to be analyzed, although it has been theorized that due to how much the pots move, that crab may be deterred from entering the pot.

Modification of pots – Collaboration among several research groups has focused on cod pot modification to reduce RKC bycatch in recent years. The output of this collaboration has indicated several promising avenues to reduce bycatch. The lab and field results for RKC and pot cod trials so far support the concept that pot tunnel, ramp, and entry elements can change the way that cod and RKC are able to pass through gear panels and enter a pot. There were two gear variants that were expected to reduce crab bycatch, the 'sock' and the 'slick ramp' and both showed reduced passage for crab in lab results. However, there was evidence of lower cod CPUE and logistical challenges with the 'slick ramp' in field trials. The 'slick ramps' caught less cod in contrast to control pots and were not resilient on deck (tearing with use) and were omitted from further consideration after field trial reporting. Preliminary project results to date reflect lab and field summaries that support the use of 'socks' or 'sock variants' as the best likely method for reducing crab bycatch.²⁵

Fisheries Executed in Tandem

Fisheries that require similar gear types and overlap spatially can be fished in tandem in order to reduce discards for each fishery. An example of this strategy in Alaska is how the opening date of the halibut

²⁵ Source: [Comment letter provided to the Council](#) by Bering Sea Fisheries Research Foundation, Alaska Bering Sea Crabbers, and Natural Resource Consultants, Inc. January 28, 2022.

season is taken into account when determining the opening date for sablefish. The stated purpose is to reduce bycatch and regulatory discards in the two fisheries (50 CFR 679.23(g)(1)).

This strategy may prove more challenging when dealing with RKC as there are additional layers of regulation involved. All BS rationalized crab fisheries have the same opening date (October 15) but have different regulatory closure dates set by the State for biological reasons. The crab fleet has previously asked the Board of Fish for the ability to retain multiple species of crab on the same trip citing less mortality of species they have IFQ/CDQ for, but little action has occurred mainly due to issues with processing capabilities, State catch accounting, and gear specifications for each crab fishery. That said, there are currently incidental catch allowances of Western Bering Sea Tanner crab, Bering Sea snow crab and Eastern Bering Sea Tanner crab in some other directed crab fisheries. When keeping incidental amounts of Tanner and snow crab in other directed crab fisheries, the vessel operator must have available IFQ/CDQ and the directed fishery for those incidental species must be open. There is currently no BBRKC retention allowed in other directed crab fisheries, likely due to the fact that legal sized RKC are not able to enter snow crab or Tanner crab pot gear because of RKC excluder devices. In addition, BBRKC directed fishery closes by State regulation on January 15 while Tanner and snow crab remain open. Any changes to the incidental catch allowances of crab in directed crab fisheries would need to be made by the Alaska Board of Fisheries. There is currently nothing in federal regulation to prohibit the retention of incidental crab species while directed crab fishing as long as there is available IFQ or CDQ.

An additional possibility that the Council may wish to consider is the retention of BBRKC while pot fishing for Pacific cod. That approach would face many regulatory challenges but might ultimately reduce discard mortality rates.

6 Contributors and Persons Consulted

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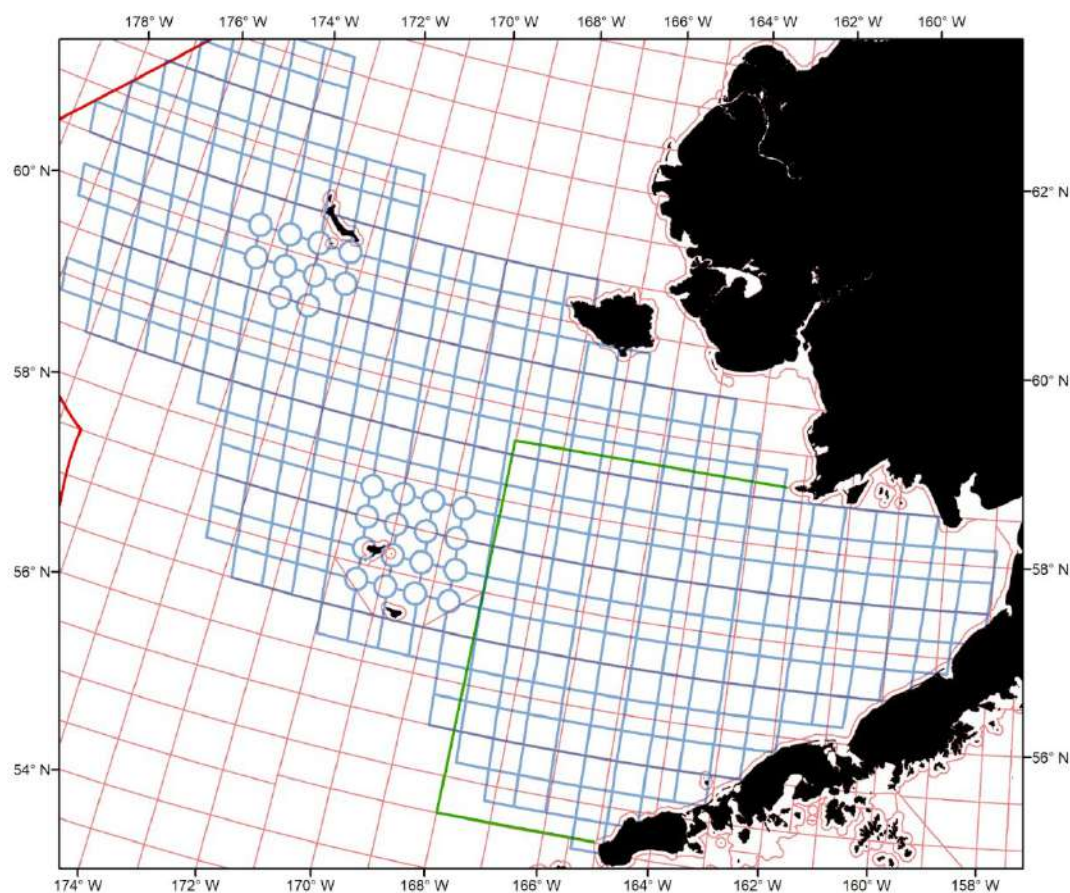
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Appendix 1: Overlay of EBS trawl survey grid, ADFG statistical areas, and ADFG Registration Area T (BBRKC)

Figure shows EBS trawl survey stations in blue, ADFG statistical areas in red, and ADFG Registration Area T in green.



Source: B. Daly, personal communication. March 2022.

Appendix 2: Month-by-month mapping of estimated swept area for pelagic trawl gear (attached separately)



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Manifestation and consequences of warming and altered heat fluxes over the Bering and Chukchi Sea continental shelves

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ARTICLE INFO

Keywords:

Pacific arctic
Chukchi sea
Bering sea
Temperature
Trend
Heat flux
Climate
Change
Sea ice
Budget

ABSTRACT

A temperature and salinity hydrographic profile climatology is assembled, evaluated for data quality, and analyzed to assess changes of the Bering and Chukchi Sea continental shelves over seasonal to century-long time scales. The climatology informs description of the spatial distribution and temporal evolution of water masses over the two shelves, and quantification of changes in the magnitude and throughput of heat and fresh water. For the Chukchi Shelf, linear trend analysis of the integrated shelf heat content over its 1922–2018 period of record finds a significant summer and fall warming of $1.4\text{ }^{\circ}\text{C}$ ($0.14 \pm 0.07\text{ }^{\circ}\text{C decade}^{-1}$); over 1990–2018 the warming rate tripled to $0.43 \pm 0.35\text{ }^{\circ}\text{C decade}^{-1}$. In contrast, the Bering Shelf's predominantly decadal-scale variability precludes detection of a water column warming trend over its 1966–2018 period of record, but sea surface temperature data show a significant warming of $0.22 \pm 0.10\text{ }^{\circ}\text{C decade}^{-1}$ over the same time frame. Heat fluxes over 1979–2018 computed by the European Centre for Medium-Range Weather Forecast (ECMWF) ERA5 reanalysis exhibit no record-length trend in the shelf-wide Bering surface heat fluxes, but the Chukchi Shelf cooling season (October–March) has a trend toward greater surface heat losses and its warming season (April–September) has a trend toward greater heat gains. The 2014–2018 half-decade exhibited unprecedented low winter and spring sea-ice cover in the Northern Bering and Chukchi seas, changes that coincided with reduced springtime surface albedo, increased spring absorption of solar radiation, and anomalously elevated water column heat content in summer and fall. Consequently, the warm ocean required additional time to cool to the freezing point in fall. Fall and winter ocean-to-atmosphere heat fluxes were anomalously large and associated with enhanced southerly winds and elevated surface air temperatures, which in turn promoted still lower sea-ice production, extent, and concentration anomalies. Likely reductions in sea-ice melt were associated with positive salinity anomalies on the Southeast Bering Shelf and along the continental slope over 2014–2018. Negative

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<https://doi.org/10.1016/j.dsr2.2020.104781>

Received 30 July 2019; Received in revised form 7 April 2020; Accepted 7 April 2020

Available online 25 May 2020

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salinity anomalies during 2014–2018 on the central and northern Bering Shelf may be related to a combination of 1) long-term declines in salinity, 2) an increase of ice melt, and 3) a decline of brine production. We hypothesize that freshening on the Bering Shelf and in Bering Strait since 2000 are linked to net glacial ablation in the Gulf of Alaska watershed. We show that the heat engines of both the Bering and Chukchi shelves accelerated over 2014–2018, with increased surface heat flux exchanges and increased oceanic heat advection. During this time, the Chukchi Shelf delivered an additional $5\text{--}9 \times 10^{19} \text{ J yr}^{-1}$ ($50\text{--}90 \text{ EJ yr}^{-1}$) into the Arctic basin and/or sea-ice melt, relative to the climatology. A similar amount of excess heat (60 EJ yr^{-1}) was delivered to the atmosphere, showing that the Chukchi Sea makes an out-sized contribution to Arctic amplification. A conceptual model that summarizes the controlling feedback loop for these Pacific Arctic changes relates heat content, sea ice, freshwater distributions, surface heat fluxes, and advective fluxes.

1. Introduction

Oceanic and atmospheric transport of heat from low to high latitudes contributes to global thermal regulation (Trenberth et al., 2009), but greenhouse warming regionally perturbs heat content and fluxes (Stocker et al., 2013), causing the earth's climate system and biological systems to adjust in response. These adjustments include alterations to

sea ice (Stroeve et al., 2005; Perovich et al., 2008), permafrost (Osterkamp and Romanovsky, 1999), precipitation (Groves and Francis, 2002), and many components of both terrestrial and marine ecosystems (Walther et al., 2002; Doney et al., 2011). At high latitudes in the Northern Hemisphere, reinforcing feedback loops induce faster rates of atmospheric warming than elsewhere, resulting in the “Arctic amplification” of global climate warming (Serreze and Francis, 2006; Hansen

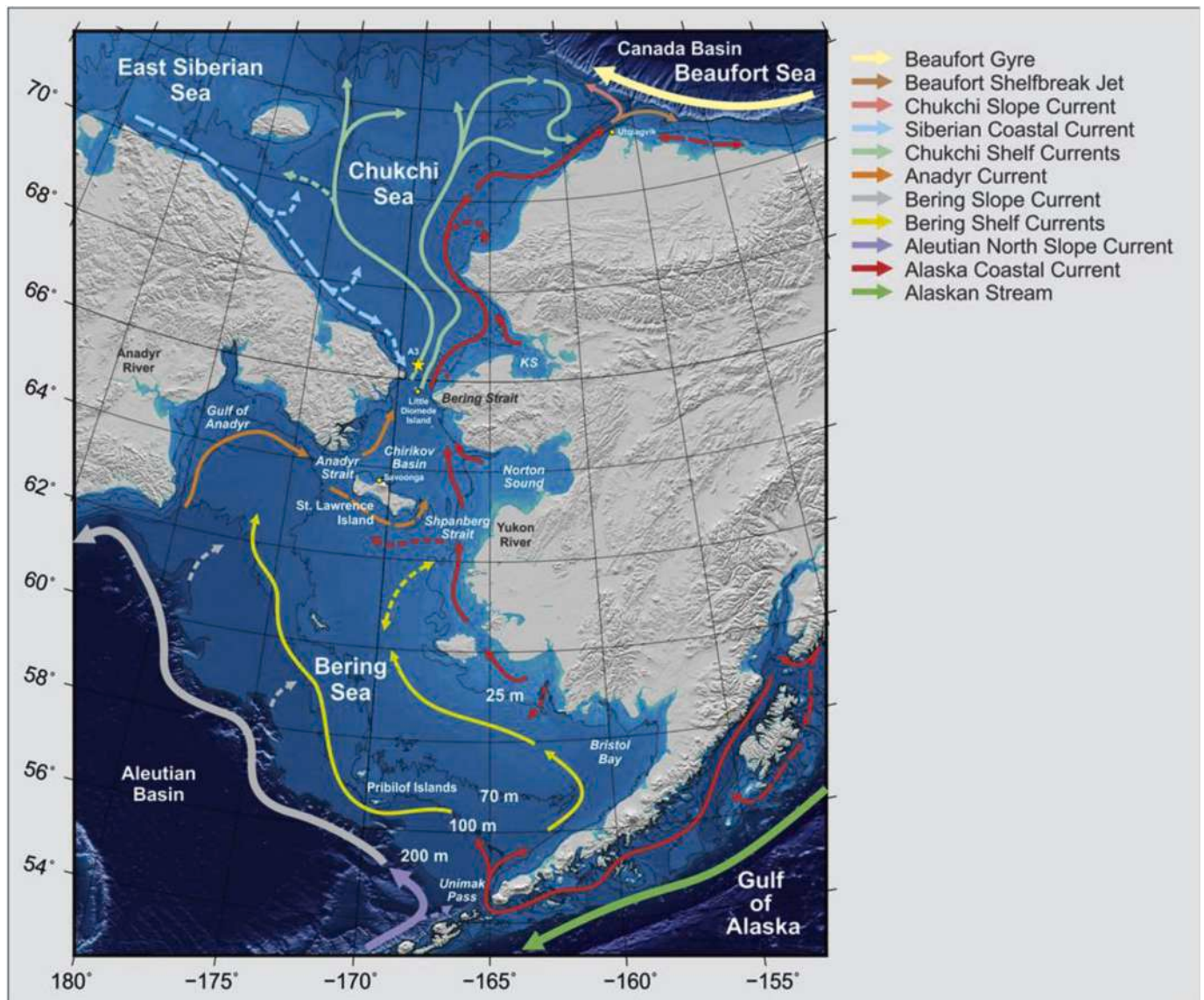


Fig. 1. Location map of the Pacific Arctic region with water body and place names. Persistent currents are shown with solid arrows; intermittent or poorly known flows are denoted with dashed arrows. Bering Strait mooring A3 is marked with a yellow star. Abbreviation KS denotes Kotzebue Sound. Depth isopleths are contoured with thin black lines at 25, 70, 100 and 200 m. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

et al., 2010; Overland and Wang, 2010; Screen and Simmonds, 2010; Serreze and Barry, 2011). In this study, we quantify recent (years) and long-term (decades to century) changes in shelf temperatures, salinities, and air-sea heat exchanges over the Bering and Chukchi continental shelves (Fig. 1), examining the local manifestation and consequences of Arctic amplification within the context of the prior period of record.

Marine ecosystems of the Bering-Chukchi shelves encompass economically important fishing grounds (Van Vorhees and Lowther, 2010), productive benthos (Grebmeier et al., 2015), and subsistence resources for Indigenous coastal communities (Suydam et al., 2006), all of which derive fundamental structure from the regional environmental conditions (Hare and Mantua, 2000; Benson and Trites, 2002; Hunt et al., 2011). For example, oceanic heat content (Walsh et al., 2018) is important to sea-ice extent and duration (Woodgate et al., 2010; Frey et al., 2015; Danielson et al., 2017; Polyakov et al., 2017), which in turn affect trophic exchanges (Coyle et al., 2011), prevalence of harmful algal blooms (Natsuike et al., 2017), and species distributions (Mueter and Litzow, 2008). Temperature is by itself an important control on growth rates (Eppey, 1972) and oxygen respiration (Ikeda, 1985, 2001). A better understanding of ongoing and past environmental change is a first step to exploring how bottom-up forcing may propagate through the Arctic ecosystem in the future.

In the 2013/2014 winter, the North Pacific experienced surface and subsurface warming that resulted from a persistent atmospheric blocking ridge located over western North America (Bond et al., 2015) and meridional modes of atmospheric teleconnections that directed heat away from the tropics (Di Lorenzo and Mantua, 2016). This was followed by a strong 2015 El Niño (McPhaden, 2015) and additional atmospheric blocking patterns that extended the marine heat wave. The Bering Sea also experienced previously undocumented and unprecedented high sea surface temperatures in 2014 (Stabenho et al., 2017), which by sea surface temperature (SST) and heat content metrics have

continued to persist into 2018 (Thoman et al., 2020) and 2019 (Cornwall, 2019; Stabenho and Bell, 2019). The upper ocean heat content (0–300 m integration) for the eastern Bering Sea exhibited warm anomalies that were correlated with SST variations (Walsh et al., 2018). The recent warm anomalies are superimposed upon longer term warming trends previously identified for the Bering and Chukchi seas (Steele et al., 2008; Woodgate et al., 2010; Woodgate et al., 2012; Tokinaga et al., 2017).

Recent weather patterns and sea ice conditions in the northern Bering and southern Chukchi seas are challenging long-held understanding of what constitutes winter norms. The two Diomed Islands, in the past connected by shorefast ice through the winter months (sufficient to support commercial airline service on an ice runway), were exposed in January and February 2018 to long fetch open water and unconsolidated sea ice that allowed massive waves to roll ashore in a late February 2018 storm (Fig. 2). Mid-winter conditions of 2019 brought similarly low sea-ice extents to the region (Cornwall, 2019). These unprecedented observations are illustrative of conditions at the epicenter of Arctic amplification over the Pacific sector: sea ice loss over the Bering-Chukchi shelves.

The broad eastern Bering and Chukchi Sea continental shelves, connected by the narrow (~85 km) Bering Strait, comprise the shallow expanse (average < 70 m) across which Pacific waters carrying heat, fresh water and nutrients are transported into the Arctic (Coachman and Aagaard, 1966; Stigebrandt, 1984; Walsh et al., 1989). Based on oceanographic mooring data, the annual mean volume flux northward through Bering Strait is thought to be approximately 1 Sv (1 Sv = $10^6 \text{ m}^3 \text{ s}^{-1}$) (Woodgate, 2018), having increased to this level from roughly 0.8 Sv in the 1990s and early 2000s (Roach et al., 1995; Woodgate et al., 2005a, 2015; Woodgate, 2018). The increasing volume transport (~0.2 Sv decade⁻¹) and a weakly increasing trend in the observed temperature ($0.27 \pm 0.23 \text{ }^\circ\text{C decade}^{-1}$) both contribute to an increasing trend in the

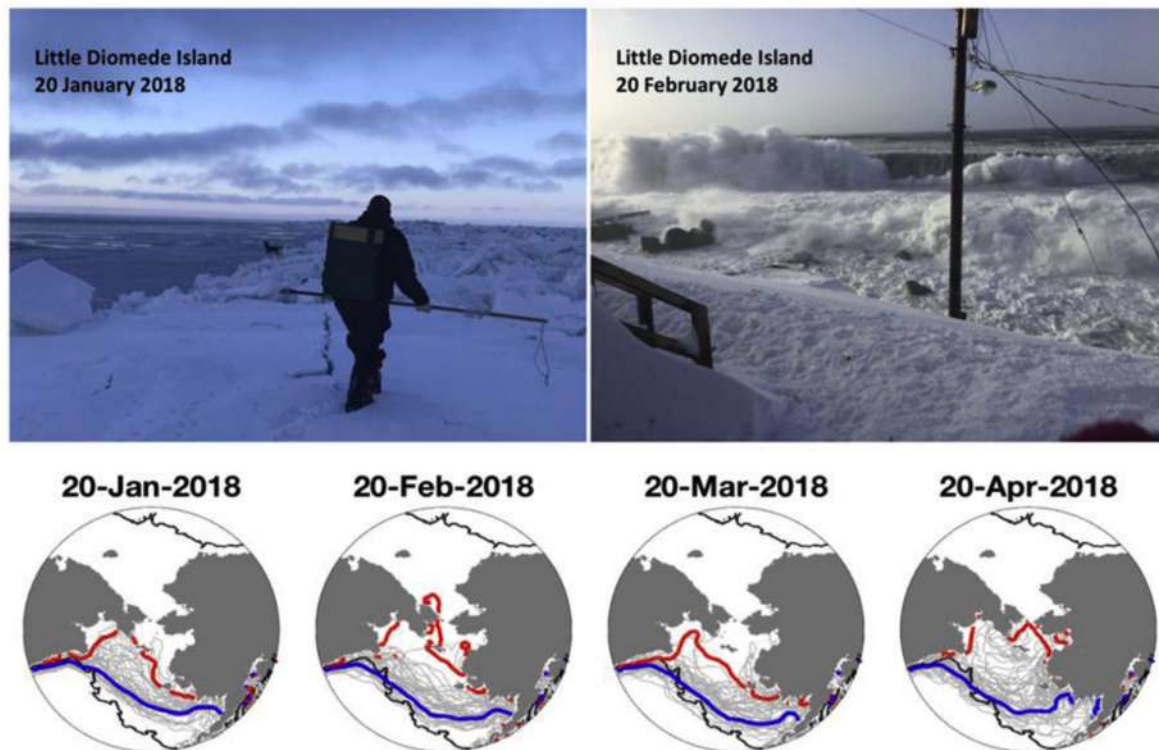


Fig. 2. Open water seen in late January (top left) and February (top right) 2018 from Little Diomed Island, which was historically located far north of the ice edge at this time of year. Satellite-derived ice edge locations (bottom) show the 1979–2018 climatological (blue) and 2018 (red) 15% concentration contours for the 20th of January, February, March, and April. Corresponding ice edges for all years over 1979–2017 are shown with gray contours. The 200 m isobath (black contour) shows the shelf break location. Photographs by O. Ahkinga (left) and F. Ozenna (right). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

northward heat flux (Woodgate, 2018). Measurements also document a modest freshening of $\sim 0.14 \pm 0.10$ decade⁻¹ over 1991–2015 that together with the increasing transport have increased the Pacific origin freshwater flux into the Arctic by $\sim 40\%$ or more (Woodgate, 2018). It is worth noting that the Bering Strait throughflow is the only oceanic inflow to the Arctic showing significant change in volume transport over 1993–2015 but the trend magnitude in Bering Strait is smaller than the trend uncertainty of other inflow pathways (Østerhus et al., 2019), leaving the system-wide balance unclear. In the absence of wind forcing, vorticity constraints confine much of the Bering Strait inflow to an advective pathway that circumscribes the Gulf of Anadyr in a clockwise fashion and enters the Bering Strait region via Anadyr Strait (Kinder et al., 1986), leaving the bulk of the eastern Bering Sea shelf as a secondary feed to the Bering Strait throughflow via Shpanberg Strait, east of St. Lawrence Island (Danielson et al., 2012a). Variations in these currents can alter Pacific-Arctic exchanges and the seasonal evolution of sea ice and water properties.

Processes that perturb the mean circulation and spatial distributions of water properties vary temporally and regionally across these shelves. For example, on interannual and longer time scales, variations in the Bering Strait throughflow have been ascribed to a combination of local wind stress (Aagaard et al., 1985; Woodgate et al., 2012; Danielson et al., 2014; Woodgate, 2018), wind stress over the adjoining basin and adjoining shelves (Danielson et al., 2014), variability in regional pressure gradients, especially in relation to the western Chukchi and East Siberian Sea (Danielson et al., 2014; Peralta-Ferriz and Woodgate, 2017; Okkonen et al., 2019), and thermohaline variations (Aagaard et al., 2006). Regional wind and buoyancy forces drive the seasonally warm Alaskan Coastal Current (ACC) (Paquette and Bourke, 1974; Ahlén and Garrison, 1984; Gawarkiewicz et al., 1994; Wiseman and Rouse, 1980; Woodgate and Aagaard, 2005) and the cool but fresh Siberian Coastal Current (Weingartner et al., 1999), which is present only in some years in the Chukchi Sea. Both coastal currents are near-shore and low-salinity features of the high latitude riverine coastal domain continuum (Carmack et al., 2015). Baroclinically unstable fronts separating ice-melt plumes from denser and warmer shelf waters (Lu et al., 2015) may be important to ocean-ice-atmosphere feedbacks and the seasonal melt-back of the Chukchi sea ice. Energetic eddies in the Bering Slope Current (Ladd, 2014), tidal energy fluxes (Foreman et al., 2006) and wind-driven exchanges, especially upwelling within shelfbreak canyons (Bourke and Paquette, 1976; Woodgate et al., 2005b; Danielson et al., 2012b) may impact cross-slope exchanges.

Although all consequences of thermal, haline, and advective variations over the Bering and Chukchi shelves are not well understood, under a warming climate it is reasonable to anticipate altered lateral and vertical property gradients that in turn will impact local and downstream habitats and potentially feed-back on the processes mentioned above. The Bering Shelf is downstream of heat and fresh water on the Gulf of Alaska shelf via Unimak Pass (Weingartner et al., 2005a). The Canada Basin is downstream of the Chukchi Shelf, which, in turn, is downstream of the Bering Sea via Bering Strait. The flows connecting these two shelves do not drain all parts of the Bering Sea shelf equally (e.g. Danielson et al., 2012a, 2012b), nor are all parts of the Chukchi uniformly flushed (e.g. Weingartner et al., 2005b; Woodgate et al., 2005c; Lin et al., 2019). The fate of Pacific-origin heat and fresh water is important to the Arctic Ocean's thermohaline structure (Aagaard et al., 1981; Shimada et al., 2005; Woodgate et al., 2012; Timmermans et al., 2014, 2018); the thickness of sea ice (Kwok and Untersteiner, 2011) and the timing with which it forms and melts (Steele et al., 2008; Jackson et al., 2012; Woodgate et al., 2010; Serreze et al., 2016); and the Arctic atmospheric heat budget (Serreze et al., 2007). Ice-related processes are critically dependent on the local heat balance so alterations to advective heat fluxes carry the potential for profoundly reorganizing the ecosystem. Given these roles for the Bering Strait throughflow in relation to a changing Arctic, an important goal for this paper is to develop an improved understanding of long-term changes in the Bering and

Chukchi Seas' heat and freshwater budgets.

For the present study, we compiled temperature and salinity hydrographic profiles for the Bering and Chukchi shelves from 1922 to 2018, from which we estimate changes in heat content and freshwater content. Atmospheric reanalysis model outputs from the European Centre for Medium-Range Weather Forecast (ECMWF) ERA5 model (Copernicus Climate Change Service (C3S), 2017) provide estimates of surface heat fluxes from 1979 to 2018, and we use oceanographic mooring data from Bering Strait (Woodgate, 2018) from 1990 to 2016 to constrain oceanic advective heat fluxes from the Bering Shelf into the Chukchi Sea. Gridded surface air temperature (SAT) (Lenssen et al., 2019) and sea surface temperature (SST) (Huang et al., 2017) datasets give alternate multi-decadal perspectives of thermal conditions.

2. Data and methods

2.1. Geography

The soundings-based Alaska Region Digital Elevation Model (ARDEM; Danielson et al., 2015) provides seafloor depths on a ~ 1 km grid across the Bering and Chukchi shelves (Fig. 1). Using the ARDEM grid and ETOPO1 (Eakins and Sharman, 2010) digital elevation model results, we compile geographic statistics (Table 1) that summarize our primary domains of interest and are used to scale area-averaged surface fluxes, heat content, and freshwater anomaly estimates. The ARDEM depth estimates are also used to help validate hydrographic profiles and form full water column estimates of fresh water and heat contents.

2.2. Hydrography

The archive of water column profile data covering the largest number of years (first samples taken in 1922 in the Chukchi Sea and in 1966 in the Bering Sea) and providing the largest number of conductivity-temperature-depth (CTD), bottle and profiling float soundings is the National Centers for Environmental Information (NCEI) World Ocean Database 2018 (WOD18) (Boyer et al., 2018). Additional profiles come from US oceanographic expeditions in recent years for which the hydrographic data are not yet incorporated into WOD18, and archives from non-US institutions. These include data from the US National Oceanographic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) and NOAA Alaska Fisheries Science Center (AFSC) hydrographic databases, the University of Alaska Fairbanks Institute of Marine Science (UAF IMS) hydrographic database, and CTD data compiled by the Synthesis for Arctic Ocean Research (Moore et al., 2018). Additional data come from archives at the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), the Fisheries and Oceans Canada's Institute of Ocean Sciences (IOS) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Temporal and spatial coverage of these data are shown in Fig. 3.

A data reduction scheme was implemented to minimize platform-associated bias and maximize consistency in handling profiles collected by discrete bottle casts, shipboard CTDs, tow-yo CTD systems, and autonomous float and glider profilers. Only profile data from the Chukchi and eastern Bering continental shelves were used, confined to stations located in less than 200 m water depth. Data locations were screened for position and depth errors, and data from stations with

Table 1
Regional depth, area, and volume statistics for the Eastern Bering Sea shelf (i.e. the shelf region shown in Fig. 1) and the Chukchi Sea continental shelf. Shelves are defined here as the region with depths less than 200 m.

	Average Depth (m)	Surface Area (km ²)	Volume (km ³)
Arctic Ocean	1205	15,558,000	18,750,000
Chukchi Shelf	57	553,842	31,478
Bering Shelf	66	915,385	60,423

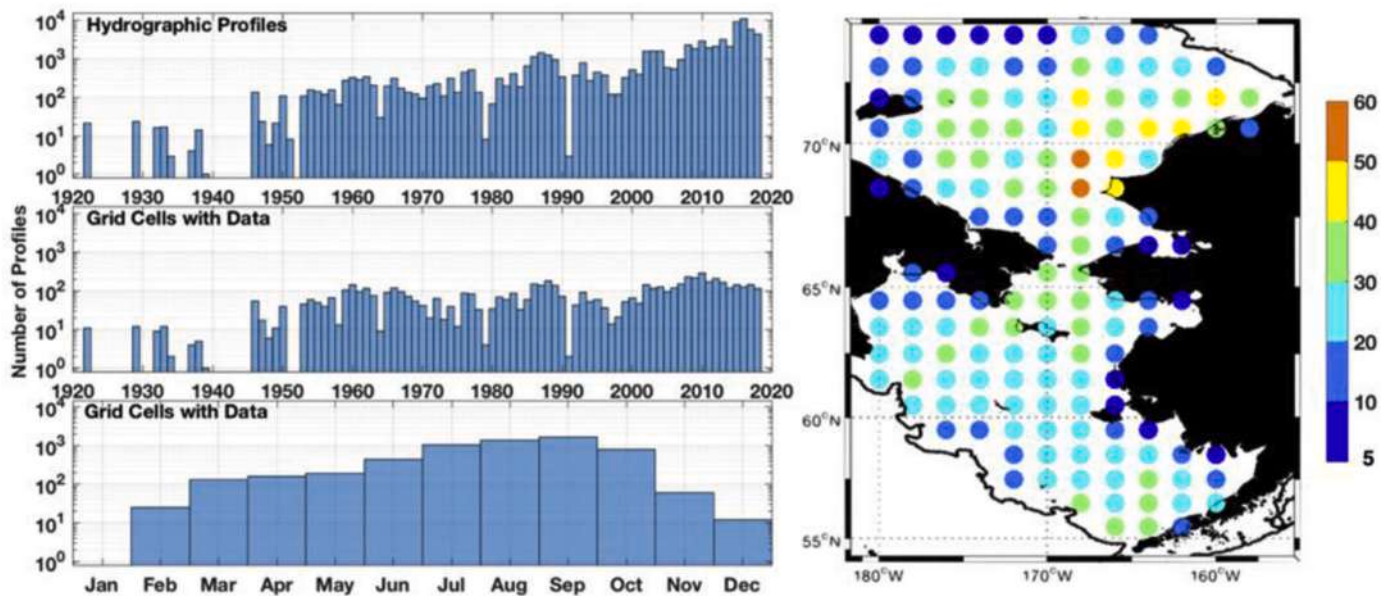


Fig. 3. Temporal and spatial coverage of gridded hydrographic profile data. The map shows the number of years represented within each grid cell. Thick black contours denote the 200 m isobath.

coordinates on land were presumed to have erroneous positions and discarded. Station data having measurements deeper than 140% of the local ARDEM bottom depth were discarded, again signaling a possible location error (errors in the ARDEM grid could also lead to spurious data discards especially in regions of steep bottom slopes). Rejecting partial profiles, we required that measurements extend at least 75% of way to the seafloor from the surface. Casts were also discarded if their shallowest measurements were from deeper than 10 m depth. Temperature data were constrained to a range of -2 to $+25$ °C and salinities to a range of 0–38. Any station having salinity of less than 20 at 75 m depth or deeper was assumed to be spurious and was discarded. We computed the freezing point for all data and removed casts showing data that were supercooled by more than 0.1 °C (suggesting problems with sensor calibration). Data profiles that included vertical density gradient inversions greater than 0.5 kg m^{-4} were also discarded. Following this initial screening and identification of usable profiles, we then linearly interpolated all profiles to 1 m depth intervals, extrapolated data from the deepest measurement depth to the shallower of the seafloor or 200 m, and extrapolated data from the shallowest measurement depth to the surface. Throughout, we employ the Practical Salinity Scale, using the dimensionless practical salinity units (PSU) for reporting all salinities.

The resulting data screened as described above were then gridded monthly from 1922 to 2018 on a 1° latitude by 2° longitude grid spanning 55°N to 74°N and 179°E to 152°W . Grid cells on the shelf containing fewer than 5 years of data were excluded from the climatology and analysis. In total, we reduced 69,224 hydrographic profiles into 6235 gridded profiles for an average of about 11 data points per resolved grid cell. Approximately 1600, 4500, and 27,000 of the profiles were taken from profiling floats, discrete bottles, and gliders, respectively.

At each grid cell, we evaluated the mean monthly temperature, heat content, salinity and density for the near-surface (0–10 m) layer, and for the near-bottom layer (within 10 m of the shallower of the bottom or 200 m depth). Following Woodgate et al. (2006) and others, we selected -1.9 °C (approximately the freezing point of Pacific Arctic waters) as a reference for heat content computations. Stratification was assessed by differencing water density between the near-bottom and near-surface levels. Recognizing a strong bias toward open water (summer) data collections, we generated monthly and seasonal climatological averages with winter, spring, summer and fall means created by combining data

from January to March, April to June, July to September and October to December, respectively.

2.3. Moorings

Mooring data from the Bering Strait climate monitoring mooring A3 (Woodgate, 2018) have been shown to give a useful measure of the mean water properties of the flow through the Bering Strait. This site (66.7°N , 171.5°W) is located ~ 100 km north of the Diomed Islands. The instruments record hourly temperature, salinity and velocity approximately 15 m above the bottom. From these data, estimates of volume, heat flux and freshwater flux are calculated (Woodgate, 2018). As sensors are located near the seafloor, alone these measurements underestimate heat and freshwater fluxes. Thus, simple corrections are made based either on sea surface temperature data or climatological estimates of stratification to include the effects of the seasonally present warmer surface layer and the Alaskan Coastal Current (Woodgate, 2018). The Bering Strait mooring period of record begins in 1990, missing many known cooler years during the 1970s (e.g. Overland et al., 2012). Mooring data from more recent extremely warm years from mid-2016 through 2018 are not available yet. For this reason, our initial heat budget estimates using the Bering Strait mooring data provide lower bound estimates of changes to the shelf heat budgets.

2.4. Gridded surface temperatures

For another perspective on temperature changes through time, we use the reconstructed sea surface temperature (ERSST) (Huang et al., 2017) version 5 and the NASA Surface Temperature Analysis (GISTEMP) version 4 (Lensen et al., 2019) datasets. These compilations also provide an opportunity to examine changes over the Bering and Chukchi shelves relative to changes over larger spatial domains. The ERSST is a coarsely gridded ($2^\circ \times 2^\circ$) global monthly mean SST dataset that combines historical and recent ocean surface temperature records. GISTEMP is a globally and monthly gridded dataset that provides estimates of land and ocean surface temperatures (using ERSST v5 over the ocean) based on other compilations of historical and recent weather and ocean platform data. Both datasets extend to the mid-1800s; we restrict our examinations to 1900–2018. Missing data in each compilation are replaced using statistical methods; in high latitudes records of sea-ice cover help

constrain SST estimates (Huang et al., 2017). Many early ERSST observations are based on ships logs. In the Bering and Chukchi seas, sea ice and temperature observations were commonly made from 19th and early 20th century whaling ships and patrol vessels such as those of the U.S. Revenue Cutter Service (Freeman et al., 2017).

We average the ERSST and GISTEMP data over four integration domains: the whole globe, the Arctic (latitudes $\geq 66^\circ\text{N}$), the Chukchi Sea ($66^\circ\text{N} \leq \text{latitudes} \leq 74^\circ\text{N}$, $180 \leq \text{longitudes} \leq 156^\circ\text{W}$), and the eastern Bering Sea ($55^\circ\text{N} \leq \text{latitudes} \leq 66^\circ\text{N}$, $180 \leq \text{longitude} \leq 160^\circ\text{W}$). Selecting a reference baseline common to the profile data coverage on both shelves, we compute annual anomalies relative to the half-century covering 1966–2016.

2.5. Surface heat fluxes

We use the ECMWF ERA5 (Copernicus Climate Change Service (C3S), 2017) dataset to assess surface heat fluxes and provide supporting wind, ice cover, and air temperature data. ERA5 is a recent version release and due to higher spatial resolution, a better data assimilation scheme, and other improvements (Haiden et al., 2017), we anticipate accuracy and precision improvements relative to the prior version, ERA-Interim (Dee et al., 2011). We are unaware of an Arctic-focused assessment of ERA5 performance but evaluation of seven reanalysis products in the Arctic found that ERA-Interim was one of the three best performing reanalyses, with this product consistently scoring well for surface precipitation, shortwave and longwave fluxes, bias of air temperature at 2 m above the surface, and both temperature and wind speed correlations (Lindsay et al., 2014). Seasonally, bias in individual heat flux terms can be as large as $20\text{--}40\text{ W m}^{-2}$ but in aggregate the net heat flux bias was found to be $< 2\text{ W m}^{-2}$ relative to the Lindsay et al. (2014) analyzed models' median. Many of the heat flux analyses in our study are based on differencing seasonal means that are aggregated across multiple years. For such analyses, the differencing procedure removes much of the stationary bias and we think that the resulting anomalies primarily reflect alterations in the heat exchange balance rather than nonstationary bias.

The net surface heat flux (Q_N) is computed as $Q_N = Q_{SW} + Q_{LW} + Q_{LH} + Q_{SH}$. Terms include the net shortwave (Q_{SW}), net longwave (Q_{LW}), latent (Q_{LH}) and sensible (Q_{SH}) fluxes. Because our main focus is the ocean, we assign a sign convention such that positive heat fluxes represent oceanic heat gain and negative fluxes denote oceanic heat loss.

2.6. Computation of anomalies and trends

Our results are not very sensitive to the differing climatological base periods amongst the various datasets because alternate options for multi-decade baselines of the hydrography appear more similar to each other than to the mean conditions observed over the 2014–2018 period. An advantage of including extra decades (prior to the start of the ERA5 integration or the Bering Strait mooring record) within the hydrographic baseline is that it facilitates building a more robust hydrographic climatology to help ameliorate sparse data limitations.

We compute time series anomalies relative to long-term means to facilitate unbiased assessments of change across space or time where different data subsets have differing means or variances. At each grid cell these include monthly anomalies $X' = X - \bar{X}_j$ where the long term (climatological) monthly mean $\bar{X}_j$ for each month ($j \in [1 \dots 12]$) is subtracted from the monthly mean parameter X to create monthly anomaly X' time series with mean zero. The monthly standard anomaly computation $X'_j = (X - \bar{X}_j) / \sigma_j$ normalizes each monthly anomaly by its corresponding monthly standard deviation σ , creating a time series with zero mean and unity variance. Anomalies retain units of parameter X and standard anomalies are non-dimensional.

Temporal trend analyses are based on linear regression of anomalies

and standard anomalies versus year of observation, with error estimates representing the 95% confidence interval. Statistical significance of trends that are statistically distinguishable from zero is ascribed for p -values < 0.05 .

3. Results

Below, we describe the mean thermohaline structure over the two shelves and quantify changes in heat and freshwater contents over seasons and interannually. This is followed by assessment of surface heat fluxes, and finally heat budgets for the two shelves. To assess changes since the onset of the recent North Pacific marine heat wave (Bond et al., 2015), the half-decade of 2014–2018 is compared to the period of record prior to 2014.

3.1. Hydrography: climatology

We begin with temperature and salinity data, constructing a coarsely gridded seasonal climatology of the vertical profiles (Figs. S1 and S2) using water mass definitions (Table 2) that apply to both shelves and all four seasons (Fig. 4). The gridding and averaging operations smooth out spatial and temporal extremes and numerous small-scale features but nevertheless capture much of the basic hydrographic structure and its seasonal evolution, depicted with maps of water mass distributions (Fig. 5). Examinations of water masses on the Bering and Chukchi shelves typically take one of two approaches to classification. Either they follow the standard nomenclature provided by Coachman et al. (1975) describing Anadyr Water (AnW), Bering Sea Water (BSW) and Alaskan Coastal Water (ACW), or they develop an alternate classification, often necessitated by the large swing in salinities from one year to the next, that is more closely tuned to a particular dataset compilation or thermal/haline processes under consideration (e.g. Pisareva et al., 2015; Gong and Pickart, 2016; Danielson et al., 2017; Lin et al., 2019; Pickart et al., 2019). In this manuscript we develop a minimal set of classifications that can be applied across both shelves and in all seasons (but again the classification resolution lacks ability to distinguish many water mass sub-classes). We deviate from the Coachman et al. (1975) water mass designations because for the large shelf regions under consideration and our multi-season perspective the classifications BSW and ACW do not describe all water mass residence locations or natal formation regions. For example, fresh waters of the riverine coastal domain may well be termed ACW along the Alaskan coast but not in the Gulf of Anadyr. We distinguish between warm Coastal Water (wCW) and cool Coastal Water (cCW) because properties in the coastal domain vary greatly over the course of the year and alternately reflect the impact of runoff, heating, cooling, melting and freezing processes. Similarly, our warm Shelf Water

Table 2

Water mass definitions (see also Fig. 4 and the color scheme in Fig. 5).

Water Mass	Abbreviations	Temperature Range	Salinity Range
Anadyr Water	AnW	$0 < T < 3$	$32.5 < S < 33.8$
Ice Melt Water & cool Coastal Water	IMW cCW	$-2 < T < 3$	$22 < S < 30.8$
cool Shelf Water	cSW	$0 < T < 3$	$30.8 < S < 32.5$
warm Coastal Water	wCW	$3 < T < 14$	$18 < S < 30.8$
warm Shelf Water	wSW	$3 < T < 14$	$30.8 < S < 33.4$
Modified Winter Water	MWW	$-1 < T < 0$	$30.8 < S < 33.8$
Winter Water	WW	$-2 < T < -1$	$30.8 < S < 35$
Atlantic Water & Bering Basin Water	AtlW & BBW	$-1 < T < 3$ $3 < T < 5$	$34 < S < 35$ $33.8 < S < 35$

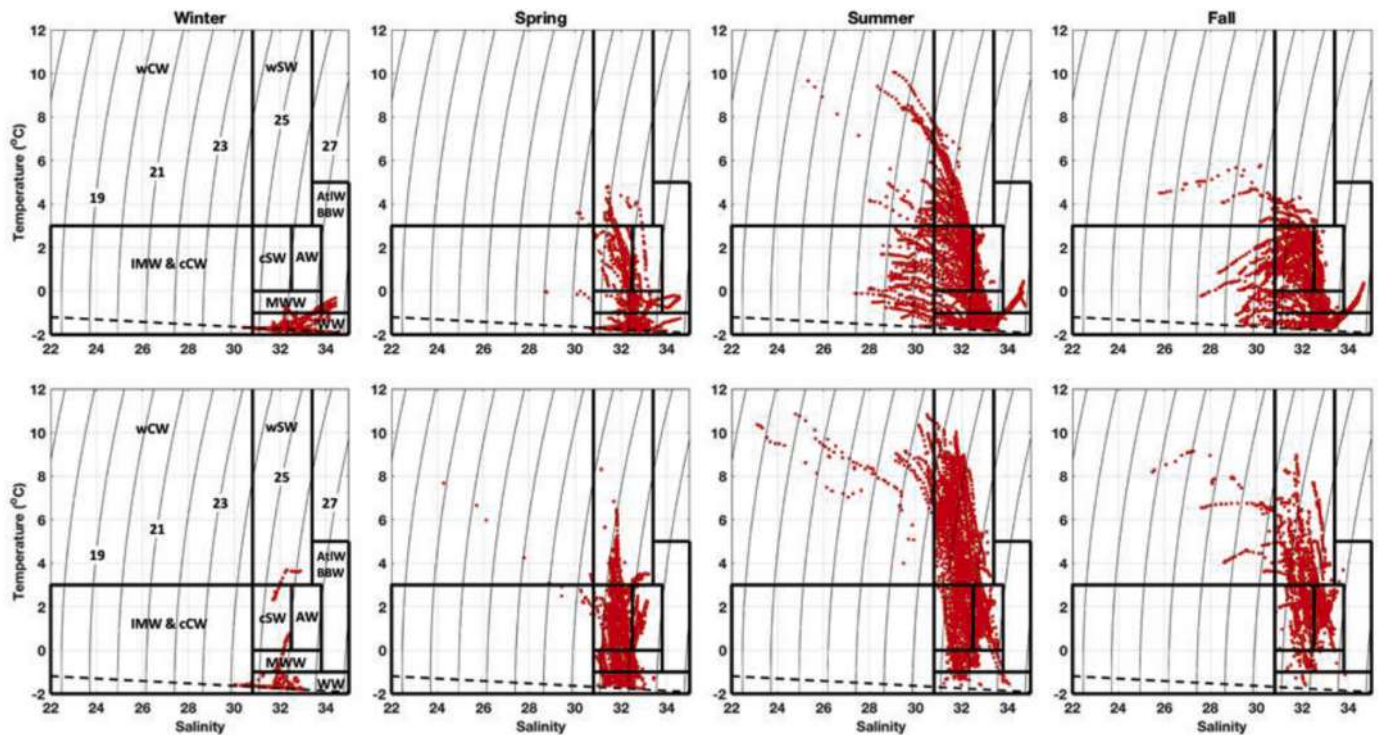


Fig. 4. Seasonal climatology T-S distributions for the Chukchi Shelf (top) and the Bering Shelf (bottom). Water masses shown in Fig. 5 are outlined by black lines and definitions are given in Table 2. The freezing point curve is marked with a dashed line. Sigma- t contours are labeled in the lower left panel. Abbreviations include wCW = warm Coastal Water; wSW = warm Shelf Water; IMW = Ice Melt Water; cCW = cool Coastal Water; cSW = cool Shelf Water; AnW = Anadyr Water; WW = Winter Water; AtlW = Atlantic Water; BBW = Bering Basin Water.

(wSW) and cool Shelf Water (cSW) designations encompass the BSW category of Coachman et al. (1975).

Winter months are the most sparsely sampled and many grid cells lack any profiles at all. For those cells containing data, most show Winter Water (WW) characteristics with temperatures close to the freezing point ($T < -1^\circ\text{C}$), although modestly elevated temperatures ($-1.0^\circ\text{C} < T < 1.0^\circ\text{C}$) are found at depth along the outer Bering Shelf and near the Chukchi Slope, including some waters at the edge of the Arctic basin below 150 m depth that exhibit contributions of Atlantic Water (AtlW). The southernmost few grid points in the Bering Sea have the warmest waters in winter ($T > 2.0^\circ\text{C}$), suggesting heat entering the Bering Shelf via advection up Bering Canyon from the North Aleutian Slope Current (Stabeno et al., 2009) or coming through Unimak Pass (Stabeno et al., 2002, 2017). Relatively high salinities (>32.5) are observed in or near to known dense water formation regions, including over much of the southern Chukchi Sea and near the St. Lawrence Island polynya (Danielson et al., 2006). In winter, riverine influence (CCW) is detected in Norton Sound and along the Chukchi Siberian coastline (Fig. 5). We note that cold and fresh coastal runoff is not readily distinguishable from Ice Melt Water (IMW) or the cold fresh water of the SCC in summer (Weingartner et al., 1999) using only temperature and salinity tracers but isotopic tracers can separate them readily (e.g. Cooper et al., 2005).

Spring data show that cSW is prevalent in the upper portion of the water column on both shelves due to the combined effects of seasonal warming and freshening from ice melt. IMW is found at some stations near coasts, but low salinity ice-melt plumes (e.g. $S < 28$) are not generally observed across the middle of either shelf in spring. The latter point suggests that ice melt ($S \sim 7$) quickly mixes and is diluted by mixing with ambient shelf waters, or possibly that interannual variability in the ice extent combined with the climatology averaging obscures the ice melt signal. We detect little IMW in the Bering Sea in the climatology, but it is a dominant surface water mass across the northern and northwestern Chukchi Sea in summer and fall. The Bering Shelf

upper water column at this time of year mostly contains wSW except for low-salinity wCW of the riverine coastal domains, especially within the large river-fed embayments: the Gulf of Anadyr, Bristol Bay, Norton Sound and Kotzebue Sound. Possibly shunted offshore by winds or bathymetry, wCW is also found offshore south of St. Lawrence Island and relatively far offshore in the northeast Chukchi Sea.

Low temperature waters ($<2^\circ\text{C}$) of the Bering Sea cold pool extend from the northwest portion of the eastern Bering Shelf along the mid-shelf region (e.g. along the 70-m isobath), past the Pribilof Islands, and into the southern reaches of the southeast Bering Sea in years with extensive ice cover (Takenouti and Ohtani, 1974). The cold pool region contains near-bottom waters classified as WW or cSW through all seasons. These temperature-salinity characteristics also occupy the lower portion of the water column across much of the northern and north-eastern Chukchi Shelf in summer.

Following the main pathway of nutrient-rich currents feeding the highly productive portions of the Pacific Arctic, saline ($S > 32.5$) AnW can be traced from the upper Bering slope counter-clockwise around the Gulf of Anadyr, into Chirikov Basin and through Bering Strait (orange color in Fig. 5). AnW can be found close to the seafloor at many stations in the western Chukchi Sea in summer and fall months, showing that at least some of the high-nutrient AnW entering the Pacific Arctic is not strongly mixed with the lower-salinity shelf and coastal waters in the energetic Anadyr Strait, Chirikov Basin, and Bering Strait mixing zones. However, the high level of nutrients characteristic of AnW entering Bering Strait may not be retained as the AnW crosses the Chukchi Shelf because nutrient draw-down can occur from the surface to the seafloor on this shallow shelf. It should be noted that south of the Gulf of Anadyr the orange color indicates basin/slope dichothermal water (Miura et al., 2002) having temperature and salinity characteristics close to AnW. In the future, AnW should be separated from the dichothermal water by nutrient parameters. The AnW flow pathway has been modeled in many studies (Kinder et al., 1986; Overland and Roach, 1987; Clement et al.,

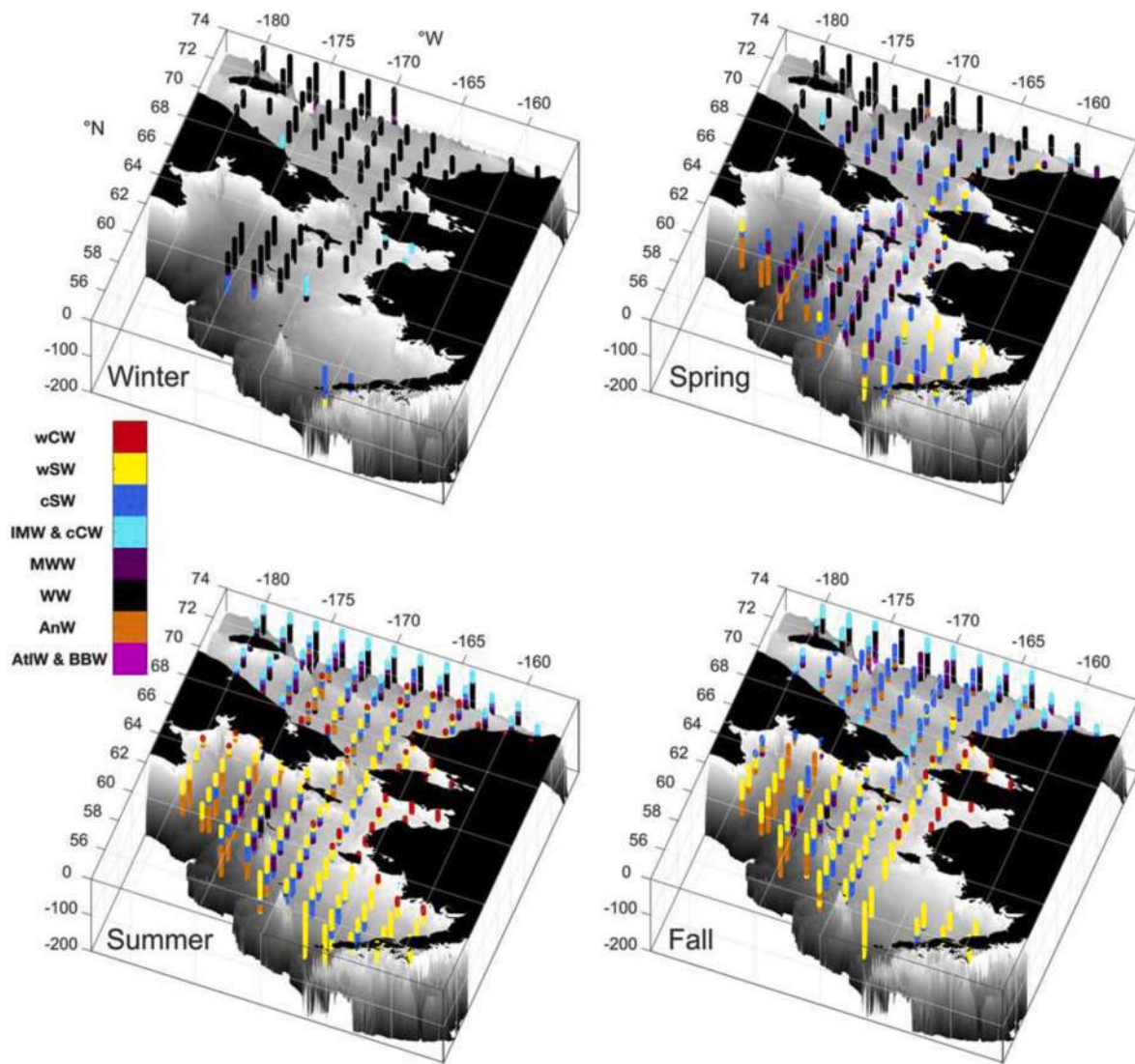


Fig. 5. Perspective view of the water seasonal climatology water mass distribution on the Bering and Chukchi shelves for winter (upper left), spring (upper right), summer (lower left) and fall (lower right) using data from before 2014. The AtlW water mass is mostly hidden behind the seafloor of the northward-facing Chukchi slope due to the perspective view. Seafloor topography (gray shading) is shown only for depths shallower than 200 m. Latitude and longitude markings are associated with the -200 depth level. Abbreviations include wCW = warm Coastal Water; wSW = warm Shelf Water; IMW = Ice Melt Water; cCW = cool Coastal Water; cSW = cool Shelf Water; AnW = Anadyr Water; WW = Winter Water; AtlW = Atlantic Water; BBW = Bering Basin Water. Note that water mass colors do not correspond to the colors of the flow field shown in Fig. 1. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

2005; Danielson et al., 2012b, 2014) but direct observations of the Anadyr Current are few (Coachman and Shigaev, 1992; Overland et al., 1996). Our climatology supports prior diagnoses of this pathway location because the near-bottom waters flowing through Bering Strait have relatively high summer salinities ($S \sim 32.5$) (Woodgate, 2018), while cold pool waters and waters farther east are for the most part considerably fresher ($S < 32$) (Fig. S2). Hence, the fresher waters of the cold pool cannot be the source for the high-salinity component of the flow field entering Bering Strait. Although moorings (Danielson et al., 2006) and shipboard data (Grebmeier and Cooper, 1995) show the presence of a mean west-to-east current on the south side of St Lawrence Island, AnW does not appear in the climatology here, suggesting that eastward advection of AnW in the St. Lawrence Current is diluted by westward-flowing low salinity surface waters from the Alaskan coastal domain (Danielson et al., 2006, 2012a).

The seasonal evolution of the water masses on these shelves (Figs. 4 and 5) reveals a few fundamental differences between the Bering and Chukchi shelves and their adjoining slope regions. In the summer and fall, Bering Shelf WW exists in the climatology only as remnants in the

northern portion of the cold pool but can be found in significant quantities year-round in the northern Chukchi Sea. IMW is prevalent in the Chukchi Sea but nearly absent from the Bering Shelf year-round. High salinity (>34) basin waters exist at shallower depths along the upper Chukchi Slope than along the Bering Sea Slope (not shown). Our examination of the seasonal climatology provides an assessment of typical water mass characteristics and locations through the year but any individual year may look considerably different (Coachman et al., 1975). To better understand temporal variations, we turn to anomalies relative to this climatology.

3.2. Hydrography: anomalies and trends

Using our long-term climatology as a reference and motivated by our interest in placing recent conditions into the context of the prior record, we examine spatial and temporal variations of the water column hydrography. Warming is evident throughout the water column of most grid cells in the 2014–2018 average summer conditions (Fig. 6, left panel). There is less extensive sampling coverage in spring and fall, but a

similar warming is also found at most grid cells sampled in these seasons (not shown). Even in the presence of top-to-bottom warming (Fig. 6), a few locations depict a mid-depth cool anomaly, reflective of a thermocline shoaled relative to the climatology. We also observe enhanced warming in the upper water column. Strong wind-induced mixing generally resets shelf stratification with water column homogenization to a depth of at 70–100 m in winter (e.g. Kinder and Schumacher, 1981; Stabeno et al., 1998), although data from recent years suggest that the maximum depth of winter mixing may be declining (Stabeno and Bell, 2019). Lower water column properties are set annually prior to the spring onset of ice melt and surface heating that forms the characteristic two-layer Bering Shelf hydrographic structure, in which the lower water column is relatively isolated from direct atmospheric exchange (Coachman, 1986). Together, these observations suggest that the deeper warm anomalies are in place before summer stratification sets in and that heat gains through the surface during spring and summer months subsequently reinforce the surface warm anomaly.

The distribution of salinity anomalies is more complex than for temperature but they exhibit organized spatial structure (Fig. 6, right panel). We find a slight freshening (negative salinity anomaly) in the southernmost portion of the Bering Sea. A positive salinity anomaly extends from inner Bristol Bay to the outer slope in the band of latitudes from 57 to 59 °N and then continues to the northwest along the continental slope. Freshening exists from ~60 °N northward through Bering Strait and across much of the nearshore Alaskan Chukchi Sea. In contrast, farther offshore in the northeast, central, and southwest portions of the shelf, near-surface salinities are considerably higher than in the climatology. Despite somewhat sparse data in any given year, examination of monthly anomalies suggests that the seasonal mean depictions of Fig. 6 are not artifacts of the gridding or uneven sampling efforts.

Seasonally aggregated monthly standard anomalies (Fig. 7) and annually averaged monthly anomalies (Fig. 8) of temperature and salinity integrated through the water column and across each shelf reveal that the two shelves do not change in tight temporal synchrony, despite being advectively linked via Bering Strait. Each shelf forms its own set of thermohaline balances consistent with its local thermohaline

inputs, sinks, and property modifications.

The Bering Shelf exhibits a record-length (1966–2018) summer freshening of -0.13 ± 0.13 (Fig. 7), which contrasts with a 1990–2018 0.08 ± 0.07 decade⁻¹ salinization of the Bering Shelf (Fig. 8), a 1991–2015 increase of freshwater transport through Bering Strait (260 ± 170 km³ decade⁻¹) (Woodgate, 2018) and a 1991–2015 decline in the Bering Strait salinity of -0.14 ± 0.10 decade⁻¹ (Woodgate, 2018).

The Bering Shelf thermal anomaly is dominated by approximately decadal-scale variability of alternating warm and cold intervals (Stabeno et al., 2012). Many of the warm/cold transitions align with qualitatively similar decadal scale alternating warm and cold atmospheric conditions in the Bering Sea (Overland et al., 2012) but a full understanding of the causes of transition between the two phases is lacking. We note that from the 1990s to the present the amplitude of each successive warm interval peak has increased (Fig. 8) and that the 2014–2018 warm interval duration of five years has matched the previous warm phase duration maximum. Continued warm conditions in 2019 suggest that the warm phase will extend at least into a sixth consecutive year for the first time since the beginning of the Bering Sea hydrographic profile record.

Both shelves show indications of warming over their record length but the linear trend is only significant in the Chukchi Sea, where we compute a 1922–2018 summer season increasing temperature trend of 0.14 ± 0.07 °C decade⁻¹. This rate increased to 0.43 ± 0.35 °C decade⁻¹ starting in 1990, the first year of the Bering Strait mooring deployment. Over 1991–2015 the Bering Strait mooring shows a temperature increase of 0.27 ± 0.23 °C decade⁻¹ (Woodgate, 2018). During 2014–2018, each shelf shows anomalies that lie 1–2 standard deviations higher than the mean, corresponding to shelf-wide monthly average temperature anomalies of up to 3 °C. Relative to the climatology for the Chukchi, we find 2014–2018 mean monthly anomalies for spring, summer and fall of 3.2, 0.5 and 0.7 °C. In the Bering, corresponding anomalies for these three seasons are 1.3, 1.1 and 1.2 °C. The mean annual temperature anomaly over 2014–2018 for the two shelves combined is 1.2 °C. The highest observed 5-year average spring anomalies in the Bering Sea occurred in 2014–2018. On an annually aggregated basis, seven of the warmest ten Chukchi Shelf years have occurred

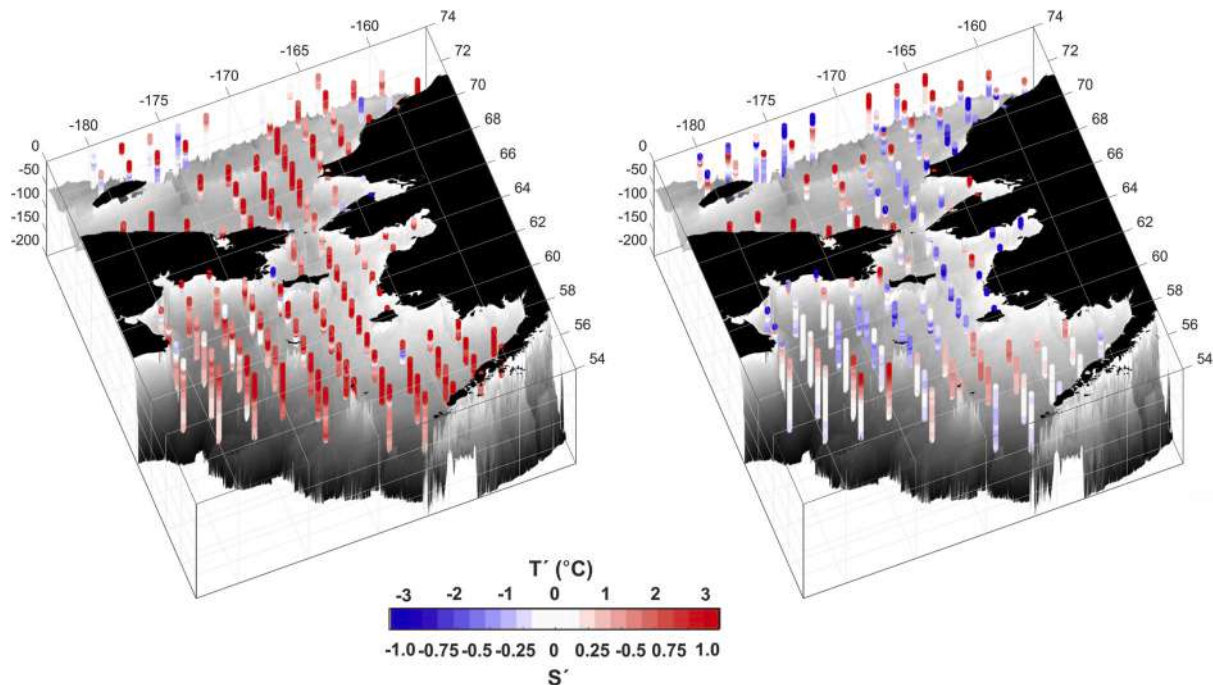


Fig. 6. Perspective view showing profiles of summer season temperature anomalies (T' ; left) and salinity anomalies (S' ; right) for 2014–2018 relative to data collected prior to 2014. Seafloor topography (gray shading) is shown only for depths shallower than 200 m.

