1991 MARINE MAMMAL OBSERVER PROGRAM FOR THE SALMON DRIFTNET FISHERY OF PRINCE WILLIAM SOUND ALASKA

FINAL REPORT

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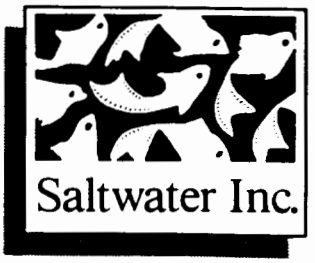

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EXECUTIVE SUMMARY

In 1991 the National Marine Fisheries Service (NMFS) contracted Saltwater Inc. to design and implement an observer program for the Prince William Sound (PWS) salmon drift gillnet fishery. The purpose of the program was to acquire knowledge about the incidental take of marine mammals in commercial fishing operations as required by the 1988 amendments to the Marine Mammal Protection Act. This report describes the methods used and the results from that observer program.

The PWS driftnet season opened 16 May and continued through 12 October 1991. Saltwater Inc. observers were on the grounds from 16 May to 1 September 1991. During that time observers boarded 531 of the 611 registered vessels, observed some 5747 hours, and monitored 5875 complete net retrievals or roughly 5% of the estimated number of sets made during the period of observer coverage. Driftnets were monitored by observers onboard active fishing vessels and remotely by observers onboard research vessels. Observers monitored the retrieval and, where possible, the soak of nets, and recorded data associated with all marine mammal and bird encounters, including fish and gear damage, harassment, and incidental take.

The 1991 observer data suggests that marine mammal encounters (approaching within 10 meters of a net) are common in this fishery (12% of observed sets), but rarely fatal. Steller sea lions and harbor seals appear to be attracted to the gillnets where they scavenge netted salmon, while sea otters and cetaceans may inadvertently encounter nets as they pass through a fishing area. Mammals became entangled in less than 1% of the total observed sets, and 85% of the entangled animals were able to release themselves unharmed or to be released with fishermen's assistance. Entanglements resulted in serious injury or death to marine mammals in less than 0.1% of sets observed. Seven marine mammals (four porpoises, two sea lions, and one harbor seal) died or were seriously injured in the 5875 observed sets. Because so few kills were observed, extrapolation of the observer data is statistically difficult, and results in wide confidence intervals. We estimate that 83 marine mammals (95% CI=7 to 296) including 29 Steller sea lions were incidentally injured or killed in PWS driftnets between 16 May and 1 September 1991. The observer data suggests that incidental marine mammal take in the PWS driftnet fishery is not "frequent" by NMFS standards.

Nearly 2000 marine birds, representing at least 19 species, were observed within 10 meters of driftnets. Of these, 62 (3.2%) became entangled, and 53 (85.5%) of the entangled birds died prior to removal. Gulls and kittiwakes were the marine birds most commonly observed near driftnets, but murres and murrelets were the species most frequently entangled and killed. As with the mammal data, marine bird take rates were low so that extrapolation of the observer data is statistically difficult, and results in wide confidence intervals. We estimate that 993 marine birds (95% CI=334 to 2097) including 430 common murres and more than 260 marbled murrelets died incidentally in PWS driftnets between 16 May and 1 September 1991.

I. INTRODUCTION

In 1990 and 1991 the National Marine Fisheries Service (NMFS) sponsored observer programs nationwide to acquire knowledge about the incidental take of marine mammals in commercial fishing operations. In Alaska, NMFS contracted Saltwater Inc. to design and implement observer programs in three salmon gillnet fisheries in 1990: the Prince William Sound driftnet fishery, the Prince William Sound setnet fishery, and the South Unimak driftnet fishery. In 1991 NMFS reclassified two of these fisheries, and contracted Saltwater Inc. to continue the observer program for the Prince William Sound driftnet fishery. This report describes the methods used and the results from the 1991 observer program.

BACKGROUND

In 1972 the U.S. Congress passed the Marine Mammal Protection Act (MMPA) to protect marine mammal populations. The MMPA generally prohibits the taking of marine mammals, but allows an exemption for the incidental take of certain marine mammals during commercial fishing operations. In 1988 Congress amended the MMPA in response to concerns that the incidental take of marine mammals in commercial fisheries posed a potentially serious, but poorly documented, threat. The 1988 amendments continued the exemption for commercial fishing operations to 1 October 1993, but required the Secretary of Commerce to collect data on the status of marine mammal stocks and their interactions with commercial fisheries. Until recently those interactions have been infrequently monitored or regulated.

The 1988 amendments required the Secretary of Commerce to establish mandatory observer programs for Category I fisheries. Category I fisheries are those with a suspected or reported "frequent" incidental take of marine mammals. NMFS considers take "frequent" if it "is highly likely that more than one marine mammal will be incidentally taken by a randomly selected vessel in the fishery during a 20-day period" [FR 54(96):21915]. Although NMFS considers all definitions of "take" when categorizing fisheries, Congress interpreted "incidental take" to mean "the entanglement, serious injury or death of a marine mammal in the course of normal fishing operations" (U.S. Senate Rept 100-592, 1988). The Prince William Sound driftnet fishery was placed in Category I because of its

long and relatively well-documented history of conflict with marine mammals (Matkin and Fay 1980; Wynne 1990).

The MMPA amendments require the Secretary of Commerce to provide observer coverage for 20-35% of fishing operations in Category I fisheries wherever possible. In Category I fisheries where 20-35% observer coverage is precluded, the Secretary of Commerce is required to establish an alternative monitoring program which will provide statistically reliable information on the species and number of marine mammals taken in the observed fisheries. The observer program for the Prince William Sound drift gillnet fishery falls into the "alternative program" category due to safety concerns and the large number of small boats involved in the fisheries. After considering the characteristics of these fisheries NMFS concluded that it was not safe or feasible to place observers on vessels to provide 20-35% observer coverage. Based on analyses by NMFS biologists, NMFS concluded that statistically reliable estimates of incidental take levels could be expected with less observer coverage.

The 1990 PWS driftnet observer program provided observer coverage of approximately 4 percent of fishing operations between 1 July and 30 September 1990 (Wynne et al. 1991). Due to a late contract award, observers were not able to monitor interactions during the early part of the fishing season (May, June) in 1990. The 1991 program was designed to provide observer coverage from the beginning of the fishing season to 1 September. The 1 September end date recognized that fleet effort and weather typically decrease appreciably in September.

DESCRIPTION OF THE FISHERY

The PWS driftnet fishery targets five species of salmon that return to spawn in Prince William Sound and the Copper River delta: sockeye *(Onchorhynchus nerka)*, chinook *(O. tschawytscha)*, pink *(O. gorbuscha)*, coho *(O. kisutch)*, and chum *(O. keta)* salmon. The fishery is managed by the Alaska Department of Fish and Game (ADFG) which has divided the fishery into five statistical districts. The Eshamy (ES), Coghill (CG), and Unakwik (UN) statistical districts are located in the deep, relatively protected waters of Prince William Sound. The Copper River (CR) and Bering River (BR) districts are

south and east of the Sound in the nearshore and offshore waters of the Copper River delta ("Flats") (Figure 1).

ADFG regulates the timing and distribution of fishing opportunities allowed within the statistical districts. Typically, fishing in the Copper River and Bering River districts begins in mid-May and lasts until late September, while fishing in the three PWS districts begins in late June and continues through August. The ADFG area management biologist establishes active fishing periods ("openings") based on desired salmon escapement. Openings vary from 12 to 168 hours per week and are established in-season by emergency order. Actual fishing effort depends on individual fishing strategies, fish prices, weather and other environmental and economic conditions.

Over 500 fishermen own a limited entry permit which allows them to fish in the PWS driftnet fishery. The permit holders use relatively small vessels (6 to 10 meters in length) and 150-fathom (273 meter) polyfilament gillnets. Each boat deploys one net, which drifts attached to the vessel and is retrieved after a "soak" period which can last from approximately 15 minutes to 5 hours. The net hangs (4-18 meters) from a corkline at the water surface, and catches fish as they attempt to swim through the mesh.

II. METHODS

ESTIMATING FISHING EFFORT

ADFG closely monitors the salmon harvest in the PWS driftnet fishery, but does not directly measure fishing effort. Each time a fisherman sells his catch, the processor fills out an ADFG fish ticket which records the date, district, weight by species, and permit holder's name. ADFG maintains in-season records of daily landings within each district, including the number of permit holders landing fish, number of salmon landed (by species), and the maximum number of hours available to fish in each district.

With these variables the catch and available fishing opportunity can be quantified, but not actual fishing effort. An appropriate measure of fleet effort is required to extrapolate observed take rates to total take estimates and to assess observer coverage. Because no direct measures of effort were available, the project team estimated fleet effort using fishing vessel days (FVday) and net retrievals or "sets". The team estimated fishing effort in FVdays to allow evaluation of the fishery's Category I status under the 1988 MMPA amendments. The team used net retrievals or "sets" to define both fishing and observer effort in all other analyses.

The team calculated weekly estimates of fleet FVdays in each district by multiplying the maximum number of vessels fishing by the maximum number of days available to fish. The number of days available to fish in each period was calculated by dividing available hours by 24. Fishing periods shorter than 24 hours were treated as one day. Weekly estimates were summed over the season to estimate fleet effort in FVdays.

To quantify fleet effort in terms of sets the team calculated weekly estimates of the number of sets made per available fishing hour in each fishing district. The actual number of hours fished in an opening, the duration of sets, and, consequently, the number of sets made per available fishing hour vary seasonally and geographically throughout the PWS driftnet fishery. These variations depend on salmon run strength, the length of openings, the amount of daylight, fishing strategies, and other factors. Estimating fleet effort per

how much variation?

available fishing hour accounts for variability in set duration and fishing intensity. It also allows estimation of sets directly from ADFG landings data.

Observers onboard vessels recorded the number of sets made during all available fishing hours of each fishing period or opening. The team calculated a weekly mean of observed sets per available fishing hour (S_h) for each fishing district. A weekly estimate of sets made by the fleet was calculated for each district by mulitiplying the weekly mean of sets made per available hours (S_h) by the weekly sum of the fleet's available fishing hours (FVhrs). FVhrs were calculated on a daily basis as the actual number of vessels landing salmon multiplied by the maximum number of hours available to fish. The team used daily landing records with ADFG vessel counts to minimize double counting of vessels which fished in more than one district per fishing period or week (see Discussion). The team estimated total fleet effort by summing the weekly estimates of sets made in each district. Thus, weekly fleet effort was estimated as the number of sets made in each statistical week (S_{wk}) and calculated as:

$$S_{wk} = S_h \times \sum \text{FVhrs}$$

where: S_h = observed # sets ÷ available fishing hrs

FVhrs = (# vessels fishing) x (# available fishing hrs)

Observer effort in the Bering River and Unakwik districts was inadequate to generate effort estimators. To derive estimates of FVsets in these districts the team assumed fishing intensity to be comparable to similar juxtaposed districts. Thus, estimates of S_h in the Copper River district were used to estimate fleet effort in the Bering River district, and estimates of S_h in the Coghill district were used to approximate effort in the Unakwik district.

To monitor fishing downtime, the team calculated a weekly index of fishing intensity (%T) in each district. Fishing intensity (%T) compares the amount of time spent actually fishing versus the time spent running the boat to and from the grounds, offloading, or engaged in other activities. Fishing intensity is calculated as the number of hours in which nets were actively fished by observed vessels divided by the total available fishing hours in that district.

OBSERVER EFFORT

Observer Platforms

The team used two observer platforms to monitor fishing activities in the 1991 driftnet season - fishing vessels (FV) and dedicated research vessels (RV). Observers were designated as either FV observers who monitored nets aboard active fishing vessels or RVs, or RV skipper/observers who operated the RVs and monitored nets only from them. Observation from shore was feasible and effective only in a limited area of the Eshamy District.

FV observers boarded fishing vessels from port prior to fishing periods or from research vessels on the fishing grounds after explaining the program's goals to the fishing vessel skipper. Boardings from port were pre-arranged and generally involved vessels capable of accommodating an observer overnight. FV observers who did not board a fishing vessel in port were assigned to an RV which took them to the fishing grounds. Each RV was assigned to a particular sampling area on the fishing grounds, and the FV observers boarded fishing vessels in those assigned sampling areas. Whenever possible, FV observers remained on fishing vessels for extended periods to obtain night coverage, observe both soak and retrieval of nets, and provide estimates of set duration. This is suspect.

RV skipper/observers were trained and required to: 1) monitor and record data from nets observed remotely from their RV, and 2) transport, deploy, and support FV observers on the fishing grounds. Prior to each fishing period field coordinators assigned each RV to a sampling area within open fishing districts .

Observers on both FVs and RVs monitored net retrievals and collected standardized data on the circumstances associated with entanglement, injury, or death of marine birds and mammals. Whenever possible, observers also monitored nets during the soak period and recorded standardized data on interactions between marine birds and mammals and fishing nets.

Observer Deployment

Field coordinators distributed observer effort in proportion to the anticipated number and distribution of vessels in each open district based on reports from fishermen and fish processors. Fleet effort and distribution are

dynamic and unpredictable in this fishery, and fishermen often spontaneously move between districts up to 150 miles (240 km) apart. After initial deployment field coordinators used real-time reports from observers on the grounds and aerial reconnaissance to reallocate observer effort as needed. The RV sampling area assignments facilitated distribution of observer effort and assured adequate RV support for FV observers. Any area adjustments necessitated by changes in fleet distribution, safety considerations, or tidal and weather limitations were made only with coordinator approval via scheduled radio contact.

Within their assigned area RV skippers approached driftnet vessels and requested permission to transfer the FV observer aboard. If granted, the FV observer was deployed and the RV continued in a random direction to another vessel for remote net observation. If denied boarding, the RV approached alternate vessels until the FV observer was allowed onboard, then generally returned to vessels denying observer boarding to monitor their nets remotely. If denials or safety concerns precluded boardings, FV observers monitored driftnet activity remotely from the RVs.

The project team maintained a "vessel boarding" database to document observer coverage of each vessel. Updated weekly, this database facilitated equitable observer coverage and prevented overburdening/oversampling of cooperative vessels. In addition, the vessel boarding database contained fishermen's contact information which was used by the field coordinators to prearrange boardings prior to fishing periods. Usually two to five boardings per period were prearranged, based on random selection from this list of registered vessel operators. Observers boarded these vessels in port prior to their departure to the fishing grounds.

As a general rule, observers did not attempt to board fishing vessels when weather reports indicated a small craft advisory (winds greater than 25 mph). However, because weather forecasts are often locally inaccurate and conditions change rapidly, RVs (with FV observers aboard) often travelled to sheltered anchorages near the fishing grounds during small craft advisories to assess actual sea conditions. If local conditions improved or were deemed safe for transferring observers to fishing vessels, RV skippers deployed their FV observers and observed driftnets remotely as usual. If inclement weather precluded safe

boardings but remote observations were feasible, both the FV and the RV observer monitored driftnets remotely from the research vessel. If net visibility was impaired or vessel safety was compromised, RVs remained at safe anchorages and awaited improvement in local conditions.

Data Collection

Observers monitored the complete retrieval (haulback) of nets observed, and, whenever possible, the deployment and soak periods. Observers recorded standardized variables for every set monitored, including environmental conditions, identification of the observed vessel, and time, location, and physical characteristics of the set (Form 1, Appendix A). If a marine mammal or bird approached within 33 feet (10 m) of the net, the observer recorded details of the encounter on a supplemental data form (Form 2, Appendix A).

To allow assessment of potential differences in marine mammal and bird interaction rates due to physiographic differences in fishing sites the team defined six habitat zones. These zones represent unique and variable physical characteristics within the driftnet fishing area. Channels extend upstream from barrier islands and represent tidally restricted zones of relatively protected waters. Bar entrances occur where channels meet open water outside barrier islands and are characterized by tidally influenced turbulent water. A surf zone exists immediately seaward of barrier islands and is characterized by swells and extensive breakers. The nearshore zone includes waters from the surf zone out to 10-fathom depths. The offshore zone includes waters deeper than 10 fathoms other than fiords. The fiord zone describes deep waters (>10 fathoms) within 930 feet (300 m) of shore and is associated with the deep, protected waters of Prince William Sound.

Observers recorded the number, species, time, and location of all marine birds or mammals that approached within 33 feet (10 m) of monitored nets as an "encounter". They recorded the results of these encounters, including details of the encountered animal's behavior, harassment, entanglement, live-release, or incidental mortality. When possible, observers recorded the animal behavior associated with net avoidance classifying the behavior as "avoided" (voluntarily changed approach, direction, or behavior), "missed" (missed gear without

apparent change in approach, direction, or behavior), and "harassed" (actively deterred by fisherman).

Observers recorded the type and apparent effectiveness of harassment techniques used to deter approaching marine mammals from nets. The deterrent was recorded as effective if the mammal left the net area in apparent response to its use. Primary deterrents included running gear (RU: using fishing vessel to chase mammals from the net after casting it adrift), gunshots (GU: shooting a gun in the vicinity of interacting mammals), and seal bombs (SB: nonlethal underwater explosives). Observers also recorded use of combined deterrents (GR: gunshots and running gear), (SR: seal bombs and running gear), (GS: gunshots and seal bomb), as well as "Other" nonlethal deterrent techniques including shouting, slapping the water with oars, etc.

Observers recorded as an "entanglement" any instance where a marine mammal or bird contacted the net and was detained or ensnared even momentarily. When possible, observers also recorded the entangled animal's species, sex, approximate age, and size. Observers categorized the degree of entanglement by whether the animal was able to release itself or required assistance. Observers noted the condition of entangled animals as dead, released alive, or unknown. Seriously injured animals were classified as "dead" and included in mortality estimates if they were bleeding profusely, listless, or appeared mortally wounded. Observers examined incidentally killed marine mammals and, when possible, collected samples for necropsy and further study. They collected marine bird carcasses retrieved from monitored nets and submitted them to the U.S. Fish and Wildlife Service (USFWS) for species verification and processing.

Marine mammal interactions with salmon driftnets may damage nets or the netted salmon they contain. Observers onboard FVs recorded data necessary to quantify the frequency and extent of marine mammal damage to driftnets and netted salmon. For each retrieval observers recorded the number of landed salmon (by species) and nontarget species (fish and shellfish), and the number of each apparently damaged by marine mammals. They also indicated whether the monitored net had sustained obvious damage from marine mammal interactions.

Measure of Effort

The team measured observer effort in terms of 1) the number of sets observed, and 2) the number of hours spent observing active gear during soak and retrieval. As in other gillnet fisheries, lethal bycatch can be seen during retrieval or haulback of the net. Therefore, observer coverage focused on net retrievals. The team calculated take rates using only sets in which the complete retrieval was observed. Whenever possible, observers also monitored the soak of sets. Because the surface nets used in this fishery are continually attended by the fishing vessel, observers can also monitor interactions that occur when the net is soaking.

Observer coverage was categorized as "remote" if observers watched nets from land, a research vessel, or an adjacent fishing vessel, and "onboard" if the data came from an observer onboard the observed vessel. Onboard observers sought full-day coverage on vessels capable of accommodating them. Because the PWS driftnet fleet consists of small vessels fishing in dangerous conditions, observers often could not remain on vessels overnight or for prolonged periods. In these cases observers sought minimum passage of six to eight hours per vessel. In contrast, remote observers monitored only one or two sets per vessel, and maximized the number of different vessels observed.

ESTIMATING TAKE AND DAMAGE RATES

The nature of marine mammal interactions varies between fisheries, and no standard guidelines exist for defining and estimating incidental take from observer data. The project team calculated four separate estimates for marine mammal take from the 1991 observer data: 1) entanglements (lethal and nonlethal) observed during net retrievals only, 2) entanglements (lethal and nonlethal) observed during net soaks and retrievals, 3) kills observed during net retrievals only, and 4) kills observed during net retrievals and soaks. The team derived estimates for marine bird mortality from the kills observed during net retrievals.

Because marine mammal interactions are known to be seasonally and regionally distributed (Matkin and Fay 1980; Wynne 1990), the team stratified

the observed sample by district and week. The number of marine mammals and birds observed entangled, seriously injured, or killed was tallied in each district each week from 16 May to 1 September 1991. Negative binomial analyses were used to derive weekly estimates and 95 percent confidence limits from the observed take rates, and these were summed over the season to derive fleetwide estimates of marine mammal and bird take.