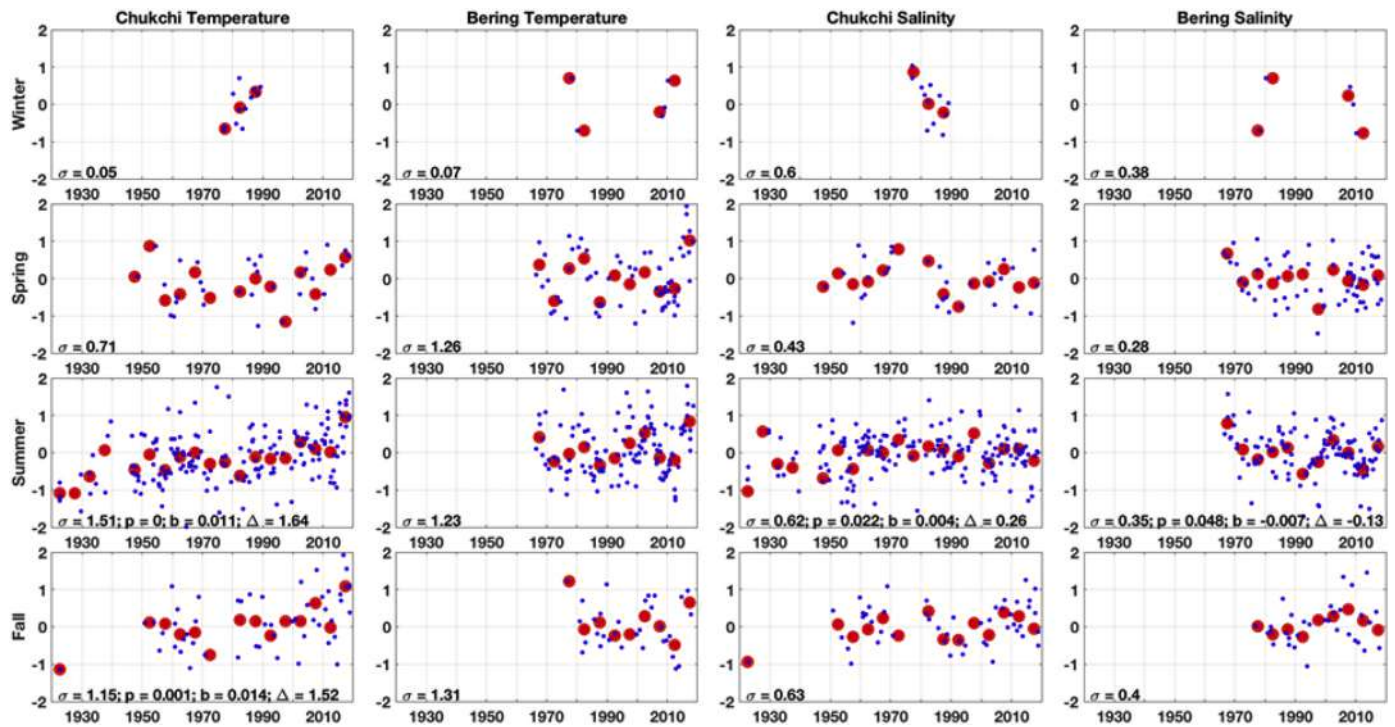


Fig. 7. Seasonally-aggregated monthly normalized temperature and salinity anomaly time series of the vertically integrated gridded profile data for the Chukchi and Bering shelves. From top to bottom, rows show seasonal aggregations for winter, spring, summer and fall, respectively. Large red dots depict 5-year averages. The standard deviation (σ) for each parameter and season is given in the lower-left corner of each panel. For records longer than 20 years that exhibit significant long-term linear trends at the 95% confidence level, the regression p-value, slope (b) and record-length change (Δ) are given. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

since 2007 (Fig. 8), which at the time was a record-low sea-ice extent year for the Arctic as a whole (Lindsay et al., 2009). In contrast, the ten coldest anomalies are fairly evenly distributed between 1922 and 1999. We note that especially for the Chukchi Shelf, sampling is generally biased to open water areas.

There exist many more records of SST and SAT than water column profiles, so for additional context we compare our gridded temperature profile data to the gridded ERSST (Huang et al., 2017) and GISTEMP (Lenssen et al., 2019) datasets, averaging over the eastern Bering Sea, the Chukchi Shelf, the Arctic, and the globe (Fig. 8 and Supplementary Table S1). Linear trend analysis shows that all four of the integration regions and time frames have significantly increasing SST and SAT trends over each of the selected integration intervals. Over 1900–2018, the SST trend for the Bering, Chukchi, Arctic and globe are 0.10 ± 0.0 , 0.08 ± 0.02 , 0.05 ± 0.01 , and 0.07 ± 0.01 °C decade⁻¹, respectively. Over 1990–2018, these four regions exhibit SAT trends of 0.34 ± 0.28 , 0.35 ± 0.14 , 0.27 ± 0.05 , and 0.13 ± 0.03 °C decade⁻¹, showing that in recent decades the Pacific Arctic is warming both in the atmosphere and the ocean more quickly than the globe as a whole.

Water column thermal anomalies are correlated ($p < 0.05$) with SST variations for both shelves, with correlation coefficients of $r = 0.52$ and 0.63 , respectively, for the Chukchi and Bering shelves (Fig. 8). A trend from 1922 to 2018 of an increase of 0.14 ± 0.07 °C decade⁻¹ for the summer/fall water column average temperature for the Chukchi Sea (Fig. 8) is consistent with the 0.11 ± 0.02 °C decade⁻¹ ERSST trend over the same period. By comparison, the Bering Sea SST trend is 0.13 ± 0.04 °C decade⁻¹ over 1922–2018, lending support to the notion that the Bering Sea heat content is likely increasing significantly but that decadal scale variability obscures the long-term trend.

Anomalies of data restricted to only July through October (Fig. 9) bear close resemblance to the annually averaged anomalies shown in Fig. 8. For the three extremely warm recent years of 2015, 2017 and 2018, the mean July through October temperature anomaly of $1.80 \pm$

0.19 °C stands 2.26 °C higher than the average anomaly, -0.46 ± 0.24 °C, for these months in all sampled years prior to 2000. These three years are 2.86 °C higher than the average anomaly of the cold 1970s decade (-1.06 ± 0.72 °C).

To summarize, trend analyses show warming of the Chukchi Shelf over the last 96 years (Figs. 7–9), and the rate of warming has increased in recent decades. This contrasts with the decadal scale variability characteristic of the Bering Shelf, which mostly masks a likely long-term warming trend in water column average temperature over 1966–2018, although the 1922–2018 Bering Sea SST record does depict a warming trend. The Pacific Arctic is warming faster than the globe as a whole and the half-decade of 2014–2018 brought previously unobserved high temperatures to both shelves that were associated with a significantly altered sea ice regime and with this, alterations to salinity distributions (Fig. 6).

3.3. Surface heat fluxes

The shelf temperature anomalies described in Sections 3.1 and 3.2 motivate us to better understand the role of atmospheric heat fluxes in setting the temperature, salinity and sea ice anomalies described above.

The Bering and Chukchi both function as high-latitude oceanic radiators, but surface heat exchanges are not spatially or temporally uniform. For the region shown in Fig. 10a, four oceanographically distinct zones of heat loss emerge in the annual averages: the central Chukchi Shelf, the Gulf of Anadyr, the eastern Bering Sea outer shelf and slope, and the Aleutian Basin (the Bering Sea Basin). Both shelves are oceanic sources of heat to the atmosphere for six months of the year and oceanic heat sinks for about four months, gaining heat from the atmosphere in spring and summer and losing heat to the atmosphere in fall and winter. April and September are transitional months, with net cooling at higher latitudes often coincident with net warming at lower latitudes. Hence, we aggregate months into quarterly and semi-annual seasonal averages.

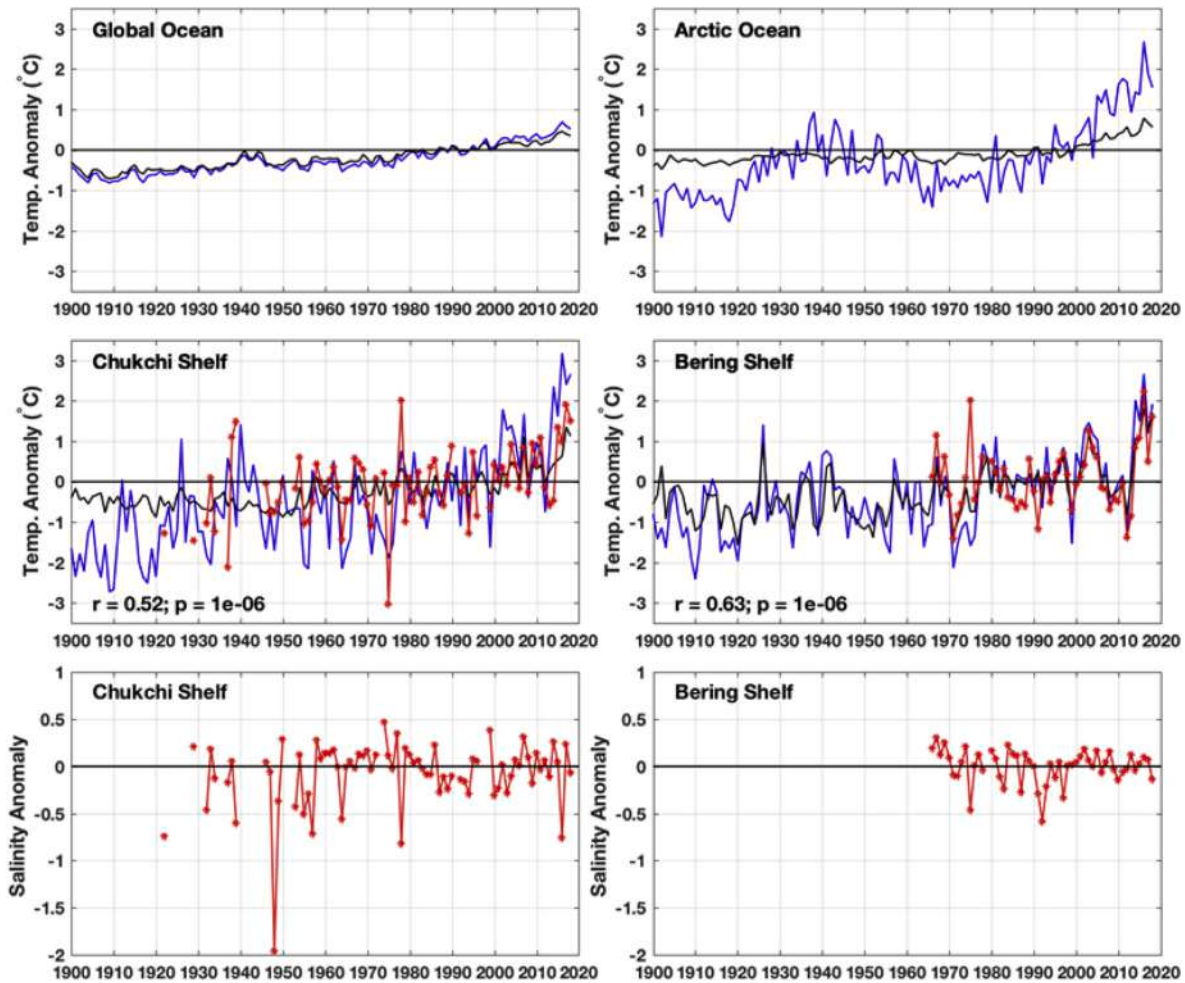


Fig. 8. Annual anomaly time series for the whole globe (upper left), the Arctic (upper right), the Chukchi Shelf (middle and lower left) and Bering Shelf (middle and lower right). Parameters include SAT (blue), SST (black), and water column temperature and salinity (both red). Correlation r and p -value statistics for the relation between the water column temperature and the SST are shown in the two middle panels. All anomalies are plotted with respect to baselines spanning the 1966–2015 half-century. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Comparing the climatological (1979–2013) surface heat fluxes on a quarterly basis (Table 3), we note strong seasonality in magnitude and sign and note that the Bering and Chukchi shelves have statistically different mean rates of heat exchange with the atmosphere in all seasons. Our primary focus is on the continental shelf regions but the deeper Aleutian Basin is also important to the regional heat balance so we begin there. On a per square meter basis, the Aleutian Basin is the North Pacific sub-region responsible for the greatest oceanic heat loss to the atmosphere during fall and winter months. Factors that contribute to this characteristic include the deep-water column, low winter air temperatures (Rodionov et al., 2005), energetic wind (Moore and Pickart, 2012) and tidal (Foreman et al., 2006) mixing, and the Bering Slope Current's continual advective supply of warm waters from the south (Johnson et al., 2004; Ladd, 2014). While ice is regularly advected over the northern portion of the basin and along the Kamchatka Shelf in winter, these factors keep the Aleutian Basin mostly ice-free. Open water and thin ice allow ocean-atmosphere heat exchange to occur much more readily than from a water column covered with even a few tens of centimeters of ice (Maykut, 1978; Wettlaufer, 1991; Martin et al., 2004), so Aleutian Basin waters effectively transfer available heat to the atmosphere in winter months. Despite lower air temperatures over the Chukchi through winter, the Bering Shelf loses more heat to the atmosphere in winter (-94 W m^{-2}) than the Chukchi (-43 W m^{-2}) because of the Bering's higher heat content at the start of fall and lower average winter ice concentrations and thicknesses. Similarly, the Bering Shelf

gains more heat from the atmosphere in spring and summer, a consequence of higher solar angle and because the Bering maintains a lower average surface albedo, so a larger fraction of the incoming shortwave radiation is absorbed.

By differencing the mean surface heat fluxes before and after 2013, we find that the northern Chukchi Shelf in the last half-decade lost appreciably more heat to the atmosphere than in years past, and the Bering Sea lost less heat (Fig. 10b and Table 3). The Chukchi Shelf increased its net cooling by $\sim 25\%$ (from -14 to -18 W m^{-2} on annual average), while the Bering Shelf remained essentially unchanged (-20 to -18 W m^{-2}) and the Aleutian Basin lost nearly 20% of its net cooling (-27 to -22 W m^{-2}). The potential of these changes to alter cyclogenesis, surface moisture transport, and other important meteorological processes is unclear but worthy of further investigation. The Chukchi Shelf and Aleutian Basin mean heat fluxes over 2014–2018 both lie outside of the 95% confidence interval for the mean of the 1979–2013 annual means. The changes over the two shelves do not balance, suggesting that the system is not just redistributing heat gains and losses and that net warming, cooling, and/or oceanic advective contributions must be significant. To the extent that some of the regional ocean-atmosphere heat exchange was effectively redistributed from the sub-Arctic Aleutian Basin into the Arctic Chukchi Sea, this represents a mechanism whose impact in part likely promotes reduced latitudinal gradients in air temperature.

Differences in the seasonal net surface heat fluxes (Fig. 11 and

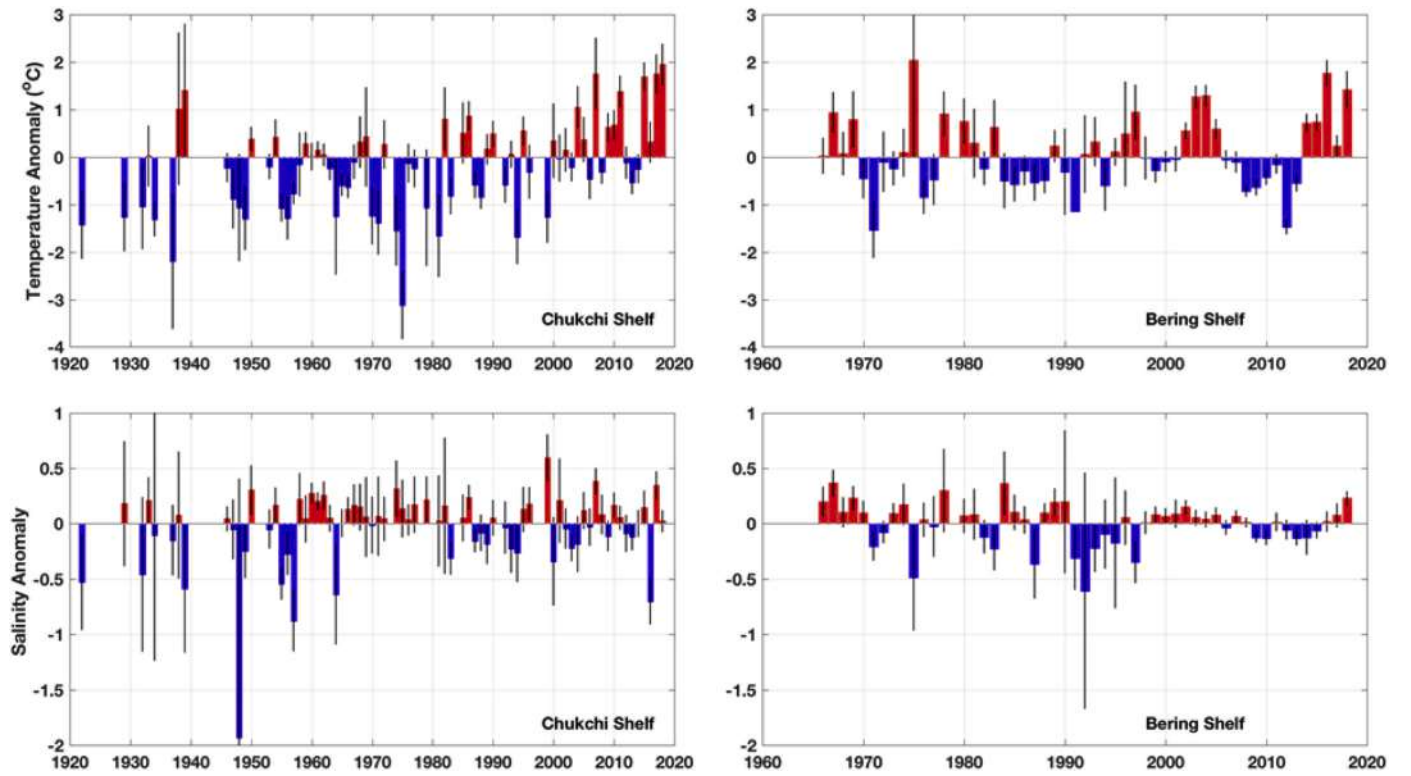


Fig. 9. Annually averaged July through October thermal (top) and haline (bottom) anomalies over the Chukchi (left) and Bering (right) continental shelves. Error bar whiskers depict 95% confidence limits on the mean for each year's anomaly.

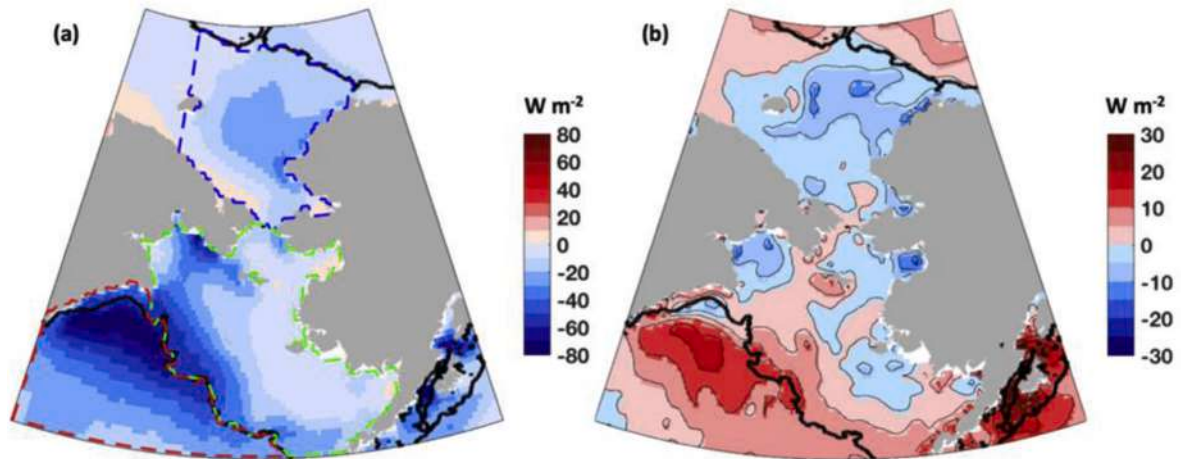


Fig. 10. (a) Mean annual surface heat flux for 1979–2013 and (b) the difference between 2014–2018 and the earlier interval, computed as the latter interval minus the earlier. Note different color bar scaling for the two panels. Edges of the continental shelves (200 m depth) are marked with a black contour. Chukchi Shelf, Bering Shelf, and Aleutian Basin integration zones discussed in the text are marked in panel (a) with blue, green and red dashed lines, respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Table 3) for 2014–2018 relative to the climatology reveal spatial structures and temporal evolutions not apparent in the annually averaged fields, including large (often $> 5 \text{ W m}^{-2}$) and significant changes in the mean seasonal surface heat exchanges. With the exception of summer for the Bering Shelf and Aleutian Basin, all three integration regions had 2014–2018 surface flux means that exceeded the 95% confidence limits of the 35-year climatological mean.

Over 2014–2018 the fall Chukchi heat loss increased by 30% to $-129 \pm 15 \text{ W m}^{-2}$, a consequence of the delayed onset of ice cover and higher oceanic heat content in the fall. Given typical rates of heat loss for the ice-free ocean in fall (Table 3), a warming of about $1.3 \text{ }^{\circ}\text{C}$ for the

Bering and Chukchi shelves would require an additional month to cool the water column to the freezing point. Hence, the Chukchi Shelf now requires more time to cool to the freezing point because the shelf begins the cooling season (near the fall equinox) with a higher heat content (Section 3.2). Furthermore, the southern Bering Shelf shows a positive heat flux anomaly in the recent years that manifests in fall and winter. Diagnosis of this signal (not shown here) suggests that it is tied to decreases in the sensible and latent heat fluxes, reflecting reconfigured balances between the air-sea temperature gradient, wind speeds, and the relative humidity.

In winter, the Chukchi Shelf shows modest yet statistically significant

Table 3

Mean ERA5 net surface heat fluxes (W m^{-2}) for seasonal and year-long averaging intervals for 1979–2013 and 2014–2018 over the three integration regions denoted in Fig. 10. Limits denote 95% confidence limit on the mean for the respective interval. Positive values denote oceanic heat gain from the atmosphere; negative values are oceanic heat loss. Bold type shows when the 2014–2018 mean value lies outside of the 95% confidence interval for the 1979–2013 mean. Non-overlapping 95% confidence intervals are shown in *italics*.

Region	Interval	Winter JFM	Spring AMJ	Summer JAS	Fall OND	Annual Mean
Chukchi Shelf	1979–2013	-43 ± 1	31 ± 3	53 ± 2	-99 ± 5	-14 ± 1
	2014–2018	-36 ± 4	44 ± 11	49 ± 8	-129 ± 15	-18 ± 4
Bering Shelf	1979–2013	-94 ± 7	96 ± 3	67 ± 2	-146 ± 5	-19 ± 3
	2014–2018	-102 ± 15	111 ± 7	64 ± 7	-146 ± 11	-18 ± 6
Aleutian Basin	1979–2013	-138 ± 7	95 ± 2	77 ± 2	-144 ± 5	-27 ± 3
	2014–2018	-116 ± 15	101 ± 6	79 ± 2	-154 ± 16	-22 ± 8

(-43 to -36 W m^{-2}) reduction of heat loss during 2014–2018 relative to the 1979–2013 base period. Note that the Aleutian Basin loses much less heat in winter compared to previous years (-138 to -116 W m^{-2}). Examination of the individual heat flux terms for this case shows that the difference is driven primarily by anomalous sensible heat fluxes, with additional contributions from latent and longwave fluxes.

In spring, both the Bering and Chukchi shelves exhibited strong positive surface heat flux anomalies during 2014–2018, a consequence of lower ice concentrations (e.g. Fig. 2) that directly led to lower average surface albedo and greater oceanic shortwave heat absorption (see also correlations in Supplementary Tables S2–S5). In the northernmost reaches of the analysis domain (e.g. north of about 72°N) the spring ice cover has not changed greatly, nor have the ocean-atmosphere heat fluxes changed there in the spring season.

Semi-annually aggregated surface heat flux trends over 1979–2018

show that the Bering and Chukchi shelves follow contrasting trajectories through time (Fig. 12). The Chukchi Shelf shows significant trends ($p < 0.05$) whereby in recent years more heat is gained in the heating season and more heat lost in the cooling season, and the cooling season standard anomaly is nearly twice larger in magnitude. These trends provide additional evidence that the Chukchi Shelf heat engine is accelerating, consistent with faster rates of transition from winter to summer ice cover conditions as identified by Danielson et al. (2017). In contrast, the Bering Shelf does not exhibit a significant trend at either time of year, in part because different portions of the Bering Shelf exhibit contrasting responses in surface heat fluxes during times of warm water and low ice, such as over 2014–2018 (see Fig. 10b).

Cross-correlations between the two shelves' seasonally averaged heat fluxes provide insights into drivers and responses. Heating season anomalies over the Chukchi Sea are correlated ($r = 0.49$, $p = 0.001$) with heating season anomalies in the Bering Sea, reflecting in part the fact that Pacific Arctic atmospheric pressure systems have typical decorrelation length scales of many hundreds or thousands of km. More importantly, surface flux anomalies of the Chukchi Sea cooling season are inversely correlated to both Chukchi ($r = -0.67$, $p < 0.001$) and Bering ($r = -0.45$, $p = 0.003$) anomalies of the prior heating season, showing that heat loss follows accumulated heat gain. In contrast, cooling season surface flux anomalies are not good predictors ($p > 0.05$) for the following summer season's heat flux because the freezing point provides a nearly invariant lower temperature re-set each winter.

The ERA5 reanalysis reports a 2017 October to December heat flux anomaly for the Chukchi Shelf of about 41 W m^{-2} , or nearly 200 EJ ($1 \text{ EJ} = 10^{18} \text{ J}$) integrated over three months. For a typical atmospheric heat capacity of $1 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$, this massive heat exchange would be sufficient to warm the entire Arctic troposphere by more than 1°C . The Chukchi Shelf occupies only about 3% of the Arctic Ocean area (Table 1). This scaling shows how, through ice cover mediated feedbacks of spring heat gain and fall heat loss, the Chukchi Sea delivers an out-sized contribution to Arctic amplification. The trends of Fig. 12 show increasing frequency of large surface heat losses from the Chukchi Sea, with five of the most recent eight years exhibiting an annually averaged anomalous flux of greater than one standard deviation away

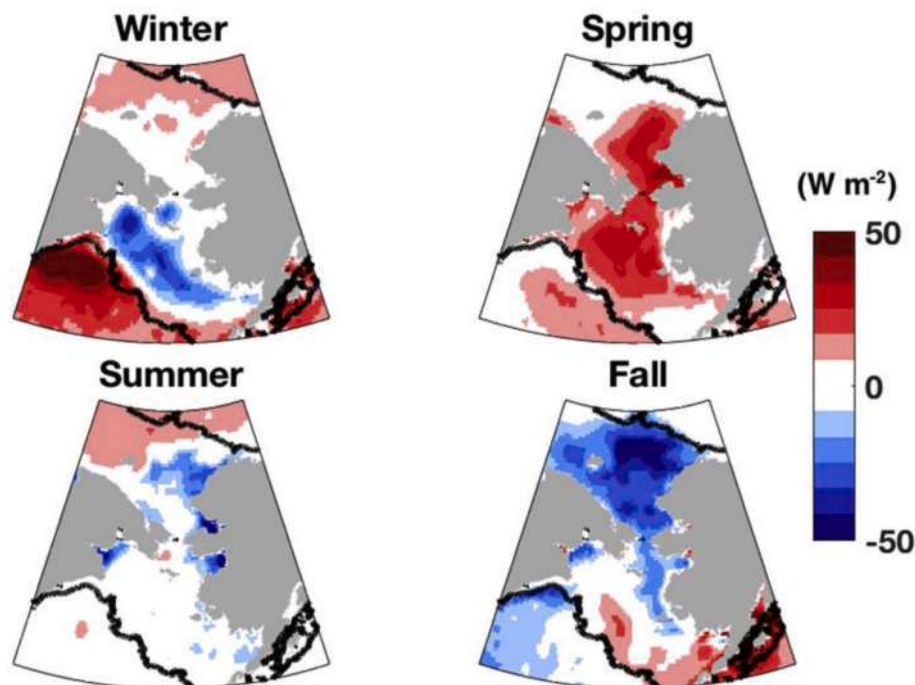


Fig. 11. Seasonal surface heat flux anomalies (W m^{-2}) for 2014–2018 relative to 1979–2013. Edges of the continental shelves (200 m depth) are marked with a black contour.

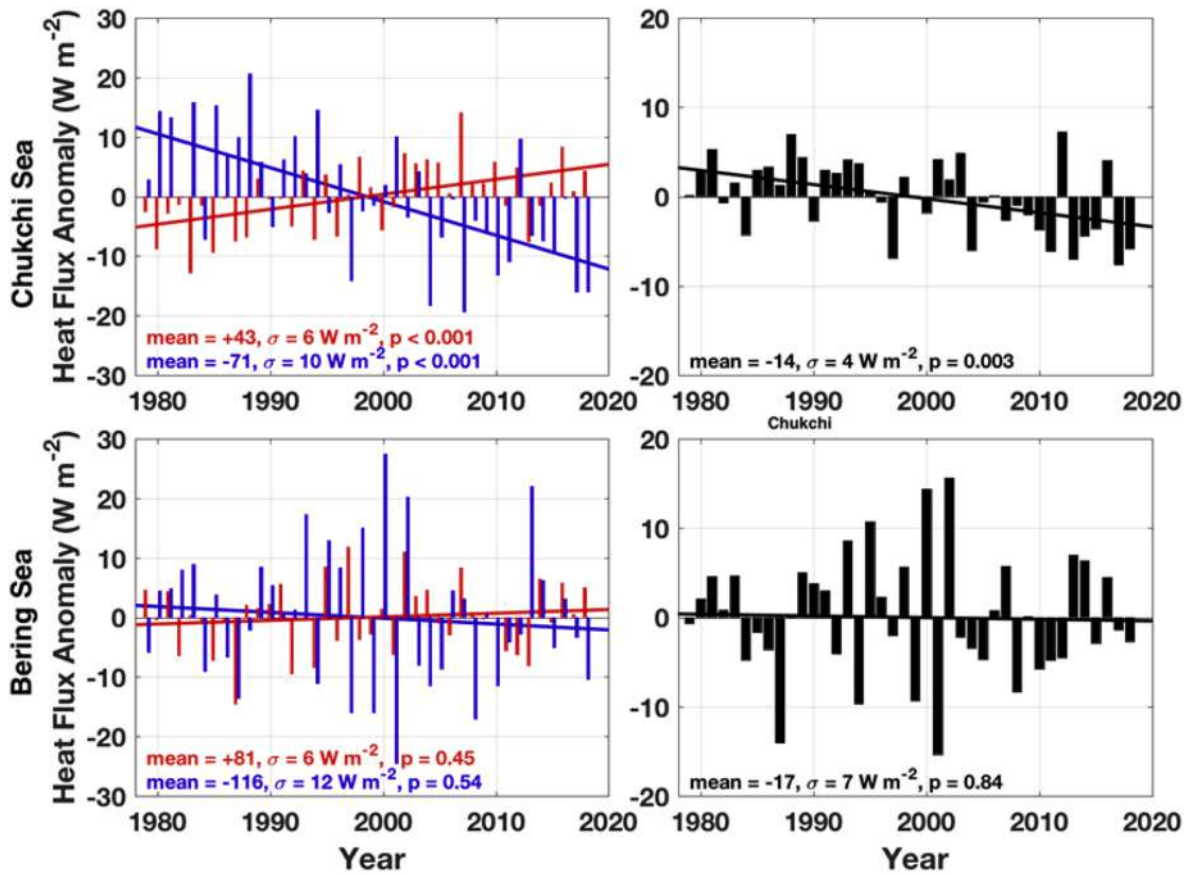


Fig. 12. Seasonally (left) and annually (right) averaged ERA5 surface heat flux anomalies for the Chukchi (top) and Bering (bottom) shelves, computed relative to a 1979–2018 record length baseline. Red bars and trend lines denote the heating spring and summer months (April–September); blue is used for the cooling fall and winter months (January–March plus October–December of the same year). Corresponding mean, standard deviations (σ) and linear trend p-values are shown at the bottom of each panel. Note different axis scales for the annual and seasonal plots. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

from the mean (1 standard deviation = $4 \text{ W m}^{-2} = 70 \text{ EJ yr}^{-1}$ for the year).

In summary, we find statistically significant trends over the 1979–2018 period of record in the ERA5 seasonal surface heat fluxes over the Chukchi Shelf, whereby spring months are absorbing more shortwave energy, and with the lack of sea ice and a warmer ocean, fall and winter months exhibit accelerated heat losses. In contrast, the Bering Shelf does not show temporal trends in the surface heat fluxes over the last 40 years, but recent winters have lost anomalously large amounts of heat and recent spring months have absorbed more heat. The Aleutian Basin also exhibits large anomalous heat fluxes seasonally, and in recent years has delivered considerably less heat to the atmosphere than in years past. Increased heat losses to the atmosphere from the Chukchi Sea are large enough to contribute appreciably to Arctic amplification.

3.4. Bering and Chukchi Shelf heat budgets

In this section, we apply estimates of heat content, surface heat flux, and oceanic heat transport through Bering Strait to form balanced heat budgets for the Chukchi and Bering shelves. For the spring and fall, data coverage is fairly sparse so we conservatively estimate heat content changes by starting with gridded observations from 2014 to 2018 and then inserting the previously computed climatological hydrography at grid cells lacking data. Hence, heat content changes for these seasons represent a lower bound because the computation is biased toward the climatology at many grid points. We are unable to make reliable estimates for the 2014–2018 winter heat content due to lack of observations

at this time of year.

A steady state solution is obtained by integrating heat fluxes over the course of the year (Table 4 and Fig. 13). The annual integration allows us to neglect ice formation, ice melt, and the work of seasonally changing oceanic heat content because integration through one climatological (or 2014–2018 mean) calendar year exhibits zero net change in ice cover or temperature. The surface heat exchanges shown in Fig. 13 come from the annual time integrations of the ERA5 net surface heat flux shown in Table 4. The heat flux through Bering Strait is based on Bering Strait mooring A3, adjusted for instrument depths and dropouts and the mean transport in Alaskan Coastal Current transport of heat assuming a 15 m surface mixed layer (Woodgate, 2018).

The steady-state solution (Fig. 13) exhibits characteristics consistent with the heat content and surface heat flux changes described in Sections 3.1–3.3. Heat loss over the Bering Shelf exceeds that of the Chukchi by about a factor of two, primarily a consequence of the Bering Shelf's greater surface area (Table 1). The Bering Shelf is a large ($\sim 900 \text{ EJ}$) sink for advectively sourced heat in the North Pacific. The Chukchi Sea net surface heat flux removes from the ocean a sizeable majority (two-thirds to three-quarters) of the heat transported northward through Bering Strait.

The analysis residual represents two heat budget contributions that we cannot separate from one another: oceanic sensible heat fluxed onto or off of the shelf and the contribution of net sea ice advection - because import of sea ice to the shelves represents a potential heat sink. Lacking adequate data about changes in the sea ice flux, if we want to assess changes in sensible heat flux to the adjoining basin we are forced to assume that the advection of sea ice onto the shelf has not appreciably

Table 4

Seasonal and annual estimates of heat content and surface heat exchanges for the Bering and Chukchi continental shelves, and the northward heat flux through Bering Strait over 2014–2018, the prior period of record for each dataset, and differences between the two time periods. Annual summaries are given as net values for the fluxes and means for the heat contents. We were unable to make estimates of the winter heat content for the recent interval so conservatively assume no change.

			Winter	Spring	Summer	Fall	Annual Mean
Oceanic Heat Content (EJ)	Chukchi Shelf	1922–2013	60	130	210	200	180
		2014–2018	60	140	260	210	200
		Difference	0	10	50	10	20
	Bering Shelf	1960–2013	520	920	1200	1200	980
		2014–2018	520	1000	1500	1300	1090
		Difference	0	120	300	100	110
Bering Strait Heat Advection (EJ)	Bering Strait		Winter	Spring	Summer	Fall	Annual Net
		1990–2013	0	60	220	70	350
		2014–2016	0	80	290	100	460
		Difference	0	20	70	30	120
Ocean-Atmosphere Heat Exchange (EJ)	Chukchi Shelf	1979–2013	–180	130	240	–430	–250
		2014–2018	–160	190	220	–570	–310
		Difference	20	60	–20	–130	70
	Bering Shelf	1979–2013	–670	690	480	–1100	–560
		2014–2018	–730	800	470	–1100	–520
		Difference	–60	110	–10	0	40

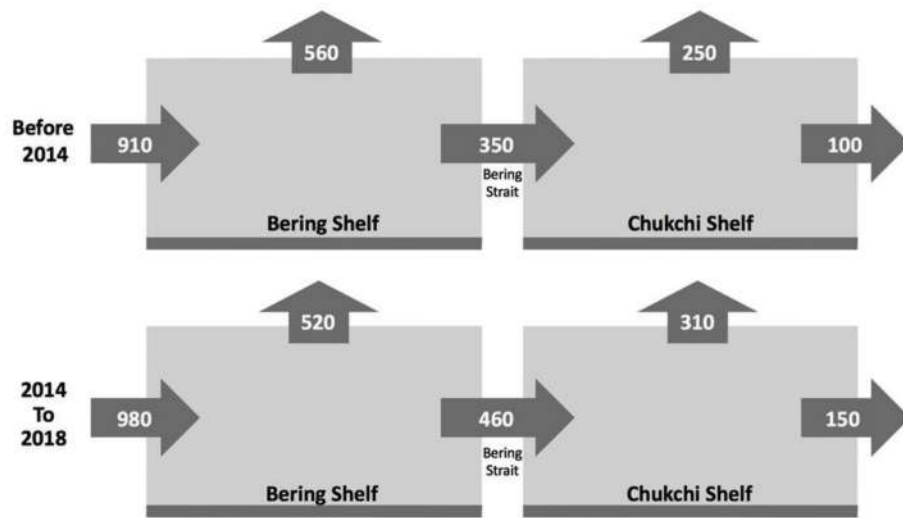


Fig. 13. Steady-state solution to the heat balance for the Bering-Chukchi Shelf system. Residual terms at the lateral shelf boundaries represent the sum of net basin-shelf sensible heat exchanges and heat budget contributions from advected sea ice. Orientation is such that the Gulf of Alaska and the Aleutian Basin are located to the left, the Canada Basin to the right and the atmosphere/ocean interface is at the top. All values reported in EJ.

changed over time. This assumption is assuredly invalid for some years so the approach has limitations but it is a useful starting point. The Chukchi Shelf annual heat budget residual is ~ 100 EJ, suggesting that in past decades the amount of heat fluxed off the shelf and directed into melting imported ice comprised about one quarter of the heat input northward through Bering Strait. Whether the Chukchi Shelf is a source or sink of ice varies seasonally and interannually (Howell et al., 2016) and this term is difficult to estimate. Ice can enter the Chukchi Shelf from Bering Strait (Woodgate and Aagaard, 2005), Long Strait (Weingartner et al., 1999), across the Chukchi Slope (Hutchings and Rigor, 2012) or from the Beaufort Shelf (Petty et al., 2016; Weingartner et al., 2017). In addition to the potentially significant impact of sea ice advection on the Chukchi heat budget, warm waters exiting Barrow Canyon (Itoh et al., 2015) may at times be carried back onto the Chukchi Shelf in summer and fall months, examples of which are shown with satellite tracked drifter observations by Danielson et al. (2017). Heat sourced farther offshore in the Beaufort Gyre may also be carried onto the NE Chukchi Shelf. Over the Bering Shelf, the typical ice volume near winter's end is $\sim 1.3 \times 10^{12} \text{ m}^3$ (Zhang et al., 2010), representing 400 EJ of extracted heat, or two-thirds of the Bering heat loss from summer to winter. If only 10% of the Bering ice is advected northward through Bering Strait, its

latent heat of fusion would represent a 40 EJ heat sink in the Chukchi Shelf, a relatively minor term in this shelf's heat budget, but a large fraction of the annual residual. The net export of ice through Bering Strait is estimated at $\sim 100 \text{ km}^3 \text{ yr}^{-1}$ (Woodgate and Aagaard, 2005); we lack any good estimate of the ice transport through the other boundaries.

Relative to the earlier time interval, during 2014–2018 the Bering Strait northward heat flux increased by 30% (110 EJ), the Chukchi Shelf net (outgoing) surface heat flux increased by 25% (60 EJ) and the net heat flux residual increased by 50% (50 EJ). Simultaneously, the Bering Shelf surface heat loss diminished by 7% (40 EJ) and the advective contribution to the Bering Shelf increased (70 EJ). This advective increase represents two-thirds of the observed increase in the northward Bering Strait oceanic heat flux. Hence, the heat budget shows that the remaining 1/3 of the Bering Strait heat flux increase over 2014–2018 derives from the net decrease in the Bering Shelf surface heat exchange.

We note that the 110 EJ yr^{-1} increase of the Bering Strait heat flux during 2014–2018 is a likely lower bound for this value because the mooring record used here misses 2017 and 2018, two of the warmest years on each shelf. Using the relation $Q = C_p \Delta T V \rho dt$ for typical annual average values of heat capacity ($C_p = 4000 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$), density

($\rho = 1025 \text{ kg m}^{-3}$) Bering Strait transport ($V = 1 \text{ Sv}$), and from Fig. 8 the average annual temperature anomaly ($\Delta T = 1.2^\circ \text{C}$) for the two shelves over 2014–2018, we estimate a more probable Chukchi throughput increase of 150 EJ for an annual mean of 500 EJ. The impact on the annual heat budget would be an increase in the 2014–2018 Bering Shelf and Chukchi Shelf residuals to 1020 EJ yr^{-1} and 190 EJ yr^{-1} , respectively. This estimate could grow further if the Bering Strait throughflow during these years continues its increasing trend (Woodgate, 2018).

The steady state approach obscures numerous potentially important factors so we turn to a seasonally explicit solution (Fig. 14). In this analysis, we separately balance the heating season and cooling season, maintaining continuity for each season at Bering Strait. Because the seasonal heat content changes (from spring to fall and then fall to spring) are approximately equal and opposite, any change in the seasonal amplitude of shelf temperatures triggers a commensurate adjustment in the residual terms. The heat balance shows that during the cooling season the warm ocean acts as a heat source, buffering the advective supply of heat and surface heat losses. In the heating season, the large heat capacities of these expansive shelves act as heat sinks. The 2014–2018 data do not show a significant change in the spring-to-fall temperature amplitude for either shelf relative to the climatology, showing that changes in heat throughput dominate over changes in heat content. This balance also shows that oceanic and atmospheric contributions to the Chukchi Shelf heat content in the heating season are similar in magnitude, but dominated by the atmospheric contribution, and that the oceanic input over 2014–2018 increased twice as fast as the atmospheric increase.

The Bering Shelf balance suggests that the increased northward heat flux through Bering Strait comes from both increase in heat gain through the ocean surface during the heating season and increase of heat supplied via advection during the cooling season. In addition to radiating advectively sourced heat, the Bering Shelf supplies a significant amount of heat ($\sim 600 \text{ EJ}$) back into the Aleutian basin during the heating

season. For a 100 m winter mixed layer and the whole of the Aleutian Basin ($\sim 2 \times 10^6 \text{ km}^2$), 30 EJ – the increase of Bering Shelf heat export to the basin – represents a potentially significant $0.30^\circ \text{C decade}^{-1}$ Aleutian Basin upper water column warming. While removed from the Bering Shelf at least in the short term, this heat may have another opportunity to influence the Bering Shelf heat budget if it is eventually advected back onto the eastern Bering Sea shelf. In contrast, oceanic heat delivered to the Arctic through Bering Strait is lost subsequently from the Bering Sea system for many centuries.

The seasonal heat balance findings suggest that the heating season advective heat loss from the Chukchi Shelf increased by 120 EJ relative to the prior climatology. This value, more than twice the magnitude of the steady state balance increase (50 EJ), is dependent upon the magnitude of the spring-to-fall change in heat content and the influence of summer ice advection onto the Chukchi Shelf from elsewhere. Nonetheless, both heat balances describe a Chukchi Sea advective throughput that has increased appreciably. Note that Timmermans et al. (2018) document a 2014–2017 increase of heat content in the Beaufort Gyre thermocline of $\sim 150 \text{ EJ}$ relative to observations made over 1987–2002.

A cross-correlation analysis of the time series assembled above can provide insight into the relations between the heat fluxes, shelf temperatures and salinities, and the Bering Strait mooring data. Correlation matrices (Supplemental Tables 2–5) show the tightly interlinked nature of the various variables and the manner in which these relations evolve with the passing seasons and their adjusting heat budget balances. For example, the Chukchi ice concentration most closely co-varies with the latent heat flux in winter, the net surface heat flux in spring, and the air temperature and latent fluxes nearly equally in fall. The correlation between Chukchi latent heat flux and the ice concentration anomaly has a very high coefficient of regression in fall ($r^2 = 0.71$, $p < 0.01$) and winter ($r^2 = 0.79$, $p < 0.01$). The winter Bering ice concentration is most strongly correlated with the inverse of air temperature and shortwave

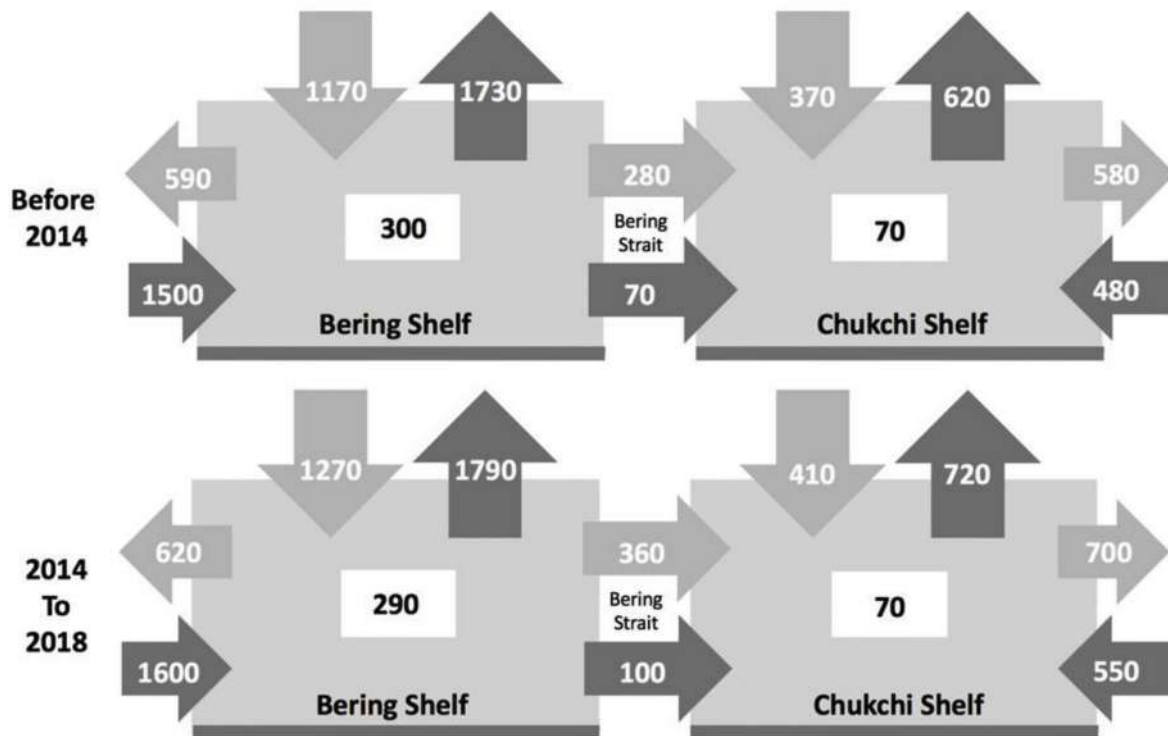


Fig. 14. Semi-annual solution of the Bering-Chukchi Shelf heat budget for the two integration intervals. Light and dark arrows denote heating and cooling season fluxes, respectively. Values in the central white boxes show the seasonal change in oceanic heat content across the heating and cooling seasons (from spring to fall and vice-versa). Figure orientation is such that the Gulf of Alaska and the Aleutian Basin is to the left, the Canada Basin is to the right, and the atmosphere/ocean interface is at the top. All values reported in EJ.

radiation fluctuations. The Bering Sea spring ice concentration is positively correlated with the Bering Strait mooring salinity, showing that years with high ice concentrations exhibit higher salt flux to the Chukchi Sea, presumably due to enhanced brine production. The Chukchi ice concentration is negatively correlated with the Bering Strait heat flux.

Low ice anomalies in the Chukchi Sea appear to generate southerly wind anomalies (wind blowing anomalously from the south to the north) that could potentially advect ice and/or oceanic heat northward in a positive feedback relation (Tachibana et al., 2019). Thus, we examine regional wind field anomalies for 2014–2018 and correlations between monthly wind anomalies and our other variables of interest (Supplemental Tables 2–5). For the Chukchi Sea, we find that the 2014–2018 anomalous heat fluxes of winter were associated with southerly wind anomalies (Fig. 15). The net Chukchi Sea surface heat flux variations are significantly correlated ($r^2 = 0.45$, $p < 0.01$) with the meridional wind component in winter and weakly, but still significantly correlated, in fall ($r^2 = 0.08$, $p < 0.05$). The surface heat flux versus meridional wind relation in the Bering Sea is significant in both fall ($r^2 = 0.42$, $p < 0.05$) and winter ($r^2 = 0.33$, $p < 0.05$). Furthermore, the correlation analysis shows that southerly wind anomalies are significantly correlated to northward flow anomalies in Bering Strait. These findings are all consistent with the hypothesis proposed by Tachibana et al. (2019); namely, that low sea ice concentrations and excess ocean-to-atmosphere heat fluxes in the Pacific Arctic are associated with wind anomalies that also help promote reduced ice cover. Stabeno and Bell (2019) identify southerly winds in conjunction with the positive air temperature anomalies advected by these winds as key factors in driving the low ice concentrations of recent years.

In this section, we documented altered heat exchanges between these shelves, the overlying atmosphere, and the adjacent basins over 2014–2018 relative to the prior 35-year climatology. We found that the Chukchi Shelf heat engine significantly accelerated over this time, with larger heat gains in spring, larger heat content in summer in fall, and greater heat throughput to the high Arctic (110–150 EJ yr⁻¹). Anomalous high heat content of the shelves entering fall results in high oceanic heat loss to the atmosphere in fall and winter, triggering southerly wind anomalies that in turn advect warm air northward and drive water and sea ice northward.

4. Summary and discussion

Our results provide evidence for recent acceleration of the Pacific Arctic heat engine and show that the ocean plays multiple roles in the ocean-ice-atmosphere feedback loop, which are depicted schematically in Fig. 16. Relative to prior decades, the 2014–2018 heat balance is one in which the shelves absorbed more heat in the spring because of low ice concentrations and lost more heat in the fall because they begin the fall warmer and thus must lose more heat in order to reach the freezing point. Chukchi Sea surface heat fluxes trigger southerly wind anomalies that in turn promote northward advection of ice, water, and warm air, all of which lead to further reductions in winter and spring ice cover. The year-round shelf heat content has increased and the advective throughput of heat has increased. These changes are all consistent with recent observations of low ice concentrations, warm North Pacific and Pacific Arctic waters, and unusual winter storms in the northern Bering Sea. Some of these process changes were anticipated recently but have been obscured in the noise of interannual variability (see Stroeve et al. (2012) for a detailed discussion). The changes documented here help explain why the rate of warming in the Pacific Arctic has increased in recent decades, and why the Arctic is warming faster than the globe on average.

We think that some of the haline anomalies of Fig. 6, both fresh and salty, are mechanistically linked to an altered sea-ice regime, although some of the freshening is also likely due in part to the long-term decline of salinity recorded by the Bering Strait moorings (Woodgate, 2018). In the past, advection from the north carried ice southward across the Bering Sea shelf each winter and its subsequent melt at the edge of the ice pack represented a significant freshwater contribution to the shelf in water depths greater than about 70 m and especially between latitudes 56–60 °N (Zhang et al., 2010). We suggest that in recent years, the diminished southward advection effectively removed this freshwater input, resulting in the positive salinity anomalies seen near 57–59 °N. We find a typical water-column salinization of ~0.4 on the mid-shelf here (in ~70 m of water), which represents a freshwater deficit of ~0.9 m and appears reasonable relative to the expected accumulation of ~1.5 m of ice melt in a three-month winter season predicted by Zhang et al. (2010). In the northern Bering Sea and possibly the Chukchi Sea, we speculate that compounding factors likely account for the observed freshening: reduced brine production due to reduced sea-ice growth and extent (Fig. 2), and sea-ice melt along the leading (southern) ice edge

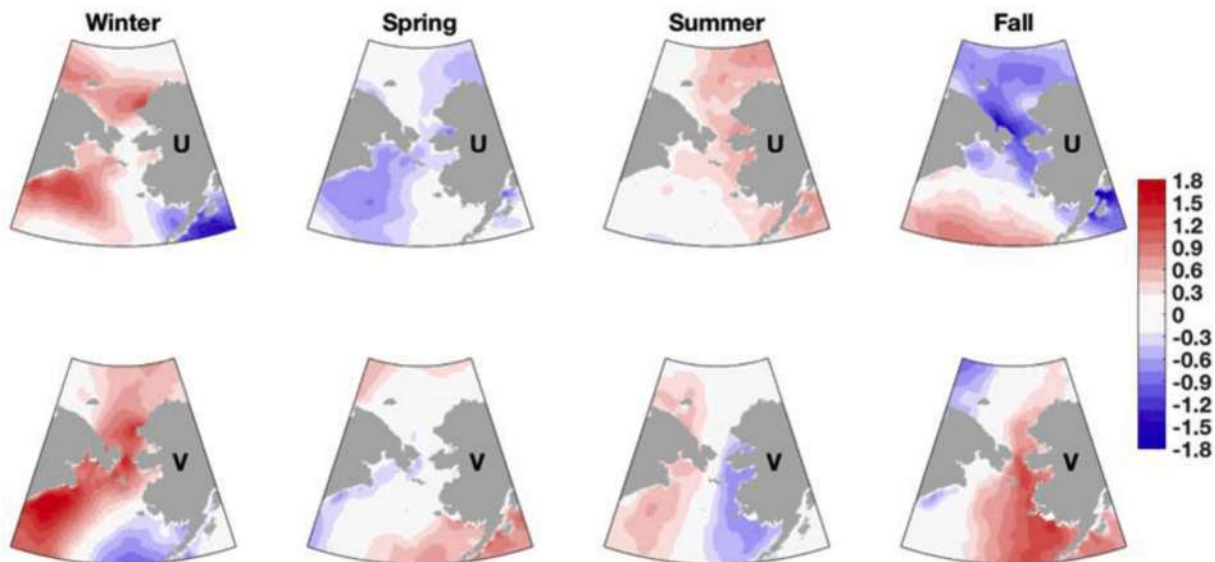


Fig. 15. Differences of seasonally averaged ERA5 wind vector components U (top row) and V (2014–2018 minus 1979–2013), units of m s⁻¹. Note the fall and winter wind V anomalies over the Bering and Chukchi seas.

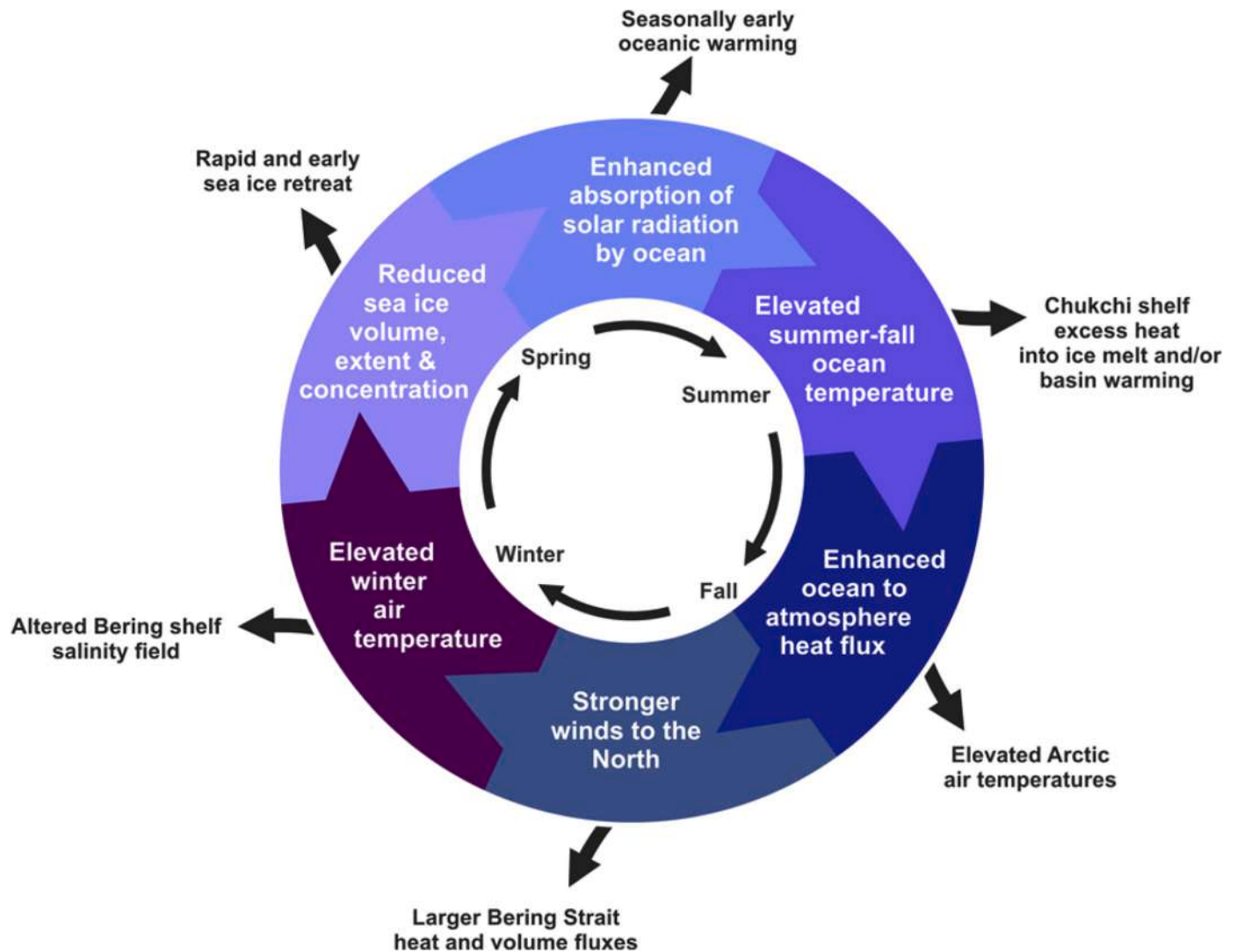


Fig. 16. The ocean-ice-atmosphere feedback loop for the Pacific Arctic's role in contributing to the Arctic amplification of air and ocean temperatures. The approximate seasonal sequence of events is shown with the inner loop (black). Physical consequences of the altered heat balances (black) include both local and remote impacts. The feedback loop promotes cascading effects on the regional physical system; not depicted here are equally important consequences for the ecosystem, for biogeochemical cycles, and for climate teleconnections that may influence weather far from the Pacific Arctic.

occurring farther north than in years past (in association with a northward-displaced freezing isotherm). Farther north, the positive salinity anomaly found near the surface in the northeast Chukchi Sea may result from at least two sources. Thinner arctic sea ice (e.g. Kwok and Rothrock, 2009; Zhang et al., 2018) would contribute less fresh water upon melting in summer. A positive saline anomaly could also develop in the ice edge plume region if the relative orientation between the winds and the ice edge is altered to promote northward ice advection. Lu et al. (2020) finds that winds from the southwest, south or east should trigger positive salinity anomalies in the meltwater plumes associated with the Chukchi marginal ice zone, so a salinization of the meltwater plume is consistent with observations of enhanced polar easterlies (e.g. Pickart et al., 2013). Further diagnosis of the sea-ice regime in relation to the shelf salinity field is clearly warranted.

Warming permafrost, outflow timing, and other hydrological changes are impacting Yukon River discharges into the Bering Sea and increasing winter season discharge rates, but annual discharge trends have not been well established for this river (Brabets and Walvoord, 2009). Since 2000, the Yukon has discharged on average $209 \text{ km}^3 \text{ yr}^{-1}$: an increase of $3 \text{ km}^3 \text{ yr}^{-1}$, or 1.5% above the period of record mean (Holmes et al., 2018). On the other hand, temperate glaciers around the

northern and eastern rim of the Gulf of Alaska are rapidly losing $57 \pm 11 \text{ km}^3 \text{ yr}^{-1}$ of volume (Hill et al., 2015), a rate maintained since at least the early part of this century (Jacob et al., 2012; Hill et al., 2015). Long-term declines in salinity have been identified in the coastal Gulf of Alaska (Royer and Grosch, 2006) and oceanic realms of the North Pacific (Freeland, 2013). The magnitude of net glacier melt represents more than a quarter of the annual Yukon River outflow and more than 15% of all river systems that discharge onto the eastern Bering Sea shelf (Aagaard et al., 2006). Might the glacier melt in the Gulf of Alaska be partially responsible for the 2000 to present freshening observed in Bering Strait (Woodgate, 2018) and over the shelf?

We can estimate the Gulf of Alaska glaciers' potential contribution to declining Bering Shelf salinity since 2000 with the relation $S_{GF} = (S_S \cdot V_S) / (V_S + V_G)$, where S_{GF} is the shelf salinity under the influence of glacial freshening, S_S and V_S are the unfreshened shelf salinity and shelf volume, and V_G is the volume of glacial melt. Given the volume of the Bering Shelf (Table 1) and a typical shelf salinity of ~ 32 , if only one-quarter of the Gulf of Alaska net glacial ablation were to enter the Bering Sea shelf via Unimak pass, we can account for a shelf-wide freshening of $0.015 \pm 0.003 \text{ yr}^{-1}$ (or about five times greater than the amount of freshening that the Yukon River appears to be contributing).

We conclude that the freshening signal observed in Bering Strait is at least consistent with a terrestrial discharge source from Gulf of Alaska glacial ablation.

Altered latitudinal atmospheric temperature gradients and the changing Arctic ice cover may play a role in triggering baroclinic perturbations to the atmospheric polar vortex, and with it, alterations to mid-latitude weather (Serreze and Francis, 2006; Francis and Vavrus, 2012). While a complete understanding and description of mid-to-high latitude ocean-atmosphere-climate-weather linkages is still needed, the concept is supported by theoretical considerations and evidence derived from observations, reanalysis hindcast models, and idealized process-oriented models (e.g. Holland and Bitz, 2003; Johannessen et al., 2004; Taylor et al., 2018). Very likely, when these linkages are fully resolved, our understanding will hinge on the roles played by sea ice, heat content, and heat fluxes within and between both the ocean and the atmosphere.

Tachibana et al. (2019) propose that the very presence of severely reduced ice cover over the Chukchi Shelf triggers a flow of warm southerly wind over the Bering Sea, a reinforcing feedback mechanism. Their focus was on winter, but our analysis suggests that this component of the feedback loop may be just as important in fall when the surface heat flux anomalies are the largest over the Chukchi Sea. Such feedbacks may be particularly difficult to disrupt once strongly established. As the fall warm ocean conditions become more common in a warmer world, we speculate that such winds could provide a potentially important control on the phase of polar vortex meanders (Serreze and Francis, 2006; Francis and Vavrus, 2012). If so, then improved understanding of this mechanism could lead to better predictability of atmospheric weather systems beyond the Pacific Arctic.

Only time will tell if these recent conditions represent a “new normal” as the data record shows that decadal scale variability exerts a fundamental influence. Our results suggest that to return to the pre-2014 heat balances, the cycle of low spring ice concentrations and associated low albedos must be interrupted. The heat balance suggests that such an interruption could result from advection of cooler waters onto the Bering Sea Shelf and/or winters having particularly strong and cold northerly winds. We have not determined exactly how the system entered the present state; it may have been a combination of both oceanic advection of warm waters and anomalously large surface heat fluxes.

There are physical limits to how much additional solar radiation the ocean can absorb as ice diminishes: the maximum addition available is the difference between that absorbed under current ice conditions and that reflected. As the system approaches the limit, the incoming short-wave radiation influence on the rate of change now observed in the Pacific Arctic will slow. However, continued atmospheric warming will continue to impact the oceanic heat content, latent, longwave, and sensible surface heat fluxes, and the regional heat balances. Thoman et al. (2020) find that the anomalously sparse winter sea ice conditions of 2018 will likely become the norm by the 2040s, suggesting that the 2014–2018 conditions will become increasingly common and eventually expected in any given year.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

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Writing - original draft, Data curation. **K.B. Iken:** Writing - original draft, Data curation. **J.M. Grebmeier:** Writing - original draft, Data curation. **L. Juranek:** Writing - original draft, Data curation. **G. Khen:** Writing - original draft, Data curation. **S.R. Jayne:** Writing - original draft, Data curation. **T. Kikuchi:** Writing - original draft, Data curation. **C. Ladd:** Writing - original draft, Data curation. **K. Lu:** Writing - original draft, Data curation. **R.M. McCabe:** Writing - original draft, Data curation. **G.W.K. Moore:** Writing - original draft, Data curation. **S. Nishino:** Writing - original draft, Data curation. **F. Ozenna:** Writing - original draft, Visualization. **R.S. Pickart:** Writing - original draft, Data curation. **I. Polyakov:** Writing - original draft, Data curation. **P.J. Staben:** Writing - original draft, Data curation. **R. Thoman:** Writing - original draft, Data curation. **W.J. Williams:** Writing - original draft, Data curation. **K. Wood:** Writing - original draft, Data curation. **T.J. Weingartner:** Writing - original draft, Data curation.