Entanglements and mortality were rarely observed in this fishery. The relative frequency of such rare events is most commonly approximated by the Poisson distribution. (Pella and Masuda, NMFS Auke Bay Lab, pers. comm.). This analysis assumes that unobserved take rates equal observed take rates, and generates probabilities for the frequency of take (Pella and Masuda, NMFS Auke Bay Lab, pers.comm.):

$$\text{Prob}[Y=y] = (¥ n)^y e^{-¥n} / y!$$

where $y = 0,1,2,3...$,

Y represents random number of deaths in n retrievals

¥ represents underlying take rate approximated by observed takes per retrieval

The team used three characteristics of observed sets to examine spatial and temporal patterns of marine mammal and bird encounters, entanglements, and mortality - statistical district, habitat zone, and time of day. We divided time of day into four six-hour segments based on typical fishing patterns and relative periods of dark and light (0500-1100, 1101-1700, 1701-2300, 2301-0500). When sample size was adequate, we used Chi-square goodness of fit analyses to test whether the observed frequency of interactions in each category was proportionate to expected, assuming the sampled effort was uniformly distributed (Zar 1984; Neu et al. 1974).

Category I fisheries are defined as those in which it is "highly likely that more than one marine mammal will be incidentally taken by a randomly selected vessel in the fishery during a 20-day period" [FR 54(96):21915]. To assess the appropriateness of the fishery's Category I status using aggregate data, we interpreted this definition to equal one marine mammal entanglement, injury, or death per 20 fishing vessel days (FVdays) by the fleet.

Because FV observers moved from vessel to vessel and often monitored an individual fishing vessel for less than 24 hours, observed marine mammal take rates per fishing vessel day were impossible to calculate. From the estimated fleet effort in FVdays we back-calculated to determine the minimum take estimate which would meet the definition of "frequent." We compared this minimum take estimate to our estimates of take (total and lethal) derived per retrieval to evaluate the appropriateness of the fishery's Category I status.

To estimate fleetwide losses due to marine mammal depredation the team applied observed damage rates to overall fleet landings and effort. Then, we multiplied the observed ratio of damaged to undamaged fish by total landings (by species) to estimate marine mammal-associated fish damage experienced by the fleet. We used the average ex-vessel value per fish (average value per pound mulitiplied by average pounds per fish) to estimate the monetary equivalent of loss due to mammal depredation. The ratio of damaged to undamaged sets multiplied by fleet effort (in sets) allowed us to estimate total fleetwide gear damage caused by marine mammals.

BEACHCAST CARCASS SURVEYS

The project team conducted weekly surveys of barrier island beaches of the Copper River delta to locate beachcast marine mammal carcasses. The team systematically conducted the surveys in a manner comparable to those of 1988, 1989, and 1990 (Wynne 1990; Wynne et al. 1991). A Cessna 180 on wheels was flown at an altitude of 30 to 150 feet (10 to 50m) along the high-tide line to locate carcasses. Whenever possible, team members landed and examined carcasses to determine the species, sex, and cause of death, took standard measurements, and collected teeth and other tissue samples. Prior to the driftnet season the team surveyed to locate preexisting carcasses and map their locations to prevent recounting. The team "ground-truthed" aerial surveys three times in 1991. Paired observers, walking abreast along a stretch of beach immediately following an aerial survey, searched through clumps of eelgrass and debris for undetected carcasses. To chart annual trends the results of the 1991 surveys are compared in this report to the survey results in 1988, 1989, and 1990 (Wynne 1990; Wynne et al. 1991).

III. RESULTS

FISHING EFFORT

The PWS driftnet season opened 16 May and continued through 12 October 1991. The number and duration of open fishing periods varied weekly between districts (Table 1). Fishing during the first month of the five-month season was limited entirely to the Copper River district, which opened 16 May and remained open for 0 to 120 hours per week through 12 October. The other four districts opened in mid-June and closed by 12 October.

Of the 537 PWS driftnet permit holders, 519 fished during the 1991 PWS driftnet season. Some permit holders used more than one vessel during the season, and registered each under the Marine Mammal Exemption Program. A total of 611 PWS driftnet vessels were registered in the exemption program in 1991. The number of active driftnetters varied each week in response to fish run strength, ex-vessel prices, weather, and economic alternatives (Table 1). The number of hours available to fish in each district also varied weekly. The summed estimate of FVdays per district resulted in an estimate of 18,415 FVdays for the fleet (Table 1).

Effort by active driftnetters varied weekly and between districts due to changes in the number and duration of sets made and the proportion of available fishing time actually fished (% T) (Table 2). Our estimate of total effort in sets reflects this weekly variability of effort in each district (Table 3).

OBSERVER EFFORT

Between 16 May and 31 August 1991 RV and FV observers monitored more than 5747 hours of driftnet operations and 6357 sets including 5875 complete net retrievals (Table 3). Observers monitored the fishing operations of 531 different fishing vessels, 87 percent of the 611 vessels registered in the fishery. Observers boarded 279 different vessels, of which 194 (69.5%) were boarded once, 67 (24%) were boarded twice, 16 (5.7%) were boarded three times, and 2 (0.7%) were boarded four times during the season. No vessel was boarded more than four times. Observers monitored the activities of 529 individual driftnet vessels from remote platforms.

Observer effort was geographically distributed throughout open districts in approximate proportion to weekly fleet effort (Table 3). Observers monitored approximately 5 percent of the fleet's total fishing effort as measured in sets from 16 May to 31 August 1991 (Table 3). Observers onboard active driftnet vessels accounted for 66 percent of the hours and 44 percent of the complete retrievals observed during 1991 (Table 4).

Observers monitored nets in all habitat zones described within the study area (Table 5). The vast majority (90%) of observations were made in the geographically largest sampling areas - offshore, nearshore, and channel. Because ADFG does not monitor the fleet or its landings by habitat zones, it was not possible to determine observer coverage relative to fleet effort in the six habitat zones.

Observers monitored driftnet retrievals in each of four six-hour time periods (Table 6). Retrievals were less frequently observed at night (23:01-05:00) than during other periods because lengthier night soaks reduced the number of sets made during this period, and observer access to night sets was limited.

MARINE MAMMAL INTERACTIONS

Encounters

Observers recorded a total of 1023 encounters in which marine mammals approached within 33 feet (10 meters) of a fishing net (Table 7). Encounters occurred in 704 (12%) of the 5875 observed sets. The encounters were not uniformaly distributed either spatially or temporally. The frequency of observed encounters in the six habitat zones differed significantly from projections based on sample frequency in each zone. The number of encounters exceeded expectations in bar entrances, surf, and nearshore zones, and were less frequent than expected in the offshore zone (Table 5). Although observers recorded marine mammal encounters in all driftnet districts, more than 90 percent of sets (641 of 704) with observed mammal encounters occurred in the Copper River district (Table 8). The frequency of observed encounters in the four time periods differed significantly ($p<0.001$) from the sampled frequency (Table 6). More

encounters were observed between 0501-1100 than expected, and fewer than expected were observed between 2301-0500.

Species-specific differences in observed marine mammal encounter rates also occurred. Harbor seals (*Phoca vitulina*) were the most frequently encountered mammal throughout the fishery, approaching more than 7 percent of observed sets (Table 7). Harbor seals encountered nets more frequently than expected in all habitat zones except fiords and offshore areas (Table 5). Steller sea lions (*Eumatopias jubatus*) encountered more than 3 percent of observed sets (Table 7), and encountered nets more frequently than expected in the bar, surf, and nearshore sets (Table 5). Sea otters (*Enhydra lutris*) encountered 1.7 percent of observed sets (Table 7), and encountered nets more frequently than expected in channel and nearshore sets (Table 5).

Entanglements

Although marine mammals encountered 12 percent of observed sets, they entangled in less than 1 percent. Observers recorded 48 marine mammal entanglements - 22 (45.8%) were observed during driftnet retrievals and 26 (54.2%) were observed during soaks. Steller sea lions and sea otters were the most frequently entangled mammals, although each entangled in fewer than 0.4 percent of observed sets (Table 7).

Of the 22 marine mammal entanglements observed during net retrievals, 15 occurred in retrievals monitored by FV observers (n=2713) and 7 occurred in retrievals monitored by RV skippers (n=3162). The proportion of entanglements per observed retrieval reported by the two types of observers did not differ significantly ($0.10 < p < 0.20$). RV obs. saw less than ½ of entanglements than FV obs. even though RV obs saw more retrievals. !!!?

Based on the 22 mammal entanglements observed during driftnet retrievals, we estimate that 275 marine mammals (95% CI=33 to 819) were entangled in the 1991 PWS driftnet fishery (Table 9). This estimate more than doubles to 614 (95% CI=152 to 1418) if entanglements observed during driftnet soaks are also included (n=48) (Table 9).

Observers recorded both lethal and nonlethal entanglements. Entanglement was fatal to fewer than 15 percent of mammals entangled in PWS driftnets (Table 7), as the rest either broke free or were released by fishermen. Although live-release was more frequent than mortality for each species, a greater proportion of porpoises (43%) died as a result of entanglement than other species. None of the 13 sea otter entanglements observed resulted in serious injury or death (Table 7).

All but one of 48 observed entanglements (98%) occurred in the Copper River district, and most occurred near the barrier islands of the Copper River delta. Twenty-one entanglements (43.8%) occurred in nearshore sets, and 19 (39.6%) occurred in channel sets. Entanglements were too infrequent to test for statistical differences between observed and expected rates in districts and habitat zones. The frequency of entanglement (including mortality) occurring in the four six-hour time periods did not differ significantly from the expected frequency ($p>0.5$) (Table 6).

Mortality

Incidental marine mammal mortality occurred in fewer than 0.1 percent of observed sets. Seven marine mammals (four porpoises, two sea lions, and one harbor seal) died or were seriously injured in the 5875 observed sets (Table 7). All observed mortality occurred during net retrievals; none was observed during driftnet soaks. The proportion of mortalities per observed retrieval reported by RV skippers (one per 2713) and FV observers (six per 3162) did not differ significantly ($p > 0.05$).

Six of the seven mortalities (85.7%) were observed in the Copper River district (Table 8). The frequency of observed mortality was too rare to test for differences between the four six-hour periods, but their distribution appears to be seasonally biased. Five of the seven (71.4%) mammal mortalities were observed between 16 and 26 July (Table 10). Most fatal incidental mammal entanglements were singular events, however, the two harbor porpoises (*Phocoena phocoena*) that died in week 30 were entangled in the same driftnet set. Because all observed mortality occurred during net retrievals, the mortality rate per retrieval and the mortality rate per set (soak+retrieval) are identical.

Incidental mortality was rare in this fishery. Point estimates of incidental marine mammal mortality were derived weekly for each district based on the observed take rate (kills per set) and the estimated number of sets made by the fleet per district. Because few takes were observed these weekly estimates of mortality exhibit high variance and, consequently, are bounded by large confidence intervals. Summed weekly mortality estimates suggest 83 marine mammals (95% CI = 7 to 296) were incidentally injured or killed in PWS driftnets during the 1991 observer season (Table 9). The proportion of lethal marine mammal entanglements observed in 1990 (three per 3166 observed retrievals) did not differ significantly ($p>0.4$) from the proportion observed in 1991 (seven per 5875 observed retrievals). Porpoises (harbor and unidentified porpoise combined) comprised half of the estimated marine mammal mortality in this fishery between 16 May and 1 September 1991 (Table 10).

It was not possible to directly derive an observed marine mammal mortality rate per fishing vessel day because observers generally monitored FVs for periods of fewer than 24 hours. We estimate total fleet effort from 16 May through 31 August as 18,415 FVdays. An observed take rate of one per 20 FVdays would represent 921 marine mammal interactions. For incidental take in this fishery to be considered "frequent" using aggregate data, either the estimated take rate would exceed one per 20 FVdays or the estimated number taken would exceed 921 marine mammals.

Our point estimates of retrieval entanglement (275 mammals), retrieval+soak entanglements (614 mammals), and mortality (83 mammals) from observed retrievals do not exceed the standards above. Using these point estimates and the estimated 18,415 FVdays of fleet effort, ratios of take were approximated as one retrieval+soak entanglement per 30.0 FVdays, one retrieval entanglement per 66.8 FVdays, and one serious injury or death per 221.9 FVdays (Table 9).

Deterrence and Net Avoidance

Observers recorded the behavior of marine mammals as they approached driftnets to determine the animals' relative awareness of the net.

Reactions were recorded for 975 of the 1023 observed marine mammal encounters. All species were able to detect and avoid driftnet collision during most observed net approaches (Table 11A), as evidenced by an apparent change in the animal's course or behavior. The majority (76.2%) avoided entanglement in the gear without being actively harassed or deterred (Table 11A).

Fishermen actively harassed 178 of 834 (21.3%) pinnipeds that approached observed sets, primarily to prevent them from scavenging netted salmon (Table 11A). Fishermen harassed 5 percent of sea otters that approached observed nets, primarily to prevent entanglement and loss of fishing time required for their release. No harassment of cetaceans was observed.

The relative success of observed deterrence varied between techniques and mammal species (Table 11B). Although running the gear alone (RU) was the most common method of harassing marine mammals (48.7% of records), the most effective deterrent combined the use of seal bombs with running the gear (SR). This method proved effective on both harbor seals and sea lions and was the most effective technique observed (77.8% effective). Seal bombs alone (SB) were the second most commonly used (22.6% of records) and effective deterrent method (73.1% effective) observed (Table 11B).

MARINE BIRD INTERACTIONS

Encounters, Entanglement, and Mortality

Nearly 2000 marine birds, representing at least 19 species, were observed within 33 feet (10 m) of PWS driftnets (Table 12). Of these, 62 (3.2%) became entangled in the driftnets they encountered (Table 13). Although the majority (85.5%) of entangled marine birds died prior to removal, incidental mortality was observed in less than 1 percent of monitored sets in 1991 (Table 13).

Gulls and kittiwakes were the marine birds most commonly observed near driftnets (Table 12), but murres and murrelets were the species most frequently entangled and killed (Table 13). The team derived weekly point estimates of total and species-specific mortality in each district (Table 14). Summed weekly estimates suggest 993 marine birds (95% CI = 334 to 2097) were killed incidentally in PWS driftnets from 16 May to 31 August 1991. Point estimates of

species-specific mortality suggest more than 430 common murres and more than 260 marbled murrelets died incidentally in 1991 (Table 14).

The spatial distribution of marine bird mortality observed in 1991 differed significantly between districts ($p<0.05$) and habitat zones ($p<0.01$) (Table 15). Observed bird entanglement and mortality were more frequent in nearshore sets and less frequent in channel sets than expected based on sample frequency. Although bird entanglement and mortality were observed in only three of the five driftnet districts, their frequency differed from expected only in the Eshamy district, in which fewer than expected were observed (Table 15).

Some species exhibited spatial and temporal patterns of mortality (Table 14). Marbled murrelet mortality was observed throughout the summer in three districts, usually in nearshore sets. Common murre mortality, however, occurred only in May and June, only in the Copper River district, and only in nearshore (27%) and offshore (68%) sets.

OTHER INTERACTIONS

Marine mammal interactions with salmon driftnets may result in damage to the nets or to the netted salmon they contain. Of 91,122 salmon landed during monitored retrievals, 395 (0.43%) had apparently been damaged by scavenging pinnipeds. Harbor seals and Steller sea lions were the source of damage in 69 percent and 30 percent of sets where observers were able to identify the scavenger.

Cohos and sockeyes were the species most frequently damaged by marine mammals and represent 21 percent and 57 percent of the total fleet harvest (by number), respectively. Their observed damage rates (1.0% and 0.65%, respectively) suggest pinnipeds damaged 15,778 of 2,687,007 salmon landed by PWS driftnetters in 1991 (ADFG unpubl. rept.). Assuming each damaged salmon was unmarketable, the PWS driftnet fleet lost approximately $92,300 based on ex-vessel value of $5.85 per fish (ADFG unpubl. rept.) to scavenging pinnipeds in 1991. No method exists to count or estimate the number of salmon that were removed entirely from the nets without evidence.

Observers recorded the occurrence but not the extent of net damage attributed to marine mammals. Gear damage occurred during 28 (0.5%) of the observed net retrievals. Damage was attributed to sea lions in 21 of the 28 sets. No effort was made to quantify fishing time lost while deterring or releasing marine mammals from nets.

BEACHCAST CARCASS SURVEYS

The project team aerially surveyed the barrier island beaches of the Copper River delta 16 times between 15 May and 26 September 1991 to locate and identify beachcast marine mammal carcasses. No fresh carcasses were observed during the preseason survey conducted just prior to the season's first driftnet fishing period. The remaining surveys were flown weekly, usually between fishing periods. Team members landed whenever possible, and each carcass was examined to determine sex, approximate age, and apparent cause of death (Table 16).

Twenty-four carcasses representing five species were observed - eight harbor seals, seven Steller sea lions, four harbor porpoise, four sea otters, and one gray whale (Table 16). Males comprised the majority of each species examined. Although we saw pinniped carcasses intermittently through early July, all harbor porpoises were found prior to mid-June. We found sea otter carcasses as late as 26 September (Table 16).

Cause of death was difficult to ascertain for half of the carcasses (Table 17). Definite gunshot wounds were evident in three (37.5%) of the harbor seal carcasses, and another two (25%) bore suspected gunshot wounds. Although we found no evidence of definite gunshot wounds in any of the sea lion carcasses, two (40%) may have been shot though no bullets were recovered. All three harbor porpoises examined bore net marks around the flukes, flippers, or dorsal fin, indicating entanglement and probable drowning as their cause of death. Two of the four sea otters examined had fractured skulls. These injuries may have resulted from a human-induced blow to stun a severly tangled otter prior to their extraction from a driftnet (Wynne 1990).

Although located throughout the survey area, eight (33.3%) marine mammal carcasses including more than half of all pinniped carcasses were found

in the center of the Copper River district. Harbor porpoises were found throughout the area, but sea otter carcasses were found exclusively on western beaches.

IV. DISCUSSION

The Prince William Sound driftnet fishery involves a widely dispersed fleet of small vessels with unpredictable, dangerous, and highly variable fishing patterns. Designing and implementing a viable observer program for this fishery presents numerous operational and statistical challenges. The 1991 program incorporated changes inspired by experience gained in the 1990 program, but still faced considerable challenges which should be considered in assessing the results.

ESTIMATING FISHING EFFORT

Fishing effort in the PWS driftnet fishery varies weekly between districts. ADFG controls the fleet's fishing opportunity (available fishing hours) by opening fishing districts for designated lengths of time (fishing period or opening). Within these guidelines, however, actual effort varies considerably between individual fishermen. Fishermen spend different amounts of the available fishing hours in nonfishing activities such as travelling, delivering fish, and anchoring up to sleep or await changes in weather or tide. During this time their nets are not in the water actively fishing. The amount of available time spent in nonfishing activities varies between fishermen and depends on a variety of factors including fishing strategy and success, weather, length of opener, area fished, and economic alternatives.

Observer coverage represents a percentage of fishing effort and is defined here in terms of sets or observed net retrievals. The number of sets made per available fishing hour is a function of set duration and fishing downtime and varies seasonally and regionally throughout the fishery. The effort estimator S_h (sets per available hour) acknowledges these sources of variability, and allows direct application to ADFG landings data.

Because the number of sets made by the fleet is not recorded in this fishery, the team estimated fleet effort using ADFG fish ticket data. To estimate weekly fishing effort in each district the team multiplied the number of vessels landing salmon in each district by the maximum available fishing hours and observed mean sets per available hour in each district. In doing this we assumed fishermen landing fish in a district had fished 1) all available hours, and 2) only in one district. In reality, it is only possible to actively fish driftnet gear during

all available fishing hours in a short opener. Also, especially when fishing near district lines, driftnetters frequently land salmon in more than one district per day, and their effort is treated as fulltime in each district. Consequently, our estimate of fleet effort is unrealistically high and tends to overestimate take rates while underestimating observer coverage.

OBSERVER EFFORT

The 1991 observer program included two types of observers - FV observers who monitored nets aboard active fishing vessels or remotely, and RV skipper/observers who monitored nets remotely from research vessels. Several variables could affect the quality and quantity of data collected by these two types of observers including 1) visibility of gear, 2) individual observer bias, 3) sample independence, and 4) portion of the set monitored. Although it was not within the scope of this study to quantify these biases, the team recognized the possible sources of bias and their implications.

Darkness and distance affect visibility of monitored nets. During dark hours (generally 2300-0500 hours), only the observers onboard fishing vessels could safely and reliably monitor net retrievals. Because of the distance between an RV and the fishing net, remote observers could view the net's entire retrieval, but could not reliably collect data on salmon landings or damage. Similarly, remote observers may not have detected small birds entangled in nets. It is highly unlikely, however, that the remote observers would have missed entangled marine mammals during net retrievals.

Individual observer bias is a potential problem in any observer program. To uncover possible bias and to ensure data accuracy both fishing vessel and research vessel observers were debriefed and their data checked weekly by field coordinators. Because RV skippers were responsible for the safe operation of their vessel as well as the collection of observer data, it is likely that navigational and safety concerns affected RV observer effectiveness to varying degrees. Operational concerns expressed by RV observers included maintenance of safe and proper distance from nets, assessment of vessel limitations under dynamic environmental conditions, and safe transfer and transport of FV observers.