Acknowledgements

The authors thank the many scientists and mariners whose work and dedication have contributed to the massive field efforts that this century-long climatology represents. We thank Shaun Bell, Liz Dobbins, Jeanette Gann, Leah Trafford McRaven, Stephen Okkonen and Hank Statscewich for assistance in assembling the CTD climatology. We thank the editors and two anonymous reviewers for comments that improved the manuscript. Data in this manuscript come from multiple sources and are available online and by request from the host institutions as noted below. ECMWF ERA5 data are archived and available online at <https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5>. NSIDC sea ice data are archived online and available at <https://nsidc.org/data/nsidc-0051>. Data sourced from Japan's R/V Mirai are archived online and available online at <http://www.godac.jamstec.go.jp/darwin/e/>. The R/V Mirai cruises were supported by the Green Network of Excellence (GRENE) Program/Arctic Climate Change Research Project and the Arctic Challenge for Sustainability (ArCS) Project, which were funded by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT). ALAMO float data are available online at <http://argo.whoi.edu/alamo/>. Data sourced from Russia are archived at the TINRO Center (<http://www.tinro-center.ru/>) and available upon request for permitted uses. Data from Fisheries and Oceans Canada's Institute of Ocean Science can be accessed by request via <https://www.pac.dfo-mpo.gc.ca/science/index-eng.html>. WOD18 can be accessed online at https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html. Bering Strait mooring data are available from NCIS (www.nodc.noaa.gov) and the Bering Strait project page (psc.apl.washington.edu/BeringStrait.html) which also carries various data products (e.g., annual and monthly means). Data from NOAA-PMEL can be accessed online at <https://www.pmel.noaa.gov/epic/ewb/>. Data from NOAA-AFSC (<https://www.fisheries.noaa.gov/alaska/commercial-fishing/alaska-physical-and-oceanographic-research>) are available upon request. Data from the SOAR project, the ARDEM bathymetric grid, and the UAF-IMS database are available online at the Alaska Ocean Observing System, <http://www.aaos.org>. SLD assembled CTD data, performed analyses and the initial draft. OA and FO provided photographs and contextual background information. GWKM assembled ERA5 data; RT assembled GISTEMP and ERSSTv5 data. CA, EB, LWC, LE, EF, KBI, JMG, LJ, GK, SJ, TK, CL, KL, GWKM, RMM, SN, RSP, IP, PJS, RT, WJW, KW and TJW provided CTD data. All authors contributed to writing and/or discussion of the analytical approach. SRJ was supported by ONR grant N000141812475. LWC and JMG acknowledge support from multiple NSF and NOAA grants. RMM acknowledges support from NPRB grants A92-02a and A92-02b; and from JISAO under NOAA Cooperative Agreement NA15OAR4320063. SLD was supported by NPRB grants A91-99a and A91-00a and NSF grants OPP 1603116 and OPP 1708427. This manuscript is PMEL contribution #4997 and JISAO contribution #2019-1049. This manuscript is a product of the North Pacific Research Board Arctic Integrated Ecosystem Research Program, NPRB publication

number ArcticIERP-04.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dsr2.2020.104781>.

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Article

A Synthesis of Laaquadax (Northern Fur Seal) Community Surveys and Commercial Fishery Data in the Pribilof Islands Marine Ecosystem, Alaska

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Abstract: Indigenous communities on the Pribilof Islands have longstanding cultural and economic ties to their marine ecosystem and, in particular, to laaquadax (in Unangam Tunuu) or northern fur seals (NFS; *Callorhinus ursinus*). Indigenous and Local Knowledge holders from the Pribilof Islands have long expressed concerns about declines in NFS abundance, and research increasingly suggests that nutritional limitation is a key factor in the decline. Using a co-production of knowledge approach, we explore perceptions of NFS ecology and commercial fishery interactions in the Pribilof Islands Marine Ecosystem (PRIME). We synthesize results from community surveys and analyses of commercial pollock (*Gadus chalcogrammus*) fishery catch data from 2004–2018 relative to documented NFS foraging areas. Community survey results highlighted ecosystem changes and nutritional limitation as primary drivers of recent declines in Pribilof Islands NFS. Consistent with these results, pollock catch data indicate there are concentrated areas of pollock harvest over time near the Pribilof Islands where female NFS forage. These results reinforce the value of considering Indigenous and Local Knowledge and western science together to better understand ecosystem interactions. Our findings also support the consideration of Indigenous and Local Knowledge-based approaches in combination with spatiotemporal management to mitigate NFS nutritional limitation and Pribilof Islands NFS declines.

Keywords: knowledge systems; Indigenous Knowledge; Local Knowledge; northern fur seals; Pribilof Islands; pollock commercial fishery



Citation: Divine, L.; Williams, M.J.P.; Davies, J.; LeVine, M.; Robson, B. A Synthesis of Laaquadax (Northern Fur Seal) Community Surveys and Commercial Fishery Data in the Pribilof Islands Marine Ecosystem, Alaska. *J. Mar. Sci. Eng.* **2022**, *10*, 467. <https://doi.org/10.3390/jmse10040467>

Academic Editor: Jeffrey Short

Received: 1 February 2022

Accepted: 5 March 2022

Published: 25 March 2022

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1. Introduction

1.1. The Pribilof Islands Marine Ecosystem (PRIME)

Coastal areas in the Bering Sea are home to more than 70 Alaska Native communities of the Iñupiat, Central Yup'ik, Cup'ik, St. Lawrence Island Yupik, and Unangan Peoples [1,2], diverse fish, seabird and marine mammal populations [3], as well as some of the world's largest commercial fisheries [4]. The region surrounding the Pribilof Islands includes a unique hydrographic domain that is oceanographically distinct from the surrounding Bering Sea shelf waters and is key to the overall structure and function of the broader Bering Sea marine ecosystem [5–7]. Primary production associated with the bathymetry and oceanographic fronts around the Pribilof Islands provides enhanced feeding opportunities for higher trophic level species that support traditional activities such as hunting and harvesting [7–10]. In this study, we define this productive region as the “Pribilof Islands Marine Ecosystem (PRIME)”. The minimum extent of the PRIME is an area encompassing 100 nautical miles (nm; ~185 km) around the islands. This boundary is based on Indigenous Knowledge (IK—held exclusively by Indigenous Peoples; see Section 2.2), Local Knowledge

(LK-held by Indigenous and/or non-Indigenous individuals; see Section 2.2), physical oceanography, and ecosystem modeling [6–9,11–13] (Figure 1).

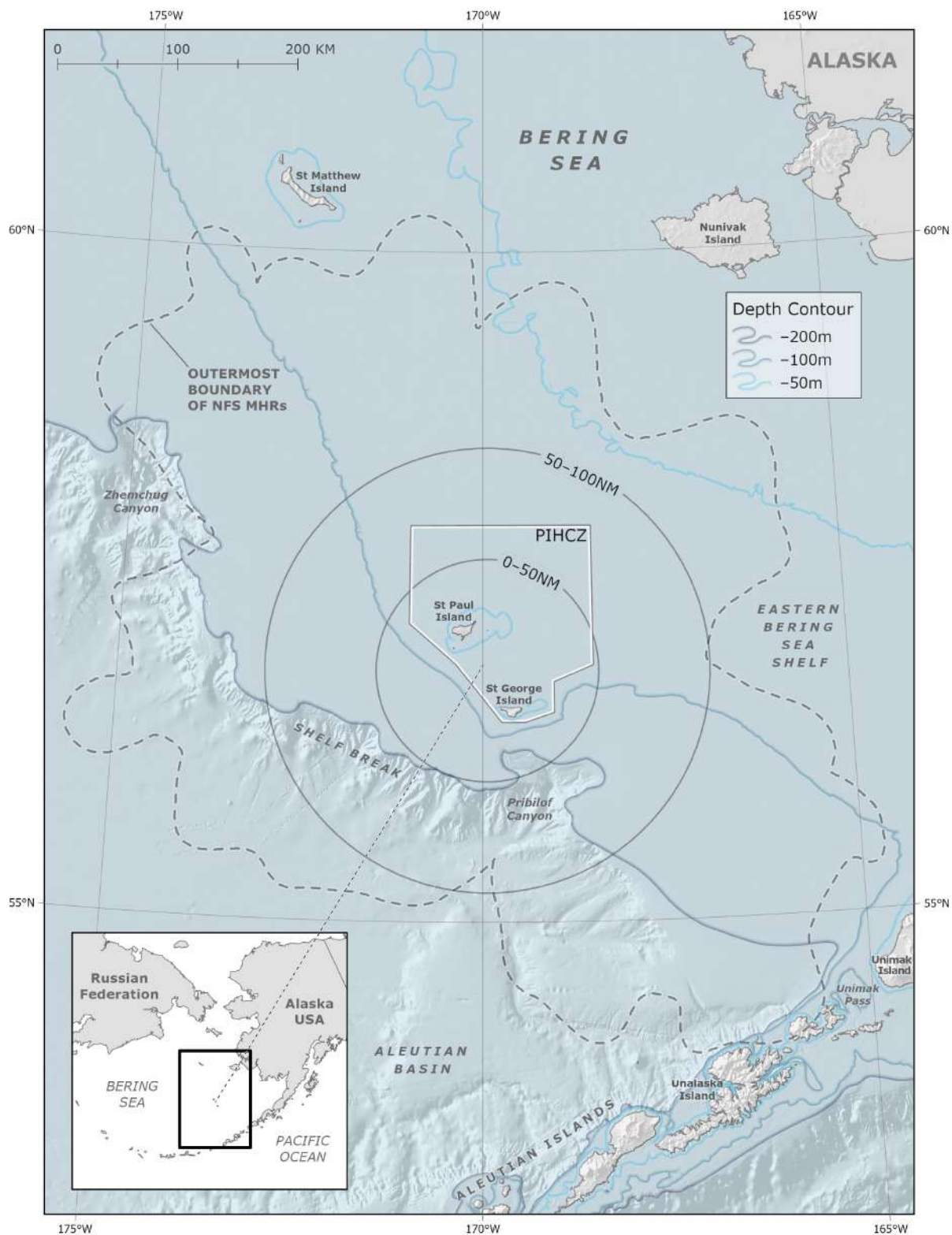


Figure 1. Map showing northern fur seal (NFS) outermost boundary of all meta-home ranges (MHRs) as defined by Robson et al. (2004) around St. George and St. Paul Islands, Alaska (black dashed polygon), and the 0–50 nm and 50–100 nm subzones of the Pribilof Islands Marine Ecosystem (PRIME, black solid polygons). The Pribilof Islands Habitat Conservation Zone (PIHCZ) is shown as a solid white line.

The eastern Bering Sea (EBS), including the PRIME, is experiencing biotic and abiotic changes at unprecedented rates. IK and LK holders from the Pribilof Islands have described changes in terms of extremes: warmer summers, reduced sea ice extent, longer and colder winters, stronger storms in winter, major declines in NFS, and changes in the distribution of fish species [12,13]. Winter sea ice extent in the Bering Sea in 2018 and 2019 was at the lowest levels on record, and the region exhibited warming trends not predicted to occur by regional climate models for another 10–15 years [14]. These exceptional warming conditions are impacting species at all trophic levels and are occurring at an order of magnitude capable of reorganizing ecosystems [6,15,16].

While climate change has been directly linked to changes in distribution, abundance, and body condition of some fish species, seabirds, and marine mammals [16–20], these linkages are not as well-established for NFS, a cultural keystone species for Pribilof Islands Unangan [21]. The Eastern Pacific stock of NFS is declining [22], and the current breeding population is estimated to be roughly one quarter of the historic maximum [22,23]. Ongoing NFS declines in the Pribilof Islands have significantly impacted the communities on St. Paul and St. George, which remain inextricably connected with marine resources as a cornerstone of Unanga culture, economy, and subsistence ways of life.

The EBS (which encompasses the PRIME) supports large- and small-scale commercial fisheries and small-scale subsistence fisheries. In addition to flatfish, crab, and Pacific cod (*Gadus macrocephalus*) fisheries, the EBS is home to the walleye pollock (*Gadus chalcogrammus*) fishery, the largest trawl fishery in the world. The pollock fishery has an expansive footprint in the EBS, and pollock first wholesale value (first sale after initial processing) averaged \$1.34 billion annually from 2015–2018 [24]. From 2004–2018, an estimated total of 18.8 million tons (t) of pollock were harvested in the EBS (annual average 1.25 million t) [24]. The annual pollock fishery is divided into two seasons: the A-season, running from 20 January into April; and the B-season, running 10 June to 1 November. B-season harvests, which coincide with the NFS breeding season on the Pribilof Islands, account for approximately 55% of total annual pollock harvests [24].

In this study, we use a co-production of knowledge (CPK) approach to provide a more integrated understanding of factors contributing to the NFS decline over time, potential direct and indirect stressors to NFS and Pribilof Islands communities, and impacts on broader ecosystem function and health. Specifically, we consider: (1) survey results from Pribilof Islands community members; and (2) spatial analyses of pollock fishery data in the context of NFS foraging areas defined by Robson et al. (2004) and PRIME boundaries [6–9,11–13]. The combination of methodologies provides context for observed trends and patterns by evaluating multiple ways of knowing (IK, LK, western scientific data) to investigate complex ecosystem-level concerns in the EBS.

1.2. Pribilof Islands Communities and Laaqudan (Northern Fur Seals)

Historically, the Pribilof Islands were not inhabited but were used by Unangan as marine mammal and seabird hunting grounds [21]. In 1787, 137 Unanga hunters were forcibly removed from their permanent villages in the Aleutian Islands and relocated to the Pribilof Islands to harvest NFS pelts as a source of income for the Russian government [21]. The U.S. purchased Alaska from Russia in 1867, and the federal government continued operating the commercial NFS harvest, relying on Unanga laborers, until commercial activities ceased in 1974 on St. George and in 1984 on St. Paul [25].

The present-day communities of St. Paul and St. George remain reliant on NFS for food, crafts, and as a central element of cultural and community health and wellbeing. Traditional hunting (with a firearm) and harvesting (without a firearm) are conducted pursuant to formal co-management agreements between the National Marine Fisheries Service (NMFS) and the Tribal Government of St. Paul [26] and the Traditional Council of St. George Island [27], respectively. The Ecosystem Conservation Office (ECO) on each island organizes and manages hunting and harvesting activities and works with community volunteers and experienced sealers to support traditional activities related to NFS. The

Tribal co-managers also conduct NFS research in collaboration with federal, state, and academic scientists.

The Eastern Pacific stock of NFS once numbered more than 2 million animals [28,29]. Commercial harvests of NFS during the 18th to 20th centuries, including directed culling of females, contributed to long-term fluctuations in the abundance of the Pribilof Islands segment of the NFS population [29–32]. After a brief period of stability and recovery from the early 1980s to the mid-1990s, the population entered a new period of decline that continues today and remains largely unexplained and unmitigated by current management measures [23,33]. The stock was listed as depleted under the Marine Mammal Protection Act (MMPA) in 1988 after declining to less than 50% of historic population levels [28,29].

The portion of the Eastern Pacific stock breeding on the Pribilof Islands is currently estimated to be approximately 458,500 animals [22,23]. In recent decades, declines in pup production have continued on St. Paul Island, but no significant trend has been observed across St. George rookeries since approximately 2002 [22]. The designation as depleted required development and implementation of a conservation plan. That plan was originally created in 1993 and last updated in 2007; it has thus far failed to halt and reverse the decline of the population. The only relevant conservation measure currently in place within the PRIME is the Pribilof Islands Habitat Conservation Zone (PIHCZ; Figure 1); it was established in 1995 to the north and east of the Pribilof Islands to protect areas that are biologically important to certain crab stocks and, as a secondary objective, to reduce potential fishery interference with seabird and marine mammal populations [34]. The PIHCZ has not been formally evaluated since its implementation to determine if any conservation benefits have been realized.

During the winter months, adult NFS are generally pelagic and spend as much as 80% of their time at sea [35]. During the summer breeding season, NFS are central place foragers [36,37]. Females give birth to a single pup at terrestrial breeding rookeries (the central place), typically in July and August, and then undertake foraging trips at sea, interspersed with regular visits to the central breeding site on land to nurse their dependent offspring [38–44]. This central place foraging behavior continues from July to November annually, at which time most NFS begin overwintering migrations to the broader North Pacific [39].

NFS satellite tracking and diet studies conducted on the Pribilof Islands suggest that “rookery complexes” associated with distinct at-sea foraging areas exist on the western and eastern coasts of St. Paul Island, and to a lesser extent on the northern and southern coasts of St. George Island [38,40,41,44]. Zeppelin and Ream (2006) used a primary prey frequency of occurrence analysis to summarize scat samples of NFS across rookeries from 1987–2000 and found that NFS diets were dominated by walleye pollock at all rookery complexes. Pollock accounted for 68–74% of NFS diets at rookeries along the western side of St. Paul Island. Conversely, southern St. George rookeries were relatively less reliant on pollock, which constituted 43–48% of NFS diets [40,45]. Although juvenile pollock (age 0–2) was the most common prey item, adult pollock (e.g., age 3–5+) were also found in both NFS scat and spew (regurgitation) samples at all locations [40]. Gudmundson et al. (2006) also found that larger (i.e., older) pollock and gonatid squid are relatively more common in spew versus scat samples, indicating that sample-type is an important consideration when evaluating the species and size composition of NFS diets.

2. Materials and Methods

2.1. Co-Production of Knowledge Approach

In the development and execution of this research, the authors were guided by principles of co-production of knowledge (CPK). While a full description of the ways in which we sought “true partnership and equity, to enhance, learn, and create new understandings” [46] is beyond the scope of this article, some explanation is warranted. Initially, the research that led to this manuscript was borne out of a series of conversations and collaborations through which the authors and others in their organizations and community

identified common concerns and a desire to better understand them. Published literature [12,13], known community needs, and an evaluation of available skills and capacities led to a narrowed focus on spatial analyses as understood by quantitative description and community knowledge understood by qualitative description. From that point, the methodology was co-developed, and the research completed.

The process was not seamless, and there were many difficult conversations and misunderstandings. It was not always apparent whether the quantitative analysis or community dialogue might be overly directive; nor was it a straightforward process to identify ways to interrelate the analyses. Even once a methodology was defined, the words used to describe both the project and the collaboration were not always easy to find. Several other authors have proffered descriptions or definitions of the term “co-production of knowledge” and the ways in which it can be pursued [46–51]. We do not offer an opinion about whether this project “counts” as defined in those or other documents and echo the sentiment that “it is far more important to do co-production than it is to talk about it or label things as it” [46].

2.2. Knowledge Systems

For purposes of this project, we define IK as,

A body or system of knowledge that any Indigenous person has. This is in contrast to Traditional Knowledge which is specialized knowledge, with a strong connection to heritage, on a topic or topics. Indigenous Knowledge is a broader term, which encompasses Traditional Knowledge as well as other forms of knowledge. All Indigenous Peoples have Indigenous Knowledge, but only some of them have Traditional Knowledge [52,53].

We define LK as,

The knowledge of Indigenous or non-Indigenous individuals obtained through experiential engagement with a place. LK may encompass language, systems of classification, resource use practices, social interactions, ritual, and spirituality [54].

Pribilof Islands community members represent a unique coalescence of different knowledge systems (IK, LK and western science). Ways of knowing in the Pribilof Islands are interconnected, based on community members’ interactions with one another and with western science and information. This diversity and these linkages in knowledge systems in the Pribilof Islands lend themselves to layered and meaningful analyses of community knowledge and experience.

2.3. Community Surveys

All community members of St. Paul and St. George were invited to complete a 15-question survey (Supplementary Materials Survey S1) via a Google form during July to October 2020. Respondents who did not have access to the online survey were invited to participate over the phone so that their answers could be transcribed into the Google form by the project team and incorporated into the study. Prior to dissemination to the communities, questions were reviewed and approved by a board of St. Paul Tribal members. The sampling method was non-random [55] and targeted all residents on both islands. All participants reviewed a consent form that included the background, goals, objectives, and risks of the study before completing the survey; each participant provided free, informed, and prior consent before completing the survey form, consistent with the ethical standards of human subjects research.

Basic demographic data were collected for each respondent. For instance, a respondent had the option to identify Residency Status (i.e., a community member currently living on St. Paul, “St. Paul Resident”, versus a community member currently living off island, “St. Paul Non-Resident”), Tribal Affiliation, Age, Gender. “Non-Resident” individuals currently live off-island but historically resided on-island and spent the majority of their lives living on-island. Tribal Affiliation denotes community members currently identified

as Tribal Members (not all community members are directly affiliated with the Island's Tribe). Results from the demographic data are summarized in Appendix A Table A1.

In addition to collecting basic demographic information, survey questions were focused around three primary themes: (1) perceived reasons for NFS declines; (2) personal and community impacts as a result of NFS declines; and (3) the relative importance of the 0–100 nm zone around the islands (defined as the PRIME). Survey question formats included Likert scales, multiple choice, and open-ended questions [56–58]. Survey responses were compiled and uploaded into Atlas.ti (Atlas.ti Scientific Software Development GmbH, Berlin, Germany). Survey data were inductively coded in Atlas.ti using a grounded theory approach to understand participant perceptions [59,60]. Grounded theory techniques are used to develop codes (Table A2), which can be grouped based on inter-relationships and organized into broader themes [59,61]. Code frequency and co-occurrence were analyzed to identify code and theme commonalities across community respondents. Likert scale responses were evaluated for statistical differences in distribution between demographic groups (e.g., age, sex, residency status) using a non-parametric rank-based Kruskal–Wallis test [62,63]. Due to the complex and integrated nature of the knowledge systems considered in this research (IK, LK), the authors did not attempt to identify the specific type of knowledge associated with each respondent based on demographic information.

2.4. Spatial Extent of the PRIME Relative to NFS Foraging Dynamics

The minimum extent of the PRIME is defined as an area extending 100 nm (107,754 km²) from a point located at approximately the center of the Pribilof Islands (57° N, 170° W) [6–9,11]. We subdivided the PRIME into a 0–50 nm sub-region (26,938.4 km²) that is broadly representative of the hydrographically defined Pribilof Domain [7] and a surrounding 50–100 nm sub-region (80,815.6 km²) that supports the additional energetic requirements of central place foraging species such as NFS and seabirds that breed on the Pribilof Islands [11]. Within the larger 0–100 nm area, the Pribilof Domain [7], approximated by the 0–50 nm sub-region of the PRIME, is uniquely characterized by the clockwise flow of currents around the Pribilof Islands, heightened primary and secondary productivity, and increased advection and mixing of the water column [5,7,11]. The 0–100 nm spatial extent of the PRIME also coincides with the median foraging trip distance of lactating female NFS [11,38,64] and was proposed by Ciannelli et al. (2004) as the minimum extent of the PRIME based on ecosystem energetics. The maximum extent of the PRIME may be indicated by the full extent of female NFS foraging distance (Figure 1).

We additionally subdivided the PRIME into at-sea foraging areas associated with distinct breeding populations. Robson et al. (2004) used satellite telemetry to examine spatial segregation of foraging habitats among lactating female NFS during the 1995 and 1996 breeding seasons. A 95% fixed kernel home-range model [65] was used to calculate a Meta-Home Range (MHR) area as a spatial measure of habitat use among NFS from each breeding area, in which there is more overlap among members of each MHR than among members of different MHRs (Figure A1). Foraging areas associated with rookery complexes and islands have remained relatively consistent over time [41,44], and subsequent satellite tracking studies have shown markedly consistent patterns of spatial segregation within and between islands during periods of differing environmental conditions [41] and continued declines of the Pribilofs NFS population [44]. The size and location of foraging areas identified in previous studies vary according to methodology, sample size, and natural variability. We consider the MHRs from Robson et al. (2004) as an approximation of the foraging area for associated breeding colonies.

2.5. Commercial Pollock Harvest Data

Pollock catch data from 2004 to 2018 were obtained from the National Marine Fisheries Service (NMFS) Catch Accounting System. To preserve vessel confidentiality, NMFS aggregates vessel and catch data into hexagons measuring approximately 20 km by 20 km (346 km²). B-season pollock landings (tons, t) were summed per hexagon for a given date

(standardized as the average of recorded fishing start and end times). Some catch data were excluded due to data confidentiality requirements, including motherships, which comprise a relatively small portion (<10%) of reported pollock catch overall. Pollock catch data during the B-season were analyzed within: (1) the 0–50 nm and 50–100 nm sub-regions; and (2) the entire EBS fishery management area. Within the PRIME, catch data were aggregated by both NFS MHRs and sub-region. For reference to the original Ecopath model by Ciannelli et al. (2004), pollock harvest data for 100–150 nm zone were calculated and reported when appropriate.

Pollock catch data in the PRIME were assessed using three primary approaches: (1) evaluation of temporal pollock harvest (t) trends in MHRs; (2) estimation of average harvest intensity (t/km^2) in MHRs; and (3) identification of pollock catch hotspots. Temporal trends in pollock harvests (t) by PRIME sub-regions and MHRs were evaluated using a linear modeling (LM) framework in R Statistical Software (R version 3.3.2 [31 October 2016]):

$$\log(\text{tons per hexagon}) \sim \beta_0 + \beta_1(\text{year}) + \varepsilon$$

The response variable, pollock catch aggregated by hexagon grid (*tons per hexagon*), was log-transformed: β_0 denotes the intercept; β_1 denotes the linear trend in the explanatory variable (*year*); and ε denotes the error [66]. Total pollock landings (t) were also summed by MHRs and PRIME sub-regions and area-standardized (t/km^2) to allow for comparative evaluations of “harvest intensity” in smaller areas relevant to NFS rookery complexes and to local communities.

Pollock harvest “hotspots” over time within the PRIME were identified using the ArcGIS Emerging Hot Spot Analysis Tool [Space Time Pattern ArcGIS Pro 2.8.3]. With this approach, data are aggregated into space–time bins and packaged into a NetCDF file (a file format for storing multidimensional scientific data). Space–time cubes enable analyses of catch data in three dimensions with the positions represented on the x and y axes and the years represented on the z axis [67]. Space–time cubes were analyzed using the Getis Ord Gi statistic (ESRI 2019), which considers the value of each bin within the context of neighboring bins and the Mann–Kendall test which compares each bin value with that of previous years [67,68]. Emerging Hot Spot Analysis accounts for the consistency and intensity of each time step in the classification of a significant hotspot. Three categories of hotspots were classified based on the ESRI (2021) classification scheme: (1) “persistent” (a location that has been a statistically significant hotspot for 90% of the time-step intervals with no discernible trend indicating an increase or decrease in the intensity of clustering over time), (2) “intensifying” (a location that has been a statistically significant hotspot for 90% of the time-step intervals, including the final time step and intensity of clustering of high counts in each time step is increasing overall and that increase is statistically significant), or (3) “variable” (a location that is an on-again, off-again hotspot; none of the time-step intervals have been statistically significant cold spots) [68]. Five-year intervals were used for neighborhood time steps for adjacent spatial neighbors [68].

3. Results

3.1. Community Surveys

Thirty-eight surveys were completed either online or with assistance from the project team for those without access to the internet. Forty-five percent (45%) of respondents were younger than 35, 34% were between 35 and 55 years old, and 21% were over 55 years old. The majority of respondents were St. Paul residents and St. Paul Tribal members (Table A1), consistent with the differing population sizes of the two islands (395 people currently reside on St. Paul Island, and 76 people currently reside on St. George Island) [69]. Differences in responses based on age group, Tribal affiliation, residency, and gender were not statistically significant for Likert survey questions (Kruskal–Wallis test; $p > 0.05$), thus we generally provide results compiled across all demographic groups.

Forty-five codes were identified and refined through iterative thematic coding of the surveys (Table A2). Results are presented in accordance with three primary identified

themes, according to the organization of survey questions and dominant responses received: (1) reasons for the NFS decline; (2) importance of the 0–100 nm PRIME to NFS; and (3) personal and community/cultural impacts of the NFS decline. Additional code co-occurrence relationships are explored within the three overarching themes identified.

3.1.1. Reasons for the NFS Decline

In response to the open-ended survey question, “Why do you think NFS are declining?” the most stated reason was nutritional limitation (Table 1A). Nutritional limitation as an ultimate cause co-occurred with changing “NFS foraging areas/distribution of prey”, “competition for prey”, “trawling”, “unspecified or general ecosystem changes/impacts”, “impacts to mothers and pups”, “fisheries-related ecosystem changes/impacts”, and “climate-related ecosystem changes/impacts” (Table 1B).

Of the 38 responses discussing reasons for the NFS decline, 19 respondents (50%) included the word “food”, referring to NFS experiencing a food shortage, lack of access or difficulty finding food, searching longer and farther for food, or competition with commercial fisheries for food. Responses were interconnected, reflecting the multifactorial nature of both direct and indirect factors contributing to the NFS decline. For example, respondents noted that climate change-related ecosystem impacts that result in changes in prey distribution were a driver for NFS declines: *“I think they’re [NFS] traveling further north than they used to because of the warming waters causing the fish to move north”*. One respondent linked ecosystem-level changes (i.e., prey distribution) to competition for prey (i.e., large-scale fishing activities): *“Access to prey and change of distribution of prey is impacted by large fisheries. This leads to reduced [food] availability [for NFS]. Pollock fisheries take their [NFS] main food source, walleye pollock, while maintaining a presence disturbing their habitat”*. Another stated, *“I believe the factory trawlers chasing pollock are competing directly with the NFS, especially [during] the summer season”*.

Regarding fisheries-related factors, respondents were specifically asked about “vessel impacts on NFS” as they related to both vessel presence and fishing activities. “Vessel impacts on NFS” co-occurred with fisheries-related factors such as “competition for prey”, “trawling”, “bycatch” or “acoustic disturbance” (Table 1C). Of the responses that related the NFS decline specifically to impacts from vessel presence and fishing activities, many statements contained multiple explanations, such as, *“Fishing the seals’ food, noise, possible debris”*, and, *“Vessels pollute the water, fish for the seals’ resources, and can even harm the seals’ bodies”*. One respondent explained, *“[Vessels are] introducing chronic pollution that can lead to entanglement and ingestion of microplastics”*.

3.1.2. Importance of the 0–100 nm Pribilof Islands Marine Ecosystem (PRIME)

Nearly all respondents, irrespective of age, Tribal affiliation, or residence status ranked the PRIME as important for NFS (26 responded with a Likert Scale 5, indicating “critically important to NFS”; 10 responded with a Likert Scale 4, indicating “more important than other areas”; Table A3). The PRIME commonly co-occurred with other factors including “essential NFS foraging habitat”; “impacts to mothers, pups, or breeding ecology”; “NFS site fidelity”; and “changing NFS foraging areas or distribution of prey”, “nutritional limitation”, “unspecified/general ecosystem-level changes/impacts”, and “need for conservation or protection” (Table 1D). In an open-ended follow-up question, respondents highlighted the PRIME as the *“range of feeding”* for NFS, *“the area [NFS] reside and feed in”*, and *“the ideal place for seals to find food.”* The consistency across responses to this open-ended question suggested broad agreement that this area has been important for NFS over time.

Table 1. Co-occurrence frequency for four themes explored in community surveys: (A) “Reasons for the northern fur seal (NFS) decline”, (B) “Nutritional limitation”, (C) “Vessel impacts on northern fur seals (NFS)”, and (D) “Importance of the 0–100 nm Pribilof Islands Marine Ecosystem (PRIME)”.

(A) Reasons for the NFS Decline		(B) Nutritional Limitation		(C) Vessel Impacts on NFS		(D) Importance of 0–100 nm (PRIME)	
Nutritional limitation	18	Changing NFS foraging areas/Distribution of prey	14	Competition for prey	21	Essential NFS foraging habitat	23
Ecosystem impacts–Climate-related	11	Competition for prey	11	Trawling	11	Impacts to mothers/pups; e.g., fecundity, survival	13
Ecosystem impacts–Fisheries-related	6	Trawling	8	Acoustic disturbance	8	Site fidelity	10
Trawling	6	Ecosystem impacts–General or Unspecified	6	Ecosystem impacts–Fisheries-related	8	Changing NFS foraging areas/Distribution of prey	10
Impacts to mothers/pups; e.g., fecundity, survival	5	Ecosystem impacts–Fisheries-related	5	Changing NFS foraging areas/Distribution of prey	7	Nutritional limitation	5
Competition for prey	5	Ecosystem impacts–Climate-related	4	Fish	7	Trawling	3
Overfishing	3	Impacts to mothers/pups; e.g., fecundity, survival	6	Bycatch	6	Ecosystem impacts–General or Unspecified	3
Predation on NFS	2	Essential NFS foraging habitat	2	Nutritional limitation	6	Ecosystem impacts–Fisheries-related	2
Ecosystem impacts–General or Unspecified	2			Entanglement	4	Ecosystem impacts–Climate-related	1
Traditional activities/foods	2			Pollution	4	Conservation/protection request	2
Contaminants	1			Marine debris	3	Competition for prey	2
Marine debris	1			Pollock	3		

Responses discussing the changing NFS foraging areas or distribution of prey most often referred to NFS having to forage further than the boundary of the PRIME more often because less food is available closer to the islands (i.e., within 0–100 nm). For example, one respondent stated, “[NFS] pup mortality may be based on the mothers [that] have to venture further and longer for food, leaving the pup alone without nourishment for longer periods. They [NFS pups] have to travel out to open water in the fall, and if malnourished, less will live”. Another stated, “They [vessels] are too close to the island taking away all the resources they [NFS] would have close, [seals] have to travel far now”.

3.1.3. Community/Cultural and Personal Impacts of NFS Decline

Regarding impacts to the community, most respondents (26) ranked the NFS decline as either having “some impact (Likert Scale 4)” or “significant or major impact (Likert Scale 5)” (Table A3). Respondents 35 years old or younger were more likely to respond with a “neutral” or “some impact” response (mean score of 3.6), while respondents older than 35 were more likely to respond with “some impact” or “significant or major impact” (mean score of 4.1).

Thirty-four respondents related the NFS decline to “community/cultural impacts”, and 21 respondents related the NFS decline to “personal impacts”. “Community/cultural impacts” and “personal impacts” also co-occurred frequently, indicating the strong linkage between individual and community and culture. “Community/cultural impacts” most often co-occurred with “traditional activities/food”, “NFS as a food resource”, “food security”, and “ecosystem impacts” (Figure 2). Responses included concern for cultural continuity across younger generations, as reflected in an earlier quotation (“I’m worried about the new generation not being able to subsistence hunt . . .”) and, “I worry for my children’s connection to the island—fur seals are a foundation of our [Unangan] relationship to St Paul”. Respondents discussed declining access to NFS as a traditional food impacting food security; for example, one respondent stated, “[There are] limited seals to fill freezers, especially with so many that are dependent on [NFS]”.

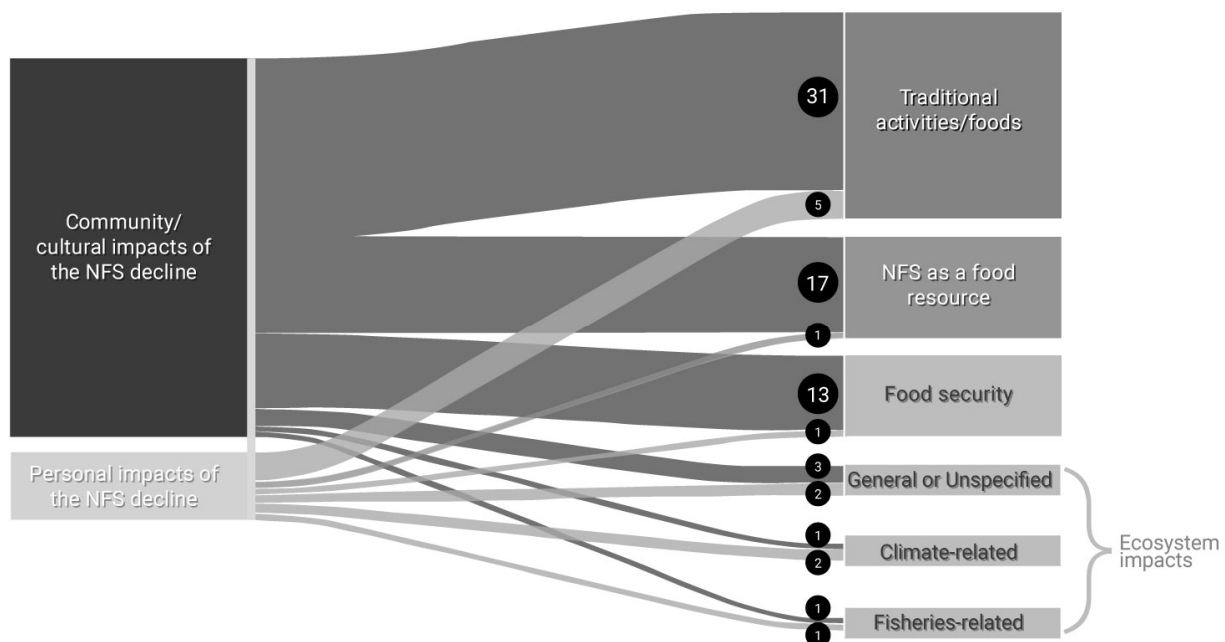


Figure 2. Sankey diagram depicting the co-occurrence frequency of “personal impacts” and “community/cultural impacts” with aspects of the NFS decline in the Pribilof Islands, Alaska. Numbers in and size of black circles denote the frequency of co-occurrences between codes.

Impacts to community and culture associated with NFS declines were a common concern among respondents. One respondent stated, “NFS is a traditional food source and a cultural focus

(clothes were made from seals, stories are told about seals). With the decline of the seal population there has also been a decline in people eating fur seal, . . . the loss of any traditional food resource is tragic for the community". Other respondents discussed how traditional activities are changing, "It's tougher to find the 'desired' age and size seals that we want to harvest. Also just hard for folks like me who have seen the decline happen over the last 30 years;" and, "[The NFS decline] is impacting the culture and the nutrition of our people. An animal that used to be the main staple of our diets is now treated as a delicacy, and it's becoming a race to get seal during the summer".

Respondents who made the connection relating "personal impacts" and "community/cultural impacts" of the NFS decline to "ecosystem changes/impacts" (Figure 2) emphasized the significance of the health of the Bering Sea to local well-being. For example, one respondent stated, "It's been a clear decline over the decades of seeing the rookeries dwindling. If their [NFS] complete loss here [The Pribilof Islands] happens that will be detrimental to our subsistence status and the Bering ecosystem". Another stated, "The fur seal decline is a visible example of climate change in my town", highlighting how some respondents linked the NFS decline to observed climatic changes.

3.2. Spatial Catch Data for EBS B-Season Pollock Harvests, 2004–2018

B-season pollock harvests (t) in the EBS annually averaged approximately 659,000 t from 2004–2018 and were relatively stable, with the exception of low harvests in 2008–2010 due to pollock biomass declines. B-season pollock harvests were highest in the EBS in July and August each year. Total estimated B-season harvests in the PRIME MHRs 2004–2018 averaged 121,342 t annually (total overall 1.82 million t) and accounted for approximately 18.4% of overall B-season EBS harvests. Pollock fishery data in the PRIME were evaluated at three levels: (1) temporal trends in MHRs (LMs); (2) average harvest intensity (t/km²) in MHRs; and (3) identification of pollock catch hotspots in the PRIME (ArcGIS Emerging Hotspot Analysis).

3.2.1. Temporal and Harvest Intensity Trends in the PRIME

Annual B-season pollock harvests from 2004–2018 within MHRs showed no significant trend over time in the 0–50 nm sub-region (LM; $p > 0.05$; Figure 3; Table 2A), with an average catch of 39,252 t/year (range = 3045–80,120 t/year). In contrast, annual harvests increased significantly in the 50–100 nm sub-region over time (LM; $p < 0.05$; Table 2B; Figure 3), averaging 82,090 t/year (range = 19,771–162,195 t/year). Total B-season pollock harvests within the 0–50 nm and 50–100 nm sub-regions accounted for approximately 6.0% and 12.5% of total B-season EBS removals, respectively. Refining in scale to MHRs, several MHRs experienced increasing annual catch over time within the 50–100 nm sub-region including the "All", "St. George" and "SW St. Paul" MHRs (LM; $p < 0.05$, Table 2B).

Highest harvest intensity (t/km²) occurred in July and August for all MHRs. The highest harvest intensities occurred within the 0–50 nm sub-region in "SW St. Paul" and "St. George" MHRs (Table 2A). High harvest intensities were also observed during the study period in the 50–100 nm sub-region where "All" MHRs overlap inshore of the Pribilof Canyon (Table 2B, Figure 4).

3.2.2. Pollock Catch Hotspots in the PRIME

Pollock harvests were evaluated to identify commercial fishery hotspot areas in the PRIME. Hotspots in this analysis are represented by adjacent and clustering hexagon grid cells that met ESRI-defined hotspot criteria [68]. There were three distinct hotspot areas of B-season pollock removals observed over the study period (Figure 5). There were two hotspots southwest and southeast of the Pribilof Islands spanning the 0–50 nm and 50–100 nm sub-regions. The third, smaller hotspot occurred west-northwest of the Islands in the 50–100 nm sub-region. Together the three hotspot areas encompass 10,392 km² and account for 41.3% of total PRIME and 7.6% of total EBS B-season catch. Consistent with relative harvest intensity values (Table 2; Figure 5), hotspots occurred in the "SW St. Paul", "St. George", "SW St. Paul & St. George" and "All" MHRs in the PRIME (Figure 4).

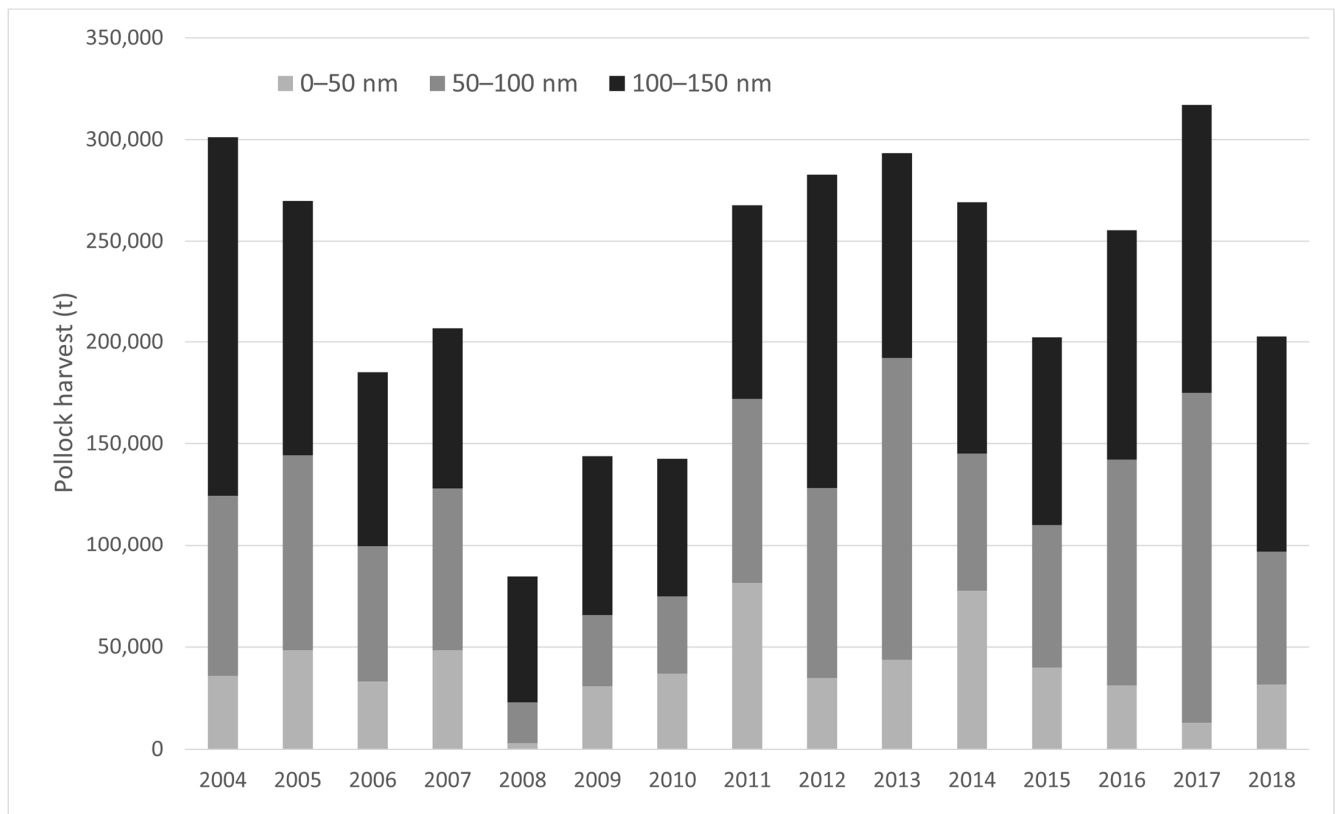


Figure 3. Annual B-season pollock harvests for MHRs within the 0–50 nm sub-region, 50–100 nm sub-region, and 100–150 nm zone (outside the PRIME) from the Pribilof Islands, 2004–2018.

3.2.3. Pollock Catch outside the PRIME

From 2004–2018, there was substantial pollock catch within NFS MHRs and immediately outside the PRIME (100–150 nm from the centroid of the islands; Figure 3), annually averaging 106,962 t and accounting for 16% of overall B-season catch (Figure 4). Total harvests in the 100–150 nm sub-region exhibited no trend during the study period (LM; $p > 0.05$). Two zones of high pollock catch outside the PRIME were evident in the B-season pollock fishery (catch within 0–100 nm is addressed in Section 3.2.1). The first zone occurred northwest of the Pribilof Islands running parallel to the continental shelf around 57° N–59° N and 174° W–177° W in the vicinity of Zhemchug Canyon (Figure 4). The second area of high pollock catch outside the PRIME occurred north of Unalaska Island, north-northwest of Unimak Pass and False Pass around 54° N–56° N and 164° W–166° W (Figure 4).

Table 2. Area (km²) that encompasses each meta-home range (MHR) and harvest intensity (average annual tons (Avg t) pollock harvested per km²) for: (A) 0–50 nm and (B) 50–100 nm MHR sub-regions. Percentage change represents linear model (LM) coefficients and confidence intervals, and *p*-values for each sub-region. MHR sub-regions with statistically significant *p*-values (*p* < 0.05) are shaded gray. * Indicates MHR sub-regions with statistically significant *p*-values (*p* < 0.05).

(A) 0–50 nm Sub-Region					(B) 50–100 nm Sub-Region				
Meta-Home Range (MHR)	Area (km ²)	Avg t/km ²	Model Coefficient % Change (CI)	<i>p</i> -Value	Meta-Home Range (MHR)	Area (km ²)	Avg t/km ²	Model Coefficient % Change (CI)	<i>p</i> -Value
SW St. Paul	6018	3.48	3.4% (−2.0–9.2%)	0.223	SW St. Paul	29,035	1.08	9.0% (4.9–13.4%)	<0.001 *
SW St. Paul & St. George	4890	2.00	4.9% (−3.5–14.0%)	0.262	SW St. Paul & St. George	1389	1.36	−1.44% (−17.4–17.6%)	0.870
St. George	2060	3.56	2.9% (−4.6–10.9%)	0.459	St. George	13,475	2.35	5.06% (0.33–10.0%)	0.036 *
All	2359	0.97	−3.3% (−14.1–8.8%)	0.581	All	3462	3.29	11.24% (3.5–19.6%)	0.004 *
SW & NE St. Paul	8475	0.08	15.3% (−2.4–36.1%)	0.099	SW & NE St. Paul	10,063	0.40	7.4% (−1.2–16.7%)	0.096
NE St. Paul & St. George	na	0	-	-	NE St. Paul & St. George	1341	1.00	11.9% (−4.0–30.6%)	0.157
NE St. Paul	2875	0	-	-	NE St. Paul	21,124	0.02	31.5% (−7.4–86.7%)	0.150
Total 0–50 nm	26,667	1.47	3.4% (−0.5–7.4%)	0.091	Total 50–100 nm	79,889	1.08	7.7% (5.0–10.5%)	<0.001 *

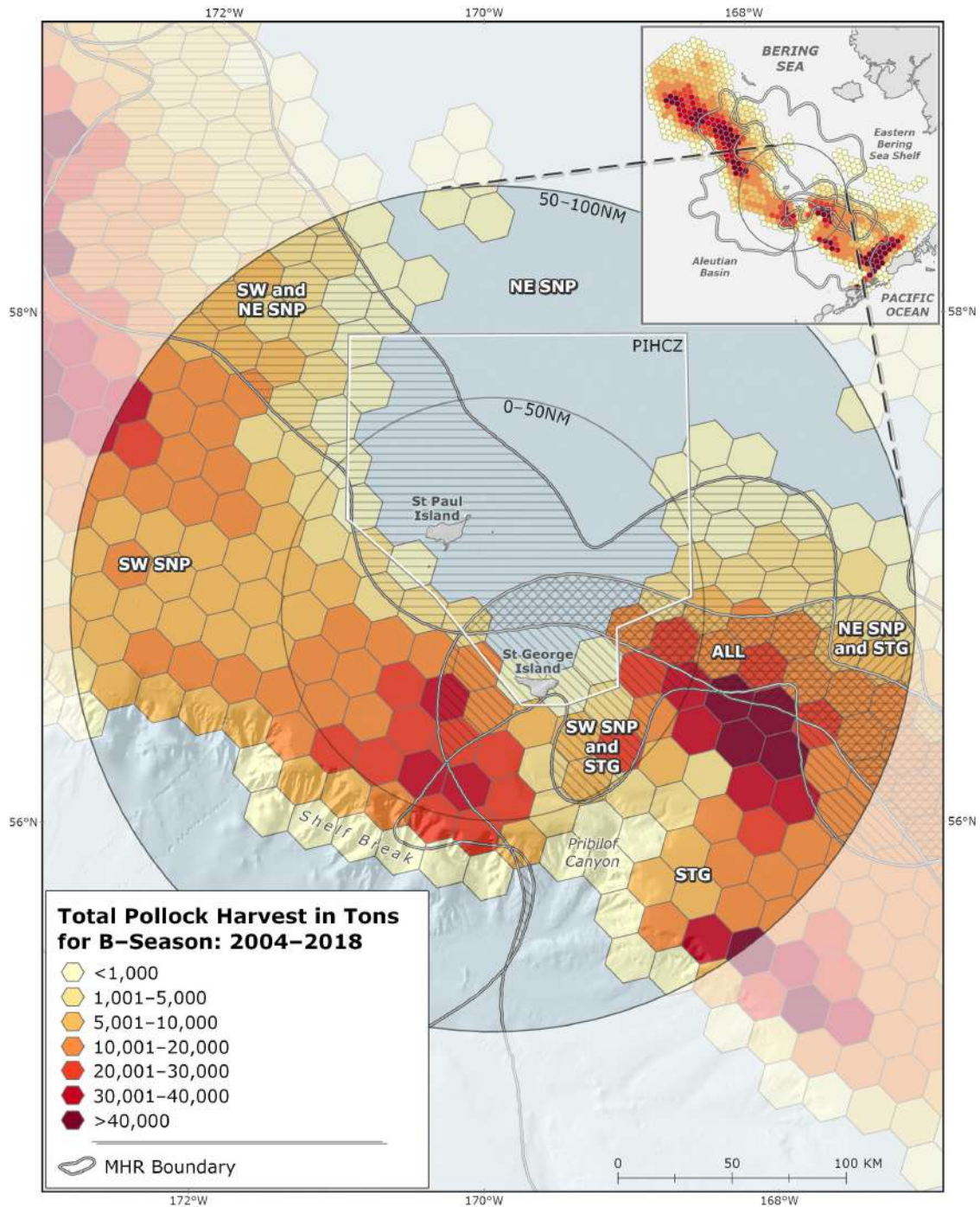


Figure 4. 2004–2018 B-season pollock harvest (t) showing meta-home ranges (MHRs) for lactating female northern fur seals (NFS) overlaid, and showing pollock harvest (t) for the entire eastern Bering Sea (inset). SW SNP = MHR representing southwest St. Paul rookeries, NE SNP = MHR representing northeast St. Paul rookeries; STG = MHR representing St. George rookeries; All = MHR representing overlapping use area from all rookeries. Gray circles are labeled at the 50 nm and 100 nm zones around the Pribilof Islands, and the Pribilof Islands Habitat Conservation Zone (PIHCZ) is pictured.

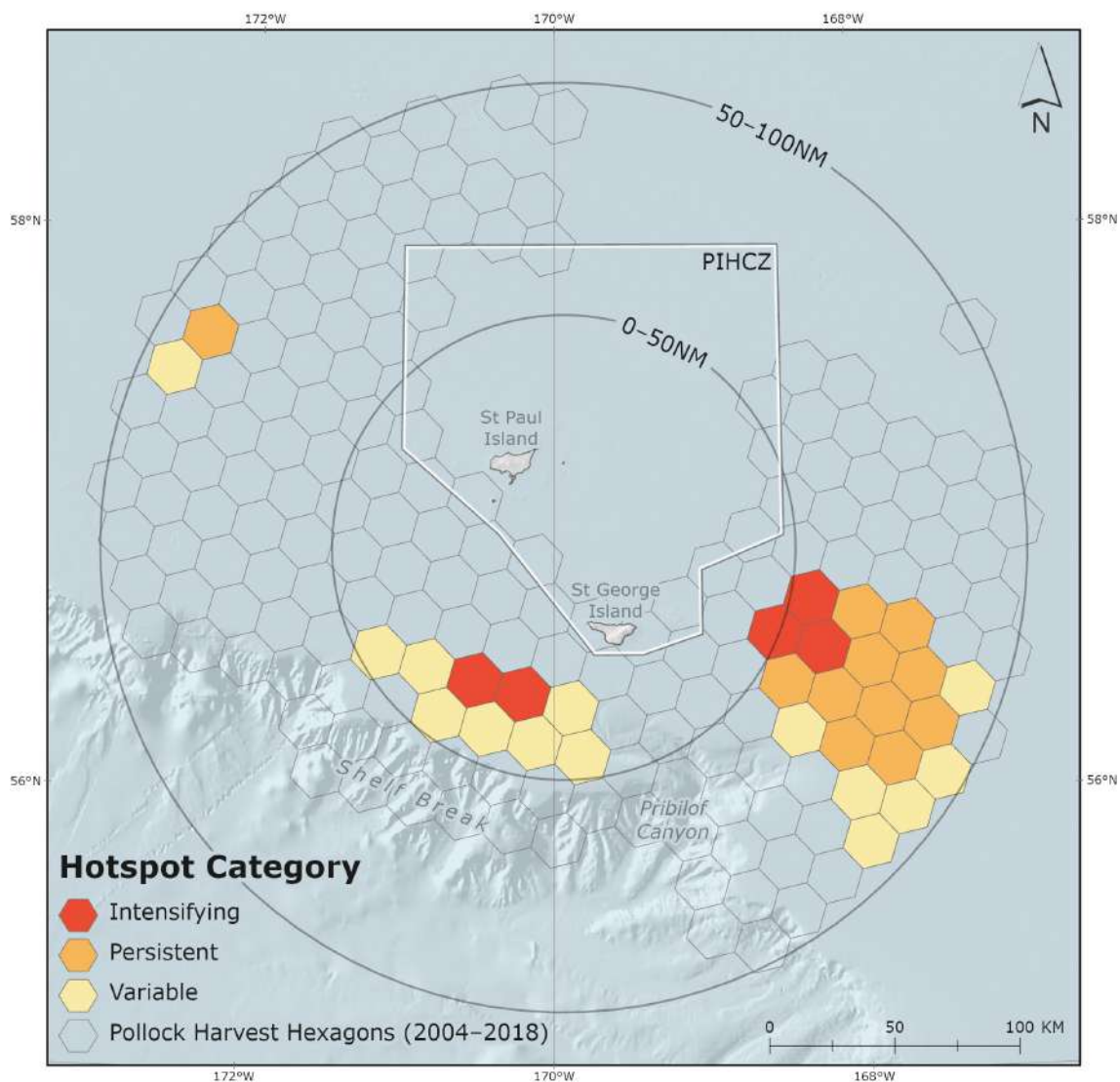


Figure 5. Three hotspot areas, categorized as intensifying, persistent, and variable, identified in the Pribilof Islands Marine Ecosystem (PRIME). The Pribilof Islands Habitat Conservation Zone (PIHCZ) is pictured.

4. Discussion

Weaving together multiple ways of knowing enables communities and western scientists to better understand the ecological and socio-cultural implications of the changing PRIME ecosystem for Pribilof Island communities, NFS, and the broader EBS. Overall, St. Paul and St. George Tribal and community members pointed to climate- and fishery-related ecosystem changes (both of which are indirect effects leading to nutritional limitation and were often specifically linked by respondents to competition with large-scale industrial fisheries), as primary drivers of NFS population declines on the Pribilof Islands. Impacts to food security and traditional activities, such as harvesting of NFS and other wildlife resources in the Bering Sea, were predominant within the community and personal impact themes from the surveys. Consistent with community perceptions of fishing activity in proximity to the islands, harvest intensity (t/km^2) was high and persistent in three regions of the PRIME. The importance of the PRIME to NFS foraging during the breeding season has been well-documented in scientific literature [11,38,41,44,70,71] as well as by IK and LK holders in the Pribilof Islands [12,13]. High pollock harvests in July and August, combined with IK and LK related to NFS behavior and demographics, reinforce the linkages between

pollock catch as an indicator of prey removal and indirect effects contributing to NFS nutritional limitation [13,32,71].

4.1. Nutritional Limitation and Climate Change-Related Ecosystem Changes/Impacts

Nutritional limitation was the most commonly identified driver of NFS declines in community surveys and was often linked to competition for prey with fisheries. Nutritional limitation was also linked to depletion of prey resources due to climate-related or general ecosystem changes/impacts, including reduced prey abundances and/or shifting prey distribution. Nutritional limitation can result from reduced access to prey due to localized depletion or disturbance of fish stocks and/or reduced abundance of preferred prey species that results in either the quantity or quality of food being insufficient for the recovery or maintenance of a population [72]. NFS nutritional limitation can be manifested directly as starvation and/or indirectly as reduced reproductive success or increased susceptibility to disease [73].

Climate change-related ecosystem changes/impacts were the second most common reason for the NFS decline articulated by community members. One community member stated, “Ocean temperatures and environments are changing and affecting the seals’ food source. They’re not finding enough food to survive”. Pollock is a key component of NFS diets on the Pribilof Islands [64,70,74,75]. Research suggests pollock distribution and productivity has been and will continue to be impacted by climate change [76–78]. In addition to changing distributions, the EBS is projected to continue warming [17,79–81], and simulations under two future emissions scenarios predict unfished pollock spawning stock biomass in the EBS could decline by as much as 47–70% by 2100 [82]. During periods of reduced pollock availability or abundance due to poor year-class survival and/or poor body condition, alternate prey resources may be insufficient to replace pollock in NFS diets, especially in rookery complexes in which NFS consistently consume a high proportion of pollock over time [8,42]. Predicted reductions in pollock productivity and/or biomass [82] during successive warm years could have longer-term negative implications for central place foragers constrained by the need to provision dependent offspring, thus negatively impacting lactating female NFS and their pups [40,42,75]. If prey availability is consistently low in the future, NFS may continue to experience long-term declines due to reduced survival of young NFS resulting from diminished ability of post-parturient females to obtain sufficient food [42,71].

Community concerns associated with shifting or declining species due to climate-related changes/impacts also extended to other marine resources important to the Pribilof Islands communities. For example, fishermen from St. Paul have indicated that chagiġ, or Pacific halibut (*Hippoglossus stenolepis*), an important traditional resource and focus of a small-scale commercial fishery in the Pribilof Islands, are traveling farther north because it is too warm for them under current conditions near the Pribilof Islands [13,83]. Community surveys, although focused on impacts to NFS, included answers concerning climate change- and fisheries-related impacts to a wide range of species, including birds, fish (*Flatfish* spp., Pacific halibut, Pacific herring [*Clupea pallasii*], *Salmon* spp.) and the “entire food chain” of the EBS. These concerns reflect how intertwined the future of Pribilof Islands Unangan is with the health and biodiversity of the marine ecosystem and show that climate change- and fisheries-related ecosystem impacts extend well beyond single species impacts or concerns.

4.2. Fisheries-Related Ecosystem Changes/Impacts and Competition for Prey Resources

Community respondents linked NFS nutritional limitation to commercial fishery impacts regionally. More than half of the survey respondents discussed nutritional limitation in conjunction with “overfishing”, “trawling”, and/or “competition for prey”. One respondent noted, “Because of the trawlers around here, they [NFS] have to swim farther away to get their food”. As noted above, another respondent stated, “Pollock fisheries take their [NFS] main food source, walleye pollock, while maintaining a presence disturbing their habitat”. The body of scientific evidence in support of this view is growing [32,71,84]. Short et al. (2021)

characterized the pollock fishery as “a major new predator” introduced into the EBS ecosystem that directly competes with NFS for high-density aggregations of pollock and leaves fragmented and dispersed schools of pollock in their wake.

The occurrence of hotspots observed in this study implies that the pollock fishery functions in a manner similar to NFS by returning inter-annually to predictable high-density prey aggregations. Data analyses confirm the presence of three distinct hotspot areas of intense localized pollock harvests in the PRIME (Figure 5). The first hotspot occurs in the 0–50 nm sub-region where “St. George” and “southwest St. Paul” MHRs (and their overlapping areas) occur. The additional two hotspot areas primarily occur in the 50–100 nm sub-region, southeast of the Pribilof Islands in the “All” and “St. George” MHRs, and northwest of the Pribilof Islands in the “southwest St. Paul” MHR (Figure 4, Table 2). Pollock harvests remained relatively stable in the 0–50 nm sub-region and generally increased in the 50–100 nm sub-region of the PRIME over the study period (Figure 3, Table 2).

Relatively high localized harvest intensities could result in reduced foraging efficiency for females [32,84–86]. Smaller marine mammals, such as pinnipeds, are the most likely to experience negative effects of localized resource depletion as a result of fishery harvests because smaller species acutely balance energy needs, such as nursing, on a shorter time scale and in smaller areas when compared with larger more pelagic marine-mammal species, such as baleen whales [86]. It is possible that localized prey depletion associated with commercial fishery hotspots could differentially impact NFS rookery complexes based on relative reliance on pollock in their diet. For example, the highest frequencies of occurrence of pollock were found in samples from rookeries along the western side of St. Paul Island, where pollock comprised as much as 68–74% of diet [40]. These rookeries have also exhibited some of the steepest declines in pup production since 2004 [23]. Conversely, St. George rookeries exhibit some of the lowest frequencies of occurrence of pollock in diet (43–48%) [40]. Thus, NFS foraging overlap with commercial fishery hotspots in the St. George MHR may be less impactful to St. George Island pup production, which has been relatively stable since 2002 [23]. While this study intentionally focuses on the PRIME, significant pollock harvests in NFS foraging areas outside the PRIME (>100 nm) could also negatively impact prey availability and metabolic demands for lactating NFS.

This study’s analyses focused on NFS interactions with the commercial pollock fishery during the B-season due to identified community concerns and the overlap of the pollock commercial fishery in space and time with lactating female NFS foraging areas [24,32,71,84]. There is, however, the potential for additional NFS-fishery interactions during the A-season (January–May) when NFS are in their pelagic phase, which can extend throughout the Bering Sea as far south as California [35]. While NFS distribution is more dispersed during the winter months, it is possible that remaining adult and/or juvenile NFS in the EBS could be impacted by pollock fishery operations through prey dispersal or reductions in total available prey biomass [32]. The impacts of NFS-fishery interactions during the A-season are likely to be less acute than B-season interactions, especially for central place foraging female NFS provisioning their offspring in July and August.

Recent studies suggest that NFS may have hit a “metabolic ceiling” early in their recent decline (mid-1990s), and reductions in pup production may be a result of this long-term prey limitation [71,84]. Consistent with views expressed by survey respondents, research suggests that high metabolic costs associated with longer foraging trips reduce the energy available for lactation and also likely preclude females from accumulating fat reserves to compensate for periods of poor foraging success [71]. McHuron et al. (2020) concluded that increases in localized prey densities are the most feasible mechanism to reduce maternal foraging effort and consequently increase pup growth rates. Increasing catches in the 50–100 nm sub-region and hotspots of pollock catch documented in the study area suggest that management measures designed to increase prey availability in closer proximity to the rookeries might be considered to reduce foraging trip distance and duration as longer trips adversely impact pup growth [71].

Short et al. (2021) inferred a significant inverse correlation between NFS pup births and total annual pollock catch within a broadly defined NFS foraging area within approximately 300 km (~162 nm) of the Pribilof Islands. Drawing on the bioenergetic modeling from McHuron et al. (2019, 2020), Short et al. (2021) propose that the reduced foraging efficiency of females results in low pup growth rates and lower mass at weaning, leading to reduced first year survival and causing subsequent declines in the Pribilof NFS population. Short et al. (2021) further hypothesize that the pollock fishery catch reduced female NFS foraging efficiency through repeated trawling through high density aggregations of pollock, which effectively reduces the size of pollock schools and disperses prey patches within NFS foraging habitat. The occurrence of persistent hotspots within the PRIME lends support to this hypothesis.

In a management context, competition for prey between upper trophic level predators and commercial fisheries is usually characterized as an “indirect effect”. Indirect effects are typically difficult to prove through western scientific research, and they are identified as possible explanations for species declines by community members who rely on these species for traditional harvesting. This dichotomy highlights the need to better understand and address the indirect effects of commercial fisheries, especially in combination with ongoing changes to marine ecosystems due to climate change.

4.3. Other Considerations in the NFS Decline

In addition to climate and ecosystem-level changes/impacts, survey respondents mentioned a number of direct and indirect factors that contribute to the NFS decline, including: acoustic disturbance, contaminants and pollution, marine debris and entanglement, and predation on NFS [29,87]. These additional direct and indirect factors likely compound the primary factors identified by community surveys and spatial data presented here (e.g., ecosystem changes/impacts, prey competition); the relative contribution of these additional direct and indirect factors to the overall decline of NFS remains undetermined [28,29].

Traditional harvests of NFS (i.e., harvests after the cessation of commercial operations in the Pribilof Islands) by Tribal members are not considered a factor in the broader Eastern Pacific NFS stock decline. Local harvests exclusively target juvenile males and male pups, and harvest levels have remained well below the potential biological removal (PBR) level as defined by the MMPA and established annually by NMFS [22]. Conversely, the long term NFS population decline is considered to be at least partially responsible for declines in the number of NFS traditionally harvested in recent years as tribal members self-limit consumption and opportunities to access NFS become less abundant. For example, one respondent stated, “*With the decline in the seal population there has also been a decline in people eating fur seal, too. I don’t know if the two declines are related or are people eating less seal because there are fewer seals, or for other reasons? But the loss of any traditional resource is tragic for a community*”. Another predicted, “*[We have enough seal] for now but will get worse, the local people [will] not be able to subsistence hunt and collect meat for the winter*”.

4.4. Importance of the PRIME to NFS

It is important to note several points regarding the 100 nm boundary of PRIME. First, the boundary is approximately equal to the median foraging distance (97 nm) for lactating NFS during 1995–1996 [38,64]. Second, the circular shape of the PRIME used by Ciannelli et al. (2004) for computational convenience was used in this analysis for consistency with existing scientific information and IK and LK. However, Ciannelli et al. (2004) noted that NFS foraging distances are measured from the rookery of origin, and therefore the actual median foraging distance may slightly exceed the 100 nm boundary. In this regard, an elongated shape defined by the combined circular boundaries measured from the centroid of both St. Paul and St. George Island may better represent the area defined as the PRIME. Importantly, Ciannelli et al. (2004) also noted that the full foraging range of the most distant central-place foragers (e.g., NFS) may better indicate the maximum spatial extent of an open marine ecosystem. The mean maximum distance for foraging trips during the

1995–1996 study was 130.4 nm (~241.4 km), indicating that lactating NFS spent considerable time foraging outside of the 100 nm boundary of the PRIME [11,64]. The mean maximum foraging trip distance reported by Kuhn et al. (2014) for lactating NFS tracked during 2010 was 133.7 nm (247.7 km), a remarkably similar result despite the fact that the population was 1.8 times greater in 1995–1996 than in 2010 [44]. The consistency in foraging distance over time indicates the importance of both the PRIME and more distant foraging areas and may also serve as a useful metric for evaluating measures that may be implemented to increase the allocation of NFS foraging effort closer to the breeding rookeries [71].

Irrespective of age, Tribal affiliation, and gender, survey respondents consistently expressed that the PRIME provides essential foraging habitat for NFS. One respondent noted, *“Fur seals haul out and breed on the Pribilof Islands. Once pups are born, mothers need to return to the waters for food to feed themselves and their newborns. The waters 0–100 miles off the coasts of the Pribilofs are critically important because the ideal place for a seal to find food is nearby”*. As a species with a remarkable history of management research and experimentation, NFS provide a unique opportunity to develop novel spatio-temporal management approaches.

When coupled with existing literature about the potential nutritional limitations on NFS, the results of the present study indicate that the significant amounts of pollock harvested annually in close proximity to the Pribilof Islands may contribute to the long-term decline at some NFS rookeries. Measures to address the concentration of this catch and including NFS in multi-species stock assessment models for the EBS as recommended by McHuron et al. (2020) should be considered as part of efforts to stabilize the Pribilof Islands NFS population and begin to reverse the population decline.

4.5. Community/Cultural and Personal Impacts

Studies that use detailed community input and the documentation of IK and LK are invaluable when addressing complex ecosystem interactions. Results from the community survey highlighted the community/cultural and personal impacts that the NFS decline has had on food security, traditional activities, and other wildlife resources in the PRIME. The observed pattern in responses is not surprising given the deep interconnectedness among biophysical, spiritual, and emotional health and wellbeing experienced by engaging in traditional activities such as hunting and harvesting or preparing and sharing a traditional meal with family and friends. The dominance of “traditional activities”, “NFS as a food resource”, and “food security” based on co-occurrence frequencies in relation to “community/cultural and personal impacts” underscores the importance of NFS to maintaining food security and cultural continuity in the Pribilof Islands.

The relationship between the overall NFS population decline and the decline of traditional harvest opportunities is complex, as described in survey responses. For example, one respondent described warming waters from climate change and bycatch from trawl fisheries as compounding reasons for the NFS decline and linked the population decline to a reduction in traditional harvests, which has negatively impacted the transfer of IK in the community. Another Tribal member noted that global warming and overharvest of fish was impacting *“not only the seals, but the entire food chain,”* and expressed a desire to remove seal from their diet to reduce impacts to NFS. These comments highlight the potential for a food security crisis in the Pribilof communities in relation to the decreased availability of NFS and other traditional food resources.

Access to traditional, culturally preferred foods through engaging in traditional harvesting and hunting is especially important in remote areas where access to imported foods (e.g., from the local grocery store) may be limited due to long flight times and distances, canceled flights, and high prices. Even with access to imported foods, traditional foods are central to culture and identity and are critical to achieve food security, as defined by the Inuit Circumpolar Council [88] and the Aleut Community of St. Paul Island (M. Mergulieff, pers. comm.). Thus, the decline of NFS has resulted in a myriad of spiritual, emotional, cultural, and non-consumptive impacts, as well as reduced availability of a nutrient-dense traditional food resource. Conservation and recovery of the NFS population on the Pribilof

Islands is critical to mitigate these observed impacts as well as future potential individual, community, and cultural impacts.

5. Conclusions

The body of IK and LK reflected in community surveys is consistent with the spatial analyses of pollock harvest presented here and in recent scientific literature [32,44,71,78], and indicates the need to evaluate dynamic (spatiotemporal) management solutions within the PRIME in order to reduce competition for prey with lactating female NFS in close proximity to the Pribilof Islands rookeries. Survey results also highlight the value of IK- and LK-based approaches when evaluating relationships between discrete and diffuse indicators, such as reproductive failure and decreased foraging success, over a period of multiple decades.

There are opportunities for Indigenous and non-Indigenous groups and agencies interested in cooperative management approaches to evaluate linkages between pollock catch and NFS population status. For example, explicit inclusion of NFS predation in multi-species stock assessment models [71], in combination with reductions in spatial harvest intensity within 100 nm of the Pribilof Islands, may result in increased prey abundance closer to rookeries. This, in turn, could result in shorter travel distances and trip durations, and therefore less energy expenditure for lactating NFS. In the short term, this may result in increased pup weights at weaning, which has been shown to be a factor contributing to increased over-winter survival [89]. In the long-term, higher pup survival could result in overall population increases [32].

This study also highlights the need to further investigate the effects of fisheries and climate change impacts on NFS in the context of a changing Bering Sea ecosystem and food web to enhance food security in the Pribilof Islands. These linkages could be evaluated in conjunction with synergistic factors, including competition for prey with fisheries (described above) to develop NFS conservation and recovery strategies designed to address issues of food insecurity and ensure cultural continuity for generations to come.

As one St. Paul resident communicated, *“Emotionally, I feel sad to see noticeably less fur seals each year and I have lived here five years but it’s apparent. As a citizen, I wonder why better alternatives or ways are not more part of our culture as humans. I feel like we, as humans, could do so much better”*. Survey respondents also discussed the need for conservation measures, such as, *“We need to know what threatens seals and their food sources in these waters [0–100 miles] and take steps to protect these waters for the fur seals’ sake”*.

Supplementary Materials: The following is available online at <https://www.mdpi.com/article/10.3390/jmse10040467/s1>, Survey S1: Community survey distributed online to St. Paul and St. George Community Members.

Author Contributions: As a body of work following a Co-Production of Knowledge approach, L.D., M.J.P.W., J.D., M.L. and B.R. contributed to conceptualization; methodology; software; validation; formal analysis; investigation; resources; data curation; writing—original draft preparation; writing—review and editing; visualization; supervision; project administration; funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study because all study methods were reviewed and approved by the St. Paul Island Tribal Council and/or designated Tribal representatives, which can serve as a substitute for the Institutional Review Board process in the case of Tribally-led research.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not Applicable.

Acknowledgments: The authors would like to acknowledge and thank the Unanga communities of St. Paul and St. George Islands, AK, for their strong Indigenous leadership in marine mammal research and monitoring. The Aleut Community of St. Paul Island Tribal Council provided feed-

back and support throughout this project and to the contributing authors. We especially appreciate guidance and review of early drafts from Paul Melovidov, Aaron Lestenkof, Christopher Tran, Noah Oppenheim, and Marissa Merculieff, as well as four independent reviewers including Henry Huntington, Anna Zivian, and Lowell Fritz. We thank the National Marine Fisheries Service for providing fishery data as well as Patricia Chambers for digital support. The authors also gratefully acknowledge the contributions of two Pribilof Elders: the late Father Michael Lestenkof for discussions leading to the early formulation of the concept of separation of foraging habitats among NFS; and the late Mayor St. George Patrick Pletnikoff for his steadfast and visionary contributions to efforts to protect the Pribilof Islands marine ecosystem. The authors wish to note the difficult but worthwhile efforts that were undertaken by all participants to co-produce this manuscript. In so doing, they strove to develop research questions and methods together, to interpret and understand the data and information collectively and within the context of the communities needs and perspectives, and to produce a document that reflects the understanding and expertise of the communities and the authors, and that respects the existing body of information and science on laaquadan, or northern fur seals. The Aleut Community of St. Paul Island appreciates the expertise, willingness to listen and learn together, and capacity shared by Ocean Conservancy and Community and Ecology Resources, LLC. Ocean Conservancy is grateful to the Aleut Community of St. Paul Island and Community and Ecology Resources, LLC for the trust, sharing, and partnership reflected in this document and the significant investment in the process leading to it. Community and Ecology Resources, LLC is grateful to the Aleut Community of St. Paul Island for the invitation to participate in this process and Ocean Conservancy for support to facilitate full and active participation by all authors. The collaborative approach taken here made the final product much stronger. We hope to carry forward the lessons learned and to provide a meaningful example of the ways in which partnership- and equity-based research can be beneficial.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Community survey respondent general demographics.

Demographics Summary		
(A)	Age Category	
	18–24 years old	2
	25–35 years old	16
	36–45 years old	6
	46–55 years old	6
	56–65 years old	5
	66–75 years old	3
(B)	Tribal Status	
	St. George Tribal Member	5
	ACSPI Tribal Member	23
	Non-Tribal Member	8
	Prefer Not to Say	2
(C)	Residency Status	
	St. George Resident	5
	St. Paul Resident	30
	St. Paul Non-Resident	3
(D)	Gender	
	Female	23
	Male	15

Table A2. Code groups/themes, code names and definitions for Atlas.ti Codes.

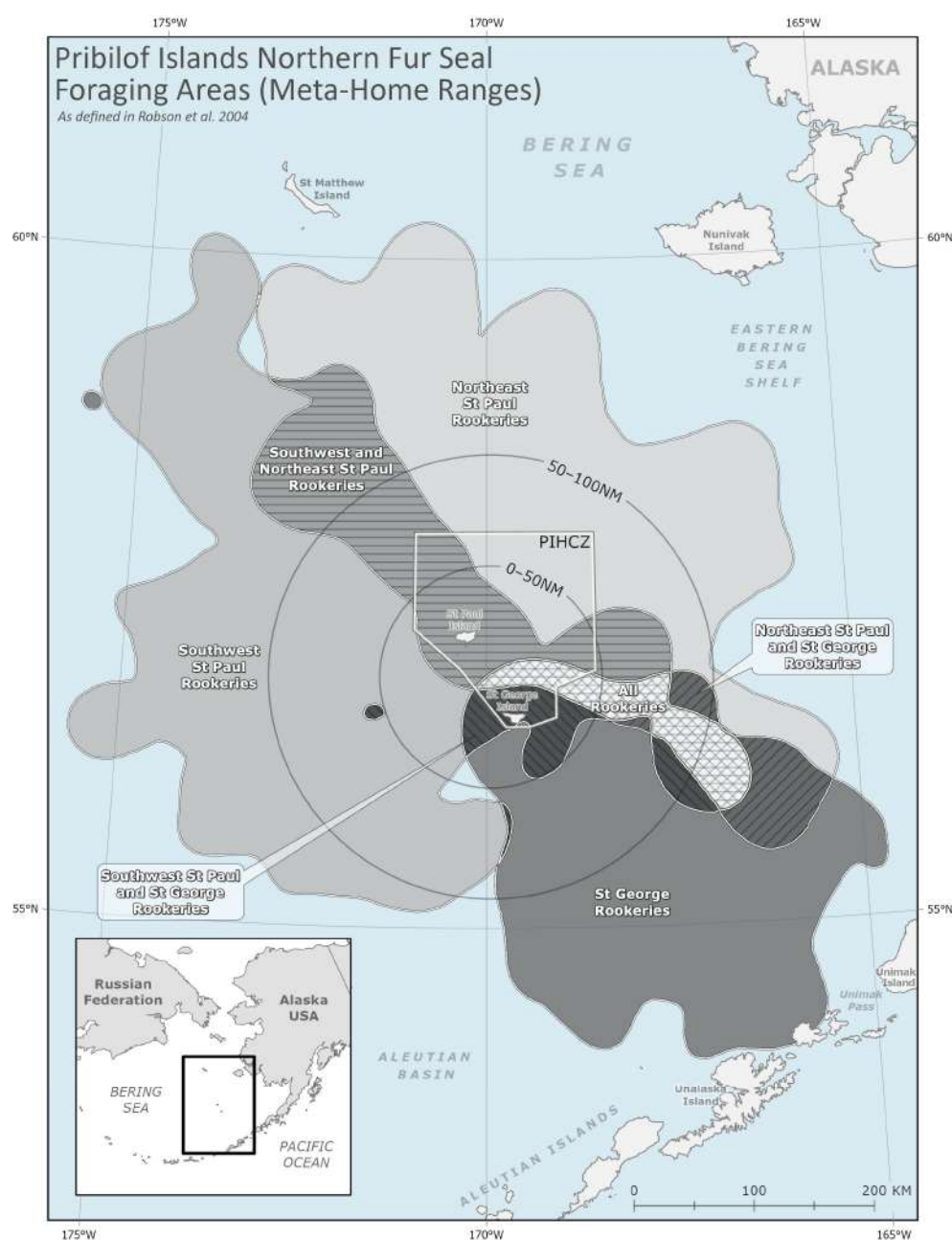
Code Groups/Themes	Codes	Definition of Code
Possible reasons for NFS decline	Climate change–related ecosystem–level impact or change	Discussion of climate change and/or warming conditions in the region
	Fisheries-related ecosystem–level impact or change	Discussion of fisheries-related impacts to the larger ecosystem in the region
	General/unspecified ecosystem–level impact or change	Discussion of changing environmental conditions generally in the region
	Contaminants	Reference to contaminants impacting NFS declines
	Entanglement	Reference to entanglement of NFS in human-made/synthetic materials
	Marine debris	Reference to marine debris or garbage impacting NFS declines
	NFS emigration	Reference to NFS permanently leaving Pribilof Islands rookeries
	NFS winter habitat	Habitat where NFS spend time at sea excluding summer breeding season
	Nutritional limitation	Negative impacts to NFS due to lack of food availability
	Pollution	Reference to materials or chemicals that contribute to pollution of the environment
	Predation on NFS	Mortality of NFS by other animal predators, such as killer whales and Steller sea lions
Personal and community/cultural impacts	Decline of shelf forage species (junk food hypothesis)	Reference to reduced prey quality and abundance of shelf forage species
	Acoustic disturbance	Anthropogenic sounds in the ocean that negatively impact NFS
	Personal impacts of the NFS decline	Perceived impacts to individuals on St. Paul and/or St. George due to declining abundance of NFS in the Pribilofs.
	Community/cultural impacts of the NFS decline	Perceived impacts to the community well being of St. Paul and/or St. George due to declining abundance of NFS in the Pribilofs OR perceived impacts to the cultural continuity or ability to participate in traditional and cultural ways of life on St. Paul and/or St. George due to declining abundance of NFS in the Pribilofs. Community and cultural impacts are interdependent and thus combined for the purpose of analysis.
	NFS as a food resource	Descriptions of NFS consumption and use it community/cultural diets
	Traditional activities/foods	Refers to any activities that are part of traditional and customary way of life for Unangax̂ including aspects of traditional foods and diet, subsistence harvests, etc.
Impacts of vessels/fishing on NFS	Food security	Statements associated with food security as defined by the Aleut Community of St. Paul Island, including the availability of, or lack of available, preferred resources (including NFS) to tribal members on St. Paul/St. George
	Community impacts of vessel activity	Perceived impacts of vessel presence and/or activity around the Pribilof Islands on the community
	Vessel impacts on NFS	Perceived impacts of fishing vessel presence and/or activity on NFS (individual or population level)
	Overfishing	Perceived impacts of overharvest of targeted or non-target species specifically or overfishing in general
	Trawling	Statements specifically citing trawling or dragging fishery operations
	Competition for prey	NFS competing with commercial fisheries for access to prey resources
	Bycatch	Impacts to NFS associated with non-target species catch in commercial fisheries

Table A2. Cont.

Code Groups/Themes	Codes	Definition of Code
NFS ecology	Impacts to mothers or pups, e.g., fecundity, survival	Consideration of mother and/or pup nutrition and impacts
	Changing NFS foraging areas or distribution of prey	Changes to NFS primary foraging areas due to environmental changes or moving food resources that force NFS to forage in different areas
	NFS diet	Perceived diet composition or dietary preferences for NFS
	Importance of 0–100 nm	Perceived importance of the 0–100 nm area around the Pribilof Islands.
	Essential NFS foraging habitat	Areas identified as key foraging areas important to NFS foraging
	Site Fidelity	Consistency in NFS key foraging habitat over time
Local fisheries and revenue	Deep sea forage	Perceived NFS habitat preference of deep-sea areas
	Local fisheries	Refers to small scale local halibut fisheries in the Pribilof Islands
	Local revenue (fishing, tourism, other)	Statements associated with local revenue considerations or opportunities
Research and conservation	Additional research explanation or need	Areas for additional research needed.
	Need for conservation or protection	Requests to conserve, protect, limit activities in certain zones as an environmental conservation measure
	Long-term observations	Long-term observations (decades plus) regarding the ecosystem or NFS
Perceived dietary preferences of NFS	Fish general	Fish generally as a perceived dietary preference of NFS
	Flatfish	Flatfish as a perceived dietary preference of NFS
	Mollusks/cephalopods	Mollusks or cephalopods as perceived dietary preferences of NFS
	Pacific cod	Pacific cod as a perceived dietary preference of NFS
	Pollock	Pollock as a perceived dietary preference of NFS
	Salmon	Salmon as a perceived dietary preference of NFS
	Shellfish general	Shellfish as a perceived dietary preference of NFS
	Small forage	Small forage general as a perceived dietary preference of NFS
Seabirds	Seabirds	Text referencing seabirds

Table A3. Likert questions and response frequency from community surveys.

Question	Likert Category				
	1	2	3	4	5
Please rate on a scale of 1–5, is this area (0–100 nautical miles) important to northern fur seals? [1 = Not Important at all, 2 = Less important than other areas 3 = No different than other areas, 4 = More Important than other areas, 5 = Critically important to fur seals.]	1	0	1	10	26
Please rate on a scale of 1–5 what impact has the decline of northern fur seals had on our community? [1 = Not at all, 2 = Not much, 3 = Neutral, 4 = Somewhat, 5 = Significant/major impact to our community.]	0	3	9	15	11

**Figure A1.** Meta-home ranges (MHRs) and their overlapping areas as defined by Robson et al. (2004).

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Juvenile western Alaska chum salmon and critical periods during their marine life history in a changing climate

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ABSTRACT: Recent precipitous declines in western Alaska chum salmon (*Oncorhynchus keta*) returns followed unprecedented warming in the northern Bering Sea ecosystem. To better understand the role of anomalous events on juvenile chum salmon early marine ecology in the northern Bering Sea, we utilized time-series observations over a 17 yr period (2003–2019) of juvenile chum salmon size (length and weight), diet, energy density, relative abundance, and of the sea surface temperature (SST). Particular attention was paid to more recent (2014 to 2019) years that had unprecedented loss of sea ice in the northern Bering Sea in comparison to previous warm (2003 to 2005) and cold (2006 to 2013) periods. Our findings indicate significant correlations between SST and juvenile chum salmon relative biomass (positive) and energy density (negative). We found that juvenile chum salmon were larger during warm periods than during cold periods; however, there was no significant difference in their length and weight between the warm periods. Juvenile chum salmon fed on lower quality prey during warm periods when compared to during cold periods, with an increase in the proportion of lower quality prey during the recent warm period. Consequently, energy density of juvenile chum salmon was also lower during warm periods than during cold periods, with the lowest values occurring during the recent warm period (2014 to 2019). These results identify a shift in energy allocation and/or prey quality of juvenile Chum salmon with temperature and illustrate how marine ecosystems have altered the nutritional condition of juvenile Chum salmon prior to winter when energy reserves are considered critical to survival.



MAGAZINE

THE FRIDAY READ

Alaska's Fisheries Are Collapsing. This Congresswoman Is Taking on the Industry She Says Is to Blame.

Mary Peltola won her election by campaigning on a platform to save the state's prized fisheries. A powerful fishing lobby is standing in her way.



Alaskan fishermen feel threatened by a trawling industry they say is destroying the oceans with wasted bycatch. | Nathaniel Wilder for POLITICO

By ADAM FEDERMAN
03/03/2023 04:30 AM EST



This article was produced in partnership with [Type Investigations](#), where Adam Federman is a reporting fellow.

HOMER, Alaska — The late 1990s and early 2000s were boomtimes for halibut fishermen in Alaska. Over 80 million pounds of the flatfish were being harvested annually. Deckhands could earn \$250,000 a season. The small boat harbor in the southcentral city of Homer, known as the “halibut capital of the world,” was bustling.

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Erik Velsko, 39, was one of those fishermen. He started buying annual shares in 2001 when the halibut population was at near historic highs. But within a few years, the stock plummeted by more than half and the quotas for

commercial fishermen were slashed accordingly. Velsko's share has gone from 12,000 pounds annually to less than 4,000 pounds. His brother-in-law, who also fishes out of Homer, has had his quota cut from about 90,000 pounds to 20,000 pounds. Many fishermen have gotten out of the business altogether.

"That whole dock was all long liners, you know, 15 years ago," Velsko told me last year, pointing to a row of idled boats in the harbor. "It's two or three now. My brother-in-law and another one."



Captain Erik Velsko on his boat "Kaia" in Homer, Alaska. Velsko sits on the Alaska Bycatch Review Task Force. | Nathaniel Wilder for POLITICO

Halibut wasn't the only so-called directed fishery to experience such a catastrophic drop. The crab fleet — made famous in the reality show "Deadliest Catch" — has been mostly stuck in port for two years after the near total collapse of the snow crab population and the decades long decline of red king

crab. This year both fisheries were closed, a major blow to many of Alaska's coastal communities, who rely on related industries, including processing, to float their economies. At the same time, subsistence and sport salmon fishing on the state's two largest rivers has been shut down because of dwindling salmon runs.

There is one fishing industry that has not suffered.



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The fleet of nearly 250 trawl boats that catch groundfish (species such as pollock and yellowfin sole that congregate on or near the ocean floor), have recorded banner seasons — permitted to bring in between 3 and 4 billion pounds of fish annually for worldwide distribution. What makes this inequity especially jarring for the captains of halibut, crab and salmon boats is that the trawlers, some as long as a football field, which drag vast nets along the sea bottom, also scoop up millions of pounds of species they don't actually want, and they throw most of it overboard no matter how valuable it might otherwise be.

It's called bycatch. Roughly two-thirds of the total halibut caught in the Bering Sea since 2006 has been bycatch taken in trawler nets most of which is dumped. In 2021, when subsistence fishermen were prohibited from fishing for chinook and chum salmon on the Yukon River, pollock boats swept up more than half a million individual salmon from the Bering Sea. And while red king crab and snow crab fisheries have been shuttered this year, the trawl industry has still been permitted to discard up to 4.3 million individual snow crab and 32,000 red king crab though they don't always reach their cap.

The reasons for the crash of the halibut, crab and salmon populations — a collective disaster that has sucked hundreds of millions of dollars from [the Alaskan economy](#) — have been hotly debated for years. The Bering Sea, which has long been one of the world's most productive marine ecosystems, accounts for nearly 40 percent of all seafood caught in the United States, generating billions in revenue and tens of thousands of jobs. But evidence is growing from

government agencies including the National Oceanic and Atmospheric Administration, conservation groups and fisheries scientists that the trawl industry is causing greater damage to marine habitat than previously assumed and that the removal of vast quantities of pollock, an important source of food for other species such as fur seals and Steller sea lions, is causing disruptions to the larger ecosystem. At the same time, the groundfish fishery, which accounts for roughly 80 percent of the annual catch in Alaska, has come to dominate the regulatory system that sets fishing quotas for all species, Velsko says. In some ways, conflicts of interest are built into federal fisheries management and have become entrenched. Industry representatives or commercial operators with ties to the trawl fleet frequently serve on the North Pacific Fishery Management Council, the regional NOAA body which regulates the industry, and vote on policy that affects their sector.





The trawl industry is causing greater damage to marine habitats than previously assumed. | Nathaniel Wilder for POLITICO

“It should’ve been more obvious two decades ago,” said Jim Balsiger, who served as NOAA’s top fisheries official in Alaska for 20 years before retiring in 2021. “Removing three to four billion pounds of fish from the Bering Sea every year for four decades is not a benign activity.”

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But, in the case of halibut and the other recently closed sectors, it has been the directed and subsistence fisheries that have had to limit their quotas to help restore depleted populations. The trawlers on the other hand have been allowed to maintain at or near the same levels of wasted bycatch for certain

species. “The directed fishery has had to bear the burden of conservation,” Velsko says.

Trawl industry representatives say that bycatch, which the industry is required by law to discard, is not the driving force behind recent crab, salmon, and halibut declines. They point to climate change and warming waters as well as natural population variability as the primary culprits. Over the last couple of decades, trawl vessels have significantly reduced waste and improved efficiency, according to Chris Woodley, executive director of the Groundfish Forum, which represents about 18 boats that fish in the Bering Sea and account for the majority of halibut bycatch. (Directed fisheries still bring in most of the halibut caught in Alaska waters when the Gulf of Alaska and Aleutian Islands fishing grounds are included.) Since the mid-1990s, the fleet has dramatically reduced the volume of fish — both targeted and non-targeted species — it tosses overboard. The discard rate has gone from about 50 percent to less than five over the last 20 years, according to Woodley.

Rebecca Skinner, executive director of the Alaska Whitefish Trawlers Association, which represents about 40 small to medium-sized trawl vessels based out of Kodiak, one of the largest commercial fishing ports in the United States, says that zeroing out bycatch would have a negligible effect on other species while potentially shutting down an important commercial fishery. “Bycatch did not drive the crab stocks down. Bycatch is not driving the salmon stocks down,” she said. “So even if you completely eliminated bycatch, it’s not going to make those stocks rebound. And that’s the hard part.”

This years-long dispute between the directed fisheries and the trawl industry has been confined to meetings of obscure state and federal agencies and has received only local coverage for the most part. But in November, amid a groundswell of anti-trawl sentiment in the state (a popular Facebook group launched in 2020, Stop Alaskan Trawler Bycatch, [now has more than 20,000 members](#)), Alaskans elected Mary Peltola as the state's only member of Congress. Peltola, the first Alaska Native to serve in the House of Representatives, campaigned on a platform that placed issues of bycatch and the viability of smaller commercial and subsistence fisheries at the forefront of her legislative agenda. She posted frequently about the impacts of trawl fishing on the environment to her tens of thousands of followers on social media and elevated the issue to national attention. The first sentence of Peltola's "story" on her website reads: "I'm a Yup'ik Alaska Native, salmon advocate, and Democrat."



Trawl industry representatives say that bycatch, which the industry is required by law to discard, is not the driving force behind recent crab, salmon and halibut declines.

“For 30 years, this industry has been tossing over juvenile salmon, halibut and crab by the metric ton,” she said to POLITICO and *Type Investigations*. “At some point we have to imagine that that is not sustainable. That that catches up with us.”



The trawl vessel "Cape Kiwanda" in Kodiak, one of the largest commercial fishing ports in the United States. | Nathaniel Wilder for POLITICO

Peltola is quick to acknowledge the role climate change and warming waters have played in impacting Alaska's fisheries but says the trawl industry and the council that regulates it have not done enough to reduce bycatch or expand habitat protections for vulnerable species. The council, which sets bycatch

quotas and manages commercial fisheries up to 200 miles from shore, has been captured by the largest industry players, Peltola says. Subsistence users and smaller commercial operators have been pushed to the margins. Economic interests rather than sustainability have come to dominate the decision-making process.

“The council works well if you are from the biggest, wealthiest most connected among us,” Peltola said.



Rep. Mary Peltola, the first Alaska Native to serve in the House of Representatives, campaigned on a platform that placed bycatch at the forefront of her legislative agenda. | Tom Williams/CQ Roll Call via AP

In a written statement, David Witherell, the council's executive director, disputed the notion that the council favors any given sector or that it prioritizes economic interests over the long-term health of the ecosystem. In addition, Witherell noted that any proposed changes to fishery regulations are evaluated

by the council's scientific and statistical committee and are part of an open and transparent public comment process.

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“The council has a successful record of science-based, conservative and sustainable fisheries management, and the U.S. is widely considered to have one of the best, if not the best, fishery management programs in the world because of its stringent sustainability and conservation standards,” Witherell wrote.

As Alaska's lone House representative, Peltola is now in a position to make sweeping changes to the way the council operates. She is a member of the House Natural Resources Committee and has supported an overhaul of the Magnuson-Stevens Fishery Conservation and Management Act, legislation passed in 1976 that governs how federal fisheries are managed and that has only been updated twice before. If it passes, the bill could alter the balance of

power between the trawl industry and the smaller commercial operators and subsistence fishermen in Alaska.

The bill would add two tribal seats to the council, which would give subsistence users greater influence over council decisions and policy making. It would also enable the federal government to further reduce bycatch quotas — a move the trawl industry says would have catastrophic effects on Alaska's economy.

“We’re looking at a multi-species collapse,” Peltola said. “And it’s not just subsistence, but these smaller mom and pop fisheries. The commercial industry isn’t just these industrial players. It’s so many Alaskan families. It is part of our identity.”



‘Once I Started Seeing the Destruction, It Was Hard To Watch’

“WE’RE LOOKING AT A MULTI-SPECIES COLLAPSE,” PELTOLA SAID. “THE COMMERCIAL INDUSTRY ISN’T JUST THESE INDUSTRIAL PLAYERS. IT’S SO MANY ALASKAN FAMILIES. IT IS PART OF OUR IDENTITY.” | NATHANIEL WILDER FOR POLITICO

When Magnuson-Stevens was passed in 1976, the fisheries industry in the North Pacific was dominated by foreign fleets mostly from Japan, Norway and the former Soviet Union. There was little oversight, and several species were heavily overfished. Commercial fishing and unregulated bycatch likely contributed to the collapse of Bristol Bay red king crab in the early 1980s, a low point from which the species has never recovered. Magnuson-Stevens and subsequent amendments gradually pushed foreign operators out of U.S. waters and established eight regional councils to manage and protect the nation’s fisheries. The North Pacific Fishery Management Council oversees fisheries in federal waters in the Gulf of Alaska, Bering Sea and the Aleutian Islands.

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Over time, foreign operators were replaced by a trawl industry based largely in Washington state. That fleet has had its own impacts on fish populations in the Bering Sea, the 772,000 square mile expanse of the northern Pacific that yields nearly half of all the fish consumed in the U.S. and an increasingly [large share](#) of all seafood that ends up in school lunchrooms and in the frozen food section of the supermarket. (McDonald's sells roughly 300 million Filet-O-Fish sandwiches a year, made, according to the company, with “ [wild-caught Alaska pollock...which is 100 percent sourced from sustainable fisheries.](#)”)



The Bering Sea yields nearly half of all the fish consumed in the U.S. and the majority of all seafood that ends up in school lunchrooms and in the frozen food section. | Christoph Mohr/picture-alliance/dpa/AP

The method of fishing that produces that volume of fish dates back to the late 19th century when the advent of steam power transformed the industry. Unlike the long lines with thousands of baited hooks used to catch halibut or the boxy metal traps with mesh webbing used to catch crab, trawling relies on massive nets, some three quarters of a mile long, that are dragged along the ocean floor. The mouth of the net can be up to 300 feet wide— environmental activists like to say a 747 airplane would fit comfortably inside the opening. As the net and other hardware is pulled along the ocean floor, it acts like a plow, churning up sediment and leveling deep sea coral gardens and kelp forests that support a complex array of marine life. In a 2002 report, the National Academy of Sciences said that trawling can “reduce habitat complexity by removing or damaging the biological and physical structures of the seafloor.” During a single tow, which can last up to 10 hours and cover the same ground multiple times, a large trawl vessel can impact 1 to 2 square miles of ocean floor, according to NOAA’s own data. A single factory trawler can catch and process up to 225 metric tons of fish daily. Pollock is by far the largest fishery in the Bering Sea and Gulf of Alaska; on average more than three billion pounds of the white fish are removed from the region every year.



Pollock is by far the largest fishery in the Bering Sea and Gulf of Alaska; on average more than three billion pounds of the white fish are removed from the region every year. | Christoph Mohr/picture-alliance/dpa/AP

Trent Matthews grew up commercial salmon fishing in Southeast Alaska. Ten years ago, he took a job on a trawler operated by US Seafoods, the *Alaska Endeavor*, which is involved in the Bering Sea groundfish fishery. It was the best money he'd ever made — about \$1,000 a day. But after five weeks he quit. Matthews said he was appalled by the waste, particularly halibut, but also crab and non-commercial fish species, and what he described as the leveling of marine ecosystems. (US Seafoods declined to comment.)

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“Once I started seeing the destruction, it was hard to watch,” Matthews said.

Alaska's fisheries, [once lauded as the best managed](#) and most abundant in the country, appear increasingly fragile. Climate change — the Arctic is warming at least two times faster than the rest of the planet — has led to sea ice loss and warming ocean temperatures, which is further stressing already vulnerable populations. Last year, NOAA surveys revealed that nearly 11 billion snow crab

in the Bering Sea had disappeared over the last two years, a population collapse across all size and age classes, which the agency has attributed to a “ [marine heat wave](#).” Others, though, [have questioned whether warming seas can fully explain the decline](#).

It's not just commercial fisheries that have been impacted by warming waters and decades of industrial fishing. The decline of chinook and chum salmon, species that are integral to Native communities on the Yukon and Kuskokwim Rivers, led to the closure of subsistence fisheries in 2021 and 2022 and forced the state to fly in thousands of pounds of frozen fish to remote villages for the first time ever.

NOAA Fisheries, which is part of the Department of Commerce and is responsible for overseeing the nation's fisheries, is still working to understand the recent salmon and crab declines. It says that [preliminary genetic analysis shows](#) that bycatch makes up a relatively small percentage of chinook and chum salmon bound for the Yukon and Kuskokwim rivers, and that “unprecedented warming” is thought to have led to poor growth and survival of the species. But when runs are as low as they are, even relatively small amounts of bycatch, depending on where they are occurring, can make a difference, according to Gordon Kruse, a fisheries biologist who served on the North Pacific Fishery Management Council's science and statistical committee for more than two decades.

“If [bycatch] is proportional and just evenly spread out, then it might be hard to make a case that this is impacting the populations of salmon,” Kruse said. “On the other hand, if salmon are aggregating by river system in the ocean and most of the catch is coming from a few rivers or streams, then the impact could be huge.”

NOAA also noted that environmental and “human activities” likely affected Bristol Bay red king crab which was heavily exploited in the 1970s and early 1980s. In addition, commercial crabbing associations and conservation groups allege that the agency is likely undercounting the volume of crab bycatch in the Bering Sea. NOAA only counts whole crab that end up in the trawl nets brought on board. Individual animals that are maimed and crushed or that slip through the nets that drag along the ocean floor where crab tend to cluster are not counted. This is known as “unobserved mortality.”

In a written statement, NOAA Fisheries said, “The level of unobserved mortality of crab species...is unknown,” but that the agency factors this variable into its population estimates.

According to Jon Warrenchuk, a senior scientist with the conservation group Oceana, 165,000 square miles of ocean floor, an area roughly the size of California, has been impacted, most of it in the Bering Sea. NOAA confirmed the figure and said, “The area of the EEZ (exclusive economic zone) off Alaska is more than 900,000 square miles. So approximately 18 percent of the ocean floor has been impacted by trawl nets or trawl gear.” Once compromised, it can take decades if not longer for these areas to recover. One recent NOAA [study has shown that deep sea sponges](#), invertebrates attached to the seafloor that provide habitat for juvenile and adult fish, have been damaged by trawl fishing which the organization says permanently alters the deep sea ecosystem.

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In part because of its natural abundance, pollock also plays an important role in the larger ecosystem. Some studies have linked the growth of the commercial U.S. pollock fishery, beginning in the 1970s, to the decline of Steller sea lions, now an endangered species, and fur seals, which have declined by about 70 percent. Seabirds, including kittiwakes and murrelets that nest on the Pribilof Islands in Bering Sea and rely on pollock, have also decreased significantly during the same period.

“The footprint of industrial trawling is huge — it’s massive,” said Warrenchuk. “We would contend there is ecosystem overfishing occurring.”



‘They Have the Best Available Science and They Choose Not To Act’

ACTIVISTS AND SUPPORTERS OF THE INDIGENOUS GROUP “PROTECTORS OF THE SALISH SEA” MARCH IN OLYMPIA, WASH. IN JAN. 2020. ALASKA’S FISHERIES, ONCE LAUDED AS THE MOST ABUNDANT IN THE COUNTRY, APPEAR INCREASINGLY FRAGILE. | TED S. WARREN/AP PHOTO

The council charged with managing the fisheries that depend on those ecosystems is now at the center of a very public battle between the smaller commercial operators and subsistence fishermen and the trawl industry. Conflicts of interest among council members are long-standing and, in some ways, unavoidable. Magnuson-Stevens was designed to allow industry representatives and commercial operators to vote on policy, the belief being that those directly involved in fisheries would be incentivized to protect them.

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The regional fishery councils, established after Magnuson-Stevens was passed, are responsible for managing commercial fisheries, setting annual quotas for individual species and bycatch limits for each sector. (In Alaska, crab stocks are co-managed with the state's Department of Fish and Game. The state also manages salmon, but bycatch quotas are set by the council.) The North Pacific Fishery Management Council has 11 voting members and includes representatives nominated by governors from Oregon, Washington, and Alaska, which has a majority of the seats. Final appointments are made by the Secretary of Commerce and there are a handful of seats reserved for agency representatives. Currently four of the council's 11 members have direct ties to the trawl industry or pollock processors, many of which also operate vessels in the Bering Sea.

According to critics of the council process, including Peltola, the mandate in Magnuson-Stevens that fisheries be managed to achieve "optimum yield,"

while also protecting fish stocks, has privileged economic considerations over environmental protection. This has led the council to favor the biggest players and the largest, most profitable fisheries. “The council process seems to be heavily influenced in supporting the investment that has been made in the fisheries infrastructure,” Kevin Bailey, a fisheries biologist and former NOAA employee wrote in *Billion-Dollar Fish*, a history of the pollock industry.

Velsko, who served on the North Pacific Fishery Management Council’s advisory panel and was a member of the state’s bycatch review task force, established by Alaska Gov. Mike Dunleavy in late 2021 amid growing controversy over the issue, argues that the council has become too cozy with the trawl sector and its many lobbyists. Dozens of state and federal officials, many of whom have served on the council, have gone to work for the trawl industry or trade associations that lobby on behalf of groundfish fisheries. Buck Laukitis, another commercial fisherman in Homer who served on the council from 2016 to 2019 said, “It’s a typical revolving door. You work for the council. You become an expert. You write the analysis and a week later you’re working for the industry.”

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Though council members submit financial disclosure forms, which are posted on the NOAA website, they are only required to recuse themselves from voting on policy if it is deemed to have a “significant and predictable effect” on their financial interests. In practice, according to Balsiger, the former NOAA official, recusals are rare.

Witherell, the council’s executive director, said all decisions are driven by science and that a broad cross section of representatives from the commercial, recreational and sport fishing sectors currently serve on the council. Four of the members are state and federal representatives with no ties to industry. “The Council does not prioritize economic considerations over environmental protection for crab stocks or any other fish stock,” he said. Witherell also pointed to recently updated [NOAA policies](#) that are designed to strengthen financial disclosure requirements and clarify the process for determining whether council members must recuse themselves from a particular vote.

The council ultimately answers to NOAA Fisheries, which is part of the Department of Commerce. But NOAA has historically deferred to the council and rarely overturns decisions made at the regional level, a pattern that has continued under the Biden administration.

Last fall, crabbers petitioned Secretary of Commerce Gina Raimondo to intervene directly to temporarily close an area in the Bering Sea considered important for the reproduction and survival of red king crab. Known as the red king crab savings area, the approximately 3,600-square-mile zone has been off limits to trawl vessels since the mid-1990s. But because of a loophole that allows “mid-water” trawl vessels to fish in the protected area, pollock boats have been exempted. The exemption was based on the assumption that these boats do not drag their nets along the ocean floor.



Over the last decade, according to NOAA's own data, fishing by pollock boats in the savings area has increased significantly, much of it during the early winter season when crab are molting and highly vulnerable. | Klas Stolpe/AP Photo

For at least two decades, though, NOAA scientists have known that these vessels actually make frequent contact with the ocean floor. Last year, the agency published an analysis showing that pollock nets, despite their mid-water designation, are on the ocean floor 40 to 70 percent of the time.

“Trawling that contacts the seafloor is assuredly one of the factors that challenge the red king crab stock,” [agency scientists wrote in the paper](#). And over the last decade, according to NOAA’s own data, fishing by pollock boats in the savings area has increased significantly, much of it during the early winter season when crab are molting and highly vulnerable.

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NOAA Fisheries initially turned the emergency request over to the council, which voted it down in December (the vote was 10-0 with NOAA’s regional administrator in Alaska, Jon Kurland, abstaining). Then, in January, the [agency officially denied the request](#) because it did not “meet the criteria necessary to determine that an emergency exists.” (A similar [emergency request](#) brought by five tribal organizations asking the agency to eliminate chinook salmon bycatch and set hard caps for chum bycatch in the Bering Sea was also denied.)

The council, according to Witherell, has identified the red king crab and snow crab stock as a “priority conservation concern,” and will take additional actions when supported by the scientific data. The council is currently considering implementing additional protection measures to reduce impacts to red king crab habitat, part of a larger review process that will be discussed at meetings this spring.

Stephanie Madsen, executive director of the At-Sea Processors Association, which represents some of the largest pollock fleets in the Bering Sea, said the vessels account for a tiny fraction of crab bycatch and that the nets they use are not designed to bottom trawl. She acknowledged that the nets do make contact with the seafloor, which has been well-known for years, but said the recently published NOAA figures were “overestimates.”

“We’re using the nets that are legally required and there have been no violations, that I’m aware of, of the performance standard,” she said.

Jamie Goen, executive director of the Alaska Bering Sea Crabbers Association, which represents commercial crab boats, doesn’t pin the red king crab decline on the pollock fishery, but said the mid-water trawl vessels could be impeding the species ability to recover at a pivotal moment. NOAA’s own scientists have been urging the council to investigate the impacts of the pollock fishery on crab stocks for well over a decade, she says. Now it might be too late.

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“We’ve been coming forward to the council with different measures that would help these stocks grow,” said Goen. “We’ve been bringing measures forward for years now. What I’m seeing over and over is they [the council] have the best available science in front of them and they choose not to act.”



‘I Do Not Want Them To See Me as a Threat.’

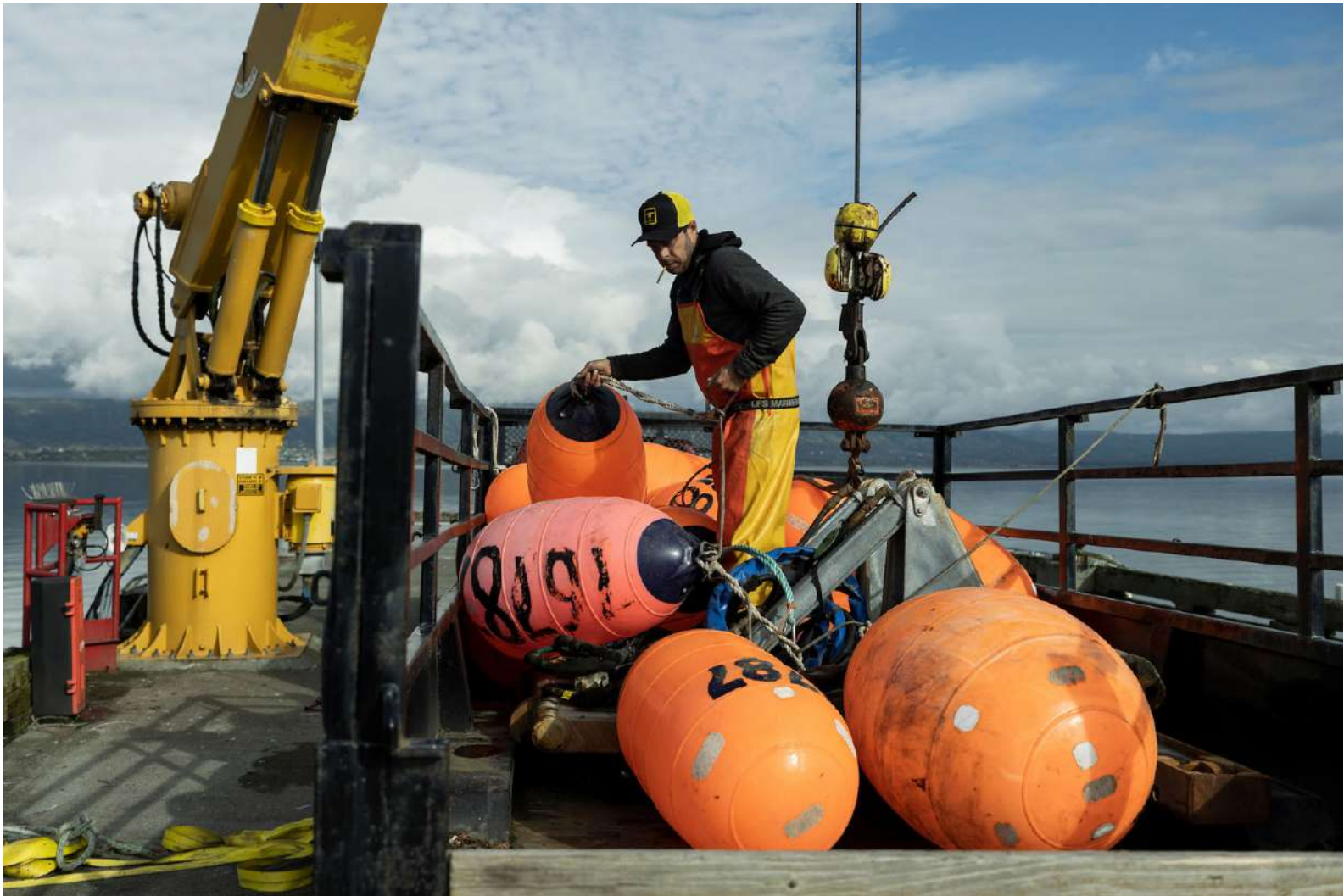
THOUGH PELTOLA WON HANDILY, MANY FISHING GROUPS ARE INCREASINGLY ANXIOUS ABOUT THE POSSIBILITY OF MORE INTENSE FEDERAL OVERSIGHT OF THE INDUSTRY. | MARK THIESSEN/AP PHOTO

Mary Peltola was the only U.S. House candidate in Alaska to openly support the new version of Magnuson-Stevens. Though she won handily, many fishing groups are increasingly anxious about the possibility of more intense federal oversight of the industry.

“I am definitely worried,” said Julie Bonney, the founder and executive director of the Alaska Groundfish Data Bank, which represents about 40 trawl boats and seafood processors based out of Kodiak. Bonney was disappointed that Peltola supported the bill before having met with groups like her own.

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In September, a coalition of more than 150 fishing industry groups (Bonney's, as well as several trade associations representing the trawl sector) sent a [letter to the House Committee on Natural Resources](#), opposing the changes to Magnuson-Stevens. Language that would allow NOAA to further limit bycatch quotas, among other reforms, would lead to “chaos” within the seafood sector and higher prices for consumers, the groups warned.



The reform bill was voted out of committee. If the reauthorization passes, it would be the first major reform of Magnuson-Stevens in 16 years. | Nathaniel Wilder for POLITICO

“A mandate to absolutely minimize bycatch in all circumstances could very well lead to managers or the courts shutting down fisheries where bycatch cannot be eliminated,” they wrote.

About a week later, the bill, with Peltola's support, was voted out of committee. If the reauthorization passes, it would be the first major reform of Magnuson-Stevens in 16 years.

The bill would improve council transparency by establishing stricter requirements related to ethics and lobbying. It would give the Secretary of Commerce greater authority to intervene in council processes if it is determined that a species has been overfished or is "approaching a depleted status." And, for the North Pacific in particular, it would allocate two council seats to Alaska Natives, a provision that Don Young had endorsed before he died in March 2022. In addition, the proposed legislation would invest in research on the impacts of climate change on Alaska's fisheries and make it easier for the Commerce Department to allocate emergency funding in the event of a fishery closure.

If the Magnuson-Stevens reauthorization doesn't pass, the council will continue to operate as it has for decades, which Velsko believes could lead to a larger collapse or terminal decline of the state's commercial fisheries. It has already become increasingly difficult for younger fishermen to enter the industry. And without any assurance that populations will remain stable — or at least at a level that can sustain smaller commercial boats — there's little incentive to invest in larger quotas or equipment. This year's halibut stock assessment showed [continued population declines across most regions](#), which means catch shares for commercial fishermen will likely remain low for years to come. Responding in part to the long-term decline of halibut, NOAA is in the process of adopting a new method of managing bycatch, which will adjust the

annual allocation to the groundfish fishery based on changes in the species abundance

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Goen said it could take three to five years before scientists have a better understanding of whether the snow crab population is likely to recover. Red king crab, once one of the state's most lucrative fisheries, may be a cautionary tale. Both crab fisheries generate more than \$250 million in revenue annually and support thousands of jobs in coastal communities across Alaska. The industry will have about 2 million pounds of tanner crab to harvest this year, enough for two or three vessels out of a fleet that is normally made up of about 60 boats, according to Goen.

"Boats are going to be tied up," she said. "They're not going to be able to pay their moorage fees. Their insurance. Or maintenance."



It's still going to take decades for us to gain ground," Peltola said. "If we do everything right and if we do it now." | Nathaniel Wilder for POLITICO

According to Peltola, it could take a generation for chinook and chum salmon to return to levels needed to sustain Native communities and the roughly 25,000 residents along the Yukon and Kuskokwim rivers. And, she says, that's only if measures are put in place to protect the species and the larger ecosystem, now under enormous pressure from a rapidly warming climate, among other factors. "It's still going to take decades for us to gain ground," Peltola said. "If we do everything right and if we do it now."

But Magnuson-Stevens, in its current form, will face stiff opposition in a narrowly divided Republican-controlled Congress, not only from the trawl industry and its lobbyists, but possibly from the rest of the Alaska delegation.



Trident Seafoods is was one of the top contributors to both Sen. Murkowski and Sullivan's most recent electoral campaigns. | Christoph Mohr/picture-alliance/dpa/AP

Trident Seafoods, one of the largest operators in Alaska with nearly two dozen pollock boats and 11 onshore processing plants, was one of the top contributors to both Sen. Lisa Murkowski and Sen. Dan Sullivan's most recent electoral campaigns and has spent close to \$200,000 lobbying on issues related to the

legislation in the past two years. Trident is a member of the At-Sea Processors Association, which signed the letter opposing the bill. The [company also had close ties](#) to [Don Young](#), who was viewed by industry as one of the only members of Congress with the credibility and stature to get a bill like Magnuson-Stevens through both the House and Senate.

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“We are concerned some of the changes proposed to MSA could undermine regional authority and overburden Council resources at a time they are strained,” Trident Seafoods said in a statement. “We believe the broad structure of MSA provides sufficient framing to advance integrating climate impacts, adaptation, and more resilience into management.”

Sullivan is a member of the Commerce subcommittee that oversees fisheries and would be closely involved in any effort to draft a Senate version of the bill. (Sullivan’s office did not respond to requests for comment.) Murkowski, [in a](#)

[recent interview](#) with Alaska Public Media, said any changes to Magnuson-Stevens need to be carefully considered because of its potential impact to Alaska's economy.

After Young's death last March, the House delayed work on the legislation until his seat was filled. But the version voted on by the committee in September, after Peltola won the special election to serve the remainder of his term, has not been endorsed by a single Republican. Rep. Bruce Westerman (R-Ark.), who now chairs the House Committee on Natural Resources, described it as "blatantly partisan legislation," that Young never would have supported. A spokesperson for Rep. Jared Huffman (D-Calif.), who sponsored the legislation, said he plans to reintroduce the bill later this year but would not comment on whether any changes will be made.



Pro-Fish stickers on display at a campaign event for Peltola at the International Brotherhood of Electrical Workers Local 1547 in Anchorage, Alaska. | Patrick Fallon/AFP via Getty Images

Peltola was also a good friend of Young's and has kept several of his former staffers and policy advisers on her team, including his [chief of staff](#) — a nod, she has said, to Young's legacy of working with members of both parties. Even

as she takes on one of the most powerful industries in the state, Peltola has vowed to follow in his footsteps.

“I do want to work with them,” Peltola said, referring to the trawl industry. “I do not want them to see me as a threat.”

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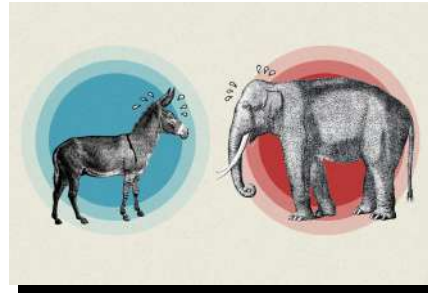


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Cetacean Interactions with Trawls: A Preliminary Review

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Abstract

Cetaceans interact with trawls to an undetermined extent. A preliminary review of global data indicates that individuals of 25 cetacean species (two mysticete, 23 odontocete) have been documented to have died in working trawls or discarded trawling gear. Cetacean interactions with trawls are complex, in part because both fishermen and cetaceans are drawn to areas of high prey density. Furthermore, within such areas, cetaceans are probably often attracted to trawling activities because they make it easier for the animals to exploit a concentrated food source. Individuals of 15 (possibly 16) cetacean species (13 odontocete, and one or even two mysticete) have been reported to feed in association with trawls. Animals follow working nets (feeding on stirred-up organisms or fish gilled in mesh) and also feed on discarded by-catch. Damage to gear as a result of feeding interactions or entanglement has been reported. Such damage results in (1) harm to the animals, (2) creation of negative opinions of cetaceans by fishermen (regardless of whether a cetacean or a shark is, in fact, responsible for the damage in question), and (3) loss of time and money for repair and replacement of gear. The relationships of cetaceans with trawls need to be further studied to determine what effects the trawl fisheries have on the ecology and population status of the whales and dolphins involved.

Key words: behaviour, by-catch, cetacean, feeding, fishery interaction, mysticete, odontocete, trawl

Introduction

Interactions between various cetacean species and fisheries are geographically widespread and diverse (see reviews in Northridge, 1984, 1991; Currey *et al.*, 1990, 1991). Interactions are potentially harmful to cetaceans (e.g. depletion of fish stocks, direct kills in fisheries, and incidental captures in fishing gear) and to humans (e.g. gear damage and depletion of commercially valuable fish stocks) (Beddington *et al.*, 1985). Incidental catches of cetaceans in nets, especially purse seines, gillnets, and drift nets, are extensive and cause considerable mortality (Bjørge *et al.*, 1991; Perrin *et al.*, 1994). Mortality in trawls has been less frequently reported and all but ignored in evaluations

of fisheries impacts, even though many of the causes of catches in trawls are similar to those associated with gillnet captures.

Many fisheries in the world use trawl nets (Nedelec and Prado, 1990). Trawl nets are towed nets consisting of a cone-shaped net with a cod-end or bag for collecting the target species. Trawls can be bottom, midwater, or surface, and are operated from one, or occasionally two, boats to take various species of fishes, squids and crustaceans. Many national fishing fleets include a broad class of trawlers, ranging from small coastal trawlers to large catcher/processing vessels. To a large degree, net size and type (bottom, midwater, etc.) is dependent on vessel size (i.e. fishing power).

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² Deceased January 1997

Incidental takes of cetaceans exist in most areas where trawling occurs, for example, the North Sea, Bering Sea, Atlantic Ocean, Gulf of Mexico, Gulf of California, Mediterranean Sea, Indian Ocean, and waters off Australia and New Zealand (Appendix 1). Information on the numbers of animals caught and the causes of by-catches in trawls is not readily accessible (e.g. it is often embedded in the literature on gillnets); this paper compiles and summarizes existing information.

Cetacean catch and composition

Individuals of two mysticete species, 23 odontocete species, and several unidentified cetaceans (including beaked whales) have been documented to have been incidentally caught in trawls (Appendix 1 and 2)¹. The condition of incidentally caught cetaceans varies. It has been suggested that cetaceans found in nets are rarely alive when caught, and that dead or dying animals are sometimes scooped up as the nets pass (T. Loughlin, National Marine Mammal Lab., Seattle, WA, USA, pers. comm., 1991). There are a number of reports of trawls bringing up dead and decomposed bodies of cetaceans (Scheffer and Slipp, 1948; Testaverde, 1978; Perez and Loughlin, 1991), as well as skulls (Anonymous, 1979; Smith *et al.*, 1989; Lake, MS 1995). Some workers contend that healthy cetaceans should be able to avoid trawl nets easily, since the vessels' forward progress is quite slow (van Utrecht, 1978; Niazi, 1990; T. Loughlin, pers. comm., 1991). This is clearly not the case for pinnipeds that interact with trawls, many of which are caught alive and perish in the nets [e.g. Steller sea lions (*Eumetopias jubatus*) (Alverson, 1992); Cape fur seals (*Arctocephalus pusillus*) (Shaughnessy and Payne, 1979); Hooker's sea lions (*Phocarctos hookeri*) (MAF Fisheries, 1991); northern fur seals (*Callorhinus ursinus*) (Perez and Loughlin, 1991); California sea lions (*Zalophus californianus*) (Miller *et al.*, MS 1983), and New Zealand fur seals (*Arctocephalus forsteri*) (MAF Fisheries, 1991)]. Similarly, most cetaceans caught alive in trawls die, while few can be released alive (Appendix 1). One incident involved a minke whale (*Balaenoptera acutorostrata*) harpooned in Newfoundland that was found with trawl mesh web grown into its rostrum (D. E. Sergeant, Hudson, Quebec, Canada, pers.

comm., 1992). It was thought that this whale had been cut out of a trawl net at some point in its life.

Why do cetaceans become caught in trawls? Trawling is an active fishing process; therefore, cetaceans are probably aware of the net and the boat's activity. Engines on trawlers produce a characteristic sound, particularly when changing stages of operation. It has been suggested that some odontocetes are able to acoustically distinguish between stages of trawl operation. Bottlenose dolphins (*Tursiops truncatus*) are sometimes attracted when nets are deployed (e.g. Gunter, 1954) and have been seen approaching shrimp boats to wait for by-catch to be culled (e.g. Norris and Prescott, 1961; Leatherwood, 1975; Delgado-Estrella, MS 1991). Killer whales (*Orcinus orca*) have been observed to do the same with trawlers in the Bering Sea (J. R. Heimlich-Boran, Cambridge, UK, pers. comm., 1991). Gruber (MS 1981) documented various reactions of bottlenose dolphins to operational stages, including following the net as it was being hauled in and, at other times, switching to boats trawling in the vicinity. On the other hand, Fertl (MS 1994) suggested that factors other than just the trawler's operational stage, such as social interactions, may play an important part in dolphin movements around shrimp boats.

A variety of biological factors can influence catches of marine mammals: species distribution, various behavioral traits, sensory capacities, and attention and searching images (Nelson, 1990). Many of the possible causes of cetacean entanglement in gillnets (IWC, 1994) can be applied to catches of cetaceans in trawls; for example, behavior (curiosity, exploration, attention and perception, social patterns, and feeding) of the cetacean appears to be an important consideration. It has been reported that there have been higher catches of cetaceans in trawls at night (Waring *et al.*, 1990; Maigret, 1994; Baird, 1995; Crespo *et al.*, 1997); Maigret (1994) suggests that this is perhaps the time that dolphins (e.g. *Delphinus* spp., and *Stenella* spp.) are moving slowly near the surface and are less alert, while Waring *et al.* (1990) noted that the reason higher catches of *Delphinus* spp. occur at night is not readily apparent, but did seem related to a behavioral phenomenon of the

¹ A northern right whale (*Eubalaena glacialis*) was reported as having been caught in a trawl [the single incident was reported in O'Hara *et al.* (1986), Waring *et al.* (1990) and Kraus (1990)]. Kenney and Kraus (1993) published a correction to this; therefore, this species is not included in the tally.

dolphins. Unfortunately, there is little systematic knowledge of many behavioral processes that cause cetaceans to be vulnerable to incidental takes in fishing gear (IWC, 1994).

Feeding behavior

Marine mammals frequently exploit fisheries for food. California sea lions, bottlenose dolphins, and botos (*Inia geoffrensis*) are known to remove fish from nearshore gillnets (Everitt *et al.*, 1981; Cato and Prochaska, 1976; S. Leatherwood, unpubl. data, respectively); bottlenose dolphins (Cato and Prochaska, 1976; Iversen, MS 1975), rough-toothed dolphins (*Steno bredanensis*) (Iversen, MS 1975), false killer whales (*Pseudorca crassidens*) (Leatherwood *et al.*, 1989), and killer whales (Sivasubramanian, 1964) steal hooked fish; and long-finned pilot whales (*Globicephala melas*) frequent traps to remove the target species, which is the squid *Illex illecebrosus* (Lien, 1994). It appears that some cetacean species, like pinnipeds, are attracted to trawl nets because of the easy food source they represent (e.g. Shaughnessy and Payne, 1979; Beddington *et al.*, 1985).

Individuals of at least 15–16 cetacean species (13 odontocete and two, possibly three mysticete) have been documented to feed in association with trawling (Table 1, Appendix 3). Such associations appear to occur in all areas of the world. Individuals exploit food concentrated by trawling operations. This process is best illustrated by the long-standing relationship between bottlenose dolphins and shrimp trawlers, in which the dolphins show readiness to make use of a variety of easily procured food items (e.g. Leatherwood, 1975; Gruber, MS 1981; Corkeron *et al.*, 1990; Fertl, MS 1994).

Animals tend to be attracted to food that is clumped or patchy in distribution (Krebs, 1978). A trawler might well be considered as a mobile patch. By remaining with this moving patch, in which available food is frequently concentrated, dolphins presumably can reduce the proportion of time spent foraging (searching for and consuming food) and possibly increase the quantity and quality of the food they do consume. The less time they spend foraging, the less energy they use. By this logic, trawling may provide an abundance and diversity of food in a small area and permit the cetaceans to select food of higher-than-usual caloric value.

Fishing operations may also open up some food niches not otherwise available to some cetaceans,

such as in the Alaskan fishery for sable fish (*Anoplopoma fimbria*) (Matkin *et al.*, 1986). Killer whales are often observed taking sablefish from long lines; these fish otherwise live too deep for killer whales to catch them (Matkin and Saulitis, 1994). There are two reports of humpback whales (*Megaptera novaeangliae*) feeding behind trawl nets (von Ziegeler, 1984 in NMFS, 1991; D.E. Sergeant, pers. comm., 1992). Sergeant suggested that, since humpback whales usually do not dive very deeply, the additional food supply brought up by trawl nets gives the whales a broader feeding resource (D.E. Sergeant, pers. comm., 1992). There is, however, little evidence to demonstrate that, for humpback whales, associating with trawl fisheries is really beneficial.

There is considerable overlap of prey species in the stomachs of cetaceans that have been feeding opportunistically around trawlers and on prey species that are targets of commercial trawl fisheries or in stomachs of target species of the commercial fishery. Analyses of stomach contents of bottlenose dolphins from the Gulf of Mexico (Barros and Odell, 1990) indicated prey composition similar to that of the non-shrimp catches of shrimp boats (Bryan, MS 1980; Pellegrin, 1982). Pellegrin (1982) calculated an overall fish/shrimp ratio (measured in tons) in by-catches of the Gulf of Mexico shrimp fishery of 9.1:1. Stomach contents of pilot whales (*Globicephala* spp.) caught in the North Atlantic mackerel (*Scomber scombrus*) fishery suggested that mackerel may be a major component of the pilot whales' diet, though feeding on Atlantic mackerel may well be an opportunistic phenomenon related only to the fishery (Waring *et al.*, 1990; Overholtz and Waring, 1991). Analysis of stomach contents of trawl-caught Atlantic white-sided dolphins (*Lagenorhynchus acutus*), bottlenose dolphins and common dolphins (*Delphinus* spp.) southwest of Ireland showed that the dolphins were feeding on the target species of the fishery (Couperus, 1997). Couperus also noted that, based on otoliths retrieved from their stomachs, the white-sided dolphins appeared to have had a completely different diet before they arrived in the area and fed in association with trawling activities. The above observations do not necessarily indicate that the cetaceans are scavenging from trawls, but they do show that they are exploiting the same species targeted by the fisheries. Cetaceans could be feeding on fish that are ancillary to the catch (as is the case for bottlenose dolphins feeding in association with the shrimp fishery) or feeding on

TABLE. 1. Worldwide interactions (feeding or bycatch) of cetaceans with trawl nets. • = reports of bycatch; Δ = reports of feeding association; * possible record; × marked as unidentified pilot whale species during feeding associations, it is most likely this species; + marked as *Delphinus delphis* before Heyning and Perrin (1994) on genus *Delphinus*.

Minke whale (<i>Balaenoptera acutorostrata</i>)	•		
Fin whale (<i>Balaenoptera physalus</i>)	Δ		
Humpback whale (<i>Megaptera novaeangliae</i>)	•	Δ	*
Finless porpoise (<i>Neophocaena phocaenoides</i>)	•		
Dall's porpoise (<i>Phocoenoides dalli</i>)	•		
Harbor porpoise (<i>Phocoena phocoena</i>)	•	Δ	
Vaquita (<i>Phocoena sinus</i>)	•		
Sperm whale (<i>Physeter macrocephalus</i>)	•		
Commerson's dolphin (<i>Cephalorhynchus commersonii</i>)	•		
Heaviside's dolphin (<i>Cephalorhynchus heavisidii</i>)	•		
Hector's dolphin (<i>Cephalorhynchus hectori</i>)	•	Δ	
Common dolphin (<i>Delphinus</i> spp.)+	•	Δ	
Short-finned pilot whale (<i>Globicephala macrorhynchus</i>)	•		
Long-finned pilot whale (<i>Globicephala melas</i>)	•	Δ	×
Risso's dolphin (<i>Grampus griseus</i>)	•		
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>)	•	Δ	
White-beaked dolphin (<i>Lagenorhynchus albirostris</i>)	•		
Peale's dolphin (<i>Lagenorhynchus australis</i>)	•		
Pacific white-sided dolphin (<i>Lagenorhynchus obliquidens</i>)	•		
Dusky dolphin (<i>Lagenorhynchus obscurus</i>)	•		
Killer whale (<i>Orcinus orca</i>)	•	Δ	
Tucuxi (<i>Sotalia fluviatilis</i>)	Δ		
Indo-Pacific hump-backed dolphin (<i>Sousa chinensis</i>)	Δ		
Striped dolphin (<i>Stenella coeruleoalba</i>)	•	Δ	
Atlantic spotted dolphin (<i>Stenella frontalis</i>)	•	Δ	
Spinner dolphin (<i>Stenella longirostris</i>)	•	Δ	
Bottlenose dolphin (<i>Tursiops truncatus</i>)	•	Δ	
Franciscana (<i>Pontoporia blainvillei</i>)	•		
Northern bottlenose whale (<i>Hyperoodon ampullatus</i>)	Δ		

the fishery target species (such as the association of pilot whales with the Atlantic mackerel fishery in the northeastern United States) (see Appendix 3 for sources). A cetacean could be attracted to nets because of prey caught in the trawl nets, as well as scavengers feeding on fish caught by the nets. One dramatic example of the latter was reported for the Bering Sea, where killer whales pursued Steller sea lions that were waiting to feed on discarded bycatch from a trawler (Branson, 1971).