Though it may have been possible to conduct blind paired tests where RV and FV observers simultaneously and unknowingly monitor the same set, the effort would have been expensive and labor intensive, and the team deemed it impractical in a fishery where take is so infrequently observed. In the data analysis, the team looked for differences in data collection by FV and RV observers, but found no significant differences in the proportion of entanglement and mortalities reported during driftnet retrievals.

Most RVs observed only one or two retrievals of the same driftnet before moving to a different area, whereas FV observers monitored repeated sets of the same driftnet from boarded vessels. Although we assume each retrieval to be an independent event, it is possible that FV observers "reencountered" mammals in closely spaced consecutive sets. We believe that RV coverage probably enhanced the sample independence by increasing observer mobility and coverage of different vessels.

Observers on both platforms monitored retrievals, the period during which lethal entanglements are generally observed. Because the retrieval is typically the shortest part of a driftnet set cycle (deployment, soak, retrieval), RVs effectively increased sample size by reducing time spent monitoring soak periods. FV observers generally observed more driftnet soak time than RVs, and were thus more likely to observe nonlethal marine mammal and bird encounters. Only observers onboard FVs were able to monitor night sets and individual fishing effort.

Safety

The PWS driftnet fishery is notoriously dangerous due to the small vessels, extensive breakers, rough weather, and seas. Two vessels boarded by observers in 1990 capsized by season's end, resulting in the death of one captain and near death of the other. As a safety policy Saltwater Inc. did not deploy observers in this fishery when weather reports indicated small craft advisories (winds greater than 25 mph) with a deteriorating forecast. In 1990 this deployment limitation resulted in the loss of approximately 30 percent of potential observer days (Wynne et al. 1991). Because most observers boarded FVs in town prior to the fishing period in 1990, the decision to deploy observers was based on relatively long-range, often inaccurate, weather forecasts.

In 1991 most FV observers left town on research vessels and were deployed while on the fishing grounds. This allowed flexibility and assured that deployment decisions were based on real, site-specific environmental conditions rather than forecasts. Observers could 1) assess local conditions and wait in a sheltered area for a break in the weather, 2) make remote observations from RVs if weather improved, but still precluded at-sea transfers, or 3) transfer onto FVs from the RV if the weather improved and transfers were safe. Likewise, if the weather deteriorated without warning, RVs were able to safely remove observers from FVs and seek the shelter of a temporary anchorage or return to port. The use of RVs as remote observer platforms allowed limited observer coverage to continue even in winds exceeding 25 mph, accounting for 0.5 percent of retrievals and 0.3 percent hours observed in 1991.

Many of the smaller vessels in the PWS driftnet fleet have only one bunk and approximately nine square meters of living space. Safety, lack of space, and insurance were significant fleet concerns in both 1990 and 1991. Research vessels on the grounds allowed Saltwater Inc. to control the duration of observer boardings. The ability to retrieve observers from FVs for safety and convenience lessened the fleet's concerns regarding carrying observers. Ultimately, the use of dedicated RVs improved program success by increasing fleet support and cooperation.

Sample Distribution

In 1990 the PWS observer program depended on active fishing vessels and processing tender vessels for observer coverage and transportation. The resulting sample size, composition, and distribution was limited by the opportunistic use of these vessels. In addition to introducing sample biases, this dependence resulted in the loss of approximately 15 percent of potential observer days in 1990 while observers were stranded on tenders or fishing vessels seeking a ride (Wynne et al. 1991). In 1991 the use of dedicated research vessels as observer platforms and transport vessels increased observer mobility and the resulting sample size, independence, and randomness. The widely dispersed RVs provided a critical means of assessing changes in fleet distribution and redistributing observer effort accordingly.

Use of RVs as remote observer platforms also improved the equitability of deployment and representative sampling throughout the fleet. Although many driftnet vessels can accommodate an observer for long periods (some overnight), many others have only one bunk and very limited living space. Vessels of this size are not required by law to carry an observer, but their fishing activities can still be monitored remotely by RV observers. In 1991 observers monitored the fishing activities of nearly 90 percent of vessels in the fleet, including many that were not monitored in 1990 because they were unsafe, unable, or unwilling to carry an observer under some circumstances.

Observer dependence on cooperative driftnetters for boardings biased the 1990 sample toward cooperative vessels, and overburdened these FVs with observer coverage. By combining remote and onboard observations in 1991, fishing operations of cooperative and uncooperative FVs alike were monitored. Observer coordinators maintained updated vessel tracking files that tended to reduce the "randomness" of vessel selection, and more equitably distributed coverage. More than 93 percent of driftnet vessels boarded by observers in 1991 were boarded fewer than three times.

Despite these sampling improvements, certain unavoidable sampling limitations remain in this fishery. Fleet effort is dynamic and unpredictable, making truly random sampling impossible. In addition, the inability of many vessels to accommodate an overnight observer, and the fact that night soaks are generally longer than daylight soaks limited observation of night sets (23:00-05:00).

MARINE MAMMAL INTERACTIONS

Marine mammals are common in the PWS driftnet area. Observers documented both sea lions and harbor seals scavenging netted salmon from driftnets, while cetaceans and sea otters inadvertently encountered nets while in fishing areas. Pinnipeds damaged an estimated 0.4 percent of the salmon harvested by the fleet in 1991. Despite their presence near driftnets, marine mammals entangled in fewer than 1 percent and died in fewer than 0.1 percent of sets observed in 1991. Only 15 percent of entanglements were fatal. Marine

mammals were able to avoid entanglement in most driftnets without being actively deterred.

Marine mammal entanglement and mortality were not uniformly distributed throughout the fishery. The vast majority of marine mammal entanglement and mortality occurred in nets set in the Copper River district. Consequently, future monitoring and management of mammal conflicts in this fishery would most effectively focus on this district rather than the entire fishing area. In addition, realistic extrapolation of fisherywide take estimates must consider regional and seasonal differences in take rates. The team acknowledged these patterns in our assessment of take by deriving weekly take rates and estimates for each PWS district. Similar spatial and temporal patterns were reported in previous studies of marine mammal interactions with this fishery (Matkin and Fay 1980; Wynne 1990).

The estimation and definition of incidental take is not standardized in U.S. observer programs due in part to fishery-specific differences in fishing operations and mammal interactions. Congress interpreted incidental take to mean "the entanglement, serious injury, or death of a marine mammal in the course of normal fishing operations": (U.S. Senate Rept. 100-592, 1988). Observers in PWS recorded momentary entanglements and the team derived an estimate of take observed during soak and retrieval, but we assume entanglement to be inconsequential for animals that free themselves prior to the net's retrieval.

We believe a more appropriate assessment of serious entanglements involves those animals which remain in the net through its retrieval. Because observers in most other fisheries monitor only net haulbacks, calculation of incidental take rates per haulback (retrieval) also provides a more equitable basis for comparison of take estimates between Category I fisheries nationwide.

The low frequency and high variance associated with marine mammal mortality in this fishery results in a wide confidence range for entanglement and mortality estimates. We estimated that 276 marine mammals (95% CI = 33 to 819) entangled in PWS driftnets in 1991, of which 83 (95% CI = 7 to 296) were seriously injured or killed. Although the rate of kills per set are comparable in 1990 and 1991, the mortality estimates are not comparable between the two years. In 1990 observer coverage was abbreviated and missed May and June

when many Steller sea lion interactions occur. Only mortality estimates were derived in 1990, and they assumed a normal rather than a negative binomial distribution.

From aggregate data it is not possible to determine the probability that a marine mammal would be taken by one randomly selected vessel during 20 days of fishing. Instead, the team used point estimates of entanglement and mortality derived from observed retrievals, and compared them to estimated fleet effort to approximate the ratios of entanglement (1: 66.8 FVdays) and mortality (1: 221.9 FVdays) in this fishery. This analysis suggests that the occurrence of incidental marine mammal entanglement and mortality in the Prince William Sound salmon driftnet fishery was less than "frequent" (1:20 FVdays) in 1991. Observer reports similarly indicated the occurrence of entanglement, injury, or death was less than frequent in this fishery in 1990 (Wynne et al. 1991).

We did not estimate take rates based on observed interactions per salmon landed because remote observers were unable to effectively count salmon in nets monitored from a distance. Although few observer program summaries are available for comparison, the observed rates and estimates of incidental mortality in the PWS driftnet fishery are far lower than preliminary estimates reported in other Category I coastal gillnet fisheries (Perkins and Barlow, 1991).

MARINE BIRD INTERACTIONS

Marine birds encountered more than 10 percent, but entangled in fewer than 1 percent of driftnet sets observed in 1991. Although the overall frequency and rate of bird entanglement is fairly low, most entangled birds drowned. In both 1990 and 1991 lethal marine bird entanglement was observed in fewer than 1 percent of monitored retrievals, which is noticeably higher than previously reported. Wynne (1990) observed no bird entanglements during 387 net observations on the Copper River delta in 1988 and 1989. This may substantiate informal reports from fishermen that the local abundance of murrelets in the Copper River district in 1990 and 1991 is a recent and unusual phenomenon.

Although entanglement was observed in fewer than 1 percent of observed sets, species-specific estimates indicate that incidental mortality in PWS driftnets may be substantial for some species, particularly common murres and marbled

murrelets. We estimate that 432 common murres died in this fishery, primarily in the Copper River district early in the season (May-June). Approximately 263 marbled murrelets were taken throughout the season and region in 1991.

As with marine mammals, the frequency and distribution of marine bird entanglement and mortality in this fishery are not uniform. Therefore, incidental take extrapolations and future management considerations should consider the species-specific spatial and temporal patterns of bird interactions with this fishery.

BEACHCAST CARCASS SURVEYS

Surveys for beachcast carcasses can provide a valuable supplement to observer data. These standardized, systematic surveys allow monitoring of unobserved intentional and incidental take and can be used as an index to monitor mortality trends between years. The total number of beachcast marine mammal carcasses found during these surveys has decreased from 100 in 1988 to 24 in 1991. Although annual differences in mammal and prey distribution may affect local carcass abundance, fishing-related mortality has undoubtedly been affected by changes in fleet attitudes toward marine mammals. Historically, mammal mortality in this fishery has been primarily intentional rather than incidental (Matkin and Fay 1980; Wynne 1991). Recent environmental and political concerns raised by Steller sea lion declines has substantially reduced the use of lethal deterrents by the fleet. The result has been the increased use of nonlethal deterrents (seal bombs and running gear) and reduced overall marine mammal mortality in the area.

Unfortunately, a number of variables and uncertainties preclude the use of these surveys to derive absolute estimates of fishery-related mortality (Wynne 1990). The cause of death is often indeterminable, and the effects of carcass deposition and loss rates have not been quantified. Despite these limitations, carcass surveys provide valuable information on unobserved take and identify trends in mortality between years.

V. CONCLUSIONS/ RECOMMENDATIONS

1. Marine mammal encounters with the Prince William Sound salmon driftnets are fairly frequent (12% of observed sets), but rarely fatal (0.1% of observed sets).

2. Observers recorded 48 marine mammal entanglements. Most entangled marine mammals (85%) released themselves unharmed or were released with fishermen's assistance.

3. Marine mammal mortality occurred in fewer than 0.1 percent of observed sets. Observers recorded seven marine mammal deaths or serious injuries in 5875 net retrievals (four porpoises, two sea lions, and one harbor seal).

4. Because of the low take rates, extrapolation of the observer data is statistically difficult and results in wide confidence intervals. We estimate that 276 marine mammals (95%CI=33 to 819) became entangled in this fishery between 16 May and 1 September 1991. Of those we estimate 83 (95%CI=7 to 296) were seriously injured or killed. Although the estimates of take are not directly comparable, the 1991 mortality rate is comparable to the mortality rate observed during the abbreviated 1990 observer season.

5. The observer data suggests that incidental marine mammal take in the PWS driftnet fishery is not "frequent" by NMFS standards.

6. Observers recorded 53 marine bird deaths during 5875 observed retrievals. As with the mammal data, marine bird take rates were low and extrapolation of the data results in wide confidence intervals. We estimate that 993 birds (95%CI =334 to 2097) including 430 common murres and more than 260 marbled murrelets died incidentally in this fishery between 16 May and 1 September 1991.

7. Marine mammal and bird entanglement and mortality exhibit spatial and temporal patterns of frequency, precluding blanket extrapolation of fisherywide take estimates. The vast majority of marine bird and mammal mortality was observed in the Copper River district.

8. The use of dedicated research vessels in 1991 improved observer sampling efficiency and safety, and reduced several sample biases encountered during the 1990 observer effort.

9. Weekly surveys for beachcast marine mammal carcasses provide a means of monitoring local and annual trends in mammal mortality on the Copper River delta. The number of carcasses found has declined substantially from 100 in 1988 to 24 in 1991.

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The most critical element in accurate data collection is the source. Our team of skilled, experienced, and dedicated skippers and observers worked hard to collect data under difficult and ever-changing conditions. Their pride and professionalism inspired cooperation by the fleet. Our thanks to:
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Thanks to Brad Hanson of NMFS Juneau for taking more than the requisite administrative interest in the program. His personal involvement helped further mutual understanding and cooperation between NMFS, the fleet, and the observer program. We greatly appreciate his assistance in portions of our analyses.

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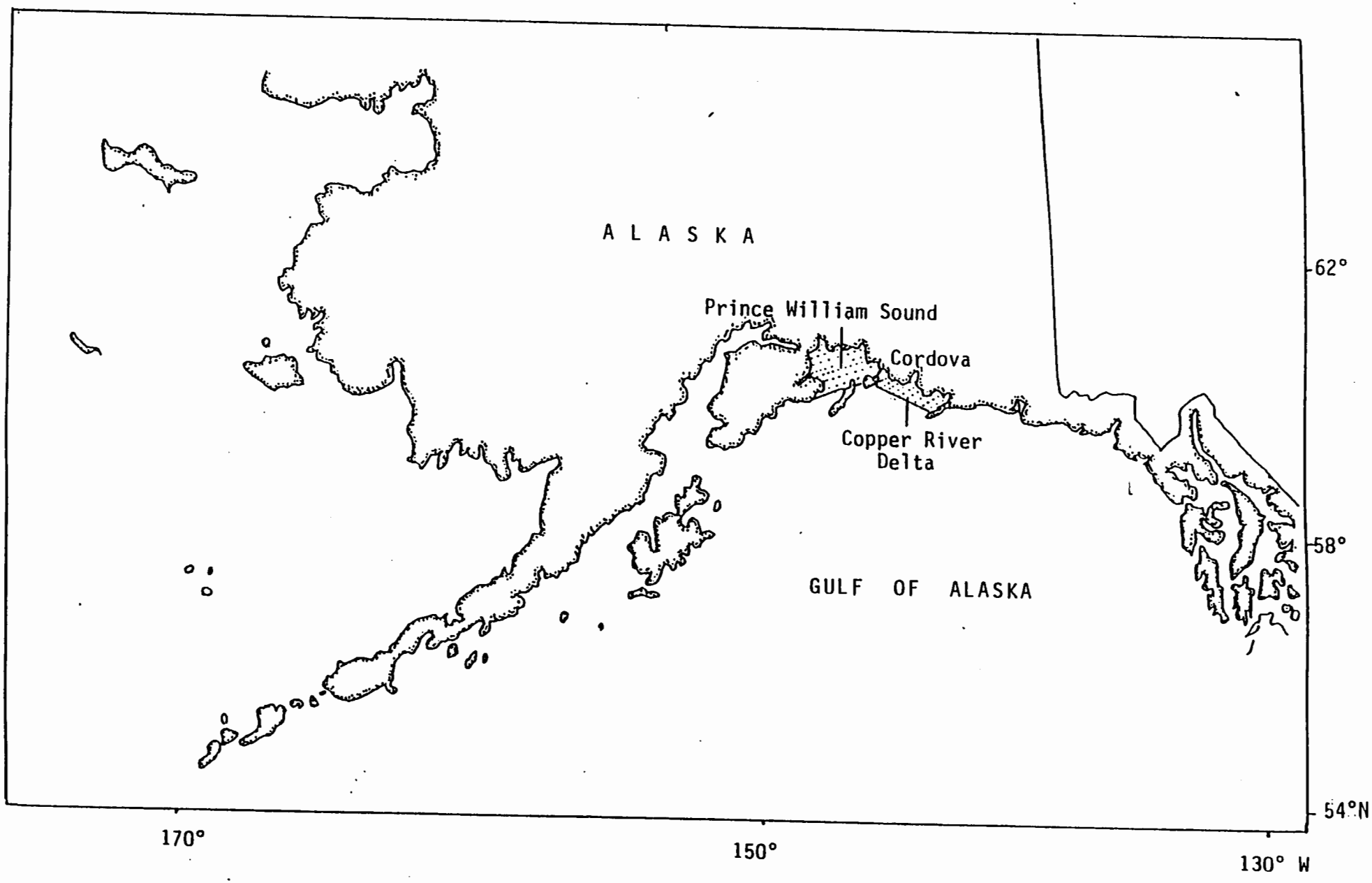

Figure 1. Approximate location of the Prince William Sound salmon drift gillnet fishery monitored by MMPA observers in 1991.

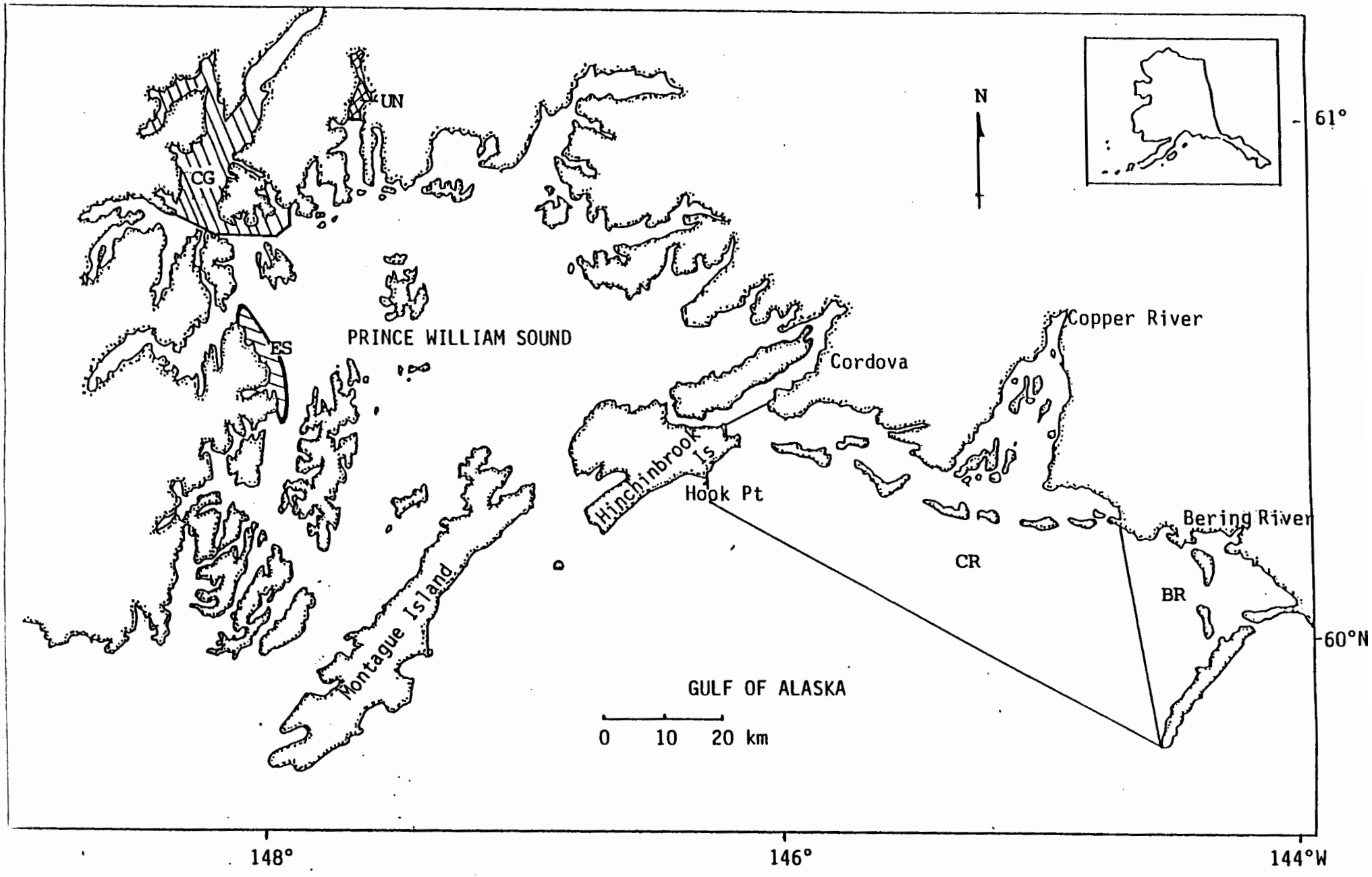

Figure 2. Relative location of the Bering River (BR), Copper RIver (CR), Coghill (CG), Unakwik (UN), and Eshamy districts open to PWS drift gillnet fishing in 1991.