The bottlenose dolphin is the cetacean species most often documented to feed in association with trawls. Leatherwood (1975) describes three feeding patterns that bottlenose dolphins use when associating with shrimp boats: (1) foraging behind working boats, (2) feeding on trash fish discarded or fallen from the net, and (3) feeding on fish

attracted to non-working shrimpers. The vast majority of episodes of cetaceans feeding around trawls involve feeding behind working trawlers (Appendix 3). In such instances, the animals typically follow a vessel and feed on organisms stirred up by the trawl, pick out fish entangled in the net's mesh, or possibly feed on fish that pass through the mesh. It is reasonable to assume that in all three of these circumstances the prey are dead, injured, or disoriented and therefore easier for the dolphins to catch than individuals of the same species that are healthy and actively avoiding capture. Bottlenose dolphins, pilot whales (*Globicephala* spp.), and Indo-Pacific hump-backed dolphins (*Sousa chinensis*) have been observed feeding around the mouth of nets (bottlenose dolphins: Fertl, MS 1994; Delgado-Estrella, MS 1991; Leatherwood, unpubl. data; pilot whales:

Waring *et al.*, 1990; Indo-Pacific hump-backed dolphins: S. Leatherwood, unpubl. data), presumably on fish escaping the net's pathway. In interviews, many Gulf of Mexico shrimpers told one of us that they had witnessed bottlenose dolphins entering trawl nets to feed. Crespo and Corcuera (1990) provided similar reports of dolphins (unid. species) in Argentine waters moving into and out of trawl net mouths to feed

Opportunistic feeding by cetaceans in association with fisheries is perhaps best exemplified by cetaceans feeding on discarded by-catch. This behavior has been described for killer whales in the Bering Sea and off the Shetland Islands (Teshima and Ohsumi, 1983; Couperus, 1994, respectively) and bottlenose dolphins in the Gulf of Mexico (e.g. Caldwell and Caldwell, 1972; Leatherwood, 1975; Gruber, MS 1981), southeastern United States (Davis, 1988), and Moreton Bay, Australia (e.g. Corkeron *et al.*, 1990; Wassenberg and Hill, 1990). Typically, the animals have been seen to wait alongside the vessel for by-catch to be discarded. Wassenberg and Hill (1990) calculated that dolphins scavenging behind a trawler can eat about 86% of fish discarded from a single trawl. In observations of bottlenose dolphins feeding on trash fish, the dolphins were found to show preferences for some prey species over others (Shane, MS 1977; Gruber, MS 1981; Corkeron *et al.*, 1990; Wassenberg and Hill, 1990; Fertl, MS 1994).

Leatherwood (1975) suggested that bottlenose dolphins have learned the advantages of following and feeding in conjunction with shrimp boats. Females with calves, in particular, have been observed following shrimp boats, and it has been speculated that the calves learn this foraging behavior by observation and participation (Shane *et al.*, 1986). Studies of other marine mammals, such as sea otters (*Enhydra lutris*) and killer whales, have suggested that youngsters develop feeding skills through imitation of the mother's feeding behaviors (Riedman *et al.*, 1989; Guinet, 1991 and Guinet and Bouvier, 1995). It has been speculated that females with calves may be taking advantage of the concentrated food resource provided by shrimp boats to meet increased energetic needs due to lactation (Fertl, MS 1994; P. Corkeron, Univ. of Sydney, Sydney, Australia, pers. comm., 1993). Lactating mammals have greater energetic needs, and may need to eat greater quantities of food or change to a diet richer in nutrients (Bernard and

Hohn, 1989). Caloric consumption by captive, lactating bottlenose dolphins in the six months following parturition increases from 129% to 204% of that of resting dolphins (Ridgway *et al.*, 1992). The association of cetaceans with trawls may well be a strategy to increase the rate of feeding, while decreasing the energy expenditure associated with foraging.

The association of cetaceans with trawls indicates the behavioral flexibility of these animals to capitalize on human activities. This feeding pattern may be beneficial in that it reduces time required to forage, and provides the animals with an easier way to obtain food that is outside their usual foraging depths or otherwise too energetically costly for them to exploit. Associations with working trawlers may be harmful in that it may expose dolphins to greater risk of injury or death. Corkeron *et al.* (1990) noted that bottlenose dolphins spent seemingly "unnecessary" time taking preferred items in shrimp boat by-catches, appearing to place themselves at a greater risk of shark attack; at least one dolphin was known to have been bitten by a shark while following a trawler. There also may be cause for concern that generations of dolphins that have fed largely or exclusively in association with such fisheries may be at disadvantage when these fisheries collapse.

Gear damage during feeding

Many trawl fishermen blame dolphins for holes in their nets (Gunter, 1942, 1944, 1951, 1954; Cadenat, 1957; Ravel, 1963; Reynolds, 1985; Northridge, 1984, 1991; dos Santos and Lacerda, 1987; Bearzi and Notarbartolo di Sciara, 1992; Consiglio *et al.*, 1992; Silvani *et al.*, 1992; Fertl, MS 1994), but such damage may likely be as a result of sharks tearing at the nets (as reported in Shane, MS 1977; Gruber, MS 1981; Delgado-Estrella, MS 1991; Fertl, MS 1994) as from dolphins attempting to pull fish out of the nets. The areas with the most frequent complaints appear to be the Mediterranean and the Gulf of Mexico, and the species most fishermen blame is the bottlenose dolphin (when species was designated). Gulf of Mexico shrimpers insisted that dolphins were "attacking" the nets in response to low fish productivity in the area (Fertl, MS 1994).

Attempts to reduce damage to trawl nets on the Gulf Coast of the United States and the Mediterranean have included the use of firecrackers detonated near the animals and bullets fired into

the water nearby (Gunter, 1944; Cadenat, 1957; Reynolds, 1985; Bearzi and Notarbartolo di Sciara, 1992; Consiglio *et al.*, 1992; Silvani *et al.*, 1992; Fertl, MS 1994). Acoustical deterrents appear to be successful only for a very short time period, if at all (Caldwell and Caldwell, 1972; Consiglio *et al.*, 1992). Non-acoustical methods used by shrimp fishermen include tying ribbons to nets and installing an extra skirt on the net to frighten dolphins away; these methods have met with mixed results. On the coast of the Adriatic and Tyrrhenian seas, there is a story of fishermen putting a fake dolphin in the net — like a scarecrow — to scare dolphins away. The results were apparently good for a few days, but then the dolphins "saw the cheating" and tore the nets with their teeth (L. Marini, Univ. of Rome, Rome, Italy, pers. comm., 1993).

Holes in nets and incidental captures of dolphins can result in loss of fishing time, while the crew disentangles carcasses or live animals, and loss of money while crews fix or replace damaged gear. Dolphins sometimes blunder into a tow or handling line and do minor damage while struggling to free themselves (Leatherwood and Reeves, 1982; Fertl, MS 1994). Netting and rope may be lost in trying to free live or dead cetaceans. In one instance, a net was cut to release a bottlenose dolphin caught in a groundfish trawl (C. Pharr, NMFS, Pascagoula, Mississippi, USA, pers. comm., 1991). In another, a stranded bottlenose dolphin from Mississippi was found lodged in a complete, small trawl net (stranding record SE3983, Southeast U.S. Stranding Network Region). Northridge (1988) reported an incident of a pilot whale (*Globicephala* spp.) that became lodged in a trawl and drowned; the net was subsequently lost.

Distribution of entanglements

It is not surprising that cetaceans and humans that exploit similar food resources have overlapping ranges. Potential cetacean and trawl fishery interactions are likely to occur when spatial and temporal habitat use coincides, for example, Atlantic white-sided dolphins and trawlers both taking migrating mackerel southwest of Ireland (Couperus, 1997) and white-beaked dolphins (*Lagenorhynchus albirostris*) and midwater trawlers taking spawning herring in the North Sea (Northridge, 1988). The frequency with which individuals of a cetacean species are caught accidentally in trawls is a function of the abundance of that species in a fishing area, as well as

operational characteristics of the fishery. For abundant species in heavily fished areas, it would be surprising if some animals were not taken in fishing nets. For example, high catch rates in the North-west Atlantic may be related to the distribution of fishing effort in particular areas of high pilot whale density (Northridge, 1991). Harbor porpoises (*Phocoena phocoena*), generally found near-shore, may be particularly susceptible to incidental captures because inshore areas are often heavily fished (Nelson, 1990). Movements and seasonal changes in distribution of a species will be reflected in seasonal and geographic differences in net catches (it should be noted that in some fisheries, the fishing effort in certain areas may be very different interannually, depending on the market situation, quota regulations, and behavior of fish schools, particularly if they are a pelagic species). Some species' abundance, however, may have little connection to catch rates. For example, the size and behavior of the animal, and net size could determine the possibility of the animal's being caught.

Gear characteristics

Individuals of more cetacean species are caught in mid-water trawls than in bottom trawls. Northridge (1988) discussed several reasons why mid-water gear is more likely to catch cetaceans. First, mid-water nets generally target small pelagic fish species, which are often the same species preyed upon by marine mammals. Second, mid-water gear is generally towed at relatively high speeds. Finally mid-water trawls are generally much larger than most demersal trawls. Niazi (1990) speculated that the smaller size and openings of bottom trawls in Pakistan make them harmless to finless porpoises (*Neophocaena phocaenoides*). Whether he felt the trawl openings were small enough to deter animals from entering the nets is not clear. Pair trawlers tow nets with higher headlines and greater overall dimensions and they tow them faster than single trawlers (Anonymous, 1981; Kuiken *et al.*, 1994); pair trawlers account for about 50% of all cetacean catches in waters off New Zealand, with gillnets and single trawlers making up the remainder (Anonymous, 1981).

Northridge (1988) and Waring *et al.* (1990) speculated that the mouth in many trawl nets permits dolphins to enter and get caught. It is generally thought that some individuals enter the trawl and become trapped when the boat stops hauling and the trawl entrance collapses

("haulback") (Clausen and Andersen, 1988; Northridge, 1988; Waring *et al.*, 1990) or when the net is being put out into the water ("shot") (Moreno, 1993), and then the net is relatively shapeless and slow-moving. This is the time when many pinnipeds appear to become caught (e.g. MAF Fisheries, 1991). It is highly probable that many cetaceans trapped during shooting or haulback are alive when caught, but die because the nets are kept in the water for long periods of time before being checked. Bottlenose dolphins in the Gulf of Mexico have been reported with their rostrums caught in the net mesh, perhaps when pulling fish scraps from the nets (Leatherwood and Reeves, 1982; R. Ford, NMFS, Pascagoula, Mississippi, USA, pers. comm., 1991); one bottlenose dolphin in the Gulf of Mexico was caught by its teeth in the net, but was released alive (Fertl, MS 1994). Ironically, there are two separate reports of bottlenose dolphins that were found caught in turtle excluder devices (installed on trawls to allow turtles caught as by-catch to escape from shrimp trawls) (Burn and Scott, 1988; Fertl, MS 1994).

Behavior and social structure

Cetacean social structure may play a significant role in incidental capture potential. Incidental catches of pilot whales (*Globicephala* spp.), very social cetaceans, often involve multiple animals (G. Waring, NMFS, Woods Hole, Massachusetts, USA, pers. comm. 1991). Cetaceans that forage in dense groups, such as common dolphins (*Delphinus* spp.) and pilot whales (*Globicephala* spp.), often become victims of trawls (Waring *et al.*, 1990). Where cetaceans feed in the water column also affects how frequently they are caught. For example, the frequent feeding at mid-water depths may account for the large number of cetaceans (e.g. pilot whales, *Globicephala* spp., common dolphins, *Delphinus* spp., and harbor porpoise) trapped in mid-water trawls.

It appears that of all cetaceans captured, a disproportionate number are young animals (Teshima and Ohsumi, 1983; Corkeron *et al.*, 1990; Niazi, 1990; Vidal, MS 1990; V. Cockcroft, Port Elizabeth Museum, Humewood, South Africa, pers. comm., 1992). Most of the common dolphins (*Delphinus* spp.) killed in squid (*Loligo*) and Atlantic mackerel fisheries are likely sexually immature (Waring *et al.*, MS 1990). Vidal (MS 1990) suggested that because vaquita (*Phocoena sinus*) calves move too slowly they become trapped in trawls. It is also probable that young cetaceans

are caught because of their inexperience with fishing gear (Nelson, 1990). Young animals may learn safe movements around nets by watching conspecifics. Phocoenids have a shorter dependency period and shorter lifespan than delphinids (Gaskin, 1984; Perrin and Reilly, 1984), and thus, have less opportunity to learn from their mothers or conspecifics. Tyack (1986) reviewed the importance of a long period of parental care as it relates to the importance of social learning in odontocetes. It is also probable that younger animals are not as attentive as adults to the dangers that nets pose, and become caught accidentally, panic, and are unable to free themselves. Young cetaceans may also be greater "risk takers" than adults (Nelson, 1990), as is true in most animal species (Fagen, 1981).

Lack of attention (also discussed in IWC, 1994, for gillnet captures) may be another reason for incidental takes. Mature cetaceans, as well as young and inexperienced individuals, may become "careless" around nets. Attention to social activity, such as play, may distract individuals. Trawl fishermen insist that dolphins do not get caught in their nets because they are too fast and too smart (Davis, 1988; Moreno, 1993; Fertl, MS 1994). Bottlenose dolphins sometimes drown when they are caught around the tail stock in the hanging line of the trawl (Fertl, MS 1994). We have witnessed several episodes of bottlenose dolphins playing with lines while nets were being pulled.

Additional considerations

Discarded or lost gear. Entanglement in discarded gear is an often over-looked, but important, problem. Trawl fisheries are major activities in the North Pacific Ocean, with 5 500 km of nets in use (Uchida, 1985). When proportions of litter were studied on southeastern Alaska beaches, 76–85% by weight consisted of trawl-web fragments (Low *et al.*, 1985). There are many reports of marine mammals becoming entangled in trawl webbing (O'Hara *et al.*, 1986), but few data on the numbers of entangled animals that die. Fowler (1982) has shown that entanglement in trawl net fragments could account for about a 5% mortality rate of northern fur seals a year. These fragments may act as ghost nets, not unlike fragments of monofilament gillnet. It is probable that some of these fragments may have food organisms in them. One sperm whale (*Physeter macrocephalus*) stranded in Oregon was reported to have had approximately one liter of tightly packed trawl nets in its stomach (Mate, 1985). De-

spite the link between frequency of entanglement and resultant death, there seems little doubt that this, and perhaps other kinds of operational interaction arising from the increased trawling in the Bering Sea, is a major factor in determining the otherwise inexplicable decline of the northern fur seal (Beverton, 1985) and Steller sea lion (Alverson, 1992).

Ecological/Resource Depletion. There has been some concern that trawling may disperse and alter distributional features of prey species for some cetaceans and other marine mammals. Biomass of epifaunal organisms has dropped dramatically in some areas due to trawling, and changed the dominant species of fish caught (Sainsbury, 1988 in Hutchings, 1990). The Steller sea lion has already experienced a population collapse, reputedly from the vast overfishing in its habitat (Alverson, 1992). Populations of these sea lions are suggested to be in danger because of a nutritional deficiency resulting from the absence of fatty fishes in their diet (Alverson, 1992). Similar impacts may gravely endanger cetaceans in areas of heavy trawl-fishing, such as the Bering Sea, Mediterranean Sea, and Gulf of Mexico. It has been thought that shrimp trawling operations have a net beneficial effect for bottlenose dolphins, providing more easily captured food (Wang *et al.*, 1994); however, while trawling (of any type) may open up new feeding niches, it probably destroys others. As noted earlier in this paper, bottlenose dolphins may currently be taking advantage of the easily concentrated food resource that shrimp boats provide, but future generations may be disadvantaged by shifts, or even severe declines, in prey species. Trawl fisheries not only affect takes of target species, but also the food web. For example, high-seas trawl fisheries off Patagonia take hake (*Merluccius hubbsi*) as one of their targets. Hake is a predator of anchovy, the main prey item of dusky dolphins (*Lagenorhynchus obscurus*) (Crespo *et al.*, 1997). Unbalancing of the marine ecosystem may cause shifts that initially seem beneficial to the dolphins, but may soon or ultimately prove detrimental to all participants in the system.

Concluding Remarks

Intensive trawling occurs in many areas of the world, with resulting incidental catches of cetaceans. However, considering the intensive trawl fisheries that exist in some areas, it appears that

comparatively smaller numbers of cetaceans are caught by trawls in contrast to other fishing gear such as purse seines (Coe *et al.*, 1985; Bjørge *et al.*, 1991) and gillnets (Leatherwood, 1994; Perrin *et al.*, 1994).

Cetacean distribution, social structure, and behavior are important biological factors that interact with characteristics of trawl nets to cause entanglements. Cetacean feeding habits may be important in many of the incidental captures. In fact, common dolphins (*Delphinus* spp.) in New Zealand (Anonymous, 1982) and bottlenose dolphins in the Gulf of Mexico (Leatherwood, 1975) feed on fish attracted to non-working trawlers; when boats are anchored at night, their lights often attract fish and other animals to feed. Trawlers may make it easier for individuals, especially juveniles, old individuals, or mothers with calves, to capture food that is otherwise difficult (in volume) for them to catch.

As also reported by the IWC (1994): entanglements may occur where the target species are prey or potential prey for cetaceans; the fish caught are not prey species but cetaceans are attracted to the nets because other potential prey are associated with the net; the target and incidental species are seeking similar prey; or the cetaceans and fisheries occur in the same vicinity for reasons related to physiography and biological productivity. In general, the behavior of cetaceans near nets is poorly understood. Several additional causes for these bycatches may be an individual's inattention or inexperience, and patterns of social interactions.

In summary, the evidence summarized in this report, while preliminary, suggests that fishing trawls can represent a significant source of cetacean mortality and that inadequate attention has been paid to this problem to date. Existing data do not permit us to determine the relative incidence of such mortalities among the different trawl types: sample sizes are too small, and many areas have no observer coverage. However, it seems likely that the greatest potential for conflict exists with mid-water and surface trawls operating in areas of high cetacean density, notably where both fishermen and cetaceans target the same prey.

It can probably be taken for granted that, as with gillnet fisheries, the number of cetacean mortalities reported by trawl fishermen underrepresents the

true situation. Fear of prosecution or other legal sanctions (and absence of observers) probably results in many or most incidentally killed animals being discarded. Because an assessment of this problem is not possible without directed research, we recommend that an observer program be established to collect information on the frequency of cetacean mortality among the various types of trawling operations. Observer data would also permit an assessment of the extent to which mortality rates differ by area and by target fish species. Inevitably, this research must be conducted in concert with studies to address broader biological and management questions relating to abundance, population structure, and seasonal movements of the cetacean species concerned.

Acknowledgements

Drafts of this manuscript were improved by comments from P. Clapham, V. Cockcroft, A. S. Couperus, T. Jefferson, R. R. Reeves, J. Sigurjonsson, J. Stern, B. Würsig, and an anonymous reviewer. T. Jefferson, A. Schiro, and L. Haase helped locate and double-check pertinent references. Communications with the following people provided valuable insight, vital documents, and unpublished numbers: R. Baird, S. J. Baird, J. Barlow, G. Bearzi, P. Best, B. Clausen, V. Cockcroft, P. Corkeron, H. Coulson, A. S. Couperus, K. Dudzinski, M. Earle, R. Ford, J. Gruber, J. Heimlich-Boran, T. Jefferson, R. Kenney, T. Loughlin, L. Marini, R. Mattlin, P. Moreno, K. Mullin, G. Notarbartolo di Sciarra, M. Perez, C. Pharr, C. Rogers, G. Rountree, D. E. Sergeant, G. Silber, E. Slooten, K. Teshima, O. Vidal, K. Wang, and G. Waring. R. Ortiz and J. Rodriguez helped with translations. This represents contribution number 57 of the Marine Mammal Research Program, Texas A&M University at Galveston.

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APPENDIX 1. Individual cetaceans documented to have been incidentally caught in trawl nets in various areas of the world.

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
Bering Sea and Aleutian Islands					
1	Minke whale	1973–88	2 (decomp.)	0	Perez and Loughlin (1991)
2	Minke whale	1989	1	N/A	NMFS (1995)
3	Harbor porpoise	1973–88	4 (3 dead, 1 decomp.)	0	Perez & Loughlin (1991)
4	Dall's porpoise	1973–88	13 (11 dead, 2 decomp.)	0	Perez & Loughlin (1991)
5	Dall's porpoise	1989	1	N/A	NMFS (1995)
6	Dall's porpoise	1990	6	N/A	NMFS (1995)
7	Dall's porpoise	1991	1	N/A	NMFS (1995)
8	Dall's porpoise	1992	5	N/A	NMFS (1995)
9	Dall's porpoise	1993	4	N/A	NMFS (1995)
10	Risso's dolphin	1973–88	1 (decomp.)	0	Perez and Loughlin (1991)
11	Killer whale	1982	1 calf	1 calf	Teshima and Ohsumi (1983)
12	Killer whale	1973–88	4 (1 dead, 1 alive, 2 decomp.)	N/A	Perez and Loughlin (1991)
13	Killer whale	1991	1	0	NMFS (1995); Matkin and Saulitis (1994)
14	Killer whale	1992	1	N/A	NMFS (1995)
15	Killer whale	1993	1	N/A	NMFS (1995)
16	Unid. cetacean	1973–88	25 (7 dead, 18 decomp.)	0	Perez and Loughlin (1991)
17	Unid. cetacean	1990	1	N/A	NMFS (1995)
18	Unid. cetacean	1991	1	N/A	NMFS (1995)
19	Unid. cetacean	1992	1	N/A	NMFS (1995)
20	Unid. cetacean	1993	1	N/A	NMFS (1995)
British Columbia					
21	Dall's porpoise	1990	1	0	Baird <i>et al.</i> (MS 1991)
Gulf of Alaska					
22	Dall's porpoise	1973–88	2 (1 dead, 1 alive)	N/A	Perez and Loughlin (1991)
23	Dall's porpoise	1993	1	N/A	NMFS (1995)
24	Killer whale	1973–88	1 dead	0	Perez and Loughlin (1991)
25	Unid. cetacean	1973–88	2 dead	0	Perez and Loughlin (1991)
Alaska					
26	Harbor porpoise	1941	1 (dredged by trawler)	0	Scheffer and Slipp (1948)
27	Harbor porpoise	1986–88	3	N/A	Barlow <i>et al.</i> (1994)
28	Dall's porpoise	1986–88	20	N/A	Barlow <i>et al.</i> (1994)
29	Dall's porpoise	1989	1	N/A	Barlow <i>et al.</i> (1994)
30	Pacific white-sided dolphin	N/A	3	N/A	Barlow <i>et al.</i> (1994)
31	Killer whale	1986–88	2	N/A	Barlow <i>et al.</i> (1994)
32	Unid. cetacean	N/A	18	N/A	Barlow <i>et al.</i> (1994)
West Coast of United States					
33	Dall's porpoise	1973–88	9 (8 dead, 1 alive)	N/A	Perez and Loughlin (1991)
34	Dall's porpoise	1989	1	N/A	NMFS (1995)
35	Dall's porpoise	1990	3	N/A	NMFS (1995)
36	Dall's porpoise	1992	1	N/A	NMFS (1995)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
37	Harbor porpoise	N/A	# not given	N/A	Leatherwood and Reeves (1986)
38	Pacific white-sided dolphin	1973–88	3 (dead)	0	Perez and Loughlin (1991)
39	Pacific white-sided dolphin	1990	8	N/A	NMFS (1995)
40	Unid. cetacean	1973–88	10 (9 dead, 1 alive)	N/A	Perez and Loughlin (1991)
41	Unid. cetacean	1990	2	N/A	NMFS (1995)
Gulf of California					
42	Vaquita	1961	1	N/A	Norris & Prescott (1961)
43	Vaquita	1984	# not given	N/A	Vidal (MS 1990)
44	Vaquita	1985	2	N/A	Vidal (MS 1990)
45	Vaquita	1990	2	N/A	Vidal (MS 1990)
46	Vaquita	N/A	1	1	G. Silber, pers. comm. (1993)
Gulf of Mexico					
47	Short-finned pilot whale	N/A	# not given	N/A	NMFS (1995)
48	Risso's dolphin	N/A	# not given	N/A	NMFS (1995)
49	Atlantic spotted dolphin	1985	2	N/A	R. Ford, pers. comm. (1991)
50	Atlantic spotted dolphin	1988	2	N/A	R. Ford, pers. comm. (1991)
51	Bottlenose dolphin	N/A	small numbers	N/A	Gunter (1942)
52	Bottlenose dolphin	1976	1	N/A	Prescott <i>et al.</i> (1980)
53	Bottlenose dolphin	1988	2	N/A	Burn & Scott (1988)
54	Bottlenose dolphin	N/A	# not given	N/A	Reynolds (1985)
55	Bottlenose dolphin	1978–79	1	1	Gruber (MS 1981)
56	Bottlenose dolphin	N/A	small numbers	N/A	Leatherwood and Reeves (1982)
57	Bottlenose dolphin	1987	1	1	C. Pharr, pers. comm. (1991)
58	Bottlenose dolphin	N/A	small numbers	3	Fertl (MS 1994)
Southeastern United States					
59	Bottlenose dolphin	N/A	1	N/A	Wang <i>et al.</i> (1994)
60	Bottlenose dolphin	N/A	small numbers	N/A	Reynolds (1985)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
Northeastern United States/Atlantic Ocean					
61	Humpback whale	1986	2 (1 alive, 1 dead)	N/A	O'Hara <i>et al.</i> (1986)
62	Harbor porpoise	1977	1 (decomp.)	0	Testaverde (1978)
63	Harbor porpoise	1982	1	N/A	O'Hara <i>et al.</i> (1986)
64	Common dolphin	1977–83	8	N/A	Waring <i>et al.</i> (1990)
65	Common dolphin	1983	1 (alive)	N/A	O'Hara <i>et al.</i> (1986)
66	Common dolphin	1984	3	N/A	Waring <i>et al.</i> (1990)
67	Common dolphin	1985	66	N/A	Waring <i>et al.</i> (1990)
68	Common dolphin	1986	76	N/A	Waring <i>et al.</i> (1990)
69	Common dolphin	1987	19	N/A	Waring <i>et al.</i> (1990)
70	Common dolphin	1988	31	N/A	Waring <i>et al.</i> (1990)
71	Common dolphin	1989	4	0	Overholtz and Waring (1991)
72	Common dolphin	1990	11	N/A	NMFS (1995)
73	Common dolphin	1991	2	N/A	NMFS (1995)
74	Common dolphin	1992	3	0	Gerrior <i>et al.</i> (1994)
75	Common dolphin	1993	6	N/A	NMFS (1995)
76	Pilot whale	1977–83	35	N/A	Waring <i>et al.</i> (1990)
77	Pilot whale	1984	2	N/A	Waring <i>et al.</i> (1990)
78	Pilot whale	1985	47	N/A	Waring <i>et al.</i> (1990)
79	Pilot whale	1986	20	2	Waring <i>et al.</i> (1990)
80	Pilot whale	1987	26	1	Waring <i>et al.</i> (1990)
81	Pilot whale	1988	142	3	Waring <i>et al.</i> (1990)
82	Pilot whale	1989	5	0	Overholtz and Waring (1991)
83	Pilot whale	1990	1	N/A	NMFS (1995)
84	Pilot whale	1990	107	N/A	Young <i>et al.</i> (1993)
85	Pilot whale	1991	13	N/A	Young <i>et al.</i> (1993)
86	Pilot whale	1992	12	N/A	NMFS (1995)
87	Risso's dolphin	1985	1	N/A	Waring <i>et al.</i> (1990)
88	Risso's dolphin	1986	1	N/A	Waring <i>et al.</i> (1990)
89	Risso's dolphin	1987	1	N/A	Waring <i>et al.</i> (1990)
90	Risso's dolphin	1992	1	0	Gerrior <i>et al.</i> (1994)
91	Atlantic white-sided dolphin	1990	4	N/A	Young <i>et al.</i> (1993)
92	Atlantic white-sided dolphin	1990	10	N/A	NMFS (1995)
93	Atlantic white-sided dolphin	1991	1	N/A	Young <i>et al.</i> (1993)
94	Atlantic white-sided dolphin	1991	7	N/A	NMFS (1995)
95	Striped dolphin	1991	2	N/A	NMFS (1995)
96	Bottlenose dolphin	1977–83	2	N/A	Waring <i>et al.</i> (1990)
97	Bottlenose dolphin	1984	1	N/A	Waring <i>et al.</i> (1990)
98	Bottlenose dolphin	1985	3	N/A	Waring <i>et al.</i> (1990)
99	Bottlenose dolphin	1988	2	N/A	Waring <i>et al.</i> (1990)
100	Bottlenose dolphin	1991	1	N/A	NMFS (1995)
101	Bottlenose dolphin	1992	4	N/A	Gerrior <i>et al.</i> (1994)
102	Bottlenose dolphin	1993	17	N/A	NMFS (1995)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
103	Unid. dolphin	1977–83	3	N/A	Waring <i>et al.</i> (1990)
104	Unid. dolphin	1985	1	N/A	Waring <i>et al.</i> (1990)
105	Unid. dolphin	1988	1	N/A	Waring <i>et al.</i> (1990)
106	Unid. dolphin	1992	4 (1 alive, 1 dead)	N/A	Gerrior <i>et al.</i> (1994)
107	Unid. baleen whale	1977–83	1	1	Waring <i>et al.</i> (1990)
108	Unid. cetacean	1992	3 (1 alive?)	N/A (1 alive?)	Gerrior <i>et al.</i> (1994)
Northwest Atlantic					
109	Risso's dolphin	N/A	a few captures	N/A	O'Hara <i>et al.</i> (1986)
110	Atlantic white- sided dolphin	1978–85	3	N/A	O'Hara <i>et al.</i> (1986)
Argentine Waters					
111	Commerson's dolphin	N/A	tens of individ/yr	N/A	Scialabba (MS 1989)
112	Commerson's dolphin	N/A	# not given	N/A	Crespo and Corcuera (1990)
113	Commerson's dolphin	N/A	2	N/A	Goodall <i>et al.</i> (1988)
114	Commerson's dolphin	N/A	# not given	N/A	Goodall <i>et al.</i> (1990)
115	Common dolphin	N/A	# not given	N/A	Crespo and Corcuera (1990)
116	Long-finned pilot whale	N/A	1	N/A	Goodall <i>et al.</i> (1988)
117	Peale's dolphin	N/A	# not given	N/A	Crespo and Corcuera (1990); Goodall <i>et al.</i> (1990)
118	Dusky dolphin	N/A	3	N/A	Scialabba (MS 1989)
119	Dusky dolphin	N/A	# not given	N/A	Crespo and Corcuera (1990)
120	Dusky dolphin	1989	1	N/A	Crespo <i>et al.</i> (1994)
121	Franciscana	N/A	2	N/A	Goodall <i>et al.</i> (1988)
122	Franciscana	N/A	rare event	N/A	Crespo and Corcuera (1990)
123	Franciscana	N/A	# not given	N/A	Perez Macri and Crespo (1989)
124	Bottlenose dolphin	N/A	1	N/A	Goodall <i>et al.</i> (1988)
125	Unid. dolphin	N/A	5 in one trawl	N/A	Crespo and Corcuera (1990); Crespo <i>et al.</i> (1994)
Northeast Atlantic					
126	Harbor porpoise	1980–81	28	N/A	Andersen and Clausen (MS 1983)
127	Harbor porpoise	—	3	N/A	Anonymous (1988b)
128	Harbor porpoise	1973–87	21	N/A	Lindstedt and Lindstedt (1989)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
129	Harbor porpoise	1986–89	4	N/A	Kinze (1994)
130	Common dolphin	1971–81	15	N/A	Duguy and Hussenot (1982)
131	Common dolphin	1971–76	1	N/A	Duguy (1977)
132	Long-finned pilot whale	1971–76	1	N/A	Duguy (1977)
133	Long-finned pilot whale	1971–81	3	N/A	Duguy and Hussenot (1982)
134	Long-finned pilot whale	–	possible 1 record	N/A	Northridge (1988)
135	Risso's dolphin	–	occasionally caught	N/A	Northridge (1984)
136	Striped dolphin	–	occasionally caught	N/A	Northridge (1984)
137	Striped dolphin	1971–76	1	N/A	Duguy (1977)
138	Bottlenose dolphin	1971–76	2	N/A	Duguy (1977)
139	Bottlenose dolphin	1977–81	3	N/A	Duguy and Hussenot (1982)
140	Bottlenose dolphin	–	1	N/A	Anonymous (1988b)
Baltic Sea					
141	Harbor porpoise	1952	1	N/A	Ropelewski (1957)
142	Harbor porpoise	N/A	2	N/A	Skora <i>et al.</i> (1988)
143	Harbor porpoise	1987/90	1	N/A	Benke <i>et al.</i> (1991)
North Sea					
144	Harbor porpoise	–	several tens/yr	N/A	Currey <i>et al.</i> (1990)
145	Harbor porpoise	1963–82	18	N/A	Gaskin (1984)
146	Harbor porpoise	1987–88	7	N/A	Anonymous (1989a)
147	Harbor porpoise	–	few	N/A	Mitchell (1975)
148	Harbor porpoise	1992	137	N/A	Moreno (1993)
149	Harbor porpoise	–	regularly caught	N/A	Reijnders and Lankester (1990)
150	Common dolphin	–	regularly caught	N/A	Reijnders and Lankester (1990)
151	Pilot whale	–	regularly caught	N/A	Reijnders and Lankester (1990)
152	Pilot whale	1994	3(dead) in 1 haul	0	N. Lowry, pers. comm. (1994)
153	Risso's dolphin	–	not given	N/A	Reijnders and Lankester (1990)
154	White-beaked dolphin	–	few	N/A	Leatherwood and Reeves (1983)
155	White-beaked dolphin	1958	1	N/A	van Bree and Nijssen (1964)
156	Bottlenose dolphin	–	# not given	N/A	Currey <i>et al.</i> (1990)
157	Bottlenose dolphin	–	few	N/A	Mitchell (1975)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
Mid-Atlantic Bight					
158	Bottlenose dolphin	N/A	3 in 8 years	N/A	Northridge (1991)
Scotland					
159	Harbor porpoise	1988–89	20+	N/A	Northridge (1991)
Britain					
160	Harbor porpoise	N/A	# not given	N/A	Northridge (1991)
161	Harbor porpoise	N/A	1	N/A	Northridge (1988)
162	Harbor porpoise	1989	2	N/A	Anonymous (1990c)
163	Common dolphin	1982	5 (3 alive, 2 dead)	3	Pascoe (1986)
164	Common dolphin	N/A	# not given	N/A	Couperus (1994)
165	Pilot whale	1986	towed in trawl	N/A	Northridge (1988)
166	Long-finned pilot whale	N/A	# not given	N/A	Couperus (1994)
167	Atlantic white-sided dolphin	N/A	# not given	N/A	Couperus (1994)
168	White-beaked dolphin	1986, 1987	# not given	N/A	Northridge (1988)
169	White-beaked dolphin	N/A	# not given	N/A	Couperus (1994)
170	Unid. porpoise	N/A	entangled at least 6, one drowned in net	N/A	Northridge (1988)
171	Unid. porpoise	N/A	3	N/A	Northridge (1988)
172	Unid. whale	1986	1	N/A	Northridge (1988)
Eastern Central Atlantic					
173	Common dolphin	N/A	# not given	N/A	Scialabba (MS 1989)
174	Bottlenose dolphin	N/A	# not given	N/A	Scialabba (MS 1989)
Bay of Biscay					
175	Long-finned pilot whale	N/A	# not given	N/A	Gerrior <i>et al.</i> (1994)
Mediterranean					
176	Common dolphin	N/A	1	N/A	Di Natale (1983)
177	Common dolphin	N/A	not given	N/A	Di Natale (1989)
178	Striped dolphin	N/A	not given	N/A	Di Natale (1989)
179	Bottlenose dolphin	N/A	3	N/A	Duguy and Hussenot (1982)
180	Bottlenose dolphin	N/A	incidental catches said to be high, although some dolphins reported to be freed	N/A	Currey <i>et al.</i> (1990)
181	Bottlenose dolphin	N/A	not given	N/A	Di Natale (1989)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
182	Bottlenose dolphin	N/A	1	N/A	Silvani <i>et al.</i> (1992)
183	Sperm whale	N/A	3	N/A	Di Natale and Mangano (1983)
184	Sperm whale	N/A	1	N/A	Di Natale (1989)
Portugal					
185	Harbor porpoise	1977–91	1	N/A	Sequeira and Ferreira (1994)
186	Common dolphin	1977–91	18	N/A	Sequeira and Ferreira (1994)
Central Cantabrian Sea					
187	Harbor porpoise	1977–91	1	N/A	Nores <i>et al.</i> (1992)
188	Common dolphin	1977–91	1	N/A	Nores <i>et al.</i> (1992)
189	Long-finned pilot whale	1977–91	1	N/A	Nores <i>et al.</i> (1992)
Northwest Africa					
190	Common dolphin	N/A	# not given	N/A	Northridge (1984)
191	Common dolphin	N/A	large numbers	N/A	Currey <i>et al.</i> (1990)
192	Common dolphin	1980	'6-22' dolphins per haul' at night for one trawler. 12 trawlers in area also caught dolphins, exact number unknown. An estimated minimum of 500–1 000 common dolphins and <i>Stenella</i> spp. are caught per year.	N/A	Maigret (1994)
South and Southwest Africa					
193	Heaviside's dolphin	1978–79	2	N/A	Anonymous (1979)
194	Heaviside's dolphin	1978–79	small numbers	N/A	Northridge (1984)
195	Heaviside's dolphin	1977	1	N/A	P. Best, pers. comm. (1992)
196	Heaviside's dolphin	1990	1	N/A	P. Best, pers. comm. (1992)
197	Common dolphin	N/A	small numbers	N/A	Northridge (1984)
198	Common dolphin	1983	5	N/A	P. Best, pers. comm. (1992)
199	Common dolphin	N/A	2 young	N/A	V. Cockcroft, pers. comm. (1992)
200	Risso's dolphin	1986	1	N/A	P. Best, pers. comm. (1992)
201	Dusky dolphin	N/A	small numbers	N/A	Northridge (1984)
202	Dusky dolphin	1988	4	N/A	P. Best, pers. comm. (1992)
203	Dusky dolphin	1989	6	N/A	P. Best, pers. comm. (1992)
204	Dusky dolphin	1990	1	N/A	P. Best, pers. comm. (1992)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
East Africa					
205	Unid. dolphin	N/A	large number	N/A	Currey <i>et al.</i> (1991)
Pakistan					
206	Finless porpoise	1989	2 young	N/A	Niazi (1990)
India (Gulf of Mannar)					
207	Bottlenose dolphin	1980–82	3	0	Pillai & Kasinathan (1987)
Thailand					
208	Spinner dolphin	1970–71	10	N/A	Perrin <i>et al.</i> (1989)
China (Hong Kong)					
209	Finless porpoise	1987	1	0	T. Jefferson, pers. comm (1995)
New Zealand					
210	Hector's dolphin	1970's	7	N/A	Baker (1978)
211	Hector's dolphin	N/A	occasionally	N/A	Anonymous (1981); Scialabba (MS 1989); Slooten and Dawson (1988)
212	Hector's dolphin	1988	5	N/A	Anonymous (1990b)
213	Common dolphin	N/A	a few	N/A	Mitchell (1975)
214	Common dolphin	1978	10	4	Anonymous (1981)
215	Common dolphin	1979	23	2	Anonymous (1981)
216	Common dolphin	N/A	occasionally	N/A	Slooten and Dawson (1988)
217	Common dolphin	1980	1	N/A	Anonymous (1982)
218	Common dolphin	since April 1986	2	N/A	Anonymous (1988a)
219	Common dolphin	1987	1	N/A	Anonymous (1989b)
220	Common dolphin	1988	1	N/A	Anonymous (1990b)
221	Common dolphin	1989	2 (adult+calf)	N/A	Anonymous (1990b)
222	Common dolphin	1989–90, 1993–94	69	N/A	Baird (1995)
223	Common dolphin	1990	34–35	N/A	Anonymous (1991b)
224	Common dolphin	1995	21	N/A	R. Mattlin, pers. comm. (1995)
225	Pilot whale	N/A	1	N/A	R. Mattlin, pers. comm. (1995)
226	Dusky dolphin	1986–88	2	N/A	Anonymous (1988a)
227	Dusky dolphin	1988	1	N/A	Anonymous (1988a)

No.	Species	Time Period	No. Entangled	No. Released Alive	Source(s)
228	Dusky dolphin	N/A	occasionally	N/A	Slooten and Dawson (1988)
229	Killer whale	1979	1	N/A	Anonymous (1981)
230	Bottlenose dolphin	N/A	100's	N/A	Mitchell (1975)
231	Bottlenose dolphin	N/A	1	N/A	R. Mattlin, pers. comm. (1995)
232	Unid. dolphin	N/A	low numbers	N/A	R. Mattlin, pers. comm. (1995)
233	Unid. beaked whale	1979	1	N/A	Anonymous (1981)
Australia					
234	Bottlenose dolphin	N/A	2 juveniles	N/A	Corkeron <i>et al.</i> (1990)
235	Bottlenose dolphin	1989	1	N/A	Anonymous (1991a)
236	Unid. dolphin	1988	3	N/A	Anonymous (1990a)
237	Unid. dolphin	1990	1	N/A	Anonymous (1991a)

Sources for personal communications

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APPENDIX 2. Cetacean species for which there are reports of incidental catches in trawl nets (Record numbers correspond to entries in Appendix 1.)

Species	Record Number(s)
Minke whale (<i>Balaenoptera acutorostrata</i>)	1, 2
Humpback whale (<i>Megaptera novaeangliae</i>)	61
Finless porpoise (<i>Neophocaena phocaenoides</i>)	206, 209
Dall's porpoise (<i>Phocoenoides dalli</i>)	4–9, 21–23, 28–29, 33–36
Harbor porpoise (<i>Phocoena phocoena</i>)	3, 26–27, 37, 62–63, 126–129, 141–149, 159–162, 185, 187
Vaquita (<i>Phocoena sinus</i>)	42–46
Sperm whale (<i>Physeter macrocephalus</i>)	183–184
Commerson's dolphin (<i>Cephalorhynchus commersonii</i>)	111–114
Heaviside's dolphin (<i>Cephalorhynchus heavisidii</i>)	193–196
Hector's dolphin (<i>Cephalorhynchus hectori</i>)	210–212
Common dolphin (<i>Delphinus</i> spp.)	64–75, 115, 130–131, 150, 163–164, 173, 176–177, 186, 188, 190–192, 197–199, 213–224
Short-finned pilot whale (<i>Globicephala macrorhynchus</i>)	47
Long-finned pilot whale (<i>Globicephala melas</i>)	116, 132–134, 166, 175, 189
Unidentified pilot whale species (<i>Globicephala</i> spp.)	76–86, 151–152, 165, 225
Risso's dolphin (<i>Grampus griseus</i>)	10, 48, 87–90, 109, 135, 153, 200
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>)	91–94, 110, 167
White-beaked dolphin (<i>Lagenorhynchus albirostris</i>)	154–155, 168–169
Peale's dolphin (<i>Lagenorhynchus australis</i>)	117
Pacific white-sided dolphin (<i>Lagenorhynchus obliquidens</i>)	30, 38–39
Dusky dolphin (<i>Lagenorhynchus obscurus</i>)	118–120, 201–204, 226–228
Killer whale (<i>Orcinus orca</i>)	11–15, 24, 31, 229
Striped dolphin (<i>Stenella coeruleoalba</i>)	95, 136–137, 178
Atlantic spotted dolphin (<i>Stenella frontalis</i>)	49–50
Spinner dolphin (<i>Stenella longirostris</i>)	208
Bottlenose dolphin (<i>Tursiops truncatus</i>)	51–60, 96–102, 124, 138–140, 156–158, 174, 179–182, 207, 230–231, 234–235
Franciscana (<i>Pontoporia blainvillei</i>)	121–123
Unid. cetacean species	16–20, 25, 32, 40–41, 108
Unidentified baleen whale	107
Unidentified dolphin species	103–106, 125, 205, 232, 236–237
Unidentified beaked whale	233
Unidentified porpoise	170–171
Unidentified whale	172

APPENDIX 3. Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Bering Sea		
Killer whale	Seen following nets when trawling began.	Teshima and Ohsumi (1983)
Killer whale	Seemed attracted to winching sounds. Positioned themselves along the sides of trawlers to feed on trash fish, and offal. Jostled for positions while feeding was also noted.	J. Heimlich-Boran, pers. comm. (1991)
West Coast of United States		
Common dolphin	Feed on specimens that had escaped from the net. The fish were disabled and floating belly up.	Edwards (1960)
Gulf of California		
Bottlenose dolphin	Seen associated with shrimpers. Observed to feed on trash fish. Dolphins attracted to engines shutting down, signifying culling.	Norris & Prescott (1961)
Bottlenose dolphin	Observed feeding in mudboil behind shrimpers.	Leatherwood (1975)
Bottlenose dolphin	Habitually followed trawlers with net down (19% of sightings).	Wells <i>et al.</i> (1981)
Gulf of Mexico		
Bottlenose dolphin	Observed following trawlers. Shrimp found in stomach. Believed to damage nets.	Gunter (1942)
Bottlenose dolphin	Reported to damage nets. Could be made to move with rifle shots.	Gunter (1944)
Bottlenose dolphin	Second-hand report from E.A. McIlhenny of whole shrimp in stomachs.	Gunter (1951)
Bottlenose dolphin	Reported to distinguish changes of boat operation.	Gunter (1954)
Bottlenose dolphin	Observed to feed on trash fish off northeast coast of Florida, and to feed on catfish while operating shrimp boats were nearby.	Caldwell and Caldwell (1972)
Bottlenose dolphin	Seen following trawling boats; spent more time socializing near boats than eating discarded fish.	Hogan (MS 1975)
Bottlenose dolphin	Categorized behaviors related to shrimp boats as: foraging behind working shrimp boats, feeding on trash fish, and feeding on fish attracted to nonworking shrimpers	Leatherwood (1975)

APPENDIX 3. (continued). Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Gulf of Mexico		
Bottlenose dolphin	Observed feeding behind shrimp boats that had moved from sounds to marsh in Mississippi.	Leatherwood and Platter (1975)
Bottlenose dolphin	Dolphins' activities completely dominated by shrimp boats.	Shane (MS 1977)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats. Mother/calf pairs fed behind shrimp boats; feeding as early as 0545 and continued past 2200; following boat seemed preferable to eating trash fish. Late spring to early fall, most dolphins observed feeding in association with shrimp boats.	Gruber (MS 1981)
Bottlenose dolphin	Fed in association with shrimp boats in Mobile Bay, Alabama.	Goodwin (MS 1985)
Bottlenose dolphin	Associated with shrimp boats in Galveston Bay, Texas.	Henningsen (MS 1991)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats in Campeche Bay. Dolphins responded to motor changes associated with changes in boat operation. Observed feeding almost exclusively on bycatch. Observations of feeding at night near working shrimp boats.	Delgado-Estrella (MS 1991)
Bottlenose dolphin	Group of 7 young dolphins followed groundfish trawl in Gulf of Mexico.	C. Pharr, NMFS, pers. comm. (1991)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats. Movements of dolphins did not appear to be linked to changes in shrimp boat stages. Speculated that females with calves may be taking advantage of concentrated food resource provided by shrimp boats to meet increased energetic needs due to lactation.	Fertl (MS 1994)
Atlantic spotted dolphin	Observed feeding in association with shrimp boats.	Delgado-Estrella (MS 1991)
Atlantic spotted dolphin	Followed large otter trawl to surface as it was hauled in. Dolphins milled around the filled cod-end of the net until it was actually brought on board.	Caldwell (1955)
Atlantic spotted dolphin	Mixed herd with bottlenose dolphins "biting the bag of the trawl" and were seen in front of the bag.	C. Rogers, pers. comm. (1991)

APPENDIX 3. (continued). Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Belize		
Bottlenose dolphin	Observed feeding in association with trawls.	K. Dudzinski, pers. comm. (1992)
Brazil		
Tucuxi	On at least 4 occasions, groups of up to 5 individuals observed close were to shrimp boats. No information is available on apparent association.	Barros and Teixeira (1994)
Argentina		
Unidentified dolphins	Observed coming into and out of the mouth of the net, catching fish.	Crespo and Corcuera (1990)
Southeastern United States (North Carolina)		
Bottlenose dolphin	Observed feeding on discarded bycatch.	Davis (1988)
Bottlenose dolphin	Observed following working trawlers.	G. Rountree, pers. comm. (1993)
Northeast United States		
Pilot whale	Active pursuit and opportunistic feeding in and around mouth of net during haulback.	Waring <i>et al.</i> (1990)
Scotian Shelf		
Fin whale	"Feeding aft of codend."	Can. Fed. Dept. Fish. and Oceans, unpubl. data
Minke whale	"Followed trawl at haulback."	Can. Fed. Dept. Fish. and Oceans, unpubl. data
Common dolphin	"Followed trawl at haulback."	Can. Fed. Dept. Fish. and Oceans, unpubl. data
Pilot whale	Following codend; following codend at haulback; feeding off fish at haulback of trawl; and variations thereof.	Can. Fed. Dept. Fish. and Oceans, unpubl. data
Northern bottle-nose whale	15 records of "followed trawl during haulback".	Can. Fed. Dept. Fish. and Oceans, unpubl. data
North Sea		
Harbor porpoise	Observed following the trawls, catching fish squeezed out through the meshes.	Clausen and Andersen (1988)

APPENDIX 3. (continued). Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Northeast Atlantic (Celtic Sea)		
Atlantic white-sided dolphin	Scavenged on discards	A.S. Couperus, pers. comm (1994)
Pilot whale	Scavenged on catch pumped on board.	A.S. Couperus, pers. comm. (1994)
Killer whale	Feeding on fish that slipped through the meshes or fell overboard, when the net was being hauled or shot.	Couperus (1994)
Bottlenose dolphin	30–40 dolphins scavenging behind a freezer trawler during hauling	A. S. Couperus, pers. comm. (1995)
Mediterranean Region		
Bottlenose dolphin	Suspected to feed on fish in trawl.	Di Natale (1989)
Bottlenose dolphin	Associated with shrimp boats.	Bearzi and Notarbartolo di Sciara (1992)
Bottlenose dolphin	Reported to harass trawlers.	Northridge (1984)
Bottlenose dolphin	Feed in association with trawlers.	Goffman <i>et al.</i> (1995)
Common dolphin	Feed in association with trawlers.	Goffman <i>et al.</i> (1995)
Striped dolphin	Feed in association with trawlers.	Goffman <i>et al.</i> (1995)
West Africa		
Unidentified dolphin	Feeding at night on fish attracted to non-working trawler.	Fulton (1976)
South Africa		
Common dolphin	Suspected to feed in association with trawls	V. Cockcroft, pers. comm. (1991)
Western Sri Lanka		
Bottlenose dolphin	Fed in mudline behind trawler.	Leatherwood <i>et al.</i> (1984)

APPENDIX 3. (continued). Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Southeast Malaysia		
Bottlenose dolphin	Fed around trawl net when it was reeled in in the evening. Fed on fish dropping from the nets or discarded over the side, and occasionally rammed their rostrums into the net, causing the net contents to spill.	Abel and Leatherwood (1985)
Spinner dolphin	Fed around trawl net when it was reeled in the evening.	Abel and Leatherwood (1985)
India (Gulf of Mannar)		
Bottlenose dolphin	Reported following cod-end of net.	Pillai and Kasinathan (1987)
China (Hong Kong)		
Indo-Pacific hump-backed dolphin	Follow behind trawlers (shrimp and midwater fishes), sometimes for long periods.	S. Leatherwood, unpubl. data; T. Jefferson, unpubl. data
New Zealand		
Common dolphin	Seen feeding on "meatballing clupeids" beneath the hulls of trawlers and along the trawl warps.	Anonymous (1982)
Comon dolphin	Attracted to vessels and may take advantage of herding effect of a trawl net on fish, specifically, fish swimming ahead of the trawl mouth.	Baird (1995)
Hector's dolphin	Occasionally followed trawlers, possibly feeding on fish stirred up, but not caught by trawl gear.	Slooten and Dawson (1988)
Australia (Moreton Bay)		
Bottlenose dolphin	Reported feeding behind trawlers; feeding intensively on trash fish. Fish preferences observed. Refused floating fish. Dominance hierarchies inter- and intra-species observed. Fed in mixed groups with humpbacked dolphins.	Corkeron <i>et al.</i> (1990)
Bottlenose dolphin	Fed on discarded bycatch. Dolphins estimated to eat about 86% of fish discarded from single trawl. Dolphins scavenged only fish and cephalopods, and not crustaceans or echinoderms. Large floating fish (25–65 g) were eaten by dolphins.	Wassenberg and Hill (1990)

APPENDIX 3. (continued). Accounts of cetaceans feeding in association with trawls, reported geographically.

Species	Interaction	Source(s)
Australia (Moreton Bay)		
Bottlenose dolphin	Attempted to establish a feeding station by feeding dolphins with discards from stationary trawler. Leading the animals with the trawler was not successful for a variety of speculated reasons.	Green and Corkeron (1991)
Indo-Pacific Hump-backed dolphin	Reported to feed in mixed groups with bottlenose dolphins behind trawlers. Would generally remain farther from stern of trawler. Did not gain access to preferred food items.	Corkeron (1990)

Sources of personal communication and unpublished data:

Canadian Federal Department of Fisheries and Oceans, P. O. Box 550, Station M, Halifax, Nova Scotia B3J 2S7

V. Cockcroft, Port Elizabeth Museum, P. O. Box 13147, Humewood 6013 South Africa

A.S. Couperus, Netherlands Institute for Fisheries Research (RIVO-DLO), P. O. Box 68, 1970 AB IJmuiden, The Netherlands

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NOAA Technical Memorandum NMFS-AFSC-442

Human-Caused Mortality and Injury of NMFS-managed Alaska Marine Mammal Stocks, 2016-2020

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and J. E. Jannot

August 2022

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric
Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

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This document should be cited as follows:

Freed, J. C., Young, N. C., B. J. Delean, V. T. Helker, M. M. Muto, K. M. Savage, S. S. Teerlink, L. A. Jemison, K. M. Wilkinson, and J. E. Jannot. 2022. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2016-2020. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-442, 116 p.

This document is available online at:

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Human-Caused Mortality and Injury of NMFS-managed Alaska Marine Mammal Stocks, 2016-2020

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U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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NOAA Technical Memorandum NOAA-TM-AFSC-442

August 2022

Abstract

Section 117 of the Marine Mammal Protection Act (MMPA) requires the National Marine Fisheries Service (NMFS) to estimate human-caused marine mammal mortality and serious injury. Data from documented interactions between human activities and pinnipeds or cetaceans belonging to stocks which appear in the Alaska Marine Mammal Stock Assessment Reports (SARs) were compiled for the 5-year period from 2016 through 2020. A total of 867 unique interactions with evidence of human-caused mortality or injury are summarized in this report. Details for all reported human-marine mammal interactions (approximately 3,500) were first assessed for evidence of human-caused injury or mortality of the marine mammal; injuries and mortalities that could not be attributed with high confidence to human causes were excluded from further analysis. Injury severity determinations were then made for those injuries considered with high confidence to be human-caused. Injury determination details, including the injury cause, type, severity (non-serious, serious, or prorated serious), and criteria supporting the determination are presented in Table 1. Records of human-caused mortality, assigned to cause, are also included in this report and presented in Table 1. Mortality or injury values were assigned to each interaction for comparison with the potential biological removal (PBR) levels, calculated under the MMPA, for each stock in the Alaska SARs. The mortality and injury values included in this report are derived solely from documented interactions. Not all human-caused mortality and injury of marine mammals is documented so this report represents a minimum count of human-caused mortality and injury of Alaska marine mammal stocks.

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Introduction

The Marine Mammal Protection Act (MMPA, 1972) requires the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) to estimate the annual human-caused mortality and serious injury of marine mammal stocks by cause (MMPA, section 117) and to classify commercial fisheries based on each fishery's rate of incidental mortality and serious injury of marine mammals (MMPA, section 118). NMFS evaluates the annual level of known or estimated human-caused mortality and serious injury for each stock from all human causes, including specific commercial fishing operations, relative to the potential biological removal (PBR) levels calculated under the MMPA (Wade 1998). Mortality and serious injury events are assigned to cause and estimates of annual mortality and serious injury are calculated by cause. Assessing the severity of an injury and likelihood that an injury will result in mortality requires information about the biology of the animal, the type and severity of the injury, and the injury cause. Thorough examination of human-caused injuries of marine mammals is often not possible because these events often occur in extremely remote areas of Alaska and observed injuries are often not documented in sufficient detail to understand the level of injury severity.

A serious injury is defined in regulations as "any injury that will likely result in mortality" (50 CFR 229.2). To accurately and consistently estimate the number of serious injuries occurring in each stock, NMFS clarified its definition of "serious injury" (SI) in 2012 and stated its interpretation of the regulatory definition of serious injury as any injury that is "more likely than not" to result in mortality or any injury that presents a greater than 50% chance of death to the marine mammal (77 Federal Register 3233, 23 January 2012; NMFS 2012a). NMFS also established a consistent and transparent process for distinguishing non-serious injuries (NSI) from SI and for documenting pertinent information considered in making injury determinations (NMFS 2012a, b). Substantial information is known about the likely outcomes of particular injuries of large whales due to the analysis of historical large whale injuries with known outcomes. This allows NMFS to better estimate, or prorate, the chance that a particular injury is likely to result in mortality. For example, at the time NMFS established its injury determination criteria, there were 25 records with known outcomes involving large whales that sustained ship-strike lacerations of unknown severity, and in 13 of these instances (52%) the result was a decline in health status or death of the animal. These data are then used to inform decision-making in situations where the severity of the laceration (superficial vs. deep) is unknown. The rate of serious injury for this category is prorated by multiplying the number of events assigned to this criterion by 0.52 (NMFS 2012b).

This report consists of records from 2016 through 2020 that were assessed for human-caused mortality or injury of cetaceans and pinnipeds occurring in Alaska and U.S. West Coast waters and assessed within the Alaska Marine Mammal Stock Assessment Reports (SARs). For marine mammal stocks that are found injured or dead in Alaska water but assessed in the U.S. Pacific Marine Mammal SARs, the records are sent to the NMFS Southwest Fisheries Science Center (SWFSC) for inclusion in the report summarizing mortality and injury for U.S. Pacific West Coast marine mammal stocks (e.g., Carretta et al. 2021). Examples of stocks assessed in the U.S. Pacific SARs that range into Alaska waters include the Eastern North Pacific gray whale and the California breeding stock of northern elephant seals, whereas some stocks which range as far south as California, such as Eastern U.S. Steller sea lions and Eastern Pacific northern fur seals, are reported in the Alaska SARs. Similarly, for marine mammals under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) that are found injured or dead in Alaska waters, such as Pacific walruses and northern sea otters, records and any resulting bycatch estimates are sent to the USFWS for inclusion in those stocks' assessment reports. Mortality and injury data may be reported by marine mammal stranding networks, research programs, fisheries observer programs, fishermen, and disentanglement networks. Mortality and injury of marine mammals resulting from the Alaska Native subsistence harvest are not reported in this document, except in rare circumstances, but these data are reported in the Alaska SARs. Mortality and serious injury data from 2016 through 2020 were summarized by stock, cause, and year and used for estimates reported in the 2022 Alaska SARs (Young et al. in review); in most cases, non-serious injuries are not reported in the SARs. All information pertinent to decisions of NSI, SI, or prorated SI is presented in this report.

Methods

Data were acquired primarily from databases and archives maintained by the NMFS Alaska Regional Office (AKRO) marine mammal stranding network, the NMFS Alaska Fisheries Science Center (AFSC) Fisheries Monitoring and Analysis Division's North Pacific Observer Program, the NMFS West Coast Regional Office (WCRO) marine mammal stranding network, the NMFS Northwest Fisheries Science Center (NWFSC) Fishery Resource Analysis and Monitoring Division, Fisheries Observation Science Program (which encompasses both the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP)), the NMFS SWFSC, the Marine Mammal Authorization Program (MMAP), the NMFS Office of Protected Resources (OPR), the Northwest Indian Fisheries Commission (NWIFC), and the Alaska Department of Fish and Game (ADF&G). While reviewing 5 years of human-marine mammal interaction data, an injury determination team at the AFSC's Marine Mammal Laboratory (MML) reviewed approximately 3,500 records for evidence of human-caused mortality or injury of the marine mammal(s) involved in the interaction. All available documentation (reports,

emails, images, resight information, and necropsy results) was considered to assess interactions, make injury determinations, and attribute mortality and injury to a cause. If more information was necessary for a determination, the primary source of information was contacted.

Any interaction which met an injury category criterion in NMFS Instruction 02-038-01 (NMFS 2012b; e.g., ingested gear or hook(s), entanglements, ship strikes, lacerations, etc.) was considered to potentially document a human-caused injury, and a summary of all relevant information was recorded as a unique entry in a Microsoft Access database. Any mortality which the MML injury determination team was able to assign with high confidence to a human cause was also summarized and recorded as a unique entry in the database. When multiple records documenting a single instance of human-caused mortality or injury were identified, the relevant information from each record was consolidated into a single entry within the database. The database allowed MML staff to quickly sort and summarize many entries. Primary records, such as Level-A forms, necropsy reports, and imagery, were retained for reference. Follow-up information for a previously documented event, such as additional sightings or reports of a decline in health condition, was added to the existing database entry. When a dependent calf or pup of an injured or dead animal was observed, a separate database entry was added and the offspring was assessed as a unique, but associated, event. Interaction records in which there was no potential for human-caused injury of the marine mammal, such as reports of animals feeding on fishery discards or interactions that lacked sufficient information to assign an injury to a human cause, were retained for reference but excluded from the database and report.

Following the initial review of approximately 3,500 primary records of human-marine mammal interactions, 867 unique cases of human-caused mortality or injury of marine mammals were identified. Each of these was evaluated using NMFS' injury determination criteria (NMFS 2012b). Different sets of criteria, specific to large whales (mysticetes and sperm whales), small cetaceans (all odontocetes except sperm whales), and pinnipeds, were used to evaluate each injury event and assign it to the most appropriate injury category (NMFS 2012b; Appendix Tables 1 to 3). Some interactions fit more than one injury category. In these cases, the most severe injury category was used to determine whether an injury should be considered serious, non-serious, or prorated.

An initial and final injury determination was made for each record included in this report. The initial and final determinations were the same for events in which the animal was dead when first observed or was observed for a brief period. Initial and final determinations could differ if an animal was determined to be seriously injured but, over time and through human intervention, its condition improved. Examples of situations where initial and final determinations could differ include events where disentanglement teams successfully

removed gear from a seriously injured entangled whale (assuming there was no evidence of health decline or other injury) and events where stranded pinniped pups were rehabilitated and released. In these cases, the final injury determination would be reported in the SAR for comparison to PBR, while the initial injury determination would be used for commercial fisheries-related interactions to classify fisheries in the MMPA List of Fisheries (LOF).

Initial and final injury determinations do not differ in situations where commercial fishermen, or others, release animals from gear in real-time (i.e., at the time of the interaction). In these situations, the injury determination is made after the animal is released from the gear and this determination is used when classifying fisheries for the MMPA LOF and for comparison to PBR (NMFS 2012a). For example, if a humpback whale became entangled in an active commercial gillnet, was released by fishermen at the time of the interaction and swam away free of gear without any sign of injury, the initial and final determinations would be NSI and the same injury determination would be compared to PBR and used in the MMPA LOF. In contrast, if a humpback whale became entangled in an active commercial gillnet and broke free with a portion of gillnet forming a constricting entanglement, it would initially be considered a serious injury. However, if an experienced disentanglement team removed all gear from the animal, and there was no other sign of serious injury, the final determination compared to PBR would be NSI. This injury would not be counted in the mortality and serious injury estimates reported in the SARs since the human intervention activities mitigated the serious injury of the animal. However, for the purposes of classifying commercial fisheries for the MMPA LOF, the whale would be considered SI and included in the tier analysis for classifying that specific commercial fishery.

Serious injury determinations and assignments to cause were discussed and agreed upon by an injury determination team at MML. When necessary, other experts at MML were consulted when making determinations. All determinations and assignments were then reviewed by experienced staff at other NMFS Science Centers to ensure determinations were consistent across the Science Centers. The determinations were also reviewed by the AKRO and the Alaska Scientific Review Group, an independent group established under section 117(d) of the MMPA to advise NMFS on a range of marine mammal science and management issues. The AKRO provided fishery assignments for records of fisheries-related injuries and mortalities that were not obtained from a fisheries observer program.

Occasionally, fisheries observers opportunistically report marine mammals that were incidentally killed or injured in unsampled hauls. In previous iterations of this report, these mortalities and injuries were included and added to the bycatch estimate for the fishery in the SARs. Beginning with Freed et al. (2021), these interactions will continue to be included

in this report but generally will not be reported in the Alaska SARs or used to estimate bycatch, because the bycatch estimation process accounts for interactions in unsampled hauls. The exception is if no mortality or serious injury (M/SI) of a stock was observed in sampled hauls in a particular fishery in a particular year, in which case, M/SI in unsampled hauls is provided in the SAR as a minimum estimate of bycatch of that stock for that fishery for that year. To assist the reader in comparing interaction data between this report and the SAR, interactions in unsampled hauls are specifically noted in the Determination Details column of Table 1.