Table 1. Summary of driftnet fishing effort in PWS statistical districts during period of 1991 observer coverage.

PWS DRIFTNET DISTRICTS

Week	Total FVs	BR			CR			CG			ES			UN			Total FVdays
		avail hrs	max # FVs	max FVdays	avail hrs	max # FVs	max FVdays	avail hrs	max # FVs	max FVdays	avail hrs	max # FVs	max FVdays	avail hrs	max # FVs	max FVdays	
May 12 - 18	446				24	446	446										
19 - 25	493				48	480/476	956										
26 - 01	489				24	341/480	821										
Jun 02 - 08	503				48	496/491	987										
09 - 15	501				36	427/367	794	24	82	82	160	61/56	402				
16 - 22	491	48	26/22	48	48	300/310	610				168	99/42	735	48	4/8	12	
23 - 29	493	48	13/6	19	48	256/230	486				168	190/89	1419	48	8/5	13	
Jul 30 - 06	456	60	6/4	13	60	233/235	585				168	163/128	1269	48	0/4	4	
07 - 13	437	48	4/4	10	72	228/204	648				168	186/167	1469	48	6/4	10	
14 - 20	407				84	230/234	813				168	142/190	1184				
21 - 27	327				84	149/169	562	24	97	97	168	73/185	696				
28 - 03	141				84	109/42	248				168	21/154	301				
Aug 04 - 10	193				84	103/71	297	36	57/56	113	168	24/128	296				
11 - 17	74							88	52/9/42	173	144	36/89	305				
18 - 24	313				48	271	542	168	53	371							
25 - 31	83							168	83	581							
		204		90	792		8793	508		1417	1648		8076	192		39	18415

PWS districts: BR = Bering River, CR = Copper River, CG = Coghill, ES = Eshamy, UN = Unakwik

FV = total number of different driftnet permitholders fishing that week, all districts combined

Avail hrs = total available fishing hrs allowed by ADFG

Max #FVs = max number of vessels that fished (n/n indicates more than one period that week)

Max FVdays = weekly sum of max FVs x the available days in each opener, where a day = 1-24 hrs

Table 2. Weekly summary of fishing intensity (%T) and mean sets made per available fishing hour (s/h) derived from observations aboard fishing vessels and used to estimate the number of sets made in three districts of the PWS driftnet fishery, 1991.

		PWS DRIFTNET DISTRICTS								
		CR			CG			ES		
Wk	Date	n	%T	s/h	n	%T	s/h	n	%T	s/h
20	May 12 - 18	20	67.4	0.50						
21	19 - 25	30	86.2	0.56						
22	26 - 01	12	84.5	0.66						
23	Jun 02 - 08	24	85.1	0.51						
24	09 - 15	20	83.6	0.53	8	93.6	0.53	7	89.9	0.42
25	16 - 22	9	77.5	0.49				16	83.3	0.54
26	23 - 29	16	79.8	0.60				10	82.6	0.53
27	Jul 30 - 06	20	79.4	0.50				8	88.2	0.47
28	07 - 13	27	74.5	0.49				15	65.4	0.37
29	14 - 20	22	70.6	0.34				10	66.8	0.47
30	21 - 27	25	47.5	0.34	4	74.1	0.39	1	37.3	0.41
31	28 - 03	9	51.4	0.29						
32	Aug 04 - 10	15	36.2	0.22	11	87.3	0.45			
33	11 - 17				13	87.1	0.48	2	34.5	0.17
34	18 - 24	16	61.2	0.45	4	44.9	0.24			
35	25 - 31				4	37.3	0.21			

PWS districts: CR = Copper River, CG = Coghill, ES = Eshamy
n = sample of FV observations used to estimate %T and s/h
%T = percent of maximum available hours fishermen actively fished their gear
s/h = mean sets made per available hour of fishing

Table 3. Comparison of weekly observer effort and estimated fishing effort (sets) in PWS driftnet districts, 1991.

		PWS DRIFTNET DISTRICTS												
		BR		CR		CG		ES		UN		TOTAL COVERAGE		
Wk	Date	obs	FVsets	obs	FVsets	obs	FVsets	obs	FVsets	obs	FVsets	obs	FVsets	%
20	May 12 - 18			270	4298							270	4298	6.3
21	19 - 25			426	9574							426	9574	4.4
22	26 - 01			185	6502							185	6502	2.8
23	Jun 02 - 08			407	9154							407	9154	4.4
24	09 - 15			300	5639	73	1030	118	2434			491	9103	5.4
25	16 - 22	36	899	175	5084			336	5365	13	138	560	11486	4.9
26	23 - 29	0	274	308	4949			244	11473	0	165	552	16861	3.3
27	Jul 30 - 06	4	27	419	5225			151	7546	9	45	583	12843	4.5
28	07 - 13	0	*	444	5450			184	7362	0	89	628	12901	4.9
29	14 - 20			355	4162			158	4546	6	*	519	8708	6.0
30	21 - 27			245	2549	47	695	37	1614			329	4858	6.8
31	28 - 03			168	930			50	418			218	1348	16.2
32	Aug 04 - 10			193	780	76	824	28	389			297	1993	14.9
33	11 - 17					85	1008	6	228			91	1236	7.4
34	18 - 24			268	3537	28	876	2				298	4413	6.8
35	25 - 31					21	1396					21	1396	1.5
		40	1200	4163	67833	330	5829	1314	41375	28	437	5875	116674	
		6.1%				3.5%						5.04%		

PWS Districts: BR = Bering River, CR = Copper River, CG = Coghill, ES = Eshamy, UN = Unakwik

Wk = calendar week and ADFG statistical week

Obs = observer effort (# complete retrievals observed)

FVsets = estimated fishing effort (# sets)

* = indicates district with < 3 fishermen present; no ADFG data released

Table 4. Weekly summary of vessels, hours, and sets monitored by observers onboard fishing vessels and from remote platforms.

OBSERVER EFFORT

		ONBOARD			REMOTE			TOTAL		
Wk	Date	#FV	#Hr	#Sets	#FV	#Hr	#Sets	#FV	#Hr	#Sets
20	May 12 - 18	20	194.6	149	115	47.5	121	135	242.1	270
21	19 - 25	30	358.1	226	190	44.4	200	220	402.5	426
22	26 - 01	12	108.4	84	107	57.3	101	119	165.7	185
23	Jun 02 - 08	24	356.3	217	189	83.1	190	213	439.4	407
24	09 - 15	35	369.0	242	244	141.9	249	279	510.9	491
25	16 - 22	28	218.5	159	362	265.1	401	390	483.6	560
26	23 - 29	28	302.8	229	325	211.0	323	351	513.8	552
27	Jul 30 - 06	28	420.8	269	292	109.7	314	320	530.5	583
28	07 - 13	42	425.2	295	337	174.2	333	379	599.4	628
29	14 - 20	32	322.7	182	289	162.4	337	321	485.1	519
30	21 - 27	30	189.4	146	181	150.6	183	211	340.0	329
31	28 - 03	9	98.8	60	135	91.3	158	144	190.1	218
32	Aug 04 - 10	26	185.8	120	165	174.9	177	191	360.7	297
33	11 - 17	15	73.4	49	48	70.9	42	63	144.3	91
34	18 - 24	20	174.1	130	155	139.8	168	175	313.9	298
35	25 - 31	4	8.1	8	13	17.0	13	17	25.1	21
		383	3806	2565	3147	1941.1	3310	3528	5747.1	5875

FV = number of fishing vessels monitored by observers for 1+ retrievals

Hr = number of hours of actual fishing operations monitored by observers

Sets = number of complete retrievals monitored by observers

Onboard = monitored by observer onboard owner's FV, Remote = net monitored remotely from RV, land, or adjacent fishing vessel by an FV observer or RV skipper.

Table 5. Distribution of observer effort and comparison of the observed and expected frequency of marine mammal encounters in six habitat zones described within PWS driftnet districts, 1991.

MARINE MAMMAL ENCOUNTERS BY HABITAT ZONE

		Channel		Bar		Surf		Nearshore		Offshore		Fiord		
% obs retrievals :		26.3%		2.9%		1.9%		29.9%		33.1%		6.0%		
	N	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	Chi-square (d.f.=5) Signif ?
Species														
SL	266	48	70.0	22	7.7	20	5.0	129	79.5	41	88.0	6	16.0	138 (p<0.001)
HS	576	260	151.5	43	16.7	28	10.9	233	172.2	10	190.7	2	34.6	369 (p<0.001)
SO	133	42	35.0	6	3.9	6	2.5	52	39.8	19	44.0	8	8.0	26 (p<0.001)
HP	21	0	5.5	1	0.6	0	0.4	6	6.3	14	7.0	0	1.3	
Grouped														
Pinnipeds	859	312	225.9	67	16.3	48	16.3	371	256.8	53	284.3	8	51.5	441 (p<0.001)
Cetaceans	29	1	7.6	1	0.8	0	0.6	6	8.7	20	9.6	1	1.7	
All mammals	1023	356	269	74	29.7	54	19.4	429	305.9	93	338.6	17	61.4	416 (p<0.001)

% obs retrievals = percentage of 5875 observed complete retrievals that occured within each habitat zone

Species: SL = Steller sea lion, HS = harbor seal, SO = sea otter, HP = harbor porpoise (n=21); Pinnipeds = SL, HS, and unidentified pinnipeds (n =17); Cetaceans: includes harbor porpoise, Dall's porpoise (n = 3), humpback whale (n = 3), unidentified porpoise (n =1), and unidentified whale (n = 1)

Obs = number of interactions observed, exp = expected number of interactions, based on proportion of sampling effort in each time period

Table 6. Distribution of observer effort and comparison of the observed and expected frequency of marine mammal encounters and entanglement (including mortality) in four time periods sampled in the PWS driftnet fishery, 1991.