Alaska Native subsistence harvest information is generally not included in this report but is reported in the Alaska SARs. However, during the time period covered by this report, 4 beluga whales and 3 bowhead whales discovered entangled in fishing gear were subsequently harvested for Alaska Native subsistence use. These animals were included in the table of human-marine mammal interaction records reviewed for injury and mortality (Table 1). In iterations of this report prior to Freed et al. (2021), these types of interactions were counted as Alaska Native subsistence takes and were not assigned M/SI values for comparison against PBR or for use in classifying fisheries on the MMPA LOF (i.e., “N/A” was entered in the M/SI Value and LOF Value fields). In contrast, beginning with Freed et al. (2021), these interactions will be assigned M/SI values for comparison against PBR and for use in classifying fisheries on the MMPA LOF, if applicable, to reflect the true impact of commercial fisheries on marine mammal stocks.

Pinnipeds with gunshot wounds reported to the NMFS AKRO marine mammal stranding network were assumed to be struck and lost animals associated with the Alaska Native subsistence hunt unless there was information which indicated the animals were illegally shot. These struck and lost animals were not included in this report or in the SARs to avoid double-counting animals that were already included (as struck and lost) in the Alaska Native subsistence harvest data. In contrast, pinnipeds with gunshot wounds reported to the NMFS WCRO marine mammal stranding network, such as Eastern U.S. Steller sea lions in Washington, Oregon, or California, were included in this report.

Takes reported by the NWIFC lack details on animal condition. However, the interactions reported here occurred primarily in drift and set gillnet fisheries, where survival of pinnipeds and cetaceans is rarely observed (Carretta 2021). In this report, we assume that reported NWIFC interactions represent serious injuries or deaths and coded them as dead (i.e., in Table 1, “DEAD” was entered in the Initial Assessment and Final Determination fields and the Determination Details field describes the animals as being “incidentally killed”). Serious injuries and deaths both represent a M/SI value = 1 that is counted against PBR in marine mammal stock assessments; therefore, the coding of these cases as either “SI” or “DEAD” results in the same level of removals that is compared to PBR. Additionally,

takes reported by the NWIFC lack details on whether each interaction involved bycatch or lethal removal to prevent interference with fishing gear and/or catch. In Table 1 of this report, the mechanism and source of injury fields for these records are coded as “unknown.”

From 2016 to 2020, NMFS received 218 MMAP fishermen self-reports documenting mortality and injury of 230 marine mammals in Alaska waters. In addition, NMFS received 27 MMAP fishermen self-reports documenting mortality and injury of 36 marine mammals in waters off the U.S. West Coast from stocks that are assessed in the Alaska SARs (i.e., Eastern Pacific northern fur seals in December-May and Eastern U.S. Steller sea lions). Approximately 95% of the self-reports are not included in this report for one or more of the following reasons: (a) the reported species is under the jurisdiction of the USFWS (so data were sent to the USFWS); (b) the reported species is included in the Pacific SARs, not the Alaska SARs (so data were sent to the NMFS SWFSC); (c) the animal was previously dead, e.g., had signs of decomposition; (d) the animal was taken in a currently observed fishery and that species/stock is already accounted for in the observer data;¹ or (e) the interaction was also reported to the NMFS AKRO stranding network, usually with more details and, thus, is already accounted for in this report. In a change from previous iterations of this report (e.g., Freed et al. 2021), this report includes MMAP reports of animals that were taken in fisheries for which other sources of data (e.g., previous observer data) are used to estimate bycatch for the SARs. While these MMAP reports are informative because they indicate ongoing bycatch, NMFS is not relying on the MMAP data to quantify bycatch and, thus, the records were not assigned M/SI values for comparison against PBR or for use in classifying fisheries on the MMPA LOF (i.e., “N/A” was entered in the M/SI Value and LOF Value fields) and are not reported in the SARs.

Results

Overall

Of the 867 human-marine mammal interactions summarized in this report, 742 interactions were determined to have caused a mortality, SI, removal from the population, or were prorated to reflect the likelihood of serious injury of the marine mammal involved

¹ Similar to the procedure described for documenting interactions in unsampled hauls, MMAP reports from currently observed fisheries were included in this report if there were no observed mortalities or injuries of that species and stock in the fishery that year (i.e., the MMAP report represented the only source of information on mortalities or injuries of that species and stock in that fishery in that year).

in the interaction. The remaining 125 interactions were found to have resulted in an NSI of the marine mammal.

Across all 867 interactions, entanglement/entrapment was the most common mechanism of injury (n = 635), which resulted in 508 SI, prorated SI, or mortalities (collectively referred to as mortality and serious injury, or M/SI). The majority of entanglement/entrapment-related interactions occurred in fishing gear (n = 420, resulting in 331.5 M/SI) and marine debris (n = 208, resulting in 174 M/SI); other causes of entanglement/entrapment (n = 7 interactions, resulting in 2.5 M/SI) included an outhaul mooring, loose webbing at a remote ADF&G king salmon release site, vessel ground tackle, anchored line used for mooring docks, and MMPA-authorized research and management activities at Bonneville Dam. An additional 232 confirmed interactions included animals that were hooked by fishing gear (n = 126 interactions, resulting in 118 M/SI), shot (n = 53, resulting in 53 M/SI), or struck by vessels (n = 28, resulting in 53 M/SI); the remaining 25 interactions were due to other assorted causes, resulting in 25 M/SI.

Of the 317 interaction records that were provided by the AKRO and WCRO stranding networks, 253 documented M/SI of the animal involved in the interaction, resulting in 238.68 M/SI. The M/SI in these records was due to entanglement in marine debris (n = 95 interactions, resulting in 66 M/SI), entanglement in fishing gear (n = 91 interactions, resulting in 59 M/SI), shooting (n = 53 interactions, resulting in 53 M/SI), hooking in fishing gear (n = 40 interactions, resulting in 36 M/SI), vessel strike (n = 26 interactions, resulting in 17.18 M/SI), and other assorted causes (n = 12, resulting in 7.5 M/SI).

Fisheries observers in the North Pacific Groundfish Observer Program, West Coast Groundfish Observer Program, and At-Sea Hake Observer Program reported 327 interaction events in federal groundfish fisheries. The majority of these events resulted in mortality² (n = 268 interactions, resulting in 267 M/SI), with 51 NSI and a relatively small number of SI and prorated SI (n = 8, resulting in 7.02 M/SI), resulting in a total of 274.02 M/SI.

Approximately 600 observations of Steller sea lion entanglements and fishing gear interactions, many of which were repeat sightings of individual animals, were documented and reviewed by ADF&G based on standardized annual summer surveys conducted at most Steller sea lion haulouts and rookeries in Southeast Alaska, Prince William Sound, the

² As noted in the Introduction, mortalities and injuries in unsampled hauls were included in this report but not used to estimate bycatch or reported in the Alaska SARs unless there were no reported mortalities or injuries of that stock in observed hauls in that fishery in that year. Mortalities and injuries in unsampled hauls that were not used to estimate bycatch or reported in the Alaska SARs were not assigned M/SI values for comparison against PBR or for use in classifying fisheries on the MMPA LOF (i.e., “N/A” was entered in the M/SI Value and LOF Value fields). As such, the sum of M/SI values may be less than the total number of mortality records.

Barren Islands, and Bristol Bay. From these observations, 187 injured Steller sea lions were determined to be unique animals, resulting in 178 M/SI. Among these records, entanglement/entrapment in marine debris (n = 109 interactions, resulting in 104 M/SI), hooking and/or ingestion in fishery gear (n = 74 interactions, resulting in 70 M/SI), and entanglement/entrapment in fishery gear (n = 3 interactions, resulting in 3 M/SI) were most prevalent; the remaining interaction was a dependent animal with a seriously injured mother, resulting in 1 M/SI.

Pinnipeds

Steller sea lions were the most common species in reports of human-caused mortality and injury between 2016 and 2020 (n = 532 interactions, resulting in 479 M/SI). The most common cause of mortality and injury for the Eastern U.S. stock of Steller sea lions (n = 384, resulting in 333 M/SI) was entanglement (n = 222, resulting in 179 M/SI), followed by hooking in fishing gear (n = 113, resulting in 105 M/SI).

Hookings of Eastern U.S. Steller sea lions primarily occurred during salmon fishing in which a line with gear was towed behind a vessel (n = 91, resulting in 89 M/SI). Depending on salmon species, location, and fishermen preference, different types of lures are used to attract fish including spinners, spoons, and flashers. Steller sea lions that have ingested gear are found with flashers hanging from the edge of their mouth connected to monofilament line that is attached to a swallowed hook. Recreational fishermen, charter operators, and commercial trollers all tow lines with gear behind their vessel and all sometimes use flashers when fishing for salmon; Steller sea lions are known to interact with gear used by all three of these fishing groups. Beginning with Young et al. (2020), we have replaced the terminology “trollers” and “troll” used in previous M/SI reports with “salmon hook and line” to more accurately describe this type of salmon fishery in Alaska. We also now use the term “unknown hook and line” for interactions with similar gear (fisheries in which a line with gear is towed behind a vessel) off the West Coast when the target species is unknown, and for other instances of interactions with hooks and/or monofilament lines that cannot be identified to a fishery.

Entanglements of Eastern U.S. Steller sea lions occurred in marine debris (n = 111, resulting in 105 M/SI), in fishing gear (n = 110, resulting in 73 M/SI), and in other material (n = 1, resulting in 1 M/SI). Of the entanglements in fishing gear, 97 (resulting in 62 M/SI) were in commercial trawl gear. Other causes of mortality and injury for Eastern U.S. Steller sea lions include shooting (n = 32, resulting in 32 M/SI), unknown causes (n = 7, resulting in 7 M/SI), removal from the population (n = 6, resulting in 6 M/SI), and dependent animals with seriously injured mothers (n = 2, resulting in 2 M/SI).

Based on 15 years of annual summer surveys of Steller sea lions, ADF&G documented 15 marked individual Steller sea lions that interacted with salmon hook-and-line fishing gear as evidenced by a flasher at the edge of the mouth. ADF&G has gained information on the fate of some of these animals. Seven were able to free themselves from the flasher (presumably by biting through the monofilament line that connected the swallowed hook to the flasher) and survived at least 1 year beyond the initial observation date. The flasher was not present when these seven animals were re-sighted in subsequent years. Of the eight remaining animals, one was found dead due to the flasher and swallowed hook combination, one was taken in an Alaska Native subsistence hunt (rumored to be, in part, a “mercy killing” because the animal appeared emaciated and sickly), and six were never sighted again following the initial report (ADF&G Steller Sea Lion Research Program, unpubl. data).

ADF&G analyzed data from 1,439 individually marked Steller sea lions that were re-sighted from 2001 through 2015. The analyses indicated that Steller sea lions that had ingested salmon hook and line fishing gear had lower survival than comparable animals that had not ingested fishing gear (ADF&G Steller Sea Lion Research Program, unpubl. data). Post-mortem exams of Steller sea lions with flasher entanglements typically revealed a hook lodged in the esophagus or penetrating the pleural cavity or pericardium.

Human-caused mortality and injury of the Western U.S. stock of Steller sea lions ($n = 148$, resulting in 146 M/SI) was primarily caused by entanglement in fishing gear ($n = 117$, resulting in 115 M/SI), followed by entanglement in marine debris ($n = 19$, resulting in 19 M/SI), hooking in fishing gear ($n = 5$, resulting in 5 M/SI), shooting ($n = 5$, resulting in 5 M/SI), and injury related to MMPA authorized research ($n = 2$, resulting in 2 M/SI). Fishery interactions occurred most commonly in commercial trawl gear ($n = 113$, resulting in 111 M/SI). Interactions in the federal trawl fisheries typically resulted in mortality (the animal was already dead by the time it was observed); injuries are rare (Breiwick 2013).

Differences in the leading causes of M/SI for the Eastern U.S. and Western U.S. stocks of Steller sea lions are likely due to the geographical distribution of commercial and charter/recreational salmon hook and line fishing effort, which occurs more in Southeast Alaska than in any other part of the state. It is unknown whether differences in reported entanglement numbers for each stock are due to lower entanglement rates in the Western U.S. stock of Steller sea lions or the result of other factors, such as fewer people to notice entanglements in some of these areas, which result in fewer reports of entanglement.

The majority of human-caused mortality and injury of northern fur seals ($n = 110$, resulting in 72 M/SI) was due to constricting entanglements, mainly circumferential neck entanglements in marine debris and various components of fishing gear ($n = 86$, resulting in 54 M/SI). Because Eastern Pacific northern fur seals are known to occur off the U.S. West

Coast in winter/spring, any mortality or injury reported off the coasts of Washington, Oregon, or California during December through May was assigned to both the Eastern Pacific and California stocks of northern fur seals.

Most human-caused mortality and injury of phocids involved harbor ($n = 38$, resulting in 37 M/SI) and ringed ($n = 30$, resulting in 30 M/SI) seals, with some additional records of spotted ($n = 7$, resulting in 7 M/SI), bearded ($n = 6$, resulting in 6 M/SI), and ribbon ($n = 1$, resulting in 1 M/SI) seals. Unidentified phocid mortalities and injuries ($n = 5$, resulting in 5 M/SI) were also reported. Of all records of phocid mortalities and injuries ($n = 87$, resulting in 86 M/SI), entanglement in fishing gear ($n = 61$, resulting in 60 M/SI) was the leading cause, affecting 28 ringed seals (resulting in 28 M/SI), 18 harbor seals (resulting in 17 M/SI), 6 bearded seals (resulting in 6 M/SI), 6 spotted seals (resulting in 6 M/SI), 2 unidentified phocids (resulting in 2 M/SI), and 1 ribbon seal (resulting in 1 M/SI).

Of the human-caused mortality and injury of unidentified otariids ($n = 10$, resulting in 4 M/SI), entanglement in trawl fishing gear was the main cause ($n = 10$, resulting in 4 M/SI). For unidentified pinnipeds ($n = 10$, resulting in 2 M/SI), entanglement in trawl fishing gear was also the main cause of human-caused mortality and injury ($n = 8$, resulting in 0 M/SI).

Large Cetaceans

Human-caused mortality and injury of large whales ($n = 85$ interactions, resulting in 53.2 M/SI³) was reported for humpback ($n = 65$, resulting in 35.66 M/SI), unidentified ($n = 8$, resulting in 6.04 M/SI), sperm ($n = 5$, resulting in 4.5 M/SI), fin ($n = 4$, resulting in 4 M/SI), and bowhead ($n = 3$, resulting in 3 M/SI) whales. Entanglements of humpback whales ($n = 47$, resulting in 26 M/SI) were the most frequent interactions, followed by ship strikes of humpback whales ($n = 18$, resulting in 9.66 M/SI). Humpback whale interactions where the animal could not be assigned to a stock (i.e., based on photo-identification or information identifying both wintering and summering areas) were prorated among all stocks present in the area using area-specific proration factors. Sperm whale entanglements in federal longline fishing gear ($n = 2$) resulted in 1.5 M/SI. Sperm whales (and killer whales) are known to depredate (remove or damage) fish on longline gear during haul back, increasing their susceptibility for interaction with these fisheries (Sigler et al. 2008, Peterson and Hanselman 2017).

³ As noted in the Methods section, animals discovered hooked or entangled in fishing gear that were subsequently harvested for Alaska Native subsistence use were included in this report's summaries of numbers of interactions and counted in the M/SI estimates. This includes 3 large whales.

Many of the large whale entanglements were assigned to injury category L10 “evidence of entanglement” (Appendix Table 1), in which an entanglement was known to have occurred but there was insufficient information available on the configuration of the entanglement to determine whether the gear was wrapped in a constricting manner (category L2) or loosely wrapped, bridled, or draped (category L3). More details on the configuration of entanglements (such as written descriptions from observations; aerial, underwater, and surface images; or follow-up information from resights of entangled whales) are needed to improve the accuracy of injury determinations.

Small Cetaceans

There were relatively few reports of human-caused mortality or injury of Alaska stocks of small cetaceans from 2016 to 2020 ($n = 30$ interactions, resulting in 24 M/SI⁴). Harbor porpoise interactions occurred incidental to Alaska subsistence gillnet ($n = 7$, resulting in 6 M/SI) and commercial gillnet ($n = 4$, resulting in 1 M/SI) fisheries. Beluga whale interactions occurred because of entanglement in fishing gear ($n = 4$, resulting in 4 M/SI) and injury during MMPA authorized research ($n = 1$, resulting in 1 M/SI). The beluga whale fishery interactions involved commercial gillnet ($n = 2$), Alaska subsistence gillnet ($n = 1$), and unknown ($n = 1$) fisheries; 4 animals were subsequently harvested for Alaska Native subsistence use.

Dall’s porpoise interactions ($n = 3$, resulting in 2 M/SI) occurred as a result of entanglement in commercial gillnet fishery gear ($n = 2$, resulting in 1 M/SI) and unknown pot fishery gear ($n = 1$, resulting in 1 M/SI). Pacific white-sided dolphins were entangled in commercial trawl fishery gear ($n = 2$, resulting in 2 M/SI).

Interactions causing mortality and injury ($n = 7$ interactions, resulting in 6 M/SI) of killer whales occurred in the commercial BSAI flatfish trawl fishery ($n = 4$, resulting in 4 M/SI), an unknown pot fishery ($n = 1$, resulting in 1 M/SI), the California Dungeness crab pot fishery ($n = 1$, resulting in 0 M/SI), and the commercial BSAI Pacific cod longline fishery ($n = 1$, resulting in 1 M/SI). When ecotype and/or stock was unknown, the injury or mortality was assigned to killer whale stocks that could occur in the area. One of the killer whales entangled in California Dungeness crab pot gear, was found stranded in northern California and was included in this report because genetic analysis indicated it was a transient killer whale. However, because the stock could not be identified, this mortality was assigned to the Eastern North Pacific (ENP) Gulf of Alaska, Aleutian Islands, Bering Sea

⁴ As noted in the Methods section, animals discovered hooked or entangled in fishing gear that were subsequently harvested for Alaska Native subsistence use were included in this report’s summaries of numbers of interactions and counted in the M/SI estimates. This includes 4 small cetaceans.

Transient, and West Coast Transient killer whale stocks; it was not assigned to the AT1 Transient killer whale stock because none of the whales in that population are missing.

Finally, unidentified small cetacean interactions (n = 2, resulting in 2 M/SI) in the commercial Alaska Cook Inlet salmon set gillnet fishery were self-reported by fishermen through the MMAP.

Discussion

All records of human-caused mortality and injury of marine mammal stocks that are assessed in the Alaska SARs were obtained through dedicated efforts, such as commercial fisheries observer programs and ongoing agency research and monitoring programs, or by opportunistic reports from stranding networks, researchers, or at-sea sightings from vessel and aircraft operators. Because of the vastness and remoteness of Alaska's coastlines and the fact that not all dead or injured marine mammals wash ashore, the detection and reporting of stranded marine mammals is particularly limited in Alaska compared with other Regions. Consequently, the opportunistic reports represent minimum values for human-caused injury and mortality of marine mammals in Alaska. Actual levels of human-caused injury and mortality of Alaska pinniped and cetacean stocks are most likely greater than the values in this report.

The quality and quantity of information available for each mortality or injury record was highly variable. Some records contained a very limited amount of information, while others consisted of multiple images or videos which depicted the full nature of the injury or entanglement (e.g., underwater, aerial, and surface images). Imagery of entanglements captured from varying perspectives can confirm or rule out the presence of constricting wraps of line or fishing gear, reducing the number of L10 (evidence of entanglement) classifications, used when not enough information is known about the configuration of the entanglement to differentiate between L2 (SI) and L3 (NSI) entanglement injury categories. Even in the absence of imagery, records with detailed information about an incident can increase the chance of appropriately classifying the injury and properly assigning the interaction to the specific fishery involved. Without sufficient information, injuries must be classified in categories such as "evidence of entanglement" instead of more accurate injury categories. When documenting marine mammal mortality or injury, stranding responders, disentanglement teams, and fisheries observers should be encouraged to provide as many details as possible regarding entanglement configurations and to document the event with pictures and video. NMFS should also ensure that people responding to or reporting on injured marine mammals are informed of key information that needs to be recorded for NMFS to distinguish serious from non-serious injuries. For management purposes, fisheries

observers and stranding network participants reporting fishery interactions should also be encouraged to include details that can aid in determining and documenting mortality and injury in specific fisheries. It is also helpful for reporters to differentiate between commercial, recreational, and Alaska subsistence fishing gear or fishery interactions, when possible. In some situations, the same type of fishing gear can be used by commercial, charter, and recreational salmon hook-and-line fishing groups (e.g., in Southeast Alaska), thus, making it difficult to definitively assign fishery gear to a user group ad hoc.

Acknowledgments

We thank the stranding networks at the NMFS Alaska and NMFS West Coast Regional Offices, the AFSC Fisheries Monitoring and Analysis Division's North Pacific Observer Program, the Northwest Fisheries Science Center's Fishery Resource Analysis and Monitoring Division Fisheries Observation Science Program (which encompasses both the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP)), and the Alaska Department of Fish and Game staff and volunteers, as well as the stranding responders, fishermen, fisheries observers, vessel and aircraft operators, and other individuals who report and respond to injured marine mammals in the Alaska and West Coast regions. We also thank Jim Carretta, Allison Henry, Suzie Teerlink, and members of the Alaska Scientific Review Group for reviewing AFSC-MML's injury determinations. Jim Carretta provided helpful comments and edits to this report.

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Guide to Acronyms and Abbreviations Found in Table 1

The following acronyms and abbreviations are used in Table 1.

Areas (also used in some Fishery Names):

AK: Alaska
BS: Bering Sea
CA: California
GOA: Gulf of Alaska
OR: Oregon
PWS: Prince William Sound
SCAK: Southcentral Alaska
SEAK: Southeast Alaska
WA: Washington
WAK: Western Alaska
WC: U.S. West Coast

Sources of Records:

ADFG: Alaska Department of Fish and Game
AKRO: National Marine Fisheries Service, Alaska Regional Office
A-SHOP: National Marine Fisheries Service, At-Sea Hake Observer Program
MMAP: Marine Mammal Authorization Program
NMFS OPR/HQ: National Marine Fisheries Service, Office of Protected
Resources/Headquarters
NPGOP: National Marine Fisheries Service, North Pacific Groundfish Observer Program
NWFSC: National Marine Fisheries Service, Northwest Fisheries Science Center
NWIFC: Northwest Indian Fisheries Commission
ODFW: Oregon Department of Fish and Wildlife
Rolland et al. 2019: Rolland, R. M., K. M. Graham, R. Stimmelmayer, R. S. Suydam, and
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recorded in baleen from a bowhead whale (*Balaena mysticetus*).
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SWFSC: National Marine Fisheries Service, Southwest Fisheries Science Center
WCGOP: National Marine Fisheries Service, West Coast Groundfish Observer Program
WCRO: National Marine Fisheries Service, West Coast Regional Office

Initial Assessment and Final Determinations:

NSI: Non-Serious Injury
SI: Serious Injury

Other:

ASLC: Alaska SeaLife Center

BSAI: Bering Sea/Aleutian Islands

COD: Cause of Death

EM: Electronic Monitoring

ID: Species Identity

LOF: List of Fisheries

MMPA: Marine Mammal Protection Act

OA: Open Access

OLE: NOAA's Office of Law Enforcement

USCG: United States Coast Guard

Tables and Figures

Human-caused injury and mortality records reported for NMFS-managed Alaska marine mammal stocks between 2016 and 2020 and summary figures. A guide to the acronyms and abbreviations found in Table 1 is included in the previous pages. Note: many comments were entered verbatim from observer reports. Some terminology may be specific to a particular industry or practice (e.g., “flasher” and “hoochie” are types of lures used in salmon hook-and-line recreational/charter and commercial fisheries; “cod-end” is the narrow end of a tapered trawl net; etc.). For any questions regarding specific terminology, contact the authors for clarification.

Table 1: Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Figure 1: Total human-caused serious injury and mortality of Alaska marine mammal species appearing in the Alaska Stock Assessment Reports, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

Figure 2: Human-caused serious injury and mortality of Alaska pinniped species by mechanism of injury, 2016-2020. Dependent animals with seriously injured mothers are included in the “other” category, regardless of the mechanism of injury of their mothers.

Figure 3: Human-caused serious injury and mortality of Alaska pinniped species by general cause of injury, 2016-2020. Dependent animals with seriously injured mothers are assigned the same cause of injury as their mothers.

Figure 4: Fishery-related serious injury and mortality of Alaska pinniped species (fishery gear as the cause of injury) by fishery gear type, 2016-2020.

Figure 5: Human-caused serious injury and mortality of Alaska large whale species by mechanism of injury, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

Figure 6: Human-caused serious injury and mortality of Alaska large whale species by general cause of injury, 2016-2020. Dependent animals with seriously injured mothers are assigned the same cause of injury as their mothers. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

Figure 7: Fishery-related serious injury and mortality (fishery gear as the cause of injury) of Alaska large whale species by fishery gear type, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

Figure 8: Human-caused serious injury and mortality of Alaska small cetacean species by mechanism of injury, 2016-2020.

Figure 9: Human-caused serious injury and mortality of Alaska small cetacean species by general cause of injury, 2016-2020.

Figure 10: Fishery-related serious injury and mortality (fishery gear as the cause of injury) of Alaska small cetacean species by fishery gear type, 2016-2020.

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	5/11/2016	BS	Bearded Seal	Beringia	DEAD	A bearded seal was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	8/26/2016	AK	Bearded Seal	Beringia	DEAD	A bearded seal was caught and killed in BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/2/2017	BS	Bearded Seal	Beringia	DEAD	A male bearded seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	8/8/2017	BS	Bearded Seal	Beringia	DEAD	A bearded seal was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/27/2018	BS	Bearded Seal	Beringia	DEAD	A female bearded seal was caught and killed by BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	7/30/2020	BS	Bearded Seal	Beringia	DEAD	A bearded seal was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NMFS OPR/HQ	9/17/2016	BS	Beluga Whale	Bristol Bay	DEAD	A beluga whale died as a result of marine mammal research activities in Bristol Bay, AK.	DEAD	Research related injury	MMPA authorized research	N/A	N/A	N/A	N/A	1	0
AKRO	6/1/2018	WAK	Beluga Whale	Eastern Bering Sea	DEAD	A subadult female beluga whale was caught and killed in Alaska subsistence salmon net, and then harvested for Alaska Native subsistence purposes.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/27/2018	WAK	Beluga Whale	Eastern Bering Sea	DEAD	A subadult beluga whale was caught and killed in commercial gillnet, and then harvested for Alaska Native subsistence purposes.	DEAD	Entangled / entrapped	Fishery gear	AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	Commercial	Gillnet	N/A	1	0
AKRO	8/28/2018	WAK	Beluga Whale	Eastern Bering Sea	DEAD	A male calf beluga whale was caught and killed in commercial gillnet, and then harvested for Alaska Native subsistence purposes.	DEAD	Entangled / entrapped	Fishery gear	AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	Commercial	Gillnet	N/A	1	0
AKRO	5/30/2019	BS	Beluga Whale	Eastern Bering Sea	DEAD	A male beluga whale calf was found entangled in an unknown net. The animal was presumed to have drowned after becoming entangled and it was harvested for Alaska Native subsistence use.	DEAD	Entangled / entrapped	Fishery gear	Unknown net	Unknown	Unknown	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
Roland et al. 2019	5/5/2017	Arctic	Bowhead Whale	Western Arctic	SI	An entangled bowhead whale was harvested for Alaska Native subsistence use. The hunters described the whale as lethargic and trailing rope, and assumed it had been previously struck and lost. Once the whale was killed and landed, the hunters discovered the whale had severe rope entanglement wounds, with 100-200 m of 19-mm diameter rope attached to the whale. The rope was tightly anchored to the baleen, wrapped once around the left pectoral flipper, and wrapped tightly six times around the peduncle, where it penetrated approximately 10 cm through the skin into the blubber. The gear was not marked so could not be assigned to a specific fishery, but the rope characteristics were consistent with those used in Bering Sea pot fisheries.	SI	Entangled / entrapped	Fishery gear	Unconfirmed	Unknown	Pot	L2	1	0
AKRO	5/6/2017	Arctic	Bowhead Whale	Western Arctic	SI	A subadult bowhead whale was observed to be entangled in 100 - 200 meters of 3/4 inch synthetic line. The line went laterally through the mouth of the whale and was tightly fixed through the baleen rack, went caudally with a single wrap to the left pectoral fin, and then made six tight wraps around the peduncle. Hundreds of feet of line trailed behind the whale's flukes/peduncle. The line had cut 10 cm into the peduncle. There was white scar tissue associated with the peduncle injury. The whale's tongue was severely injured. The whale was harvested for Alaska Native subsistence use immediately following its discovery. Based on the hunter's observations and an evaluation by the onsite veterinarian, this whale was in the process of dying prior to the harvest. The entanglement gear is suggested to be from the commercial Bering Sea pot fishery, but this is unconfirmed.	SI	Constricting entanglement	Fishery gear	unconfirmed	Unknown	Pot	L2	1	0
AKRO	5/15/2017	Arctic	Bowhead Whale	Western Arctic	SI	A bowhead whale was observed to be entangled in 3/4 inch synthetic line. The entanglement involved considerable wraps through the mouth and around the neck and left pectoral fin. The tongue was badly injured with scar tissue and puffy white patches. Following its discovery, the whale was immediately harvested for Alaska Native subsistence use by Inupiat hunters in part because the whale was clearly "injured and suffering." The entanglement gear is suggested to be from the commercial Bering Sea pot fishery, but this is unconfirmed.	SI	Constricting entanglement	Fishery gear	unconfirmed	Unknown	Pot	L2	1	0
MMAP	7/4/2018	SEAK	Dall's Porpoise	Alaska	DEAD	Dall's porpoise was caught and killed in gillnet inside of the ADF&G Management Districts 6, 7, and 8. Mortality and serious injury estimates for this stock in this previously observed fishery are obtained from older observer data and not 2016-2020 stranding data or fishermen self-reported (MMAP) data; therefore, this record will not be assigned an M/SI or LOF value and is not reported in the SAR.	DEAD	Entangled / entrapped	Fishery gear	AK Southeast Alaska drift gillnet	Commercial	Gillnet	N/A	N/A	N/A
MMAP	3/29/2019	WAK	Dall's Porpoise	Alaska	DEAD	A Dall's porpoise was found caught and killed in unknown pot gear that was brought to the surface by a bottom trawl. This case is attributed to an unknown pot fishery and not the bottom trawl fishery.	DEAD	Entangled / entrapped	Fishery gear	Unknown pot	Unknown	Pot	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
MMAP	7/20/2020	GOA	Dall's Porpoise	Alaska	DEAD	A Dall's porpoise was caught and killed in an AK Prince William Sound salmon drift gillnet.	DEAD	Entangled / entrapped	Fishery gear	AK Prince William Sound salmon drift gillnet	Commercial	Gillnet	N/A	1	1
AKRO	5/29/2016	SEAK	Fin Whale	Northeast Pacific	DEAD	A freshly dead fin whale carcass was discovered on the bulbous bow of a cruise ship. The carcass was removed, a necropsy was conducted, and it was confirmed that the whale was killed by ship strike.	DEAD	Ship strike	Vessel (commercial)	N/A	N/A	N/A	N/A	1	0
AKRO	6/20/2018	Kodiak	Fin Whale	Northeast Pacific	SI	A fin whale was struck and killed by a state ferry. A video and self-report show the whale breaching, landing on the starboard stabilizer of the ship, and rolling off with bloating and mortal injuries.	DEAD	Ship strike	Vessel (commercial)	N/A	N/A	N/A	N/A	1	0
MMAP	9/27/2019	BS	Fin Whale	Northeast Pacific	DEAD	A fin whale was caught and killed in an AK BSAI pollock trawl net.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
AKRO	8/21/2020	BS	Fin Whale	Northeast Pacific	DEAD	A fresh dead adult female fin whale was observed floating in the water. Bruising along the lateral thorax was observed upon close inspection and evidence of significant blunt trauma indicated that a vessel strike was the most probable cause of death.	DEAD	Ship strike	Vessel (unknown)	N/A	N/A	N/A	N/A	1	0
AKRO	8/5/2018	WAK	Harbor Porpoise	Bering Sea	DEAD	An adult harbor porpoise was caught and killed in Alaska subsistence salmon gillnet.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/20/2018	WAK	Harbor Porpoise	Bering Sea	DEAD	An adult harbor porpoise was caught and killed in Alaska subsistence salmon gillnet.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	7/1/2020	BS	Harbor Porpoise	Bering Sea	NSI	An adult harbor porpoise was caught in Alaska subsistence salmon gillnet before it was released alive, with no reported injuries, by the fisherman.	NSI	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	S7b	0	0
AKRO	7/3/2020	Arctic	Harbor Porpoise	Bering Sea	DEAD	An adult male harbor porpoise was caught and killed in Alaska subsistence salmon gillnet.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/6/2020	Arctic	Harbor Porpoise	Bering Sea	DEAD	Three adult harbor porpoise were caught and killed in Alaska subsistence salmon gillnet. This record (female porpoise) represents 1 of 3 porpoise.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/8/2020	Arctic	Harbor Porpoise	Bering Sea	DEAD	Three adult harbor porpoise were caught and killed in Alaska subsistence salmon gillnet. This record (female porpoise) represents 2 of 3 porpoise.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/13/2020	Arctic	Harbor Porpoise	Bering Sea	DEAD	Three adult harbor porpoise were caught and killed in Alaska subsistence salmon gillnet. This record (male porpoise) represents 3 of 3 porpoise.	DEAD	Entangled / entrapped	Fishery gear	Salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	6/28/2016	SCAK	Harbor Porpoise	Gulf of Alaska	DEAD	A harbor porpoise was caught and killed in salmon drift gillnet gear. Mortality and serious injury estimates for this stock in this fishery are obtained from observer data and not stranding data or fishermen self-reported (MMAP) data; therefore, this record will not be assigned an M/SI or LOF value.	DEAD	Entangled / entrapped	Fishery gear	AK PWS salmon drift gillnet	Commercial	Gillnet	N/A	N/A	N/A

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
MMAP	6/19/2020	SCAK	Harbor Porpoise	Gulf of Alaska	DEAD	A harbor porpoise was caught and killed in an AK Cook Inlet salmon drift gillnet. This mortality will not be counted against the AK Cook Inlet salmon drift gillnet fishery because bycatch estimates from 1999-2000 AMMOP observer data are used in the SAR.	DEAD	Entangled / entrapped	Fishery gear	AK Cook Inlet salmon drift gillnet	Commercial	Gillnet	N/A	N/A	N/A
MMAP	6/28/2020	SCAK	Harbor Porpoise	Gulf of Alaska	DEAD	A harbor porpoise was caught and killed in an AK Cook Inlet salmon drift gillnet. This mortality will not be counted against the AK Cook Inlet salmon drift gillnet fishery because bycatch estimates from 1999-2000 AMMOP observer data are used in the SAR.	DEAD	Entangled / entrapped	Fishery gear	AK Cook Inlet salmon drift gillnet	Commercial	Gillnet	N/A	N/A	N/A
MMAP	5/28/2019	SEAK	Harbor Porpoise	Yakutat/SEAK Offshore Waters	DEAD	A harbor porpoise was caught and killed in a SEAK salmon cost recovery drift gillnet outside of the ADF&G Management Districts 6, 7, and 8.	DEAD	Entangled / entrapped	Fishery gear	SEAK salmon cost recovery drift gillnet	Commercial	Gillnet	N/A	1	0
NPGOP	8/5/2020	Kodiak	Harbor Seal	Alaska	DEAD	A harbor seal was caught and killed in AK GOA flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/7/2016	BS	Harbor Seal	Aleutian Islands	DEAD	A harbor seal was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/9/2018	SCAK	Harbor Seal	Aleutian Islands	DEAD	A male harbor seal was caught and killed by AK BSAI Atka mackerel trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	8/26/2020	GOA	Harbor Seal	Aleutian Islands	DEAD	A harbor seal was caught and killed by AK GOA halibut longline gear.	DEAD	Hooked	Fishery gear	AK GOA halibut longline	Commercial	Longline	N/A	1	1
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 1 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 2 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 3 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 4 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 5 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/28/2016	BS	Harbor Seal	Bristol Bay	DEAD	Six harbor seals were reported dead by Alaska State Troopers on the northern shore of Egegik Bay. All animals were reported to be shot in the head. This record represents animal 6 of 6.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	2/25/2017	BS	Harbor Seal	Bristol Bay	DEAD	A harbor seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/26/2017	BS	Harbor Seal	Bristol Bay	DEAD	A female harbor seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	10/13/2017	BS	Harbor Seal	Bristol Bay	DEAD	A female harbor seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
MMAP	6/28/2019	WAK	Harbor Seal	Bristol Bay	DEAD	A harbor seal was caught and killed in an AK Bristol Bay salmon set gillnet.	DEAD	Entangled / entrapped	Fishery gear	AK Bristol Bay salmon set gillnet	Commercial	Gillnet	N/A	1	1
NPGOP	9/2/2019	BS	Harbor Seal	Bristol Bay	DEAD	A male harbor seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/14/2019	BS	Harbor Seal	Bristol Bay	DEAD	A male harbor seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
MMAP	6/5/2020	BS	Harbor Seal	Bristol Bay	DEAD	A harbor seal was caught and killed in an AK Bristol Bay salmon set gillnet.	DEAD	Entangled / entrapped	Fishery gear	AK Bristol Bay salmon set gillnet	Commercial	Gillnet	N/A	1	1
NPGOP	5/6/2018	SEAK	Harbor Seal	Clarence Strait	DEAD	A harbor seal was caught and killed by AK GOA halibut longline gear.	DEAD	Hooked	Fishery gear	AK GOA halibut longline	Commercial	Longline	N/A	1	1
AKRO	7/5/2017	SCAK	Harbor Seal	Cook Inlet/Shelikof	SI	An adult seal was observed hauled out with fishing net wrapped around its rear flippers. The seal was also observed to have something around its head and neck.	SI	Constricting entanglement	Fishery gear	Unknown net	Unknown	Net	P6	1	0
NPGOP	10/12/2017	Kodiak	Harbor Seal	Cook Inlet/Shelikof	DEAD	An adult female harbor seal was caught and killed by AK GOA flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/6/2017	Kodiak	Harbor Seal	Cook Inlet/Shelikof	DEAD	A female harbor seal was caught and killed by AK GOA flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/6/2018	SCAK	Harbor Seal	Cook Inlet/Shelikof	DEAD	A harbor seal pup was found dead of a gunshot wound. An OLE investigation concluded that the shooting was intentional and non-subsistence.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	6/9/2018	SCAK	Harbor Seal	Cook Inlet/Shelikof	DEAD	A harbor seal was caught and killed by AK GOA Pacific cod longline gear.	DEAD	Hooked	Fishery gear	AK GOA Pacific cod longline	Commercial	Longline	N/A	1	1
AKRO	6/23/2018	SCAK	Harbor Seal	Cook Inlet/Shelikof	DEAD	A harbor seal was found dead of a gunshot wound. An OLE investigation concluded that the shooting was intentional and non-subsistence.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
MMAP	5/4/2020	SCAK	Harbor Seal	Cook Inlet/Shelikof	DEAD	A harbor seal was caught and killed by AK GOA halibut longline gear. This mortality will be counted against the AK GOA halibut longline fishery because mortality or serious injury of this stock was not observed by NPGOP observers in this fishery in this year.	DEAD	Hooked	Fishery gear	AK GOA halibut longline	Commercial	Longline	N/A	1	1

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	6/15/2020	SCAK	Harbor Seal	Cook Inlet/Shelikof	DEAD	A male subadult harbor seal was found fresh dead with lesions consistent with a gunshot injury. A necropsy was conducted and concluded the animal died from a gunshot that entered from behind the right ear, traveled through the brain, and exited partially out of the left eye. Bullet and skull fragments were found.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/4/2017	SEAK	Harbor Seal	Lynn Canal/Stephens	NSI	An adult harbor seal entangled in gillnet for approximately one hour was brought aboard, disentangled, and released to the water without any apparent injuries.	NSI	Entangled / entrapped	Fishery gear	AK SEAK salmon drift gillnet	Commercial	Gillnet	P4	0	0
NPGOP	10/30/2017	Kodiak	Harbor Seal	North Kodiak	DEAD	A male harbor seal was caught and killed by AK GOA flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/26/2018	Kodiak	Harbor Seal	North Kodiak	DEAD	A harbor seal was found dead in a barrier net of a salmon hatchery cost recovery seine.	DEAD	Entangled / entrapped	Fishery gear	Salmon hatchery cost recovery seine	Commercial	Seine	N/A	1	0
NPGOP	4/1/2020	BS	Harbor Seal	Pribilof Islands	DEAD	A harbor seal was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	7/19/2016	SCAK	Harbor Seal	Prince William Sound	DEAD	A harbor seal carcass was discovered during Copper River Delta carcass surveys. Multiple round full-thickness lesions ranging from 1 cm to 2 cm in size were located throughout the head and body.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/19/2016	SCAK	Harbor Seal	Prince William Sound	DEAD	A harbor seal carcass was discovered during Copper River Delta carcass surveys. A fractured skull indicated the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/19/2016	SCAK	Harbor Seal	Prince William Sound	DEAD	A harbor seal carcass was discovered during Copper River Delta carcass surveys. The bones of the head and neck were disorganized and there were several dorsal openings into the body cavity.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/12/2017	SCAK	Harbor Seal	Prince William Sound	DEAD	An adult male harbor seal was found dead with lesions consistent with a firearm injury. A necropsy was conducted and concluded a likely gunshot to the head. Besides the trauma to the head, the rest of the hide and body appeared uninjured. Expert opinion was used to determine gunshot source.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/26/2017	SCAK	Harbor Seal	Prince William Sound	DEAD	A subadult male harbor seal was found dead with lesions consistent with a firearm injury. The left dorsal skull had a full thickness wound. Metal detector - negative. The head was taken for radiographs plus esophageal contents. Radiographs - top of skull with displaced fracture and possibly bullet fragments.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/26/2017	SCAK	Harbor Seal	Prince William Sound	DEAD	A subadult male harbor seal was found dead with lesions consistent with a firearm injury. There was a full thickness lesion on the right dorsal neck with subcutaneous bruising/hemorrhage. The head was removed for radiographs which showed a bullet and fragments in/near the atlas.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	5/22/2019	SCAK	Harbor Seal	Prince William Sound	DEAD	An adult male harbor seal was found fresh dead with lesions consistent with a firearm injury. Two holes were found in the back of the skull and the metal detector signaled on the left side of the animal between the skull and the shoulder.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	4/5/2018	Kodiak	Harbor Seal	South Kodiak	DEAD	A harbor seal was caught and killed by AK GOA flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	12/23/2020	BS	Humpback Whale	Mex-Npac	SI	A humpback whale was observed in Los Cabos, Mexico, entangled in AK BSAI Pacific cod pot gear from Dutch Harbor, AK, in an unknown configuration. The animal was observed towing one large orange buoy and one large green buoy, which identified the gear. The owner of the gear stated the buoys were attached to 198 feet of nylon sinking line that was attached to 198 feet of poly floating line, which was usually attached to a 500-pound cod pot that is 6 feet long, 6 feet wide, and 3 feet high. It is unknown if the pot was still attached, but it is assumed that the animal is still entangled.	SI	Entangled / entrapped	Fishery gear	AK BSAI Pacific cod pot	Commercial	Pot	L10	0.75	0.75
AKRO	4/4/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale reportedly became entangled in Alaska subsistence gillnet and broke free trailing a 5 fathom section of webbing and a basketball-sized buoy. The whale was not resighted. This entanglement will be considered a prorated serious injury under criterion L10 due to the unknown configuration of the entanglement.	PRORATE	Entangled / entrapped	Fishery gear	Unknown gillnet	Alaska Subsistence	Gillnet	L10	0.75	0
AKRO	5/15/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled in line and trailing a green bullet buoy about 10-15 ft behind it. The nature of the configuration could not be determined, since the observation was from a distance of more than 100 yards. This entanglement will be considered a prorated serious injury under criterion L10 due to the unknown configuration of the entanglement.	PRORATE	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L10	0.75	0
AKRO	6/1/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A humpback whale became entangled in an outhaul mooring. Some gear was cut free initially, but the animal remained entangled in 150 ft of line that trailed a polyball and 60 ft of line that possibly terminated in a 100 lb anchor. Initially the entanglement appeared to originate in the mouth, and the tail and peduncle were free of gear. The whale was tracked over the next 20 days, and eventually lost the trailing polyball buoy, however, the final configuration is unclear; therefore, this entanglement is prorated under criterion L10.	PRORATE	Entangled / entrapped	Other	N/A	N/A	N/A	L10	0.75	0
AKRO	6/26/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale reportedly became entangled in loose webbing that hung from a remote ADF&G king salmon release site. The whale managed to free itself by the time responders arrived at the site. The whale was not resighted, and it is unknown whether any gear remained attached to the whale, therefore this entanglement is prorated under criterion L10.	PRORATE	Entangled / entrapped	Other	N/A	N/A	N/A	L10	0.75	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	6/30/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale calf was reported entangled in red-colored line. The line was trailing, and reported to possibly terminate with a buoy. The origin and configuration of the entanglement could not be determined, therefore this interaction is considered a prorated serious injury under criterion L10.	PRORATE	Entangled / entrapped	Marine debris (rope and buoy)	N/A	N/A	N/A	L10	0.75	0
AKRO	7/4/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was reported to be trailing a small amount of green line from its tail. The reporting party stated that the entanglement did not appear to be life-threatening, but no pictures were obtained and the nature and configuration of the entanglement was not determined. Therefore this interaction is considered a prorated serious injury under criterion L10.	PRORATE	Entangled / entrapped	Marine debris (rope)	N/A	N/A	N/A	L10	0.75	0
AKRO	7/7/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale became entangled in actively fished salmon drift gillnet. After the whale began towing the vessel, the fisherman began to cut the vessel free from the entangling gear. While the gear was being cut free, the whale dove and when it resurfaced it appeared to be free from gear; however, there is not confirmation from the fisherman that all gear was recovered, and some may have remained on the animal.	PRORATE	Entangled / entrapped	Fishery gear	AK SEAK salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	7/8/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A subadult humpback whale was observed entangled in gillnet gear by a whale watch vessel. The whale was observed shedding some of the gear, which was then recovered by the whale watch vessel, but when the whale was last observed it still had webbing around the tailstock and 25 ft of trailing gear. This entanglement will be considered a prorated serious injury under criterion L10 due to the unknown configuration of the entanglement.	PRORATE	Entangled / entrapped	Fishery gear	AK SEAK salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	7/11/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	A humpback whale calf was observed entangled in 3/8 inch line. The line passed through the whale's mouth, forming a bridle, and then trailed further back on either side. The whale was observed entangled for over a week before a disentanglement team responded and cut gear free. A short time later, the whale dropped the gear and multiple parties reported the calf was gear free.	NSI	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L3	0	0
AKRO	7/15/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled in gillnet. The netting was wrapped around the animal's head and the animal was swimming continuously at the surface without diving. The whale was not seen again. Although the gear wrapped around the whale's body, it was not confirmed to be constricting, therefore this entanglement is prorated under criterion L10.	PRORATE	Entangled / entrapped	Fishery gear	AK SEAK salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	7/31/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	A humpback whale became entangled in a purse seine, and was reported to swim away uninjured after being completely disentangled by the crew.	NSI	Entangled / entrapped	Fishery gear	AK SEAK salmon purse seine	Commercial	Seine	L10	0	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	7/31/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	A humpback whale became entangled in an anchor line of a small skiff. The whale began pulling the boat, so the operator cut the line, leaving the whale entangled with ~100 ft of line and an 8 lb anchor. There was originally one confirmed wrap around the whale's peduncle, and possibly another further forward. The reporting party thought it likely that the whale would shed the gear, and multiple on-the-water observers reported that the whale then shed the gear. Additional on-the-water surveys over the next week of the same group of whales did not identify any entangled whales, further confirming the belief that the whale shed the gear shortly after entanglement.	NSI	Entangled / entrapped	Ship's ground tackle	Unknown hook and line	Recreational	Hook and line	L10	0	0
AKRO	9/11/2016	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	DEAD	A humpback whale carcass was discovered stranded and in a state of moderate decomposition. A necropsy was conducted and blunt trauma and hemorrhage along the right jaw, cervical region, and thorax was noted. The examiner noted that the injuries were probably caused by a ship strike.	DEAD	Ship strike	Vessel (unknown)	N/A	N/A	N/A	N/A	1	0
AKRO	1/3/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A subadult humpback whale was observed to be entangled in a 1-inch cable running from a barge to a 6-ton anchor in ~ 30 ft of water. The cable was through the whale's mouth and around its body posterior to the blow hole. The whale was successfully disentangled and all gear was recovered. Following the disentanglement, the whale remained on the surface briefly and then slowly swam away. The entanglement caused some lacerations and a cut about 1-1.5 inches deep into the whale's soft tissue.	NSI	Constricting entanglement	Ship's ground tackle	N/A	N/A	N/A	L2	0	0
AKRO	1/21/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed with a 1.5 ft diameter bright orange-red buoy trailing 40-60 ft behind it. The whale's movements did not appear compromised, and when it dove the buoy submerged along with it. The extent of the entanglement could not be confirmed; thus, this event is prorated at L10.	PRORATE	Entangled / entrapped	Marine debris (rope and buoy)	N/A	N/A	N/A	L10	0.75	0
AKRO	6/9/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A 40 ft recreational vessel traveling at an unknown speed was observed to strike a humpback whale. The whale appeared to be bubble feeding when the vessel drove over the bubbles and struck the animal. The boat was nudged and rocked as a result of the interaction, but the observer did not notice any blood in the water and saw the whale swimming away after the incident. There is no additional information available on the health of the whale following the strike.	PRORATE	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L7b	0.14	0
AKRO	7/8/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	An anchored 47 ft sailboat was struck by a humpback whale causing the vessel to rise and fall hard. The whale was in a group of 3 or 4 animals and kept swimming following the impact. There was no sign of injury to the whale, but the boat was damaged.	NSI	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6c	0	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	7/20/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A 40 ft rigid hull inflatable whale watching vessel traveling at 13 knots struck a humpback whale. The vessel was powering up, saw the spout off the bow, and tried to power down but felt a bump. The whale surfaced behind the boat following the collision. Nothing abnormal about the whale was noticed, and no blood was seen in the water. There is no additional information on the health of the whale following the impact.	PRORATE	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6b	0.2	0
AKRO	7/21/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A subadult humpback whale was observed entangled in multiple wraps of heavy (~5/8 inch) line around its head and body. The material appeared to be heavier than gillnet (no mesh observed). Floats and line were also reported to be trailing the animal. The whale was described as bobbing up and down to breathe, barely making forward progress.	SI	Constricting entanglement	Fishery gear	Unknown	Unknown	Unknown	L2	1	0
AKRO	8/9/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	DEAD	A subadult male humpback whale was observed dead on the bulbous bow of a 950 ft cruise ship. The speed and specific timing of the ship strike are unknown. External and internal findings of the necropsy indicate that the cause of death is from significant trauma consistent with a vessel strike. The most likely scenario is that the animal was struck around the head/neck, then quickly wrapped around the bulbous bow.	DEAD	Ship strike	Vessel (commercial)	N/A	N/A	N/A	N/A	1	0
AKRO	8/21/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A commercial fiberglass charter fishing boat of unknown length traveling at 25 knots was observed striking a humpback whale. The boat struck the whale with its bow pitched upward nearly 45 degrees until the stern/engine hit, which pitched the boat back down. The strike was described as a "hard strike." The observers were unable to provide any additional information about the health of the whale following the impact.	PRORATE	Ship strike	Vessel (commercial)	AK/WA/OR/CA commercial passenger fishing vessel	Commercial	Unknown	L6b	0.2	0.2
AKRO	8/27/2017	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A subadult humpback whale was observed entangled in the ground tackle of a tour vessel at anchor in SE AK. The whale was entangled in the vessel's 7/8 inch anchor chain which was wrapped around the lower jaw with a half twist. The animal was entangled only 50 ft from the vessel, while over 400 ft of chain remained below in just over 100 ft of water. The whale was in good condition and did not appear to be fighting the weight of the chain too much. In order to disentangle the whale, the anchor chain was cut at the vessel's winch in hopes that it would allow the animal to free itself of the simple wrap and short tail of chain. After the chain was cut, the whale remained at the surface for some time before submerging. A whale thought to be the freed animal was seen about 1/4 nm away and on the next surfacing about 1/2 nm away. The team remained in the area looking for the whale, but it was not re-located. It is highly likely that the whale was free of the gear and had moved off.	NSI	Constricting entanglement	Ship's ground tackle	N/A	N/A	N/A	L2	0	0
AKRO	5/27/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	DEAD	A dead moderately decomposed humpback whale was first observed floating in the water, and then washed up on the beach. A necropsy was conducted and ultimately concluded that the evidence of significant blunt trauma indicates a vessel strike as the most probable cause of death.	DEAD	Ship strike	Vessel (unknown)	N/A	N/A	N/A	N/A	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	6/25/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale became entangled in gillnet fishing gear. The fisherman spent an hour attempting to free the whale after it hit his net, but eventually cut the gear free for the safety of his vessel. The fisherman reported that the whale took 30-40 ft of webbing and corkline, and possibly some leadline as well. During the entanglement (after putting tension on his gear) the fisherman observed some blood in the water due to the whale's resulting surface wounds. Once freed, the whale was surfacing and diving normally, with the gear wrapped around its midsection. It is not believed to be tightly wrapped, and the tail is thought to be clear of gear. The same animal was thought to be re-sighted later in the day with 10-20 corks of white gillnet cork on the whale. No additional information is available on the outcome of the entanglement; however, this animal is believed to have been re-sighted on July 8th and again on July 23rd with a very similar description of the entanglement and associated fishing gear. The July 8th observer stated that he did not think that the animal appeared compromised by the entanglement, but did say that it appeared "really tired." The July 23rd observers indicated that they watched the whale for about 2 hours, during which time it would sound (but with no fluking) for about 7 minutes, then come up for a breath and go back down. The observers did not think that it appeared to be in distress nor in bad condition. This case has been assigned an L10 with a prorated value of 0.75 because the constricting nature of the midsection wrap cannot be verified.	PRORATE	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	6/28/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A 65 ft jet drive whale watching catamaran vessel traveling 20 - 21 knots struck a humpback whale and rode up over top of the animal on the port side. The vessel stopped as soon as possible after the collision. The whale was then seen surfacing off the port stern of the vessel, at which time it took one breath and then fluked. No visible wounds, blood, or debris from the incident were observed following the strike. No damaged was reported by the vessel, and there is no additional information about the condition of the whale following the strike.	SI	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6a	1	0
AKRO	8/13/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	An adult humpback whale was struck by a 375 ft transportation ferry travelling 20.5 knots. The whale was not observed after the incident, and no damage to the vessel was reported.	SI	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6a	1	0
AKRO	9/16/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A subadult humpback whale was observed to be entangled in 100 ft of longline with 1 buoy attached. The initial observation reported that the whale had line coming out of both sides of its mouth, and that it was unable to dive. This animal was successfully disentangled, the gear was removed, and the whale swam away. There are no other reports of injury to the whale.	NSI	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	L10	0	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	11/11/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A subadult humpback whale was observed to be entangled around the upper jaw in heavy gauge lines, which were anchored to the bottom and used for mooring docks. The entanglement configuration included two buoys and a dense snarl of lines, several of which were covering the leading edge of the blowhole. The whale was reported to appear healthy and breathing normally despite being anchored / entangled. This animal was successfully disentangled, all gear was removed, and there is no report of serious injury to the whale as a result of the incident.	NSI	Entangled / entrapped	Other	N/A	N/A	N/A	L2	0	0
AKRO	12/7/2018	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed to be entangled in gillnet fishing gear. The animal was reported to have 4-5 gillnet corks coming from the corner of its mouth. The remainder of the animal did not appear to be entangled. It was unknown whether the gear was wrapped around the whale's mouth. No trailing gear was observed and the whale appeared to be in good condition and was diving upon observation. No other information about this case was reported.	PRORATE	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	6/25/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was reported to be entangled on the right pectoral flipper by a 5-foot wide snarl of unidentified green line or webbing that trailed down the body but was not wrapped around the body. The animal appeared lethargic, taking only two breaths during the 20-minute observation. Two other whales were observed pushing laterally and diagonally on the animal. The gear was never seen above the surface of the water but the reported asymmetry between left and right sides of the animal and the animal's behavior and interaction with other nearby humpback whales indicated an entanglement.	PRORATE	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L10	0.75	0
AKRO	6/27/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	A humpback whale was observed with heavy line draped on the barnacles on one of the fluke tips. Additional sightings of the whale without gear indicate the animal self-released from the entanglement.	NSI	Entangled / entrapped	Marine debris (rope)	N/A	N/A	N/A	L3	0	0
AKRO	7/10/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	An adult female humpback whale was struck by a 78-foot whale watching jet drive catamaran traveling at 22 knots. The captain reported hearing and feeling a thud on the port side and then saw a humpback whale in the boat's wake. The whale was observed breathing twice and then slowly moving out of the area. The next day a humpback whale was observed feeding in the same location with superficial injuries on its head consistent with a ship strike. The same whale had been photographed a week prior to the strike without the injuries. The whale appeared to be behaving normally with strong blows and was actively feeding. However, given the size and speed of the vessel involved in the strike, this case is being assigned as a SI.	SI	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6a	1	0

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AKRO	8/21/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A humpback whale was struck by a 154-foot USCG cutter travelling at 16 knots. The crew did not see any whales in the immediate area when the impact occurred, but CCTV footage showed a humpback whale surface 15 yards directly in front of the ship, submerge, and then strike the port bow of the ship. The impact caused the bow of the vessel to be pushed upward. The cutter turned around to return to the impact location and did not see any visible blood in the water, sheens, or any other indication of a strike. Approximately 30 minutes later a humpback whale surfaced 300 yards from the strike location but had no apparent injuries or indication of a strike; however we cannot confirm that this animal was the one that was struck, nor was the observation period long enough to determine if that whale was injured. Two humpback whale carcasses were reported in the area following the strike but a necropsy was not possible on either carcass.	SI	Ship strike	Vessel (government)	N/A	N/A	N/A	L6a	1	0
AKRO	8/25/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed to have been struck by a recreational Boulton boat (<65 feet in length) travelling at an unknown but high rate of speed (>10 knots). The boat was travelling fast enough that the impact with the whale caused the boat to become airborne. A whale watching boat provided photographs of the whale after impact, showing superficial lacerations from the propeller on the dorsal fin. No information was available regarding the animal's behavior before the impact and no additional information was available regarding the condition of the whale immediately after the impact. Since the report this whale has been resighted several times, it is known to have recovered from any sustained injuries from the boat strike, and has made a full migration, returning with a healthy calf. The injury determination is therefore changed to NSI.	NSI	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6b	0	0
AKRO	8/30/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	The port stabilizer of a 213-meter (699 feet) cruise ship traveling at 17.8 knots struck a humpback whale. The crew noticed two other humpback whales in the distance then suddenly saw a humpback whale surface 10 meters from the port side below the bridge wing. The animal dove and 2 seconds later the ship received an alarm on the port stabilizer. The crew discovered damage to the stabilizer. The whale was not seen again by the crew. CCTV shows a whale surfacing astern of the ship but the condition of the whale cannot be determined from the footage. The outcome of the impact is unknown.	SI	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6a	1	0
AKRO	9/6/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed dragging a 14-inch round, orange buoy behind it on the surface. The configuration of the entanglement is unknown. The animal was traveling at a high rate of speed and its mobility did not appear to be impaired. The entanglement is believed to be recreational pot gear.	PRORATE	Entangled / entrapped	Fishery gear	Unknown pot	Recreational	Pot	L10	0.75	0
AKRO	9/11/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled with an orange A2 buoy attached in an unknown location and configuration. The whale was observed moving without any obvious distress.	PRORATE	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	L10	0.75	0

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AKRO	10/4/2019	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was reported to be entangled in the buoy line of a 5-string shrimp pot set. The entanglement was described as forward on the body since the tail and peduncle were clear of any entangling material, but it is unknown whether the entanglement involved any constricting wraps. The animal was reported trailing about 150 feet of line with an orange or faded red medium-sized polyball attached. The animal was mobile and appeared to be in good condition.	PRORATE	Entangled / entrapped	Fishery gear	Unknown shrimp pot	Unknown	Pot	L10	0.75	0
AKRO	6/27/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was struck by a 21-foot aluminum recreational boat traveling at 25-27 knots. The captain reported that the whale surfaced about 20-40 feet in front of the vessel; the captain attempted to turn to starboard and slow down but was unable to prevent the vessel's port bow from striking the whale, denting the bow of the boat. The whale was not seen again after the collision and no additional information is available regarding the whale.	PRORATE	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6b	0.2	0
AKRO	6/28/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled in SEAK recreational shrimp pot gear attached in an unknown configuration. The gear involved in the entanglement included two 340-foot buoy lines and a 250-foot mid-line with five small shrimp pots attached with snap gear with no anchors or weights. Another reporting party spotted the entangled animal the day after the gear reportedly had been set and removed both buoys from the trailing line. The animal was observed taking frequent, shallow dives and keeping close to shore. The animal likely remains entangled.	PRORATE	Entangled / entrapped	Fishery gear	SEAK shrimp pot	Recreational	Pot	L10	0.75	0
AKRO	7/26/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	NSI	A humpback whale calf was observed entangled in a tended AK Southeast salmon drift gillnet around the head, fluke, and a pectoral fin. At the time of entanglement, a good Samaritan boat assisted the fishing vessel in pulling the gillnet over the animal's head, freeing it from the net. The animal was observed with some minor cuts and abrasions along its back but has since been resighted, with its mother with no additional wounds.	NSI	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L2	0	0
AKRO	8/3/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	A humpback whale was observed entangled in a tended AK Southeast salmon drift gillnet. The net then became entangled in the tending vessel's propeller resulting in a loss of propulsion. In order to reduce risk to the vessel and crew, another fishing vessel responded and cut the whale free of the attached gillnet set. The configuration of the remaining entanglement is unknown. The animal is believed to have parts of the net wrapped around the tailstock and the entanglement may also involve the mouth or pectoral flippers, resulting in the animal being hogtied. This is supported by the fact that the animal was observed sculling (using its pectoral flippers for mobility). Subsequent attempts to locate the animal were unsuccessful.	SI	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L2	1	1

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AKRO	8/18/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled in an AK Southeast salmon drift gillnet in an unknown configuration, including approximately 12 feet of trailing line with 8 white corks attached. The animal was making 7-minute dives and was able to swim and breathe with no apparent impacts to its mobility. No major wounds were visible, other than some chafe marks, and the whale is believed to still be entangled.	PRORATE	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
AKRO	8/24/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was stuck by an 18-foot fiberglass recreational boat traveling at 22 miles per hour. The captain reported that as soon as the vessel got up on plane, a humpback whale came out of the water 20 feet in front of the vessel and he was unable to avoid it. The captain reported there could have been more than one whale but he was unable to confirm. The whale that was struck was not seen again after the collision and no additional information is available regarding this whale.	PRORATE	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6b	0.2	0
AKRO	8/26/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	An adult humpback whale was observed entangled in an AK Southeast salmon drift gillnet in an unknown configuration. The initial entanglement included an unknown amount of white cork line. Then the reporting party observed the animal become entangled in AK salmon troll gear, breaking off 200 feet of stainless steel wire that included a 50 pound lead weight and about 20 leaders, each with a flasher and hook attached. This interaction will be attributed to both fisheries involved in the entanglement.	PRORATE	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet, AK salmon troll	Commercial	Gillnet, Troll	L10	0.75	0.75
AKRO	9/14/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	PRORATE	A humpback whale was observed entangled in unknown longline gear in an unknown configuration. The animal was observed towing three longline buoys, swimming in circles, and showing signs of distress. A response was launched but the animal was not resighted is and believed to still be still entangled.	PRORATE	Entangled / entrapped	Fishery gear	Unknown longline	Commercial	Longline	L10	0.75	0
AKRO	10/21/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	An adult humpback whale was observed entangled in AK Southeast shrimp pot gear with two body wraps on either side of the blowhole. The line may have been attached to up to five commercial shrimp pots and was possibly trailing a single 2.5 x 1-foot orange torpedo-shaped buoy. The animal was reported to be potentially anchored but was able to submerge in place and surface to breathe. The reporting party returned to the animal's location several hours later and the animal was not resighted but was assumed to still be entangled. Due to lack of information regarding whether the fisherman recovered his gear, we cannot determine whether the animal drowned or swam away with gear attached. SI criteria L10 is being assigned to this interaction because the configuration of the gear and the outcome are unknown.	SI	Entangled / entrapped	Fishery gear	AK Southeast shrimp pot	Commercial	Pot	L10	0.75	0.75

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AKRO	11/25/2020	SEAK	Humpback Whale	Mex-Npac, Hawai'i-SEA/NBC DIP	SI	An adult humpback whale was observed entangled in AK Southeast crab pot gear in an unknown configuration. The animal was not moving much, staying at the surface with a large orange buoy and a smaller yellow buoy very close to its body. A response team was dispatched and was able to cut the main line to a crab pot, freeing the animal from the pot, but the two buoys remained attached. The animal was able to swim and dive after being freed from the pot and the lines started moving on the whale. The response team noticed the buoy line traveling through the animal's mouth and wrapped twice around the tailstock. The response team was able to cut the remaining buoys off the animal to remove the strain on the wraps but had to terminate their effort due to the increasing sea state and the animal's increased mobility. Animal was resighted 7/18/21 and confirmed to be free of any entanglements.	NSI	Entangled / entrapped	Fishery gear	AK Southeast crab pot	Commercial	Pot	L10	0	1
AKRO	6/22/2016	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	SI	A humpback whale was entangled in approximately 600 ft of line that terminated in a buoy. The line wrapped around the whale and the pectoral fins, and abrasions from the line were visible. NOAA's Office of Law Enforcement responded and successfully disentangled the animal, freeing the animal of all gear.	NSI	Entangled / entrapped	Marine debris (rope and buoy)	N/A	N/A	N/A	L2	0	0
AKRO	7/4/2016	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	PRORATE	A 20 ft vessel struck a whale at 20 knots. The whale was observed 3-5 minutes later at a distance of 200 yards. The whale did not appear injured while it was observed during subsequent dive cycles. This interaction qualifies as a prorated serious injury under criterion L6b due to the vessel's size and speed.	PRORATE	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6b	0.2	0
AKRO	7/24/2016	WAK	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	DEAD	A humpback whale was found stranded in a state of moderate decomposition. The whale was entangled in a 7/8" poly line that was wrapped around its tailstock and upper jaw. There was significant scarring and abrasion at the areas of entanglement. The end of the line trailed into deep water and could not be pulled in.	DEAD	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	N/A	1	0
AKRO	7/28/2016	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	SI	An entangled humpback whale was observed from a tour vessel. The whale was trailing small gauge neon line from its fluke and another larger gauge line was wrapped around the base of the tailstock and was cutting into the animal. This is considered a serious injury under criterion L2 due to the constricting wrap around the whale's tailstock.	SI	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L2	1	0
AKRO	7/28/2016	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	NSI	An adrift 22 ft boat was struck by a humpback whale. A passenger was ejected into the water and the boat began taking on water. The whale was reported to appear uninjured. This interaction qualifies as a non-serious injury under criterion L6c due to the vessel's size and speed.	NSI	Ship strike	Vessel (recreational)	N/A	N/A	N/A	L6c	0	0
AKRO	8/24/2016	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	NSI	A humpback whale was observed by a USCG vessel's crew to be entangled in, and trailing 60 ft of line and a buoy. Then, while they were watching, the whale shed the gear. The USCG recovered the buoy.	NSI	Entangled / entrapped	Fishery gear	Recreational crab pot	Recreational	Pot	L10	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	8/26/2016	WAK	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	NSI	A humpback whale was observed to be entangled in Dutch Harbor. The animal was observed with a thick nylon line exiting the right side of the mouth which led straight down and was heavily weighted by something on the bottom. A response team attempted to grapple the weighted line in order to cut the line and free the whale, but had no success. A short time later the whale was observed to free itself and was completely free of gear.	NSI	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L2	0	0
AKRO	6/18/2017	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	PRORATE	A 24 - 28 ft commercial charter vessel traveling at 22 knots struck a humpback whale. Following the strike a small amount of blood was observed in the water, but the whale appeared to swim away unharmed. No external injuries to the whale were observed. There is no additional information on the health of the whale following the strike. L6b and L11 are both applicable criteria in this case. L11 has been assigned due to a higher level of severity.	PRORATE	Ship strike	Vessel (commercial)	AK/WA/OR/CA commercial passenger fishing vessel	Commercial	Unknown	L11	0.52	0.52
AKRO	9/27/2017	BS	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	SI	A humpback whale was observed entangled in AK BSAI Pacific cod pot fishery gear. The gear included a 500 lb pot, 66 fathoms of line, and the associated fishing floats. At one time the animal was described as appearing to be immobile. The whale was not relocated following the initial entanglement sighting on the previous day.	SI	Constricting entanglement	Fishery gear	AK BSAI Pacific cod pot	Commercial	Pot	L2	1	1
NPGOP	2/3/2018	BS	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	DEAD	A juvenile humpback whale was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
AKRO	7/1/2018	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	PRORATE	An adult humpback whale was observed to be entangled in recreational shrimp pot gear. The nature of the entanglement could not be confirmed; however, it included a buoy with 700 + ft of sinking line. It is believed that the animal self-released the gear, which was retrieved by boaters and passed on to harbor master. No injuries to the whale were observed or reported.	NSI	Entangled / entrapped	Fishery gear	Recreational shrimp pot	Recreational	Pot	L10	0	0
AKRO	8/10/2018	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	SI	A humpback whale was observed to be entangled. The animal was initially partially disentangled by a reporting party (unauthorized). Following the disentanglement attempt the whale was described to still be entangled in heavy-gauge line, originating forward on the body (mouth, flippers or both) with at least 400 ft of line trailing the animal. The entanglement configuration also included a red "A3" polyball, which trailed approximately 60 ft behind the animal, and at least another 60 ft of line trailing beyond the buoy. This case has been assigned an L2 due to the extensive amount of gear involved in the entanglement, which is likely to causing a significant amount of drag (heavily weighted), and due to the potential to become constricting. This animal was thought to be re-sighted numerous times following the initial observation with little to no change in the entanglement configuration. The outcome of this entanglement is unknown.	SI	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	L2	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	10/15/2018	BS	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	SI	A humpback whale was observed to be heavily entangled in Alaska Bering Sea, Aleutian Islands Pacific cod pot gear. The entanglement consisted of numerous buoys, a cod pot, and 200 ft of line wrapped around the animals fluke and head. The animal was unable to dive and was described as being "hog-tied." This animal was successfully disentangled with complete gear removal, and was observed to be swimming freely. There is no report of serious injury to the whale as a result of the entanglement.	NSI	Constricting entanglement	Fishery gear	AK Bering Sea, Aleutian Islands Pacific cod pot	Commercial	Pot	L2	0	1
AKRO	5/13/2019	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	PRORATE	A humpback whale was observed to be towing a 3-foot diameter orange poly buoy within 5 feet of the animal. No other details are known about the type of connecting and entangling line or its configuration on the animal. The whale was approximately 20 feet in length and alongside a larger humpback whale that was approximately 40 feet in length. The reporting party suspected that the buoy was part of shrimp pot gear but was unable to see whether a pot may have still been attached.	PRORATE	Entangled / entrapped	Fishery gear	Unknown shrimp pot	Unknown	Pot	L10	0.75	0
AKRO	10/8/2019	GOA	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	PRORATE	A humpback whale was observed entangled in Alaska subsistence crab pot gear. The entanglement involved the tail and/or the pectoral flipper. The whale at least partially self-released, and approximately 200 feet of 3/8-inch line and two 14-inch bullet Sponges were recovered. There was broken line among the recovered gear. Observers were unable to confirm if the animal was completely free of the gear. A whale was observed departing the area, but it is unknown if this was the entangled whale. The owner of the gear was contacted and confirmed that it was subsistence crab pot gear and the missing pot was a 4x4 pyramid pot with over 400 feet of attached line.	PRORATE	Entangled / entrapped	Fishery gear	Subsistence crab pot	Alaska Subsistence	Pot	L10	0.75	0
NPGOP	7/10/2020	BS	Humpback Whale	Western North Pacific, Mex-Npac, Hawai'i-NorPac unit	DEAD	A humpback whale was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	7/5/2016	BS	Killer Whale	Eastern North Pacific Alaska Resident	DEAD	A killer whale became entangled in, and was killed by longline gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Pacific cod longline	Commercial	Longline	N/A	1	1
NPGOP	4/30/2020	BS	Killer Whale	Eastern North Pacific Alaska Resident	DEAD	Two killer whales, one male and one female, were caught and killed in AK BSAI flatfish trawl gear. This record (male killer whale) represents 1 of 2 killer whales.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/30/2020	BS	Killer Whale	Eastern North Pacific Alaska Resident	DEAD	Two killer whales, one male and one female, were caught and killed in AK BSAI flatfish trawl gear. This record (female killer whale) represents 2 of 2 killer whales.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	7/28/2016	BS	Killer Whale	Eastern North Pacific Alaska Resident, Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	SI	An observer reported seeing about eight killer whales alongside the fishing vessel while it was trawling when suddenly there was a loud noise and the boat shook violently. After the shudder, blood was visible in the water at the vessel's stern. The killer whales that had surrounded the vessel immediately left the side of the vessel and remained at the location where the boat had shuddered. The observer reported that he and the captain both believed a calf was hit by the propeller.	SI	Ship strike	Vessel (commercial)	AK BSAI flatfish trawl	Commercial	Trawl	S3	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	9/4/2016	SEAK	Killer Whale	Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident, West Coast Transient	SI	A killer whale was reported to be entangled in pot gear in Icy Strait. The entanglement was thought to possibly originate at the tailstock / fluke. The reporting party attempted a disentanglement without success.	SI	Entangled / entrapped	Fishery gear	Unknown pot	Unknown	Pot	S6	1	0
NPGOP	7/25/2018	BS	Killer Whale	Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	DEAD	A male killer whale was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
WCRO	4/5/2016	WC	Killer Whale	West Coast Transient	NSI	A West coast transient killer whale was observed to be briefly entangled in CA Dungeness crab pot fishery gear. At least two buoys were visible. The gear self-released from the animal and no injuries were reported.	NSI	Entangled / entrapped	Fishery gear	CA Dungeness crab pot	Commercial	Pot	S7b	0	1
AKRO	7/10/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male fur seal was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/10/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by trawl netting.	SI	Constricting entanglement	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P8a	1	0
AKRO	7/10/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a black rubber band.	SI	Constricting entanglement	Marine debris (rubber band)	N/A	N/A	N/A	P8a	1	0
AKRO	7/10/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/12/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male fur seal was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	8/4/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal with a circumferential neck entanglement caused by a packing band was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	8/15/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female northern fur seal was entangled in yellow trawl netting. The animal was disentangled.	NSI	Entangled / entrapped	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P7b	0	0
AKRO	8/16/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult female northern fur seal with a circumferential neck entanglement caused by a packing band was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	8/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult female fur seal with a circumferential neck entanglement caused by trawl netting was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P7b	0	0
AKRO	8/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal entangled in trawl netting was captured and disentangled.	NSI	Entangled / entrapped	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P7b	0	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	9/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult fur seal was entangled in a considerable amount of netting and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown net	Unknown	Net	P7b	0	0
AKRO	9/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female fur seal was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	9/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal was observed with a circumferential neck entanglement caused by a green packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	9/22/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal with a circumferential neck entanglement caused by line was captured and disentangled.	NSI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P7b	0	0
AKRO	9/28/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male fur seal with a rigid plastic ring around its neck was captured and the ring was removed.	NSI	Constricting entanglement	Marine debris (misc. plastic)	N/A	N/A	N/A	P7b	0	0
AKRO	9/28/2016	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	10/3/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A fur seal pup that was entangled in green netting was captured and disentangled.	NSI	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	P7b	0	0
AKRO	10/5/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal with a circumferential neck entanglement caused by line was captured and disentangled.	NSI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P7b	0	0
AKRO	10/5/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal was observed with a circumferential neck entanglement caused by what appeared to be green netting or line.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	10/20/2016	BS	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal pup was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
NPGOP	5/6/2017	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	7/19/2017	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by green trawl netting.	SI	Constricting entanglement	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P8a	1	0
AKRO	7/25/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/29/2017	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female northern fur seal was observed with a constricting circumferential neck wound consistent with entanglement.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/31/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by blue twisted strand net.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	7/31/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by blue twisted strand net.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	8/5/2017	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	8/5/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal with a circumferential neck entanglement caused by gray twisted strand net was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	8/18/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A yearling male northern fur seal with a circumferential neck entanglement caused by green netting was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	9/4/2017	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a blue packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	9/4/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A juvenile northern fur seal was observed with a constricting circumferential neck entanglement caused by green netting.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	9/9/2017	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female northern fur seal was observed with a constricting circumferential neck entanglement caused by a blue rope or part of a net.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	9/14/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal pup was observed with a constricting circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	9/26/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult female northern fur seal entangled in green fishing net was captured and disentangled.	NSI	Entangled / entrapped	Fishery gear	Unknown net	Unknown	Unknown net	P7b	0	0
AKRO	9/28/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A yearling northern fur seal pup was observed with a constricting circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	9/28/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A 2-3 year old northern fur seal was observed with a constricting circumferential neck entanglement caused by yellow rope.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0
AKRO	9/30/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal entangled in yellow braided strand netting was captured and disentangled. The entanglement did not break the skin or cause an external wound	NSI	Entangled / entrapped	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	10/10/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a packing band. A disentanglement effort was attempted but it was not successful at completely removing the band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	10/10/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal was observed with a single strand circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	10/10/2017	BS	Northern Fur Seal	Eastern Pacific	SI	A 2 year old male northern fur seal entangled in blue net was captured and disentangled.	NSI	Entangled / entrapped	Marine debris	N/A	N/A	N/A	P7b	0	0
NPGOP	5/15/2018	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/1/2018	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/1/2018	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by a green net.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	7/11/2018	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female northern fur seal was observed with a circumferential neck entanglement caused by a yellow line.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2018	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a green net.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a blue packing band. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	7/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/24/2018	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a circumferential neck entanglement caused by green trawl net. The seal was captured and disentangled successfully. The green trawl net had cut deep into the neck area (about 180° around) and was bleeding heavily. Eventually the seal made its way into the water and swam away.	SI	Constricting entanglement	Fishery gear	AK BSAI unknown trawl	Commercial	Trawl	P7b	1	0
AKRO	8/15/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a rubber band.	SI	Constricting entanglement	Marine debris (rubber band)	N/A	N/A	N/A	P8a	1	0
AKRO	9/17/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by braided green netting. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	9/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by twisted blue-green netting. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	9/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by braided green netting. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	9/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by twisted gray netting. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	9/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by twisted gray netting. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
AKRO	9/19/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a blue packing band. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	11/6/2018	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by a black packing band. This animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
NPGOP	2/27/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/9/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A female northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/10/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/12/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male juvenile northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/12/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/14/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/16/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A female northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/28/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/29/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear during an unsampled haul and is not included in the bycatch estimate for this fishery because other northern fur seals from this stock were seriously injured or killed in sampled hauls in this fishery in this year.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	6/1/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/6/2019	BS	Northern Fur Seal	Eastern Pacific	DEAD	A male northern fur seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/25/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a packing band. The animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	6/25/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a white packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	6/26/2019	BS	Northern Fur Seal	Eastern Pacific	SI	An adult male northern fur seal was observed with a constricting circumferential neck entanglement caused by unknown marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/8/2019	SEAK	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal was observed with a circumferential neck entanglement caused by a thick blue packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	7/17/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with an open wound encircling sections of the dorsal and ventral neck. The entangling material was not visible around the animal's neck but the animal was not confirmed to be free of any entangling material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/22/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net with some white line interwoven.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	7/24/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net with some white line interwoven. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	7/31/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a gray trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	7/31/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a white packing band. The animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
AKRO	8/2/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	8/2/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a black string. The animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	8/5/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by unknown marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	8/22/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a 1/2-inch diameter orange braided line.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0
AKRO	8/22/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	8/22/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green fishing net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	8/25/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by an orange trawl net.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	8/25/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	8/29/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a 2-inch wide polyester belt. The animal was captured and disentangled.	NSI	Constricting entanglement	Marine debris (misc. plastic)	N/A	N/A	N/A	P7b	0	0
AKRO	8/31/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green and orange trawl net.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	9/8/2019	BS	Northern Fur Seal	Eastern Pacific	SI	An adult female northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
AKRO	9/20/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by monofilament line.	SI	Constricting entanglement	Fishery gear	Unknown hook and line	Unknown	Hook and line	P8a	1	0
AKRO	9/20/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a blue packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	9/20/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	9/20/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a yellow fishing line. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown hook and line	Unknown	Hook and line	P7b	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	9/21/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green twisted net with some white line interwoven. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	9/21/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by an orange braided trawl strand net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	11/7/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	11/10/2019	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a constricting circumferential neck entanglement caused by a green trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
NPGOP	3/15/2020	BS	Northern Fur Seal	Eastern Pacific	DEAD	A previously dead northern fur seal was caught in AK BSAI pollock trawl gear. The carcass was entangled in unknown netting that appeared to have been cut from another vessel's net; therefore, this interaction will not be counted against the AK BSAI pollock trawl fishery.	DEAD	Entangled / entrapped	Fishery gear	Unknown net	Unknown	Net	N/A	1	0
AKRO	5/18/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/1/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult male northern fur seal was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/13/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A subadult northern fur seal was observed with a circumferential neck entanglement caused by unidentified rope.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0
AKRO	7/17/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal yearling was observed with a circumferential neck entanglement caused by an unknown trawl net. The animal was captured and disentangled.	NSI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P7b	0	0
AKRO	7/21/2020	BS	Northern Fur Seal	Eastern Pacific	SI	A northern fur seal pup was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCRO	3/4/2017	WC	Northern Fur Seal	Eastern Pacific, California	DEAD	A northern fur seal was found dead with a section of bottom trawl net around its neck. The seal had hemorrhage on the right neck, its right eye was full of blood (left normal), bloody fluid in thoracic cavity, damage to its skull, and it was emaciated.	DEAD	Constricting entanglement	Fishery gear	unknown trawl	Unknown	Trawl	N/A	1	0
WCRO	3/8/2017	WC	Northern Fur Seal	Eastern Pacific, California	DEAD	Two juvenile northern fur seals were found dead and entangled in green trawl net. This record represents 2/2.	DEAD	Constricting entanglement	Fishery gear	unknown trawl	Unknown	Trawl	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCRO	3/8/2017	WC	Northern Fur Seal	Eastern Pacific, California	DEAD	Two juvenile northern fur seals were found dead and entangled in green trawl net. This record represents 1/2.	DEAD	Constricting entanglement	Fishery gear	unknown trawl	Unknown	Trawl	N/A	1	0
WCRO	1/22/2018	WC	Northern Fur Seal	Eastern Pacific, California	SI	A male northern fur seal pup was found with a circumferential neck entanglement. This animal was transferred briefly to Oregon Coast Aquarium where it was disentangled, held overnight, and released the next day at Yaquina Head Outstanding Natural Area, just north of Newport, OR.	SI	Constricting entanglement	Marine debris (misc. plastic)	N/A	N/A	N/A	P14	1	0
WCRO	1/5/2020	WC	Northern Fur Seal	Eastern Pacific, California	DEAD	A male northern fur seal yearling was found dead in a state of advanced decomposition. A necropsy found extensive injuries and trauma with associated hemorrhaging externally as well as internally, including rub marks and cuts on the flippers, and damage to the right eyeball, molars, and the muscles on the thorax and neck. The animal showed no signs of illness but had substantial pneumothorax around the right lung and a large amount of blood in the abdominal cavity. This injury is consistent with interactions with fishery gear and will be attributed to unknown fishery gear.	DEAD	Body trauma	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
WCRO	3/12/2020	WC	Northern Fur Seal	Eastern Pacific, California	DEAD	A male northern fur seal pup was found in a state of advanced decomposition. A necropsy found extensive injuries and trauma with associated hemorrhaging externally as well as internally. There was tremendous hemorrhaging throughout the right thorax, in the left pelvis area, and from the top of the head to the eye. The hemorrhaging was especially deep at the back of the head, under the left scapula, and under the sternum. There was also a suspected bullet hole in the stomach. This injury is consistent with interactions with unknown fishery gear and will be attributed to unknown fishery gear.	DEAD	Body trauma	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
WCRO	4/10/2020	WC	Northern Fur Seal	Eastern Pacific, California	SI	A male northern fur seal yearling was found alive with an excellent coat and no signs of illness. The animal was relatively thin, with ribs showing, and was not very active. It was taken to a rehab facility and died the following day. The animal had gashes and rubs on the head and around the flippers as well as a bloody and collapsed left eye. There was extensive hemorrhaging around the head, neck, sternum, and pelvis as well as blood in the thoracic cavity and bruising on some internal organs. This injury is consistent with interactions with fishery gear and will be attributed to unknown fishery gear.	DEAD	Body trauma	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
NPGOP	4/7/2019	BS	Pacific White Sided Dolphin	North Pacific	DEAD	Two female Pacific white-sided dolphins were caught and killed by AK BSAI pollock trawl gear. This record represents 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/7/2019	BS	Pacific White Sided Dolphin	North Pacific	DEAD	Two female Pacific white-sided dolphins were caught and killed by AK BSAI pollock trawl gear. This record represents 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	8/24/2016	BS	Ribbon Seal		DEAD	A ribbon seal was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NMFS OPR/HQ	8/14/2016	Arctic	Ringed Seal	Arctic	DEAD	A female ringed seal was incidentally killed during MMPA authorized research.	DEAD	Research related injury	MMPA authorized research	N/A	N/A	N/A	N/A	1	0
NPGOP	3/2/2017	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/9/2017	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/10/2017	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/17/2017	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/22/2017	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/15/2017	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/22/2017	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/23/2017	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	8/3/2017	Arctic	Ringed Seal	Arctic	DEAD	An adult female ringed seal was found dead from apparent drowning (gas bubbles in blood vessel). The seal had a line impression around the snout consistent with entanglement from an unidentified material.	DEAD	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	N/A	1	0
NPGOP	11/13/2017	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/26/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/26/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/30/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/6/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal pup was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/10/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	5/13/2018	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/15/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/18/2018	BS	Ringed Seal	Arctic	DEAD	A male ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/18/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/22/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/22/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/23/2018	BS	Ringed Seal	Arctic	DEAD	A ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/24/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/1/2018	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/2/2019	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/19/2019	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/16/2020	BS	Ringed Seal	Arctic	DEAD	A female ringed seal was caught and killed in AK BSAI flatfish trawl gear during an unsampled haul. This mortality will be counted against the AK BSAI flatfish trawl fishery because mortality or serious injury of this stock was not observed by NPGOP observers in sampled hauls in this fishery in this year.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/8/2020	BS	Ringed Seal	Arctic	DEAD	A male ringed seal pup was caught and killed in Alaska subsistence salmon gillnet	DEAD	Entangled / entrapped	Fishery gear	Unalakleet subsistence salmon gillnet	Alaska Subsistence	Gillnet	N/A	1	0
AKRO	8/12/2020	Arctic	Ringed Seal	Arctic	DEAD	A female ringed seal pup was caught and killed in Alaska subsistence gillnet. The animal was used for subsistence purposes.	DEAD	Entangled / entrapped	Fishery gear	Unknown subsistence gillnet	Alaska Subsistence	Gillnet	N/A	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	5/18/2016	GOA	Sperm Whale	North Pacific	PRORATE	An AK GOA sablefish longliner was retrieving gear when a sperm whale was observed entangled in the longline. In response, the vessel began retrieving from the other end of the line to retrieve the remaining gear. After all gear was brought aboard, three skates of gear were determined to be missing, and the observer noted the gear had been moved 2.5 miles from where it was originally set. The outcome of this interaction is prorated under criterion L10 due to the unknown final configuration of the entanglement.	PRORATE	Entangled / entrapped	Fishery gear	AK GOA sablefish longline	Commercial	Longline	L10	0.75	0.75
AKRO	6/7/2017	BS	Sperm Whale	North Pacific	SI	A subadult sperm whale was struck by a 378 ft USCG vessel traveling at 24 knots. The impact led to significant bleeding, behavioral changes, and wounds on the head, back, and pectoral fin. The whale was observed and documented following the strike until it died. L6a and L5a were both applicable criteria in this case.	DEAD	Ship strike	Vessel (government)	N/A	N/A	N/A	L6a	1	0
NPGOP	4/21/2018	BS	Sperm Whale	North Pacific	DEAD	A sperm whale was caught and killed by AK BSAI sablefish pot gear during an unsampled haul.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI sablefish pot	Commercial	Pot	N/A	1	1
AKRO	3/19/2019	SEAK	Sperm Whale	North Pacific	DEAD	A subadult male sperm whale was found dead on the beach in a state of advanced decomposition. A necropsy found that the whale had three deep, clean, parallel slices on the back from the cranium to the dorsal fin, with jumbled vertebrae that had many large and small fractures. The spinal cord was exposed and there were significant associated soft tissue injuries.	DEAD	Ship strike	Vessel (unknown)	N/A	N/A	N/A	N/A	1	0
NPGOP	5/8/2019	GOA	Sperm Whale	North Pacific	PRORATE	A sperm whale was observed interacting with AK GOA sablefish longline gear. During gear haulback, the line became taut and a sperm whale surfaced next to the vessel. After 1 minute, the line parted and the whale swam below the surface and was not seen again. This suggests the animal was attached to the gear in some way, either hooked or entangled. The observer was unable to see the whale's whole body, so cannot confirm a lack of entanglement/hooking, configuration of entanglement (if any), or location of hooking (if any). It is unknown how much gear was lost, so the amount of gear potentially still attached to the animal cannot be estimated.	PRORATE	Entangled / entrapped	Fishery gear	AK GOA sablefish longline	Commercial	Longline	L10	0.75	0.75
NPGOP	5/4/2016	BS	Spotted Seal	Bering	DEAD	A spotted seal was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NMFS OPR/HQ	7/2/2016	Arctic	Spotted Seal	Bering	DEAD	A male spotted seal was incidentally killed during MMPA authorized research.	DEAD	Research related injury	MMPA authorized research	N/A	N/A	N/A	N/A	1	0
NPGOP	5/19/2017	BS	Spotted Seal	Bering	DEAD	A male spotted seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/4/2017	BS	Spotted Seal	Bering	DEAD	A male spotted seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	4/13/2019	BS	Spotted Seal	Bering	DEAD	A male spotted seal was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/21/2020	BS	Spotted Seal	Bering	DEAD	A male spotted seal was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/29/2020	BS	Spotted Seal	Bering	DEAD	A female spotted seal was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
WCGOP	2/7/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought on deck, and then released alive.	NSI	Entangled / entrapped	Fishery gear	Catch Shares Bottom Trawl	Commercial	Trawl	P4	0	0
WCGOP	2/12/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear and then released alive.	NSI	Entangled / entrapped	Fishery gear	Catch Shares Bottom Trawl	Commercial	Trawl	P7b	0	0
WCGOP	2/13/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear and then released alive.	NSI	Entangled / entrapped	Fishery gear	Catch Shares Bottom Trawl	Commercial	Trawl	P7b	0	0
WCGOP	2/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear. This record represents sea lion 2 of 2	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCGOP	2/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear. This record represents sea lion 1 of 2	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCRO	2/21/2016	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion was originally observed in a lethargic state on shore on 2/21 and was found dead on 2/28. A necropsy was conducted and a projectile was recovered from the carcass.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCGOP	2/26/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCRO	3/7/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. Suspicious holes and associated hemorrhage, twisted intestines, and hemorrhage in the organs indicated the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	3/12/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of advanced decomposition and a necropsy was conducted. Suspicious holes, associated hemorrhage, organ damage, and twisted intestines indicated that the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	3/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of advanced decomposition and a necropsy was conducted. Penetrating wounds with associated hemorrhage, and recovery of projectiles from the carcass indicated that the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCGOP	4/5/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by longline gear.	DEAD	Entangled / entrapped	Fishery gear	Limited Entry Sablefish Longline	Commercial	Longline	N/A	1	1

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCRO	4/8/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was discovered in an advanced state of decomposition and a necropsy was conducted. Tracking wounds with associated hemorrhaging and recovery of projectiles indicate the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	4/12/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. There was substantial hemorrhage in the head, body, and organs as well as bloody fluid and sand in the thoracic cavity, indicating the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	4/18/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. Suspicious holes, marks that looked like bullet-grazes, and hemorrhage throughout the body indicated the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCGOP	4/19/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by longline gear.	DEAD	Entangled / entrapped	Fishery gear	Limited Entry Sablefish Longline	Commercial	Longline	N/A	1	1
WCRO	4/19/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. The animal had bullet holes in its body with associated hemorrhage, organ damage, and twisted intestines. Projectiles were recovered from the carcass.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
ADFG	4/22/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	4/26/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCRO	4/26/2016	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with multiple straight, parallel incisions seen on its posterior. The deepest wound was approximately 30-40 cm long. The animal appeared to have a healthy bed of granulation tissue at the site of injury.	SI	Ship strike	Vessel (unknown)	N/A	N/A	N/A	P15	1	0
NPGOP	4/28/2016	SEAK	Steller Sea Lion	Eastern US	NSI	An observer reported that a live Steller sea lion was briefly entangled in longline gear during an unsampled haul.	NSI	Entangled / entrapped	Fishery gear	AK GOA halibut longline	Commercial	Longline	P7b	0	0
WCRO	5/5/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. The animal had been shot, indicated by penetrating wounds with associated hemorrhage, twisted intestines, and an abdominal cavity filled with bloody fluid. Projectile(s) were recovered from the carcass.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	5/15/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed entangled in salmon hook and line gear that consisted of a white hoochie and green flasher.	SI	Entangled / entrapped	Fishery gear	Salmon hook and line	Unknown	Hook and line	P8a	1	0
ADFG	5/28/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	6/4/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/9/2016	SEAK	Steller Sea Lion	Eastern US	NSI	A subadult male Steller sea lion was observed with a treble hook in its lip	NSI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5b	0	0
WCRO	6/12/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was discovered in a state of moderate decomposition. The animal had a flasher in its mouth, and a hook was found perforating the animal's esophagus.	DEAD	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	N/A	1	0
ADFG	6/12/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/19/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	6/21/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed to be trailing an orange buoy through the water.	SI	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	P6	1	0
ADFG	6/22/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/24/2016	SEAK	Steller Sea Lion	Eastern US	SI		SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5a	1	0
ADFG	6/25/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/28/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/29/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	6/29/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	6/29/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/29/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	6/30/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	6/30/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	6/30/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/2/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	7/2/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion that had ingested salmon hook and lion gear was captured, the flasher was removed, and the animal was released. An ingested hook was still presumed to be present.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/3/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/3/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/3/2016	GOA	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found dead and necropsied. The animal had a 3cm round wound on its torso and a wound that matched in size and location on its right flipper where the flipper overlapped the torso. There was significant hemorrhage in the abdominal cavity associated with the wound.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
ADFG	7/4/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
ADFG	7/4/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a flasher tight to the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/6/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/6/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher in its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/6/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/6/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/7/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
WCRO	7/7/2016	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed alive with an apparent gunshot wound. Two days later, the animal was found dead. A .22 caliber bullet was recovered from the animal's head by NOAA Law Enforcement.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a constricting neck entanglement caused by unknown material / marine debris. The animal was reported with a pup. This record represents the pup.	SI	Dependent animal with mother seriously injured	Marine debris (unidentified)	N/A	N/A	N/A	P14	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth. The sea lion was captured, the flasher was removed, and the animal was released.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher tight to its mouth. The sea lion was captured, the flasher was removed, and the animal was released.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

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Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with monofilament line that appeared to be wrapped around its neck and a weight hanging at its chest.	SI	Entangled / entrapped	Fishery gear	Unknown hook and line	Unknown	Hook and line	P6	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/12/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/12/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/12/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/12/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entangled caused by rope.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/13/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/14/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/14/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/14/2016	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observe with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested salmon hook and line fishery gear and a flasher was observed tight to its right lip.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/14/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by rope.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0
WCRO	7/18/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of moderate decomposition and a necropsy was conducted. What appeared to be bullet holes, associated hemorrhage, clotting, and organ damage indicated the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/19/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested salmon hook and line fishery gear and a flasher was observed hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
WCRO	7/22/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was found in a state of advanced decomposition and a necropsy was conducted. Puncture marks of various sizes and depths on the ventral neck, tremendous hemorrhage in the ventral body, track-like wounds with entrance holes, and recovery of projectiles indicated the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	7/24/2016	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by what appeared to be a rubber band or packing band. The entanglement deeply cut into the animal.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCRO	7/24/2016	WC	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with flasher hanging from its mouth. The animal appeared to have a dependent pup. This entry represents the pup.	SI	Dependent animal with mother seriously injured	Fishery gear	Unknown hook and line	Unknown	Hook and line	P14	1	0
WCRO	7/24/2016	WC	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with flasher hanging from its mouth. The animal appeared to have a dependent pup.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/26/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested salmon hook and line fishery gear, and a flasher and pink hoochie were observed hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/29/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested fishery gear and a flasher was observed hanging from the animal's mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/1/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	8/2/2016	SEAK	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was observed hauled out on a buoy with a circle hook attached to a gangion line in its lip.	NSI	Hooked	Fishery gear	Unknown longline	Unknown	Longline	P5b	0	0
SWFSC	8/7/2016	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion with monofilament line wrapped around its head and neck was captured, disentangled, and released.	NSI	Constricting entanglement	Fishery gear	Unknown hook and line	Unknown	Hook and line	P7b	0	0
AKRO	8/9/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested salmon hook and line fishery gear and was observed with a flasher with a white/silver body and red/orange rim hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/15/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested salmon hook and line fishery gear and a flasher was observed hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	8/16/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	8/16/2016	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	8/16/2016	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/30/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out on a buoy with a plastic packing band around its neck. It had also ingested salmon hook and line fishing gear, and a black and white flasher was observed hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	9/8/2016	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out on a buoy. The sea lion had a hook in its mouth and heavy duty monofilament was reported to be around the animal's neck.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	10/4/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/5/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/14/2016	WC	Steller Sea Lion	Eastern US	DEAD	Two Steller sea lions were caught and killed by trawl gear. This record represents animal 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/14/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear. According to the observer the animal was disentangled and released by crew without injuries.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	P7b	0	0
A-SHOP	10/14/2016	WC	Steller Sea Lion	Eastern US	DEAD	Two Steller sea lions were caught and killed by trawl gear. This record represents animal 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/19/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/27/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/2/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/5/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/6/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/6/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/11/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	11/11/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/12/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, released from the net and motivated by the crew to return to the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/12/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, released from the net. It acted aggressively toward the crew, and was forced back into the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/12/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/13/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 1 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/13/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 2 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/13/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 3 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/14/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, released from the net, and was motivated by the crew to return to the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/15/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, released from the net, and was motivated by the crew to return to the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 2 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 1 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/16/2016	WC	Steller Sea Lion	Eastern US	DEAD	Three Steller sea lions were caught and killed in trawl gear. This record represents animal 3 of 3.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/18/2016	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	2/3/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, and released from the net. Once free from the net the sea lion quickly jumped off the side of the boat and into the water. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	3/16/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in Open Access (OA) CA Halibut bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA Halibut bottom trawl	Commercial	Trawl	N/A	1	1
AKRO	4/11/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out on a green buoy with a circumferential neck entanglement caused by unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCRO	4/24/2017	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found freshly dead of a gunshot wound. A necropsy found a 1 cm diameter buckshot lodged in tissue just above the lower left mandible with fractures of the left lower and upper canines.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	4/25/2017	GOA	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by an AK GOA sablefish longline gear.	DEAD	Hooked	Fishery gear	AK GOA sablefish longline	Commercial	Longline	N/A	1	1
AKRO	4/25/2017	SEAK	Steller Sea Lion	Eastern US	SI	A sub adult male Steller sea lion was observed hauled out on the west side of Benjamin Island, AK, with a constricting circumferential neck entanglement caused by unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	5/4/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	5/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	5/8/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out on Benjamin Island, AK, with a constricting circumferential neck entanglement caused by unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	5/13/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out on South Marble Island with a constricting circumferential neck entanglement caused by unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	5/29/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	5/30/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	6/9/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	6/10/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCGOP	6/13/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard, and released from the net. Once free from the net the sea lion quickly jumped off the side of the boat and into the water. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
ADFG	6/16/2017	SEAK	Steller Sea Lion	Eastern US	SI	A female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	6/19/2017	SEAK	Steller Sea Lion	Eastern US	NSI	An adult male Steller sea lion was observed with a hook in its cheek, outside of the teeth.	NSI	Hooked	Fishery gear	Unknown	Unknown	Unknown	P5b	0	0
AKRO	6/23/2017	GOA	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was hooked in the mouth with a circle hook from an Alaska halibut subsistence longline. The line was cut leaving the circle hook, gangion, and 10 feet of groundline trailing behind the animal.	SI	Hooked	Fishery gear	AK halibut longline	Alaska Subsistence	Longline	P5a	1	0
ADFG	6/23/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/27/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCRO	7/1/2017	WC	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a mass of gray trawl net wrapped around its neck.	SI	Constricting entanglement	Fishery gear	Unknown trawl	Unknown	Trawl	P8a	1	0
ADFG	7/2/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/2/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/2/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band. This animal was darted and disentangled on 6/30/2018.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a hook in its mouth with trailing baited line.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5a	1	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a hook in its lip with trailing cord.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P6	1	0
ADFG	7/3/2017	SEAK	Steller Sea Lion	Eastern US	NSI	An adult male Steller sea lion was observed with a hook in its lip, outside of the teeth.	NSI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5b	0	0
ADFG	7/4/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/4/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed hauled out with a flasher at the edge of its mouth. A disentanglement effort using a dart was unsuccessful.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	A large male Steller sea lion was observed hauled out with a fishing lure hooked in its mouth. The flasher was hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P5a	1	0
ADFG	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth with trailing monofilament line. A disentanglement attempt was unsuccessful.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by monofilament line.	SI	Constricting entanglement	Fishery gear	Salmon hook and line	Unknown	Hook and line	P8a	1	0
ADFG	7/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	A female Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion with a circumferential neck entanglement caused by a thick rubber belt was darted and disentangled.	NSI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P7b	0	0
ADFG	7/6/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by a fan belt. This animal was darted and disentangled on 7/06/2017.	NSI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P7b	0	0
ADFG	7/7/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was initially observed with a suspected circumferential neck entanglement caused by unidentified material on 07/07/2017. The animal was resighted in 08/2017 and darted on 7/04/2018 which revealed that the entanglement was gone leaving only a scar.	NSI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P7b	0	0
AKRO	7/8/2017	SEAK	Steller Sea Lion	Eastern US	SI	A sub adult male Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/10/2017	SEAK	Steller Sea Lion	Eastern US	NSI	A juvenile Steller sea lion was observed with a hook in the lip only, outside of the teeth.	NSI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5b	0	0
AKRO	7/10/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed hauled out with a flasher at the edge of its mouth with trailing monofilament line.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2017	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2017	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/12/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/12/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/13/2017	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion with a flasher at the edge of its mouth was darted, captured, and the ingested fishing gear was removed. The animal was then released.	NSI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P5c	0	0
ADFG	7/13/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/13/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed entangled with line above the eyes and around the face and mouth.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/14/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	7/14/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	7/14/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/15/2017	SEAK	Steller Sea Lion	Eastern US	SI	A male Steller sea lion was observed with a flasher at the edge of its mouth. A disentanglement effort removed the flasher but not the ingested hook.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/19/2017	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/27/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	7/29/2017	SEAK	Steller Sea Lion	Eastern US	SI	A small Steller sea lion was observed with a fishing flasher trailing behind it, and it may have swallowed fishing gear.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
WCGOP	7/30/2017	WC	Steller Sea Lion	Eastern US	DEAD	A dead Steller sea lion was caught in catch shares EM bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	N/A	1	1
WCGOP	8/27/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard the vessel, and released from the net. The crew yelled and sprayed the animal with the deck hose until it jumped off the trawl ramp. The animal seemed confused but had no visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
AKRO	8/30/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	9/12/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	9/15/2017	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	9/15/2017	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
A-SHOP	9/16/2017	WC	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a thin white line around its neck.	SI	Entangled / entrapped	Marine debris	N/A	N/A	N/A	P6	1	0
WCRO	9/23/2017	WC	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed hauled out on a buoy with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
A-SHOP	10/1/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/6/2017	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/8/2017	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	10/23/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares EM trawl gear, brought aboard the vessel, and released from the net. The animal jumped overboard a few minutes after the codend was emptied. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	P4	0	0
A-SHOP	10/23/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/24/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake - midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/25/2017	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	10/25/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/27/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake mothership catcher vessel midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	11/1/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard the vessel, and released from the net. The animal left the vessel once the haul was dumped in the trawl alley. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	11/3/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard the vessel, and released from the net. The animal left the vessel once the haul dumped in the trawl alley. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/6/2017	WC	Steller Sea Lion	Eastern US	DEAD	Two male Steller sea lions were caught and killed by at-sea hake catcher processor midwater trawl gear. This record represent 2/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	11/6/2017	WC	Steller Sea Lion	Eastern US	DEAD	Two male Steller sea lions were caught and killed by at-sea hake catcher processor midwater trawl gear. This record represent 1/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher processor midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	11/25/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in trawl gear, brought aboard the vessel, and released from the net. The animal jumped overboard as soon as the trawl net was dumped. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	11/25/2017	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in catch shares bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	N/A	1	1
WCGOP	12/7/2017	WC	Steller Sea Lion	Eastern US	NSI	Two Steller sea lions were caught in trawl gear, brought aboard the vessel, and released from the net. The animals jumped overboard as soon as the trawl net was dumped. No visible signs of injury. This record represents 2/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	12/7/2017	WC	Steller Sea Lion	Eastern US	NSI	Two Steller sea lions were caught in trawl gear, brought aboard the vessel, and released from the net. The animals jumped overboard as soon as the trawl net was dumped. No visible signs of injury. This record represents 1/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	12/12/2017	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares EM trawl gear, brought aboard the vessel, and released from the net. The animal jumped overboard on its own following release from the net. No visible signs of injury.	NSI	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	P4	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCGOP	1/4/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear and brought on deck. The animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
AKRO	1/16/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	1/17/2018	SEAK	Steller Sea Lion	Eastern US	DEAD	A subadult female Steller sea lion was found dead due to a flipper entanglement caused by line / marine debris.	DEAD	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	N/A	1	0
WCGOP	1/30/2018	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed in OA CA halibut bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA Halibut Bottom Trawl	Commercial	Trawl	N/A	1	1
WCGOP	1/31/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear. The vessel's crew cut a hole in the trawl net before bringing it onboard. The animal was then able to swim out of the net unharmed. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCRO	2/26/2018	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found dead in a state of moderate decomposition. The animal was necropsied and a fish hook was recovered from its esophagus. The necropsy also found significant signs of trauma, including bloody fluid in the thoracic cavity, areas of hemorrhage, and tissue/organ damage. The animal's intestines were twisted, but otherwise the sea lion had excellent body condition.	DEAD	Hooked	Fishery gear	Unknown hook and line	Unknown	Unknown	N/A	1	0
WCGOP	3/7/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares EM bottom trawl gear and brought on deck. The animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch Shares EM bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	3/9/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear and brought on deck. The animal was released from the gear at which time it jumped off the boat. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
AKRO	4/13/2018	SEAK	Steller Sea Lion	Eastern US	DEAD	An adult Steller sea lion was found dead of a gunshot wound to the head. An OLE investigation concluded that the shooting was intentional and non-subsistence.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCGOP	4/28/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear and brought on deck. The animal was released from the gear and jumped off the boat after 10 minutes. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCRO	5/14/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion pup was found in a state of advanced decomposition. A necropsy was conducted and found that the animal's lower jaw and nasal area of the skull were broken. There was also hemorrhage and trauma on head and neck. This animal's death is suspected to be of human causes.	DEAD	Body trauma	Other	N/A	N/A	N/A	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	5/28/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	5/29/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	5/29/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/4/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris. This animal was also observed nursing a pup.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/6/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a white packing band. This animal was also observed with a pup.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
AKRO	6/13/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/14/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
A-SHOP	6/17/2018	WC	Steller Sea Lion	Eastern US	DEAD	Two Steller sea lions were caught and killed by at-sea hake - midwater trawl gear. This record represents 2/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - MS catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	6/17/2018	WC	Steller Sea Lion	Eastern US	DEAD	Two Steller sea lions were caught and killed by at-sea hake - midwater trawl gear. This record represents 1/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - MS catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	6/20/2018	WC	Steller Sea Lion	Eastern US	DEAD	Two female Steller sea lions were caught and killed by at-sea hake - midwater trawl gear. This record represents 1/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - MS catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	6/20/2018	WC	Steller Sea Lion	Eastern US	DEAD	Two female Steller sea lions were caught and killed by at-sea hake - midwater trawl gear. This record represents 2/2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - MS catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
ADFG	6/27/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/27/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	6/28/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/28/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by a packing band. This animal was captured and disentangled on 06/30/2018.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
ADFG	6/29/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion ingested salmon fish and line gear and was observed with green flasher line hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	6/30/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/30/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/1/2018	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a constricting monofilament line entanglement around the lower hips/abdomen.	SI	Constricting entanglement	Marine debris	N/A	N/A	N/A	P8a	1	0
ADFG	7/2/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a silver flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/2/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a silver flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	N/A	Hook and line	P2	1	0
ADFG	7/3/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris. This animal was also observed nursing a pup.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2018	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/3/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher at the edge of its mouth. The sea lion also had an eye injury.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/4/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/4/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a green and red flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/4/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris. This animal was also observed nursing a juvenile.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a flasher, a 2 inch orange ball, and 20 - 30 inches of line hanging from its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed to be hooked with a white fishing lure at the edge of its mouth.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P5a	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a blue flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/5/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a green and red flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/6/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/6/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/7/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/7/2018	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/8/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion ingested fishery gear and was observed with green monofilament line hanging from its mouth.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	8/12/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion ingested troll fishery gear and was observed with a halibut hook, line, gangion, and weight hanging from its mouth.	SI	Hooked	Fishery gear	Unknown halibut	Unknown	Longline	P2	1	0
AKRO	8/20/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth. This animal was captured and disentangled.	NSI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P7b	0	0
WCRO	9/4/2018	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion hybrid was found dead in an advanced state of decomposition. A necropsy was conducted and found that the animal appeared to have excellent body condition with heavy trauma and possible pellet holes in neck with associated hemorrhage. The animal's skull appeared to be that of a Steller sea lion but the baculum was clearly a California sea lion. This animal has been categorized as a Steller sea lion for the purpose of this report.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	9/14/2018	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed with a flasher at the edge of its mouth. The animal was isolated and appeared in distress.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
A-SHOP	9/16/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	9/25/2018	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by at-sea hake - midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - mothership catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	9/30/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear and brought on deck. The animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
AKRO	10/2/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	10/2/2018	SEAK	Steller Sea Lion	Eastern US	SI	A subadult Steller sea lion was observed with a flasher at the edge of its mouth. By Oct 12, 2018 the animal started to look in poor health. No reports thereafter.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
A-SHOP	10/14/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/18/2018	WC	Steller Sea Lion	Eastern US	SI	A female Steller sea lion was caught in at-sea hake catcher processor midwater trawl gear and brought on deck. The animal was still breathing and moving around slightly but had white foam coming from its mouth. No other visible injuries were observed, but it was reported that it is unlikely that the animal made it out of the encounter unharmed. The animal was released overboard, but the observer was unsure if it survived the encounter.	SI	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	P4	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	10/18/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in at-sea hake catcher processor midwater trawl gear, brought aboard the vessel, and released from the net. After the release the animal disembarked the vessel. There were no reports of injury to the animal.	NSI	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	10/18/2018	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed by at-sea hake catcher processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/22/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake - midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - mothership catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/26/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake - midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - mothership catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/28/2018	WC	Steller Sea Lion	Eastern US	DEAD	A female Steller sea lion was caught and killed by at-sea hake - midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake - mothership catcher vessel - midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	11/3/2018	WC	Steller Sea Lion	Eastern US	NSI	Two Steller sea lions were caught in catch shares bottom trawl gear and brought on deck (2 different hauls). The animals were released from the gear and exited the vessel on their own. No injuries were reported for these animals. This record represents 2/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	11/3/2018	WC	Steller Sea Lion	Eastern US	NSI	Two Steller sea lions were caught in catch shares bottom trawl gear and brought on deck (2 different hauls). The animals were released from the gear and exited the vessel on their own. No injuries were reported for these animals. This record represents 1/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	11/12/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught twice (2 different hauls) in catch shares bottom trawl gear and brought on deck. On both occasions the animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal on either occasion. This record represents 1/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0
WCGOP	11/12/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught twice (2 different hauls) in catch shares bottom trawl gear and brought on deck. On both occasions the animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal on either occasion. This record represents 2/2.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P4	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	11/19/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in at-sea hake catcher processor midwater trawl gear, brought aboard the vessel, and released from the net. After the release the animal disembarked the vessel via the stern trawl ramp. The animal was reported as being fully alive and mobile, and there were no reports of injury to the animal.	NSI	Entangled / entrapped	Fishery gear	At-sea hake - catcher processor - midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/20/2018	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in midwater rockfish EM trawl gear and brought on deck. The animal was released from the gear at which time it jumped off the boat. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Midwater Rockfish EM - Midwater Trawl	Commercial	Trawl	P4	0	0
NWIFC	1/1/2019	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon set gillnet fishing operations.	DEAD	Unknown	Unknown	Salmon set gillnet	WA Tribal	Gillnet	N/A	1	0
WCRO	1/23/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found dead in a state of moderate decomposition. A necropsy was conducted and found that the animal was pregnant, appeared to have good body condition, and died of wounds consistent with a gunshot to the posterior abdomen/pelvic area with associated hemorrhage.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
A-SHOP	2/4/2019	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in midwater rockfish EM trawl gear and brought on deck. The animal was released from the gear, at which time it jumped off the boat. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Midwater Rockfish EM - Midwater Trawl	Commercial	Trawl	P4	0	0
WCGOP	2/7/2019	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed in OA CA halibut bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCGOP	3/10/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult Steller sea lion was caught and killed by OA CA Halibut bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCRO	3/22/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found dead in a state of advanced decomposition. A necropsy found that the animal was pregnant, appeared to have good body condition, and had a gunshot wound in the abdomen and into the uterus and stomach with associated hemorrhage.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	3/28/2019	WC	Steller Sea Lion	Eastern US	DEAD	A yearling male Steller sea lion was found dead in a state of moderate decomposition. A necropsy found that the animal appeared to have poor body condition with gouges and scrapes associated with extensive dorsal hemorrhage along the back and around the neck, as well as extensive trauma on the left side of the head and internal bleeding. The examiner believed the injuries were consistent with a fishery interaction.	DEAD	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
WCRO	3/29/2019	WC	Steller Sea Lion	Eastern US	DEAD	A yearling male Steller sea lion was found dead in a state of moderate decomposition. A necropsy found that the animal appeared to have good body condition with line marks across the stomach and associated bruising on the abdomen, hemorrhage on the head and dorsal side, internal bleeding, fluid in the lungs, and twisted intestines. The examiner believed the injuries were consistent with a fishery interaction.	DEAD	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	3/30/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCGOP	4/2/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was caught and killed by OA CA Halibut bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	OA CA halibut bottom trawl	Commercial	Trawl	N/A	1	1
WCRO	4/9/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found fresh dead. A necropsy found that the animal died of wounds consistent with a gunshot to the neck.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	4/16/2019	WC	Steller Sea Lion	Eastern US	DEAD	A yearling male Steller sea lion was found in a state of moderate decomposition. A necropsy found that the animal had excellent body condition with external rub marks, hemorrhage, and trauma on its body, especially from the head to the foreflippers. Blood was found at the back of the neck and around the posterior brain. The examiner believed the injuries were consistent with a fishery interaction.	DEAD	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
ADFG	4/17/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion with a nursing juvenile was observed with a circumferential neck entanglement caused by an unknown material / marine debris. Based on its age, the juvenile was presumed to be feeding on its own to some degree and was likely not entirely dependent on the mother, so it is not considered a separate serious injury.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
WCGOP	4/18/2019	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in catch shares bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	N/A	1	1
WCRO	4/28/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found in a state of advanced decomposition to the point where a necropsy could not be performed on the body. The right rear flipper was missing. Only the head was collected for necropsy and 13 bullet pellets were found inside the skull. The animal was assumed to have died from gunshot wounds.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	5/9/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found in a state of advanced decomposition. A necropsy found that the animal's teeth had been removed by unknown person(s), the skull was exposed, and there was deep hemorrhage at the pelvis, neck and upper back area, and a bullet/pellet hole in the esophagus with associated blood in the stomach.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	5/9/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found in a state of moderate decomposition. A necropsy found that the animal was pregnant, appeared to have excellent body condition, and had a gunshot wound to the abdomen/pelvic area with associated hemorrhage to the colon. There was no sign of illness.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
ADFG	6/4/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with an orange flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	6/4/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/10/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
ADFG	6/13/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/14/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/21/2019	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/28/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/28/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion ingested fishery gear and was observed with a blue flasher with 4 feet of line hanging from the left side of the mouth as well as four small puncture wounds and a slash scar on its left side.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	6/29/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/29/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris, possibly a white packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
NWIFC	7/1/2019	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty sablefish longline fishing operations.	DEAD	Unknown	Unknown	Sablefish longline	WA Tribal	Longline	N/A	1	0
ADFG	7/3/2019	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion ingested fishery gear and was observed with an orange and silver flasher with 2 feet of attached line hanging from its mouth	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/3/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion ingested fishery gear and was observed with a long piece of monofilament line hanging from its mouth.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/4/2019	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion was observed with a circle hook in the right side of its mouth.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P2	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	7/5/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement from a white packing band that was not cutting into the skin. The animal was later observed to have self-released from the entanglement.	NSI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P7b	0	0
ADFG	7/5/2019	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion ingested fishery gear and was observed with a green and gold flasher tight to the right side of its mouth with at least 5 feet of trailing line.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/8/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris, possibly heavy monofilament or a gangion.	SI	Constricting entanglement	Fishery gear	Unknown	Unknown	Unknown	P8a	1	0
ADFG	7/8/2019	SEAK	Steller Sea Lion	Eastern US	SI	A juvenile Steller sea lion ingested fishery gear and was observed with an orange flasher near the left side of its mouth	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/9/2019	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/10/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris, possibly monofilament.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/10/2019	GOA	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a red and white flasher hanging from the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/10/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion ingested fishery gear and was observed with a silver flasher tight against the right side of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/11/2019	SEAK	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2019	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a white or silver flasher close to its head, covering part of the face. The location of hook was not determined but it was believed to be in the head (not in the mouth or ingested) with the flasher hanging next to the face. Given the likely location of the hooking, trailing gear has the potential to interfere with feeding, be ingested, accumulate drag, or become snagged on something in the environment, anchoring the animal.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P6	1	0
WCGOP	7/21/2019	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by Catch Shares EM bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	N/A	1	1
AKRO	8/24/2019	SEAK	Steller Sea Lion	Eastern US	SI	An adult female Steller sea lion was observed hauled out with silver flasher tight against the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	8/24/2019	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a silver flasher with an orange rim at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/30/2019	SEAK	Steller Sea Lion	Eastern US	SI	A Steller sea lion was observed hauled out with a flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
WCRO	9/1/2019	WC	Steller Sea Lion	Eastern US	SI	A subadult male Steller sea lion was observed with a flasher connected to fishing line hanging from the inside right corner of its mouth. The animal was sedated and the flasher and line were removed as close to the mouth as possible. There is no information regarding the status of the hook.	SI	Hooked	Fishery gear	Unknown hook and line	Unknown	Hook and line	P2	1	0
WCGOP	9/30/2019	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear. The vessel's crew tried letting out the net to allow the animal to swim out, but the animal swam further into the net. The crew then tied off the net and opened the lower end of it, releasing the animal unharmed. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P7b	0	0
WCGOP	10/4/2019	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares bottom trawl gear. The animal was freed from the net and released alive. The observer did not note any sign of injury to the animal.	NSI	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	P7b	0	0
WCRO	12/5/2019	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found fresh dead. A necropsy found numerous shot pellets and associated hemorrhage in the head, neck and shoulder area.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	2/3/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found fresh dead. A necropsy found numerous shot pellets and associated hemorrhage in the nares, mouth, eye area, and frontal lobe of the brain.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	2/15/2020	WC	Steller Sea Lion	Eastern US	DEAD	A subadult male Steller sea lion was found fresh dead. A necropsy found a clear bullet hole on the left side of the chest, fractured ribs, and associated hemorrhaging. The animal was assumed to have died from a gunshot wound.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
MMAP	3/17/2020	SEAK	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed by AK GOA sablefish longline gear. This mortality will be counted against the AK GOA sablefish longline fishery because mortality or serious injury of this stock was not observed by NPGOP observers in this fishery in this year.	DEAD	Hooked	Fishery gear	AK GOA sablefish longline	Commercial	Longline	N/A	1	1
WCGOP	3/19/2020	WC	Steller Sea Lion	Eastern US	NSI	A Steller sea lion was caught in catch shares EM bottom trawl gear, brought on deck, and released alive. The animal had a visible injury to its eye but no other information regarding the injury was provided. "Waiting for additional info/photos to determine if SI or NSI"	NSI	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	P9	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCRO	4/14/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found in a state of advanced decomposition. A necropsy found that the animal had excellent body condition with a clear bullet entry and exit holes on the lateral anterior abdominal area and other bullet holes along the right side of the body. The animal was assumed to have died from gunshot wounds.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	4/27/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found in a state of advanced decomposition. A necropsy found that the animal had good body condition with signs of illness as well as signs of trauma and associated hemorrhage to the head, and face. The necropsy also found bullet holes, trauma, and associated hemorrhage in the animal's abdominal areas as well as in the fetus inside the animal, which had a hole in its abdomen.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCRO	4/27/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found in a state of moderate decomposition. A necropsy found that the animal had excellent body condition with a bullet hole in the right scapula and third right rib and associated hemorrhage in the thoracic cavity. There was no sign of illness.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NWIFC	5/1/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon hook and line fishing operations.	DEAD	Unknown	Unknown	Salmon hook and line	WA Tribal	Hook and line	N/A	1	0
NWIFC	5/1/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon hook and line fishing operations.	DEAD	Unknown	Unknown	Salmon hook and line	WA Tribal	Hook and line	N/A	1	0
NWIFC	5/1/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon hook and line fishing operations.	DEAD	Unknown	Unknown	Salmon hook and line	WA Tribal	Hook and line	N/A	1	0
NWIFC	5/1/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon hook and line fishing operations.	DEAD	Unknown	Unknown	Salmon hook and line	WA Tribal	Hook and line	N/A	1	0
NWIFC	5/1/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was incidentally killed in association with Washington tribal treaty salmon hook and line fishing operations.	DEAD	Unknown	Unknown	Salmon hook and line	WA Tribal	Hook and line	N/A	1	0
AKRO	5/4/2020	SEAK	Steller Sea Lion	Eastern US	NSI	A subadult Steller sea lion was observed hauled out with an unknown longline hook and gangion in its lip.	NSI	Hooked	Fishery gear	Unknown longline	Unknown	Longline	P5d	0	0
WCRO	5/11/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult female Steller sea lion was found in a state of advanced decomposition. A necropsy found that the animal had excellent body condition, was pregnant, and had numerous shot pellets in its head with associated hemorrhage in the skull.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
WCGOP	5/25/2020	WC	Steller Sea Lion	Eastern US	DEAD	Two female Steller sea lions were caught and killed in at-sea hake catcher-processor midwater trawl gear. This record represents 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
WCGOP	5/25/2020	WC	Steller Sea Lion	Eastern US	DEAD	Two female Steller sea lions were caught and killed in at-sea hake catcher-processor midwater trawl gear. This record represents 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	N/A	1	1
WCGOP	6/16/2020	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed in at-sea hake catcher-processor midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	N/A	1	1
WCRO	7/3/2020	WC	Steller Sea Lion	Eastern US	DEAD	A subadult male Steller sea lion was found in a state of moderate decomposition. The reporting party described bullet holes in the back of the animal. Given the expertise of the reporting party, the animal was assumed to have died from gunshot wounds.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/9/2020	GOA	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found fresh dead with two small holes in its head consistent with a gunshot wound. Given the expertise of the reporting party, the animal was assumed to have died from gunshot wounds.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	7/17/2020	SEAK	Steller Sea Lion	Eastern US	SI	An adult male Steller sea lion was observed hauled out with a circumferential neck entanglement caused by unknown monofilament line.	SI	Constricting entanglement	Fishery gear	Unknown	Unknown	Unknown	P8a	1	0
WCGOP	8/3/2020	WC	Steller Sea Lion	Eastern US	DEAD	A male Steller sea lion was caught and killed in catch shares bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares bottom trawl	Commercial	Trawl	N/A	1	1
AKRO	8/5/2020	SEAK	Steller Sea Lion	Eastern US	SI	A male subadult Steller sea lion was observed hauled out with a silver flasher with a pink rim at the edge of its mouth with about 8 inches of trailing monofilament line.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/11/2020	SEAK	Steller Sea Lion	Eastern US	SI	A male subadult Steller sea lion was observed hauled out with a silver flasher with a green rim at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	8/31/2020	SEAK	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found dead due to entanglement in the netting of a hatchery salmon pen.	DEAD	Entangled / entrapped	Other	N/A	N/A	N/A	N/A	1	0
AKRO	9/6/2020	SEAK	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion in a state of advanced decomposition was found on the beach with a green and silver flasher hanging out of its mouth.	DEAD	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	N/A	1	0
ODFW	10/14/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
ODFW	10/15/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
WCGOP	10/19/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and killed in rockfish EM midwater trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Rockfish EM - Midwater Trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ODFW	10/22/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
ODFW	11/3/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
ODFW	11/4/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
ODFW	11/5/2020	WC	Steller Sea Lion	Eastern US	DEAD	A Steller sea lion was caught and euthanized at the Bonneville Dam under a NMFS-authorized MMPA section 120(f) permit.	DEAD	Removal from population	MMPA authorized removal	N/A	N/A	N/A	N/A	1	N/A
WCRO	12/5/2020	WC	Steller Sea Lion	Eastern US	DEAD	An adult male Steller sea lion was found in a state of advanced decomposition. A necropsy found that the animal had a gap between the last molars and radiographs confirmed a bullet in the skull with associated hemorrhaging. The animal was assumed to have died from a gunshot wound.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	1/31/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/4/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/5/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/8/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/8/2016	BS	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were caught and killed in trawl gear. This is animal two of two.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/8/2016	BS	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were caught and killed in trawl gear. This is animal one of two.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/12/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/17/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/25/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/29/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	2/29/2016	WAK	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/3/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/10/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	3/11/2016	GOA	Steller Sea Lion	Western US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by rope or line.	SI	Constricting entanglement	Marine debris (rope)	N/A	N/A	N/A	P8a	1	0
NPGOP	3/22/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/30/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/13/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/27/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/11/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/11/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/20/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/21/2016	SCAK	Steller Sea Lion	Western US	DEAD	A Steller sea lion carcass was discovered during Copper River Delta carcass surveys. A tracking wound and damage to the skull was noted by examiners, and metal fragments were identified in the animal's head with x-ray indicating that the animal had been shot.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NMFS OPR/HQ	7/3/2016	SEAK	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were incidentally killed during MMPA authorized research. This record represents sea lion 2 of 2.	DEAD	Research related injury	MMPA authorized research	N/A	N/A	N/A	N/A	1	0
NMFS OPR/HQ	7/3/2016	SEAK	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were incidentally killed during MMPA authorized research. This record represents sea lion 1 of 2.	DEAD	Research related injury	MMPA authorized research	N/A	N/A	N/A	N/A	1	0
NPGOP	7/31/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	9/16/2016	GOA	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/21/2016	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/1/2016	GOA	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA Pacific cod trawl	Commercial	Trawl	N/A	1	1
NPGOP	1/29/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/11/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/26/2017	BS	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were caught and killed by trawl gear. This record represents 2/2 - Male.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/26/2017	BS	Steller Sea Lion	Western US	DEAD	Two Steller sea lions were caught and killed by trawl gear. This record represents 1/2 - Male.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/28/2017	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Pacific cod trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/24/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/30/2017	WAK	Steller Sea Lion	Western US	DEAD	An adult male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/22/2017	AK	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	0
NPGOP	4/23/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/15/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/15/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/18/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/21/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/27/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	6/3/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/14/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by an AK BSAI Pacific cod longline gear.	DEAD	Hooked	Fishery gear	AK BSAI Pacific cod longline	Commercial	Longline	N/A	1	1
ADFG	7/10/2017	PWS	Steller Sea Lion	Western US	SI	A male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/12/2017	SCAK	Steller Sea Lion	Western US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
NPGOP	7/13/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
ADFG	7/17/2017	Kodiak	Steller Sea Lion	Western US	SI	A male Steller sea lion was observed with a flasher at the edge of its mouth with 4' of trailing line.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
ADFG	7/17/2017	Kodiak	Steller Sea Lion	Western US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified material.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
NPGOP	9/10/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/23/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/29/2017	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/30/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	10/24/2017	SCAK	Steller Sea Lion	Western US	DEAD	A subadult Steller sea lion was found dead and entangled in gillnet fishing gear. Mortality and serious injury estimates for this fishery are obtained from observer data and not stranding data or fishermen self-reported (MMAF) data; therefore, this record will not be assigned an M/SI or LOF value.	DEAD	Entangled / entrapped	Fishery gear	AK PWS salmon drift gillnet	Commercial	Gillnet	N/A	1	1
NPGOP	11/10/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/13/2017	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	1/28/2018	BS	Steller Sea Lion	Western US	DEAD	Four male Steller sea lions were caught and killed by AK BSAI Atka mackerel trawl gear. This record represents 1/4.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	1/28/2018	BS	Steller Sea Lion	Western US	DEAD	Four male Steller sea lions were caught and killed by AK BSAI Atka mackerel trawl gear. This record represents 4/4.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	1/28/2018	BS	Steller Sea Lion	Western US	DEAD	Four male Steller sea lions were caught and killed by AK BSAI Atka mackerel trawl gear. This record represents 2/4.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	1/28/2018	BS	Steller Sea Lion	Western US	DEAD	Four male Steller sea lions were caught and killed by AK BSAI Atka mackerel trawl gear. This record represents 3/4.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/8/2018	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/16/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/19/2018	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/19/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/24/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI Atka mackerel trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Atka mackerel trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/25/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/1/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/11/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/12/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/23/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/28/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI Pacific cod trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Pacific cod trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/16/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/25/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/6/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	6/8/2018	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/8/2018	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
ADFG	7/10/2018	PWS	Steller Sea Lion	Western US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/14/2018	Kodiak	Steller Sea Lion	Western US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/22/2018	Kodiak	Steller Sea Lion	Western US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	8/10/2018	Kodiak	Steller Sea Lion	Western US	SI	A Steller sea lion was observed with a silver flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
AKRO	9/24/2018	Kodiak	Steller Sea Lion	Western US	DEAD	An adult female Steller sea lion was found dead in a seine net. The animal had net marks on its body and was in an advanced state of decomposition.	DEAD	Entangled / entrapped	Fishery gear	AK Kodiak salmon fisheries, Kitoi Bay salmon hatchery	Commercial	Seine	N/A	1	1
MMAP	11/24/2018	Kodiak	Steller Sea Lion	Western US	DEAD	Two dead Steller sea lions caught in trawl net with unidentified marine debris (rope) still attached. This interaction will not be counted against the fishery because the animals were previously killed by marine debris. This record represents 2/2.	DEAD	Entangled / entrapped	Marine debris (rope)	N/A	N/A	N/A	N/A	1	0
MMAP	11/24/2018	Kodiak	Steller Sea Lion	Western US	DEAD	Two dead Steller sea lions caught in trawl net with unidentified marine debris (rope) still attached. This interaction will not be counted against the fishery because the animals were previously killed by marine debris. This record represents 1/2.	DEAD	Entangled / entrapped	Marine debris (rope)	N/A	N/A	N/A	N/A	1	0
NPGOP	11/27/2018	BS	Steller Sea Lion	Western US	NSI	A Steller sea lion was caught in AK BSAI flatfish trawl gear and brought on deck. The animal was released from the gear at which time it began to move and snarl. The animal was then released overboard. There are no reports of injury to the animal.	NSI	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	P4	0	0
NPGOP	2/15/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/25/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/26/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/2/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	3/10/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/15/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/6/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/13/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/3/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	6/21/2019	SCAK	Steller Sea Lion	Western US	DEAD	An adult male Steller sea lion carcass was discovered during the Copper River Delta carcass survey in a state of moderate decomposition. A metal detector signaled at the head and across the back; the head was collected and radiographs confirmed a bullet in the skull.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/21/2019	SCAK	Steller Sea Lion	Western US	DEAD	A subadult female Steller sea lion carcass was discovered during the Copper River Delta carcass survey in a state of moderate decomposition. A metal detector signaled at the skull and near the pelvis; the head was collected and radiographs confirmed a bullet in the skull.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
AKRO	6/21/2019	SCAK	Steller Sea Lion	Western US	DEAD	An adult male Steller sea lion carcass was discovered fresh dead during the Copper River Delta carcass survey. A metal detector signaled at the head and across the back; the head was collected and radiographs confirmed bullet fragments and multiple fractures in the skull.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	7/5/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
ADFG	7/16/2019	SCAK	Steller Sea Lion	Western US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	7/19/2019	Kodiak	Steller Sea Lion	Western US	SI	A juvenile Steller sea lion was observed with a circumferential neck entanglement caused by an unknown material / marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	8/12/2019	SCAK	Steller Sea Lion	Western US	SI	A Steller sea lion was observed hauled out with spoon or flasher at the edge of its mouth.	SI	Hooked	Fishery gear	Salmon hook and line	Unknown	Hook and line	P2	1	0
NPGOP	8/16/2019	GOA	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by AK GOA sablefish longline gear.	DEAD	Entangled / entrapped	Fishery gear	AK GOA sablefish longline	Commercial	Longline	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	8/27/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI pollock trawl gear. Observer said animal was previously dead but examination of photos indicates fresh dead/killed by gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/21/2019	BS	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed by AK BSAI pollock trawl gear. This record represents 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/21/2019	BS	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed by AK BSAI pollock trawl gear. This record represents 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/30/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	10/1/2019	GOA	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed by AK GOA sablefish longline gear.	DEAD	Hooked	Fishery gear	AK GOA sablefish longline	Commercial	Longline	N/A	1	1
NPGOP	11/5/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/26/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/27/2019	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	11/30/2019	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	12/5/2019	GOA	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed by AK GOA flatfish trawl gear during an unsampled haul. This record represents 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	12/5/2019	GOA	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed by AK GOA flatfish trawl gear during an unsampled haul. This record represents 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK GOA flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	1/26/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/3/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI pollock trawl gear during an unsampled haul. This mortality will not be counted against this fishery since this stock has also been taken in sampled hauls in this fishery in this year.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	N/A	N/A
NPGOP	2/4/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/12/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	2/14/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	2/29/2020	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/1/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/2/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/14/2020	BS	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed in AK BSAI pollock trawl gear. This record represents 1 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/14/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	4/14/2020	BS	Steller Sea Lion	Western US	DEAD	Two male Steller sea lions were caught and killed in AK BSAI pollock trawl gear. This record represents 2 of 2.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
AKRO	4/15/2020	Kodiak	Steller Sea Lion	Western US	SI	A Steller sea lion was observed hauled out with a circumferential neck entanglement caused by a white packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
NPGOP	5/5/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/26/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/29/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
ADFG	6/1/2020	BS	Steller Sea Lion	Western US	SI	An adult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
NPGOP	6/2/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/6/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/19/2020	BS	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
ADFG	6/20/2020	BS	Steller Sea Lion	Western US	SI	A subadult male Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
ADFG	6/20/2020	GOA	Steller Sea Lion	Western US	SI	A juvenile Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
ADFG	6/20/2020	GOA	Steller Sea Lion	Western US	SI	An adult female Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/14/2020	SCAK	Steller Sea Lion	Western US	SI	An adult male Steller sea lion was observed swimming with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
AKRO	7/28/2020	SCAK	Steller Sea Lion	Western US	DEAD	A female Steller sea lion yearling was found dead in a state of moderate decomposition with lesions consistent with a gunshot injury. A necropsy was conducted and radiographs found metal fragments in the skull.	DEAD	Shot	Projectile weapon	N/A	N/A	N/A	N/A	1	0
NPGOP	7/30/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
ADFG	8/5/2020	BS	Steller Sea Lion	Western US	SI	A Steller sea lion was observed with a circumferential neck entanglement caused by unidentified marine debris.	SI	Constricting entanglement	Marine debris (unidentified)	N/A	N/A	N/A	P8a	1	0
NPGOP	8/25/2020	BS	Steller Sea Lion	Western US	SI	A free-swimming female Steller sea lion was observed entangled in green and orange trawl gear.	SI	Entangled / entrapped	Fishery gear	Unknown trawl	Unknown	Trawl	P6	1	0
NPGOP	8/25/2020	BS	Steller Sea Lion	Western US	DEAD	A female Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	8/26/2020	GOA	Steller Sea Lion	Western US	DEAD	A Steller sea lion was caught and killed in AK GOA pollock trawl gear. This take was reported through EM while the fishery was operating on an exempted fishing permit (EFP).	DEAD	Entangled / entrapped	Fishery gear	AK GOA pollock trawl	Commercial	Trawl	N/A	1	1
AKRO	8/28/2020	Kodiak	Steller Sea Lion	Western US	SI	An adult male Steller sea lion was observed hauled out and swimming with a circumferential neck entanglement caused by a packing band.	SI	Constricting entanglement	Marine debris (packing band)	N/A	N/A	N/A	P8a	1	0
NPGOP	8/31/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	9/10/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
NPGOP	10/6/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	10/12/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI pollock trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	10/13/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
NPGOP	11/15/2020	BS	Steller Sea Lion	Western US	DEAD	A male Steller sea lion was caught and killed in AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
AKRO	12/1/2018	SEAK	Unidentified Large Whale	Unknown	PRORATE	An unidentified large cetacean was observed to be entangled. The nature of the entanglement is unknown; however, the whale was seen dragging 15 feet of line and a small buoy. The whale did not appear to be struggling. No additional information was reported for this case.	PRORATE	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L10	0.75	0
AKRO	9/5/2019	BS	Unidentified Large Whale	Unknown	DEAD	A floating unidentified large whale carcass in an advanced state of decomposition was observed with line tightly wrapped around its tail stock. Local experts suspected that this animal died from entanglement in BSAI Pacific cod pot gear, but that this was not able to be confirmed, therefore is not being assigned.	DEAD	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	N/A	1	0
AKRO	8/11/2020	SEAK	Unidentified Large Whale	Unknown	PRORATE	An unidentified large whale was observed to be entangled in an AK Southeast salmon drift gillnet in an unknown configuration. The reporting party described the whale surfacing in the middle of a ballied-up net with more than 100 cork floats in 3-4 layers of line totaling 4-5 times the length of the animal. Subsequent attempts to locate the animal were unsuccessful.	PRORATE	Entangled / entrapped	Fishery gear	AK Southeast salmon drift gillnet	Commercial	Gillnet	L10	0.75	0.75
WCGOP	1/3/2018	WC	Unidentified Otariid	Eastern US	NSI	An unidentified otariid was caught in catch shares EM bottom trawl gear and brought on deck. The animal was released from the gear and exited the vessel on its own. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	Catch Shares EM bottom trawl	Commercial	Trawl	P4	0	0
A-SHOP	5/9/2018	WC	Unidentified Otariid	Eastern US	DEAD	An unidentified otariid was caught and killed in midwater rockfish EM trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Midwater Rockfish EM - Midwater Trawl	Commercial	Trawl	N/A	1	1
A-SHOP	10/6/2017	WC	Unidentified Otariid	Unknown	NSI	Four unidentified otariids were caught in at-sea hake catcher processor midwater trawl gear and hauled up to the stern ramp. The animals were slowly rolled towards the front of the net, and were eventually released from the net at the end of the stern ramp. Hoses were then utilized to coax the animals into the water. No injuries were reported. This record is 3/4.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0
A-SHOP	10/6/2017	WC	Unidentified Otariid	Unknown	NSI	Four unidentified otariids were caught in at-sea hake catcher processor midwater trawl gear and hauled up to the stern ramp. The animals were slowly rolled towards the front of the net, and were eventually released from the net at the end of the stern ramp. Hoses were then utilized to coax the animals into the water. No injuries were reported. This record is 1/4.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0
A-SHOP	10/6/2017	WC	Unidentified Otariid	Unknown	NSI	Four unidentified otariids were caught in at-sea hake catcher processor midwater trawl gear and hauled up to the stern ramp. The animals were slowly rolled towards the front of the net, and were eventually released from the net at the end of the stern ramp. Hoses were then utilized to coax the animals into the water. No injuries were reported. This record is 2/4.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	10/6/2017	WC	Unidentified Otariid	Unknown	NSI	Four unidentified otariids were caught in at-sea hake catcher processor midwater trawl gear and hauled up to the stern ramp. The animals were slowly rolled towards the front of the net, and were eventually released from the net at the end of the stern ramp. Hoses were then utilized to coax the animals into the water. No injuries were reported. This record is 4/4.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0
A-SHOP	10/8/2017	WC	Unidentified Otariid	Unknown	NSI	An unidentified otariid was caught in at-sea hake catcher processor midwater trawl gear and hauled onto the deck of the vessel. The ship's deck hands sprayed water onto the animal and pulled at the net until the animal moved out of the net through a hole that was made by the deck hands. The net was then sent back into the water with the animal still on it. Once the net hit the water the animal jumped off the side and into the water. The animal initially seemed lethargic, but perked up once it passed the top of the stern ramp during release to the water. No injuries were reported.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
WCGOP	3/6/2019	WC	Unidentified Otariid	Unknown	DEAD	An unidentified otariid was caught and killed in catch shares EM bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	N/A	1	1
NPGOP	5/3/2019	BS	Unidentified Otariid	Unknown	DEAD	An unidentified otariid was caught and killed by AK BSAI flatfish trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	N/A	1	1
WCGOP	7/25/2019	WC	Unidentified Otariid	Unknown	DEAD	An unidentified otariid was caught and killed in catch shares EM bottom trawl gear.	DEAD	Entangled / entrapped	Fishery gear	Catch shares EM bottom trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/11/2016	BS	Unidentified Phocid	Unknown	DEAD	An unidentified phocid was caught and killed in trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI Pacific cod trawl	Commercial	Trawl	N/A	1	1
NPGOP	6/14/2017	BS	Unidentified Phocid	Unknown	DEAD	An unidentified pinniped was caught and killed by trawl gear.	DEAD	Entangled / entrapped	Fishery gear	AK BSAI pollock trawl	Commercial	Trawl	N/A	1	1
NPGOP	3/20/2019	GOA	Unidentified Phocid	Unknown	DEAD	An unidentified phocid was caught and killed by AK GOA halibut longline gear.	DEAD	Hooked	Fishery gear	AK GOA halibut longline	Commercial	Longline	N/A	1	1
NPGOP	9/4/2020	BS	Unidentified Phocid	Unknown	DEAD	An unidentified phocid was caught and killed by AK BSAI Pacific cod longline gear.	DEAD	Hooked	Fishery gear	AK BSAI Pacific cod longline	Commercial	Longline	N/A	1	1
NPGOP	11/22/2020	BS	Unidentified Phocid	Unknown	DEAD	An unidentified phocid was caught and killed by AK BSAI Pacific cod longline gear.	DEAD	Hooked	Fishery gear	AK BSAI Pacific cod longline	Commercial	Longline	N/A	1	1
NPGOP	8/12/2016	BS	Unidentified Pinniped	Unknown	DEAD	An unidentified pinniped was caught and killed by longline gear.	DEAD	Hooked	Fishery gear	AK BSAI Pacific cod longline	Commercial	Longline	N/A	1	1
A-SHOP	11/8/2016	WC	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was reported by a member of the crew to have been entangled in trawl gear before being released. The observer did not witness the interaction.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
A-SHOP	11/8/2016	WC	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was found in the live tank. A plank was lowered into the live tank, and the sea lion was motivated up the plank with a hose. It exited the live tank and promptly entered the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P7b	0	0
A-SHOP	11/12/2016	WC	Unidentified Pinniped	Unknown	NSI	A member of the crew informed the observer that an unidentified pinniped had been found in the live tank and then released alive. The observer did not witness the interaction.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/12/2016	WC	Unidentified Pinniped	Unknown	NSI	A member of the crew informed the observer that an unidentified pinniped had been found in the live tank and then released alive. The observer did not witness the interaction.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/12/2016	WC	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was caught in trawl gear and brought aboard, released from the net, and then returned to the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	11/13/2016	WC	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was caught in trawl gear, brought aboard, released from the net, and was motivated by the crew to return to the water.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
A-SHOP	10/19/2019	WC	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was caught in at-sea hake catcher processor midwater trawl gear, brought aboard the vessel, and released from the net. After the release the animal went into the ship's gear locker. The vessel's crew corralled the animal by yelling at the animal while holding boards in front of themselves until the animal jumped off the stern of the vessel. No injuries were reported for this animal.	NSI	Entangled / entrapped	Fishery gear	At-sea hake catcher-processor midwater trawl	Commercial	Trawl	P4	0	0
NPGOP	3/2/2020	BS	Unidentified Pinniped	Unknown	NSI	An unidentified pinniped was caught in AK BSAI flatfish trawl gear. The animal was brought on deck and was released alive, after 40 minutes in the net, with minor superficial wounds. Both SI criteria P4 and P7b apply to this interaction.	NSI	Entangled / entrapped	Fishery gear	AK BSAI flatfish trawl	Commercial	Trawl	P4	0	0
NPGOP	7/4/2020	BS	Unidentified Pinniped	Unknown	SI	An unidentified pinniped on deck was struck multiple times with a hammer by the vessel captain. The observer on board was not notified until after the animal had left the vessel. No additional information is available regarding the injury.	SI	Body trauma	Other	AK BSAI pollock trawl	Commercial	Trawl	P9	1	1
MMAP	8/9/2017	SCAK	Unidentified Small Cetacean	Unknown	DEAD	Two unidentified small cetaceans were self-reported to have been killed by AK Cook Inlet set-net fishing gear. This record represents 1/2.	DEAD	Entangled / entrapped	Fishery gear	AK Cook Inlet salmon set gillnet	Commercial	Gillnet	N/A	1	1
MMAP	8/9/2017	SCAK	Unidentified Small Cetacean	Unknown	DEAD	Two unidentified small cetaceans were self-reported to have been killed by AK Cook Inlet set-net fishing gear. This record represents 2/2.	DEAD	Entangled / entrapped	Fishery gear	AK Cook Inlet salmon set gillnet	Commercial	Gillnet	N/A	1	1

Table 1 -- Human-marine mammal interaction records reviewed for injury and mortality, 2016-2020.

Source of Record	Date	Area	Common Name	Stock	Initial Assessment	Determination Details	Final Determination	Mechanism of Injury	Source of Injury	Fishery Name	Fishery Type	Fishery Method	SI Criteria	M/SI Value	LOF Value
AKRO	6/15/2016	GOA	Unidentified Whale	Unknown	PRORATE	A vessel struck an unidentified cetacean while underway at 20 knots. The vessel was less than 65 ft long. Blood was observed in the water and the whale was reported to appear dazed prior to disappearing from sight. This interaction qualifies as a prorated serious injury under criterion L6b due to the vessel's size and speed and L11 due to the resulting laceration.	PRORATE	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L11	0.52	0
AKRO	6/17/2016	GOA	Unidentified Whale	Unknown	PRORATE	An unidentified whale was observed during an aerial survey that was trailing netting, 120+ feet of line, and a polyball. This entanglement will be considered a prorated serious injury under criterion L10 due to the unknown configuration of the entanglement.	PRORATE	Entangled / entrapped	Fishery gear	Unknown net	Unknown	Net	L10	0.75	0
AKRO	9/14/2016	SEAK	Unidentified Whale	Unknown	PRORATE	An unidentified large whale, described as over 65 ft in length, was observed for over a week to be entangled in gear consisting of a line and a buoy in an unknown configuration near Prince of Wales Island. This entanglement will be considered a prorated serious injury under criterion L10 due to the unknown configuration of the entanglement.	PRORATE	Entangled / entrapped	Marine debris (unidentified)	N/A	N/A	N/A	L10	0.75	0
AKRO	3/18/2017	SEAK	Unidentified Whale	Unknown	PRORATE	A small humpback whale or minke whale was observed with a trailing buoy. The extent of the entanglement could not be confirmed; thus, this event is prorated at L10.	PRORATE	Entangled / entrapped	Marine debris (rope and buoy)	N/A	N/A	N/A	L10	0.75	0
AKRO	5/12/2017	SEAK	Unidentified Whale	Unknown	SI	The bow of a 959.6 ft cruise ship traveling at 20.5 knots struck an unidentified whale. The crew of the ship briefly saw the whale dead ahead of the vessel but were unable to maneuver in time to avoid impact. The ship shuddered when the whale was hit. The outcome of the impact is unknown.	SI	Ship strike	Vessel (commercial)	N/A	N/A	N/A	L6a	1	0
NPGOP	6/21/2017	BS	Unidentified Whale	Unknown	PRORATE	An unidentified animal possibly collided with the ships propeller. A very large pool of blood was observed behind the boat following a loud bang; however, the presumed animal was never seen. There is not enough definitive information in the record to make a SI/M determination.	PRORATE	Ship strike	Vessel (commercial)	AK BSAI flatfish trawl	Commercial	Trawl	L11	0.52	0
AKRO	10/11/2017	SEAK	Unidentified Whale	Unknown	PRORATE	An unidentified whale was observed to be towing a 16 inch red buoy, possibly associated with shrimp pots. The whale appeared to be smaller and traveling alone and slow. No additional information or photographs are available. The extent of the entanglement cannot be determined; thus, this case is prorated at L10.	PRORATE	Entangled / entrapped	Fishery gear	Unknown	Unknown	Unknown	L10	0.75	0
AKRO	12/6/2017	BS	Unidentified Whale	Unknown	SI	An unidentified whale was observed to be entangled in parallel pot cod fishery gear. The entangled gear included 1 beach-ball sized polybuoy with 50 ft of 3/4 inch line, a second beach-ball sized polybuoy with 66 fathoms of line, and one pot (weight ~ 600-700 lb, 6.5 ft x 6.5 ft x 36 inches tall). The base of the whale's tail was wrapped 3-5 times in the main line under the second buoy, but no other areas appeared to be wrapped. The whale and fishery gear were not re-sighted after the initial discovery.	SI	Constricting entanglement	Fishery gear	AK state waters parallel pot cod fishery	Commercial	Pot	L2	1	1

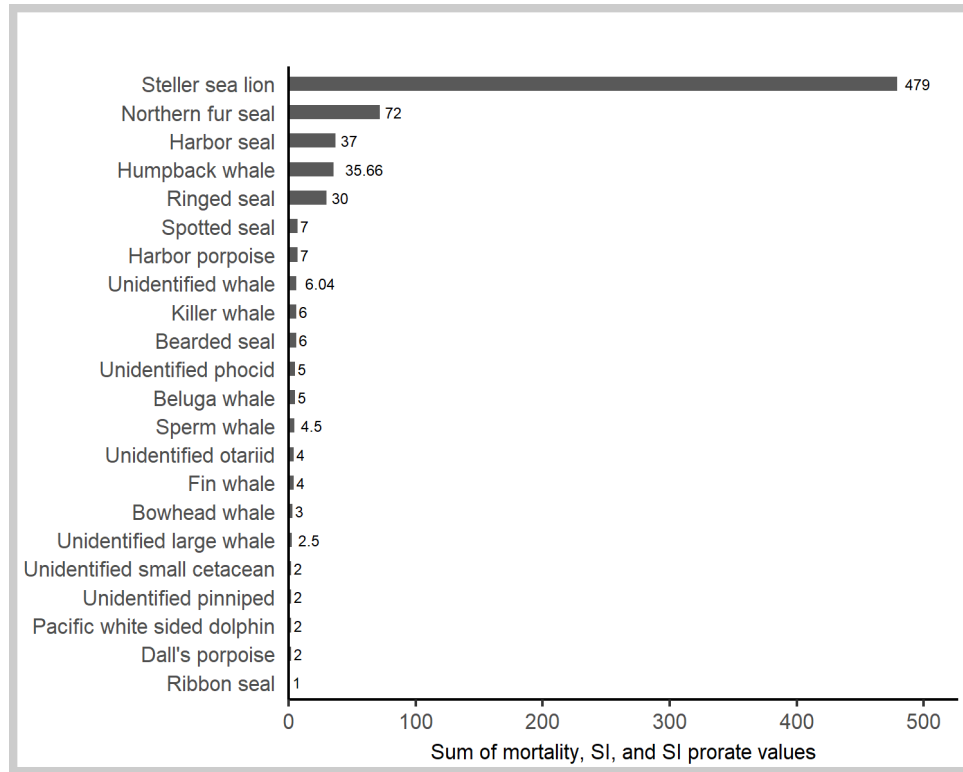


Figure 1. -- Total human-caused serious injury and mortality of Alaska marine mammal species appearing in the Alaska Stock Assessment Reports, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

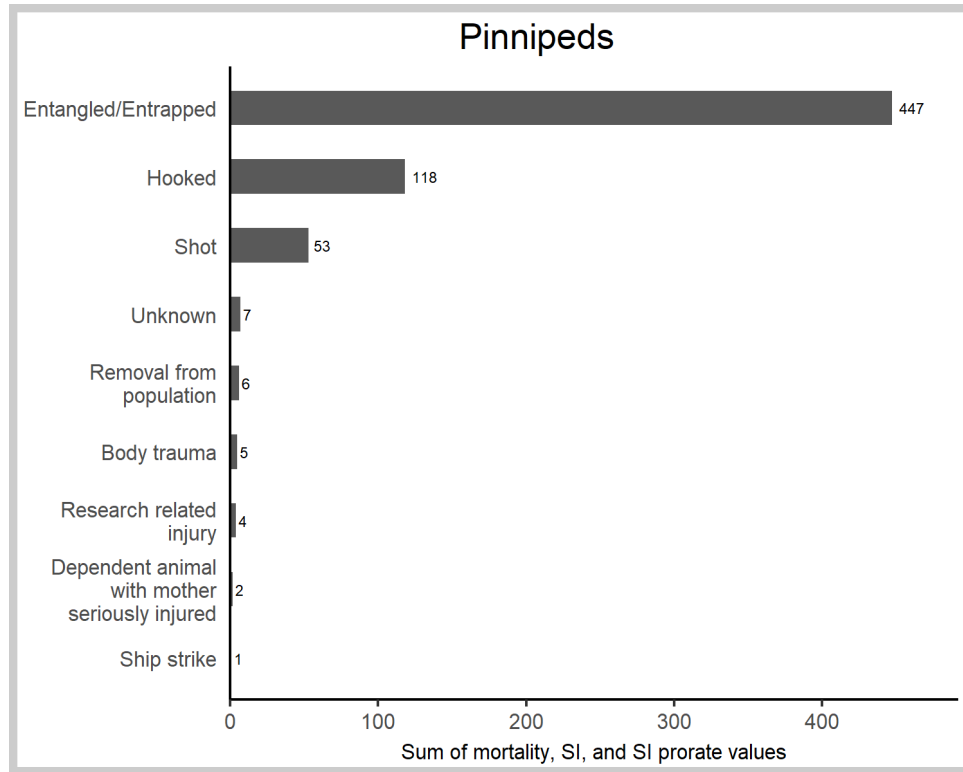


Figure 2. -- Human-caused serious injury and mortality of Alaska pinniped species by mechanism of injury, 2016-2020.

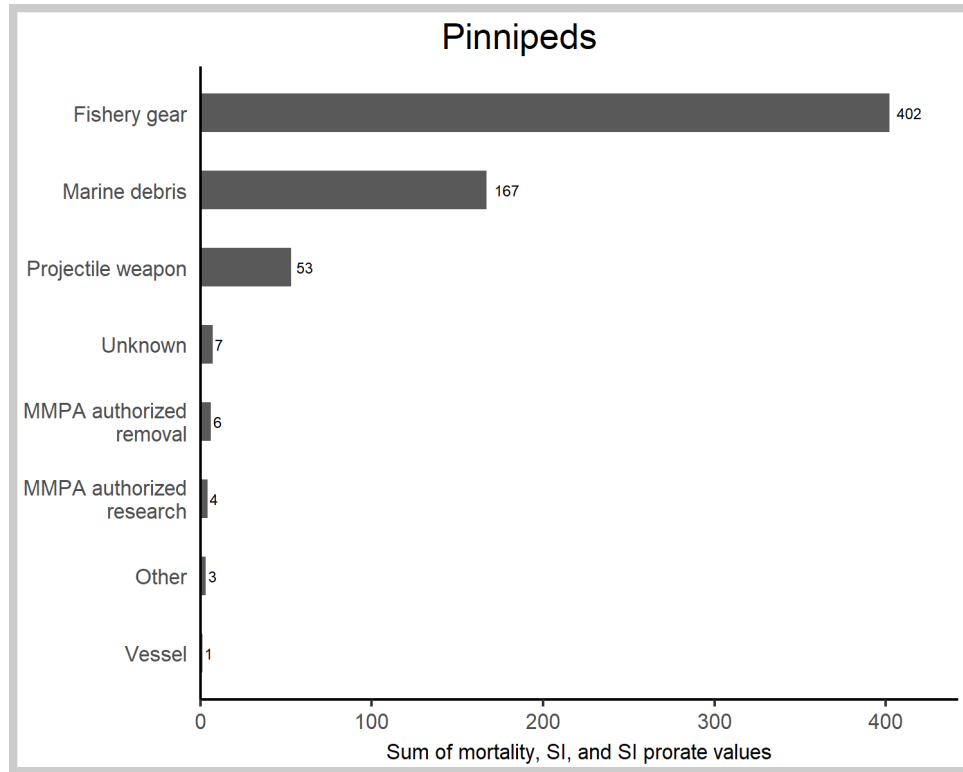


Figure 3. -- Human-caused serious injury and mortality of Alaska pinniped species by general cause of injury, 2016-2020. Dependent animals with seriously injured mothers are assigned the same cause of injury as their mothers.

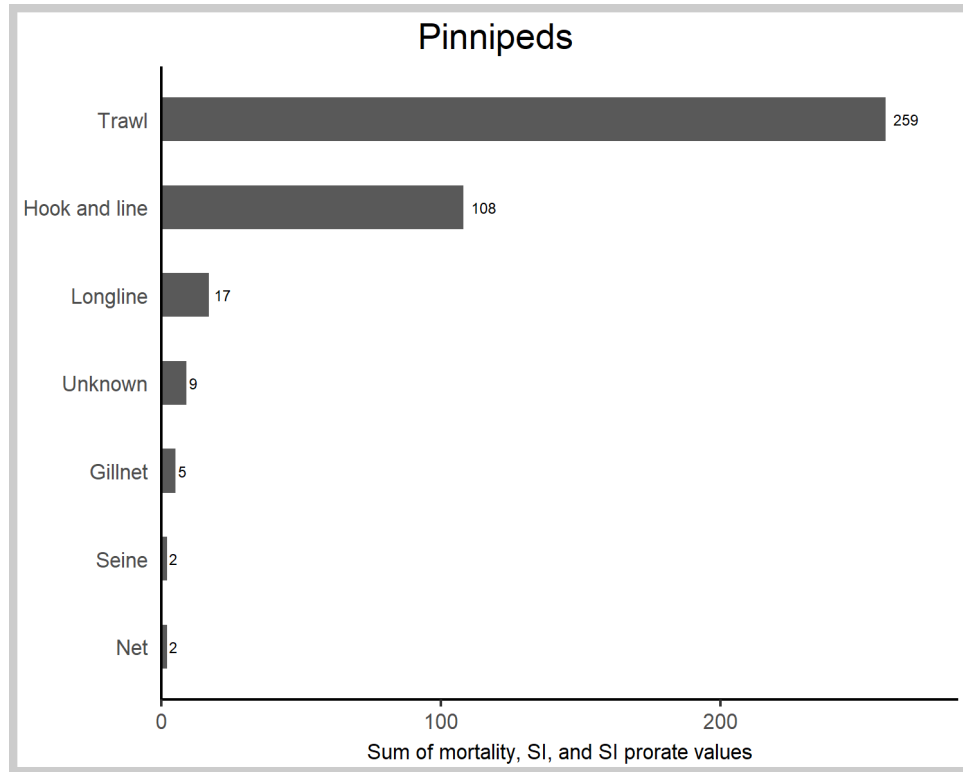


Figure 4. -- Fishery-related serious injury and mortality of Alaska pinniped species (fishery gear as the cause of injury) by fishery gear type, 2016-2020.

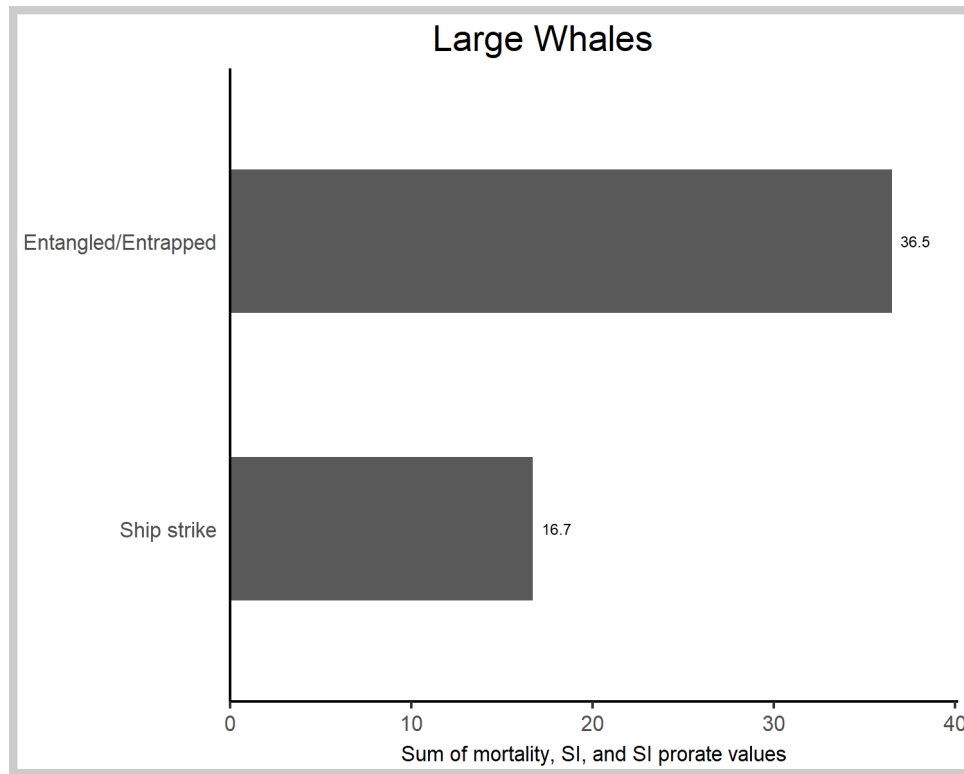


Figure 5. -- Human-caused serious injury and mortality of Alaska large whale species by mechanism of injury, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

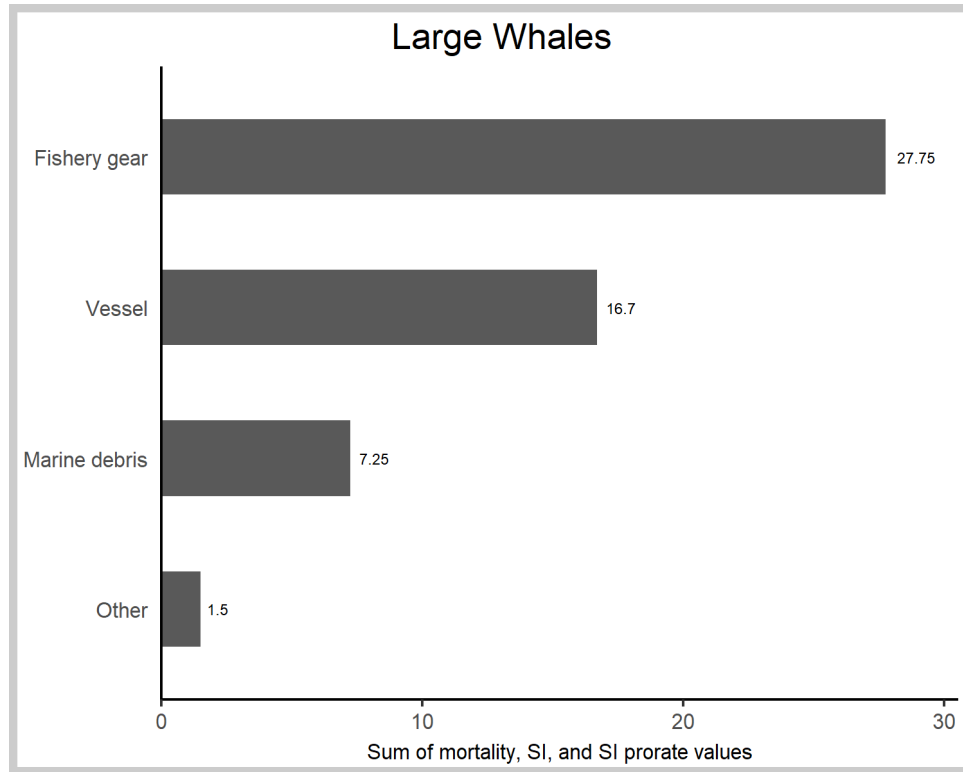


Figure 6. -- Human-caused serious injury and mortality of Alaska large whale species by general cause of injury, 2016-2020. Dependent animals with seriously injured mothers are assigned the same cause of injury as their mothers. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

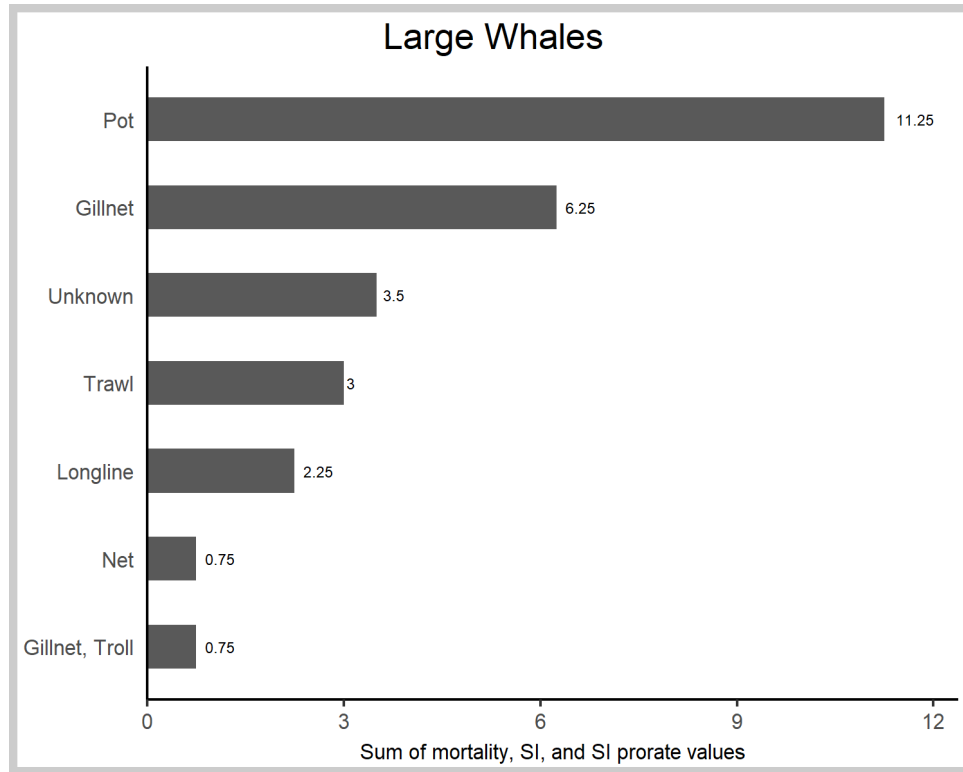


Figure 7. -- Fishery-related serious injury and mortality (fishery gear as the cause of injury) of Alaska large whale species by fishery gear type, 2016-2020. Some large whale injury categories are prorated (i.e., assigned a serious injury value less than one), so the sum of mortality, SI, and SI prorate values may not be a whole number. See the text of the report for more information.

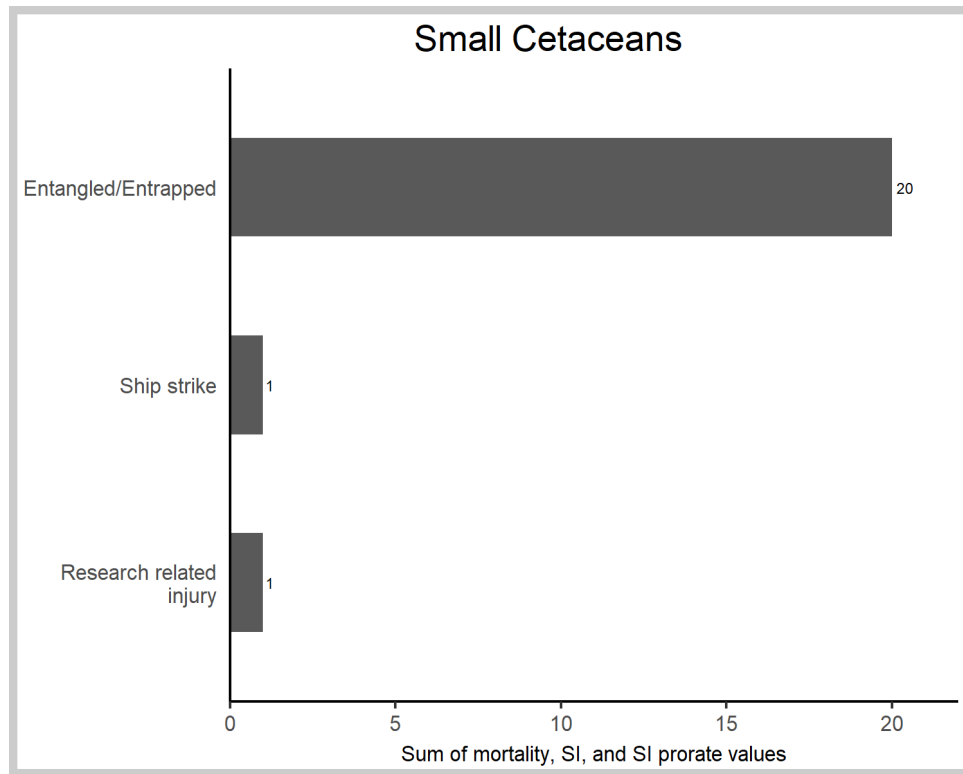


Figure 8. -- Human-caused serious injury and mortality of Alaska small cetacean species by mechanism of injury, 2016-2020.

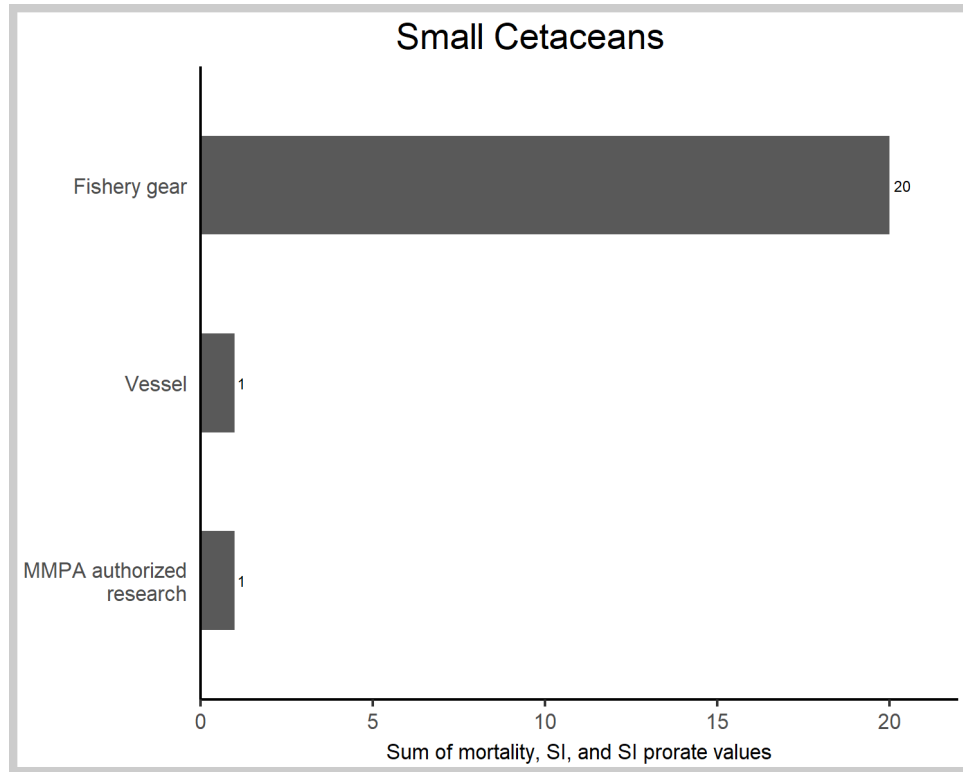


Figure 9. -- Human-caused serious injury and mortality of Alaska small cetacean species by general cause of injury, 2016-2020.

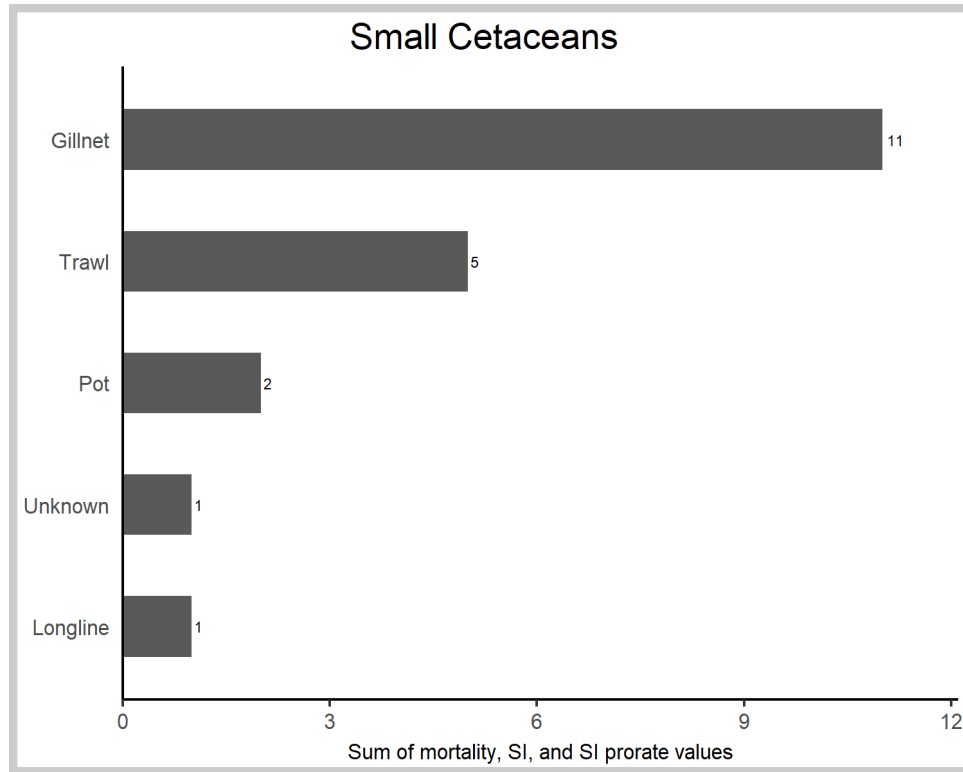


Figure 10. -- Fishery-related serious injury and mortality (fishery gear as the cause of injury) of Alaska small cetacean species by fishery gear type, 2016-2020.

Appendix

Appendix Tables 1 to 3 summarize the large whale, small cetacean, and pinniped injury categories and criteria, which are copied from tables 1 to 3 in the guidelines for “Distinguishing Serious from Non-Serious Injury of Marine Mammals” pursuant to the Marine Mammal Protection Act (NMFS 2012b). (Available online: <https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations>).

Appendix Table 1: Summary of Large Cetacean Injury Categories and Criteria.

Appendix Table 2: Summary of Small Cetacean Injury Categories and Criteria.

Appendix Table 3: Summary of Pinniped Injury Categories and Criteria.

Appendix Table 1. -- Summary of Large Cetacean¹ Injury Categories and Criteria

Instructions: Each large cetacean injury event is recorded to the appropriate injury/information category using all available information and scientific judgment, as described in the Procedural Directive. Criteria L10 - L12 accommodate events that lack details necessary for assignment to a more specific category. For a single injury event to which several categories apply, the injury determination with the highest level of severity is assigned. More detailed information or extended observation on an individual case/animal may justify a determination differing from the guidance of this table. An animal that is fully disentangled would generally be considered not seriously injured, unless there is additional evidence of a serious injury. Any injury leading to apparent significant health decline (e.g., skin discoloration, lesions near the nares, fat loss, increased cyamid loads) is a serious injury.			
Category	Injury/ Information	Injury Determination	Criteria
L1	Ingested gear ² or hook(s)	SI ³	Swallowed, not simply draped through mouth
L2	Constricting wrap	SI	Tightly wrapped line anywhere on body that indents the skin or does not shift with whale's movement, or line that is likely to become constricting as the whale grows. Indication that a whale that is heavily weighted, anchored or has a discolored appendage is sufficient evidence of constricting gear
L3	Loose wrap, bridled or draped gear	NSI ⁴	Loosely wrapped gear that moves or shifts freely with whale's movement. Absence of constricting gear must be confirmed
L4	External hook	NSI	Fishing hook of any size on any part of the body (i.e., not ingested)
L5a	Deep laceration ⁵	SI	Laceration with the potential to affect major artery (e.g., laceration or severing at insertion of flipper/fluke), penetrating body cavity, or cutting bone
L5b	Superficial laceration	NSI	Laceration not deeper than blubber layer, does not affect major artery, or cut bone
L6a	Vessel much greater in size than whale or vessel ≥65' and >10 knots	SI	Struck by vessel much greater in size than the whale and traveling greater than 10 knots, or struck by vessel equal or greater than 65' and traveling greater than 10 knots, and no information on injury to the whale
L6b	Vessel smaller in size than whale or vessel <65' and >10 knots	Prorate ⁶ : 0.20	Struck by vessel smaller in size than the whale and traveling greater than 10 knots, or struck by vessel less than 65' and traveling greater than 10 knots, and no information on injury to the whale. A strike to a calf by a vessel of any size and traveling greater than 10 knots will be considered a serious injury

¹ For the purposes of this table, "large cetaceans" include all mysticetes and sperm whales.

² For the purposes of this table, "gear" is defined as any portion of fishing gear excluding the hook, which is considered separately.

³ SI = Serious Injury.

⁴ NSI = Non-Serious Injury.

⁵ For the purposes of this table, "laceration" is defined as a ragged incision or a tearing of the skin. Lacerations are caused by trauma that results in stretching, tearing, crushing, shearing, or avulsion of the tissue. Trauma, including blunt and sharp force trauma, includes a wound or bodily harm caused by an extrinsic agent.

⁶ "Prorate" means the number of events assigned to a given category within the assessment period is multiplied by the prorate number provided for that category.

Appendix Table 1. -- Continued.

L6c	Vessel any size 10 knots	NSI	Struck by vessel of any size traveling at equal or less than 10 knots and no information on injury to the whale
L7a	Vessel much greater in size than whale or vessel ≥65' and speed unknown	Prorate: 0.56	Struck by vessel much greater in size than the whale traveling at an unknown speed, or struck by vessel equal or greater than 65' and traveling at unknown speed, and no information on injury to the whale. A strike to a calf by a vessel of any size when speed is unknown will be considered a serious injury
L7b	Vessel smaller in size than whale or vessel <65' and speed unknown	Prorate: 0.14	Struck by vessel smaller than the whale traveling at an unknown speed, or struck by vessel less than 65' and traveling at unknown speed, and no information on injury to the whale. A strike to a calf by a vessel of any size when speed is unknown will be considered a serious injury
L8	Dependent ⁷	SI	Dependent calf of a dead or seriously injured mother
L9	Brought on deck	SI	Whale removed from water and brought on deck
L10	Evidence of entanglement	Prorate: 0.75	Confirmed entanglement but insufficient information available to place in any of the L1-L4 criteria with a high degree of certainty
L11	Vessel strike laceration	Prorate: 0.52	Whale confirmed with non-entanglement related laceration but lacking details to place in either criteria L5a or L5b with a high degree of certainty. Includes observation of blood in water
L12	Vessel strike observed	Prorate: 0.36	Confirmed vessel strike report where there is insufficient detail to assign event to criteria L6a – L7b with a high degree of certainty. A strike to a calf by a vessel of unknown size traveling at an unknown speed will be considered a serious injury

⁷ “Dependent” for a large cetacean means a non-weaned calf. Weaned calves and juvenile large cetaceans are no longer dependent on their mothers.

Appendix Table 2. -- Summary of Small Cetacean¹ Injury Categories and Criteria

Instructions: Each small cetacean injury event is recorded to the appropriate injury/information category using all available information and scientific judgment, as described in the Procedural Directive. For a single injury event to which several categories apply, the injury determination with the highest level of severity is assigned. More detailed information or extended observation on an individual case/animal may justify a determination differing from the guidance of this table. Any injury leading to apparent significant health decline (e.g., skin discoloration, fat loss) is a serious injury.			
Category	Injury/Information	Injury Determination ²	Additional factors for evaluating whether “case-specific” injuries are serious or non-serious (additional factors at end of table)
S1	A free-swimming animal observed at a date later than its human interaction, exhibiting signs of declining health believed to be resulting from initial injury (e.g., a marked skin discoloration, fat loss)	SI ³	*
S2	Ingested gear ⁴ or hook(s)	SI	
S3	Visible blood loss	Case specific ⁵	Amount of blood, location of the bleeding injury, duration of bleeding
S4	Animal brought on vessel deck following entanglement/entrapment (excluding scientific research targeting marine mammals and authorized as such under a NMFS scientific research permit, where the animal is brought on and placed on the vessel deck in a controlled manner)	SI	
S5a	Hook(s) in head (excluding criterion S5b), regardless of the presence of gear	SI	
S5b	Hook(s) confirmed in lip only, external tissue outside of teeth, no trailing gear	Case specific	Prolonged restraint or struggle that could lead to capture myopathy, size of hook, depth of hooking, impairing ability to feed, presence of other injuries
S5c	Hook(s) in any body part, but hook(s) is removed or pulls out	Case specific	Prolonged restraint or struggle that could lead to capture myopathy, depth of hook, hook pulls out cleanly vs. causes further injury during dehooking, method used to remove hook, length of time hooked
S5d	Hook(s) in appendage or body (excluding criterion S5a), without trailing gear or with trailing gear that does not have the potential ⁶ to: 1) become a constricting wrap on animal; 2) be ingested; 3) accumulate drag; or 4) become snagged on something in the environment, anchoring the animal	Case specific	Prolonged restraint or struggle that could lead to capture myopathy, depth and location of hook, type and amount of gear attached

¹For the purposes of this table, small cetaceans include all odontocetes except sperm whales.

²This table includes only those criteria determined to be serious injuries or case-specific based on expert opinion at the 2007 Workshop (Anderson et al., 2008) and by small cetacean experts on the NMFS Determination Staff working group. For the purposes of streamlining the information for the reader, criteria determined to be non-serious injuries are not included in this table.

³SI = serious injury.

⁴For the purposes of this table, gear is defined as any portion of fishing gear excluding the hook, which is considered separately. Lures are considered gear. Gear also generally refers to any type of debris entangling or attached to the animal.

⁵Case-specific = Could be a serious or non-serious injury, but either 1) there is insufficient information about the impact of a particular injury, or 2) additional factors must be considered on a case-by-case basis to determine the severity.

⁶For the purposes of this table, "potential" as it relates to criterion S5d indicates that the trailing gear IS NOT capable of leading to any of the situations listed.

Appendix Table 2. -- Continued.

S6	Gear attached to free-swimming animal with potential ⁷ to: 1) become a constricting wrap on animal; 2) be ingested; 3) accumulate drag; or 4) become snagged on something in the environment, anchoring the animal	SI	
S7a	Anchored, immobilized, or entrapped and not freed	SI	
S7b	Anchored, immobilized, entangled, or entrapped before being freed without gear attached	Case specific	Duration of entanglement/entrapment, prolonged restraint or struggle that could lead to capture myopathy, gear type, where/how gear is attached to animal, associated injury (i.e., where directly or indirectly caused by initial entanglement), response of individual animal, method used by human to remove gear from animal
S8a	Gear wrapped and constricting on any body part or is likely to become constricting as the animal moves or grows	SI	
S8b	Gear wrapped and loose on any body part	Case specific	Gear type, amount of gear, potential for snag, potential to lead to criterion S8a, animal body size relative to gear (e.g., because of species or age), effect on animal movement, species sensitivity (e.g., frightens easily)
S9	Body trauma ⁸ not covered by any other criteria	Case specific	Location of wound, depth (e.g., superficial or to the bone, penetrating muscle or organs), length, number of lacerations, cleanliness (i.e., compression vs. tearing)
S10	Visible fracture(s), excluding pectoral fins (see criterion S13d for pectoral fin fractures)	SI	
S11	Vertebral transection, including fully severed flukes	SI	
S12	Body cavity penetration ⁹ by foreign object or body cavity exposure	SI	
S13a	Loss or disfigurement of dorsal fin	Case specific	Cleanliness (i.e., compression vs. tearing), nature of injury causing the loss, extent of fin loss (i.e., full or partial), amount and duration of blood loss
S13b	Partially severed flukes, transecting midline	SI	

⁷ For the purposes of this table, potential as it relates criterion S6 indicates that the trailing gear IS capable of leading to any of the situations listed.

⁸ For the purposes of this table, “trauma” is defined as a wound or bodily harm caused by an extrinsic agent. Blunt trauma is an injury (abrasion, laceration, contusion or skeletal fracture) produced by a blunt object striking the body or impact of the body against a blunt object or surface. Sharp force trauma is an injury caused by a sharp or pointed object creating a penetrating (stab, chop or incision) wound. Laceration is defined as a ragged incision or a tearing of the skin. Lacerations are caused by blunt trauma that results in stretching, tearing, crushing, shearing, or avulsion of the tissue.

⁹ For the purposes of this table, “penetration” is defined as a wound occurring when a foreign object punctures the body. Penetrating wounds can be characterized as one of three types: stab (small external wound that is greater in length into the body than is apparent on the skin surface), incised (clean cuts into the skin which are longer on the skin surface than they are deep), or chop wounds (incised wounds that penetrate deep to the bone, leaving a groove or cut in the bone).

Appendix Table 2. -- Continued.

S13c	Partially severed flukes, not transecting midline	Case specific	Cleanliness (i.e., compression vs. tearing), nature of injury causing the loss, amount and duration of blood loss
S13d	Partially or completely severed or fractured pectoral fin(s)	Case specific	Cleanliness (i.e., compression vs. tearing), nature of injury causing the loss, extent of fin loss (i.e., full or partial), amount and duration of blood loss, opened or closed fracture
S14	Social animal separated from group and/or released alone post-interaction (excluding criterion S15)	Case specific	Species (e.g., sensitivity, offshore vs. inshore), location of release (e.g., likelihood of animal locating its conspecifics)
S15	Dependent animal (i.e., calf, juvenile) released alone post-interaction or dependent animal left with a seriously injured or dead mother	SI	
S16	Observed or reported collision with vessel	Case specific	Speed of vessel, size of vessel, hull shape, part of vessel to strike the animal, size of animal compared to size of vessel, behavior of animal after collision, extent and location of wound(s) on animal

* Factors listed in the far right column of Appendix Table 2-2 are unique to the associated injury type. In addition to those listed in this column, the factors that should be considered, if available, when reviewing all case specific injury events in this table include, but are not limited to the following:

- Species
- Age or age class (e.g., calf, juvenile, adult)
- Sex
- Size of animal
- Overall health (e.g., nutritional status, body condition, pre-existing disease state, pre-existing injuries)
- Behavior during and/or after injury-causing interaction (e.g., dorsal arching, listlessness)
- Reproductive status (e.g., pregnant, lactating, has dependent calf)
- Natural history (e.g., indigenous, migratory)
- Location of injury (e.g., mouth, head, body, fin, tail, internal)
- Size of injury
- Duration of injury (e.g., single event, repeated, chronic)
- Depth of injury (e.g., superficial or to the bone, penetrating muscle or organs)
- Cleanliness of injury (e.g., compression, tearing)
- Environmental condition (e.g., individuals out of their normal habitat, climate stressors)
- Social stressors (e.g., social structure of species, separation of social individuals from the group, cow/calf separation)
- Cumulative effects of repeated exposures
- Compounding effects of multiple injuries obtained during a single event
- Availability of data on multiple sequential events involving the same individual over time
- Susceptibility of the species to capture myopathy (spinner dolphins and porpoises notoriously sensitive; bottlenose dolphins robust; many others fall in between, with some unknown)
- Ability of rehabilitated animal to be released
- Relative effect of blood loss on different species

In addition to those factors listed above, the factors that apply to all fishery-interaction related case specific injuries include, but are not limited to the following:

- Entanglement type (e.g., hooked, anchored, entrapment)
- Amount and size of gear (e.g., size, length and number of branches of line; number of buoys, traps or anchors; volume of netting)
- Entanglement constriction (e.g., tight, loose, multiple wraps)
- Habitat where animal is located (e.g., an animal with trailing gear areas of dense gear or an area with vegetation is more likely to risk snagging the gear and becoming anchored)
- Entanglement duration
- Existence, type and amount of any trailing gear
- Method of handling the animal during disentanglement

Appendix Table 3. -- Summary of Pinniped¹ Injury Categories and Criteria

Instructions: Each pinniped injury event is recorded to the appropriate injury/information category using all available information and scientific judgment, as described in the Procedural Directive. For a single injury event to which several categories apply, the injury determination with the highest level of severity is assigned. More detailed information or extended observation on an individual case/animal may justify a determination differing from the guidance of this table. Any injury leading to apparent significant health decline (e.g., skin discoloration, fat loss) is a serious injury.			
Category	Injury/Information	Injury Determination ²	Additional factors for evaluating whether “case-specific” injuries are serious or non-serious (additional factors at end of table)
P1	A free-swimming animal observed at a date later than its human interaction, exhibiting signs of declining health believed to be resulting from initial injury (e.g., a marked change in body condition, tissue necrosis, emaciation, gangrene).	SI ³	*
P2	Ingested gear ⁴ or hook(s)	SI	
P3	Visible blood loss	Case specific ⁵	Amount of blood, location of the bleeding injury, duration of bleeding
P4	Animal brought on vessel deck following entanglement/entrapment (excluding scientific research targeting marine mammals and authorized as such under a NMFS scientific research permit, where the animal is brought on and placed on the vessel deck in a controlled manner)	Case specific	Manner in which animal is brought on deck, length of time animal is on deck, environmental conditions (e.g., temperature)
P5a	Hook(s) in mouth (excluding criterion P5b), regardless of the presence of gear	SI	
P5b	Hook(s) confirmed in head (excluding criterion P5a), or in lip only (external tissue outside of teeth), no trailing gear	Case specific	Location on head (e.g., eye), depth of penetration, type of hook, prolonged restraint or struggle that could lead to capture myopathy, size of hook, impairing ability to feed
P5c	Hook(s) in any body part, but hook(s) is removed or pulls out	Case specific	Prolonged restraint or struggle that could lead to capture myopathy, location of hooking on the body, depth of hook, hook pulls out cleanly vs. causes further injury during dehooking, method used to remove hook, length of time hooked

¹For the purposes of this table, pinnipeds include all pinniped species except walrus.

²This table includes only those criteria determined to be serious injuries or case-specific based on expert opinion at the 2007 Workshop (Anderson et al., 2008) and by pinniped experts on the NMFS Determination Staff working group. For the purposes of streamlining the information for the reader, criteria determined to be non-serious injuries are not included in this table.

³SI = serious injury.

⁴For the purposes of this table, gear is defined as any portion of fishing gear excluding the hook, which is considered separately. Lures are considered gear. Gear also generally refers to any type of debris entangling or attached to the animal.

⁵Case-specific = Could be a serious or non-serious injury, but either 1) there is insufficient information about the impact of a particular injury, or 2) additional factors must be considered on a case-by-case basis to determine the severity.

Appendix Table 3. -- Continued.

P5d	Hook(s) in appendage or body (excluding criteria P5a-c and P12), without trailing gear or with trailing gear that does not have the potential ⁶ to: 1) become a constricting wrap on animal; 2) be ingested, 3) accumulate drag; or 4) become snagged on something in the environment, anchoring the animal	NSI ⁷	
P6	Gear attached in any manner to free-swimming animal with potential ⁸ to: 1) become a constricting wrap on animal; 2) be ingested; 3) accumulate drag; or 4) become snagged on something in the environment, anchoring the animal	SI	
P7a	Anchored/immobilized and not freed	SI	
P7b	Anchored, immobilized, or entangled before being freed without gear attached	Case specific	Duration of entanglement, prolonged restraint or struggle that could lead to capture myopathy, type of fishing gear, where/how gear immobilized animal, associated injury (where directly or indirectly caused by initial entanglement), response of individual
P8a	Gear wrapped and constricting any body part or likely to become constricting as the animal moves or grows	SI	
P8b	Gear wrapped loosely on any body part	Case specific	Type and amount of fishing gear, animal body size relative to gear (species, age), effect on movement, species sensitivity
P9	Body trauma ⁹ not covered by any other criteria	Case specific	Location of trauma on body, depth (superficial or to the bone, penetrating muscle or organs) length of laceration(s), number of lacerations, cleanliness (compression vs. tearing), amount and duration of blood loss, risk of infection or disease transmission (e.g., dog bites)
P10	Visible fracture(s), excluding broken appendages (see criterion P13 for broken appendages)	SI	
P11	Vertebral transection or fully severed flipper(s)	SI	
P12	Body cavity penetration ¹⁰ by foreign object or body cavity exposure	SI	

⁶ For the purposes of this table, potential as it relates to criterion P5d indicates that the trailing gear IS NOT capable of leading to any of the situations listed.

⁷ NSI = non-serious injury.

⁸ For the purposes of this table, potential as it relates to criterion P6 indicates that the trailing gear IS capable of leading to any of the situations listed.

⁹ For the purposes of this table, “trauma” is defined as a wound or bodily harm caused by an extrinsic agent. Blunt trauma is an injury (abrasion, laceration, contusion or skeletal fracture) produced by a blunt object striking the body or impact of the body against a blunt object or surface. Sharp force trauma is an injury caused by a sharp or pointed object or a bullet from a gunshot creating a penetrating (stab, chop or incision) wound. Laceration is defined as a ragged incision or a tearing of the skin. Lacerations are caused by blunt trauma that results in stretching, tearing, crushing, shearing, or avulsion of the tissue.

¹⁰ For the purposes of this table, “penetration” is defined as a wound occurring when a foreign object punctures the body, such as a bullet from a gunshot. Penetrating wounds can be characterized as one of three types: stab (small external wound that is greater in length into the body than is apparent on the skin surface), incised (clean cuts into the skin which are longer on the skin surface than they are deep), or chop wounds (incised wounds that penetrate deep to the bone, leaving a groove or cut in the bone).

Appendix Table 3. -- Continued.

P13	Partially severed or fractured flipper(s)	Case specific	Cleanliness (clean cut vs. tear), nature of injury causing the loss, extent of fin or flipper loss, opened or closed fracture, dislocation, amount/duration of blood loss
P14	Dependent animal (i.e., pup, juvenile) released alone post-interaction or dependent animal left with a seriously injured or dead mother	SI	
P15	Observed or reported collision with vessel	Case specific	Speed of vessel, size of vessel, hull shape, part of vessel to strike the animal (e.g., propeller, hull), size of animal compared to size of vessel, location of strike on animal's body, extent and location of wound(s) to animal

* Factors listed in the far right column of Appendix Table 2-3 are unique to the associated injury type. In addition to those listed in this column, the factors that should be considered, if available, when reviewing all case specific injury events in this table include, but are not limited to the following:

- Species
- Age or age class (e.g., calf, juvenile, adult)
- Sex
- Size of animal
- Overall health (e.g., nutritional status, body condition, pre-existing disease state, pre-existing injuries)
- Behavior during and/or after injury-causing interaction (e.g., listlessness)
- Reproductive status (e.g., pregnant, lactating, has dependent pup)
- Natural history (e.g., small home range, large home range)
- Location of injury (e.g., mouth, head, body, flipper/fin, internal)
- Size of injury
- Duration of injury (e.g., single event, repeated, chronic)
- Depth of injury (e.g., superficial or to the bone, penetrating muscle or organs)
- Cleanliness of injury (e.g., compression, tearing)
- Environmental condition (e.g., individuals out of their normal habitat, environmental stressors)
- Social stressors (e.g., social structure of species, separation of social individuals from the group, mother/pup separation)
- Cumulative effects of repeated exposures
- Compounding effects of multiple injuries obtained during a single event
- Availability of data on multiple sequential events involving the same individual over time
- Susceptibility of the species to capture myopathy (some sensitive, others robust, some unknown)
- Ability of rehabilitated animal to be released
- Relative effect of blood loss on different species

In addition to those factors listed above, the factors that apply to all fishery or marine-debris interaction related case specific injuries include, but are not limited to the following:

- Entanglement type (e.g., hooked, anchored, entrapment)
- Amount and size of gear (e.g., size, length and number of lines; number of buoys, traps or anchors; volume of netting; material of gear)
- Method of handling the animal during disentanglement
- Entanglement constriction (e.g., tight, loose, multiple wraps)
- Habitat where animal is located (e.g., an animal with trailing gear in areas of dense gear or an area with vegetation or on shore is more likely to risk snagging the gear and becoming anchored)
- Entanglement duration
- Existence, type and amount of any trailing gear



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