MARINE MAMMAL INTERACTIONS BY TIME PERIOD

		23:01-05:00		05:01-11:00		11:01-17:00		17:01-23:00			
% obs retrievals:		4.65%		28.53%		38.60%		28.22%			
	N	obs	exp	obs	exp	obs	exp	obs	exp	Chi-sq	Significant ? (d.f.=3)
Encounters	1023	16	47.6	341	291.9	365	394.9	291	288.7	31.5	Yes ($p<0.001$)
Entanglement (including mortality)	48	1	2.2	14	13.7	15	18.5	17	13.5	2.2	No ($p>0.5$)

% obs retrievals = percentage of 5875 observed complete retrievals that occured within each time period

Obs = number of interactions observed, exp = expected number of interactions, based on proportion of sampling effort in each time period

Exp = expected number of interactions, based on proportion of sampling effort in each time period

Table 7. Species-specific outcome of net encounters and entanglement of marine mammals during complete net retrievals observed (N = 5875) in the PWS driftnet fishery, 1991. (n = number of mammals, s = number of sets involved)

MARINE MAMMAL INTERACTION

		Encounters			Entanglements			Incidental Death		
Species	Code	n	s	% sets	n	s	% sets	n	s	% sets
Harbor seal	6	576	448	7.63	5	5	0.09	1	1	0.02
Steller sea lion	2	266	182	3.10	21	19	0.32	2	2	0.03
Sea otter	13	133	99	1.69	13	12	0.20	0	0	0
Harbor porpoise	15	21	15	0.26	7	6	0.10	3	2	0.03
Unid. pinniped	98	17	17	0.29	1	1	0.02	0	0	0
Unid. porpoise	27	1	1	0.02	1	1	0.02	1	1	0.02
Dall's porpoise	14	3	1	0.05		0				
Unid. sea lion	4	3	3	0.05		0				
Unid. whale	33	1	1	0.02		0				
Unid. marine mammal	99	2	2	0.03		0				
In N = 5875 observed retrievals:		1023			48	44	0.75 %	7	6	0.10 %

Encounters = mammal observed within 10m of active driftnet, includes entanglements

Entanglement = mammal contacted net during soak or retrieval, was released with or without assistance, includes incidental injury and death

Incidental death = serious injury or death resulting from entanglement

% sets = per cent of observed retrievals (N = 5875) involved in each interaction

Table 8. Distribution and relative frequency of marine mammal and marine bird interactions within five districts open to PWS driftnet fishing, 1991.

MARINE MAMMAL AND BIRD INTERACTIONS BY DISTRICT

	BR		CR		CG		ES		UN	
Number observed sets: (N = 5875)	40		4163		330		1314		28	
	n	[%obs sets]	n	[%obs sets]	n	[%obs sets]	n	[%obs sets]	n	[%obs sets]
SETS WITH ENCOUNTERS										
Marine mammals	4	[10.0]	641	[15.4]	9	[2.7]	44	[3.4]	6	[21.4]
Marine birds	1	[2.5]	432	[10.4]	23	[7.0]	138	[10.5]	1	[3.6]
SETS WITH ENTANGLEMENTS										
Marine mammals	0	[0.0]	43	[1.0]	1	[0.3]	0	[0.0]	0	[0.0]
Marine birds	0	[0.0]	53	[1.3]	1	[0.3]	3	0.2	0	[0.0]
SETS WITH MORTALITY										
Marine mammals	0	[0.0]	6	[0.1]	1	[0.3]	0	[0.0]	0	[0.0]
Marine birds	0	[0.0]	44	[1.1]	1	[0.3]	3	[0.2]	0	[0.0]

PWS driftnet districts: BR = Bering River, CR = Copper River, CG = Coghill, ES = Eshamy, UN = Unakwik

n = number of sets with observed interaction; %obs sets = fraction of observed sets in which interaction occured

Table 9. Incidental take estimates extrapolated from 1991 observer data using different definitions of "take."

		ESTIMATED TAKE		
Definition of take	n	Extrapolated estimate	95% C.I.	Approximate take : FVday
Entanglement (including mortality)				
observed in retrievals only	22	275.4	33-819	1 : 66.8
observed in soaks and retrievals	48	614.4	152-1418	1 : 30.0
Mortality				
all were observed in retrievals	7	83.0	7-296	1 : 221.9

Approximate take rate based on estimated fleet effort of 18,415 FVdays

Table 10. Weekly summary of observed and extrapolated incidental marine mammal take estimated from monitored nets in PWS driftnets, 15 May - 31 August 1991.

MARINE MAMMAL TAKE BY DISTRICT AND WEEK

	Copper River									Coghill		
	Entanglements						Mortality			Entanglement/death		
	Rets Only			Soak+ Ret								
Week	n	est	(95%CI)	n	est	(95%CI)	n sps	est	(95%CI)	n sps	est	(95%CI)
May 12 - 18	2	29.8	(2-85)	3	44.8	(7-110)	1 SL	14.9	(1-56)			
19 - 25	1	21.4	(1-81)	5	107.4	(32-223)						
26 - 01	1	34.2	(1-127)	1	34.2	(1-127)						
Jun 02 - 08	0			2	44	(3-122)						
09 - 15	0			0								
16 - 22	0			0								
23 - 29	3	45.2	(7-111)	6	90.4	(30-179)						
Jul 30 - 06	4	45.9	(10-103)	7	80.3	(29-153)	1 HS	11.5	(1-44)			
07 - 13	1	11.3	(1-43)	2	22.6	(2-65)						
14 - 20	3	32.2	(4-80)	6	64.3	(21-128)	1 HP	10.7	(1-41)			
							1 UP	10.7	(1-41)			
21 - 27	2	18.8	(2-54)	4	37.6	(8-85)	2 HP	21.4	(2-62)	1 SL	13.8	(1-52)
Aug 28 - 03	1	4.5	(1-18)	3	13.6	(3-35)						
04 - 10	2	6.1	(2-19)	4	12.2	(4-29)						
11 - 17	0			0								
18 - 24	1	12.2	(1-46)	4	49.2	(11-110)						
25 - 31	0			0								
	21	261.6	(32-767)	47	600.6	(151-1366)	7	69.2	(6-244)	1	13.8	(1-52)

Rets only: n = number observed in retrievals only, includes mortality

Est = point estimate of take. 95% C.I. = confidence interval

Soak+Ret: n = number observed during net soak and retrieval, includes mortality

Sps: SL = Steller sea lion, HS = harbor seal, HP = harbor porpoise, UP = unid. porpoise; all mortalities were observed during retrieval

Coghill: the only observed entanglement was lethal

Table 11. Summary of marine mammal net avoidance (A) and use and effectiveness of deterrents (B) observed in PWS driftnets, 1991.

A. MARINE MAMMALS ENCOUNTERED BUT NOT ENTANGLED

	Missed		Avoided		Harassed		Total
Species	n	% N	n	% N	n	% N	N
SL	15	6.1	145	59.2	85	34.7	245
HS	11	1.9	471	82.5	89	15.6	571
UPin	1	5.6	13	72.2	4	22.2	18
SO	20	16.7	94	78.3	6	5.0	120
HP	1	7.1	13	92.9	0		14
DP	0		3	100.0	0		3
UPor	0		0		0		0
HB	0		3	100.0	0		3
UW	0		1	100.0	0		1
	48	4.9	743	76.2	184	18.9	975

B. HARASSMENT TECHNIQUES AND RELATIVE EFFECTIVENESS

	GU			SB			RU			GS			GR			SR			OO			TOTAL		
Species	n	eff	%eff	n	eff	%eff	n	eff	%eff	n	eff	%eff	n	eff	%eff	n	eff	%eff	n	eff	%eff	n	eff	% eff
SL	0	0		29	25	86	39	28	72	0	0		2	1	50	17	14	82	2	1	50	89	69	78
HS	16	6	38	22	12	55	64	26	41	7	2	29	4	1	25	9	7	78	5	3	60	127	57	45
UPin	1	1	100	0	0		4	3	75	0	0		0	0		0	0		0	0		5	4	80
SO	1	0	0	1	1	100	5	3	60	0	0		0	0		1	0	0	1	1	100	9	5	56
	18	7	39	52	38	73	112	60	54	7	2	29	6	2	33	27	21	78	8	5	63	230	135	59

Species: SL = Steller se lion, HS = harbor seal, UPin = unidentified pinniped, SO = sea otter, HP = harbor porpoise, DP = Dall'sporpoise, UPor = unidentified porpoise, HB humpback whale, UW= unidentified whale

Harassment techniques: GU = gunshots, SB = seal bombs, RU = running gear, GS = gunshots and seal bombs, GR = gunshots and running gear, SR = sealbombs and running gear, OO = other

n in Table 11B = number of times technique was used; eff = number of times technique was effective; %eff = % of use effective

Table 12. Number and species of marine birds observed within 10m of active PWS salmon driftnets, 15 May - 31 August 1991.

Species	Code	NET ENCOUNTERS n	s
Unid. bird	400	24	10
Unid. loon	405	1	1
Common loon	407	1	1
Red-throated loon	409	4	3
Northern fulmar	431	2	2
Unid shearwater	450	1	1
Sooty shearwater	456	2	2
Unid. dark shearwater	458	1	1
Unid. storm-petrel	470	17	10
Fork-tailed storm-petrel	475	24	17
Unid. cormorant	508	2	2
Unid. phalarope	520	144	32
Red phalarope	521	17	5
Northern phalarope	522	14	2
Unid. jaeger	524	6	4
Parasitic jaeger	527	1	1
Unid. gull	530	746	255
Common (Mew) gull	533	15	9
Herring gull	534	39	6
Glaucous-winged gull	539	135	48
Black-legged kittiwake	545	402	120
Unid. tern	555	29	8
Arctic tern	558	30	10
Unid. alcid	570	54	25
Unid. murre	571	11	9
Thick-billed murre	572	3	3
Common murre	573	80	33
Unid. guillemot	574	1	1
Pigeon guillemot	576	1	1
Unid. murrelet	578	111	50
Marbled murrelet	579	27	21
Kittlitz's murrelet	580	10	9
		1955	702
		(595 different sets)	

n = number of birds involved
s = number of sets involved with bird encounters

Table 13. Species-specific outcome of net encounters and entanglement of marine birds during 5875 complete net retrievals observed in the PWS salmon driftnet fishery, 1991.

MARINE BIRD INTERACTION

		Encounters			Entanglements			Incidental death		
Species	Code	n	s	%sets	n	s	%sets	n	s	%sets
Common murre	573	80	33	0.56	29	27	0.46	22	20	0.34
Marbled murrelet	579	27	21	0.36	16	13	0.22	16	13	0.22
Kittlitz's murrelet	580	10	9	0.15	7	7	0.12	7	7	0.12
Red-throated loon	409	4	3	0.05	3	3	0.05	3	3	0.05
Unid. murre	571	11	9	0.15	2	2	0.03	2	2	0.03
Sooty shearwater	456	2	2	0.03	1	1	0.02	1	1	0.02
Unid. alcid	570	54	25	0.42	1	1	0.02	1	1	0.02
Unid. murrelet	578	111	50	0.85	1	1	0.02	1	1	0.02
Thick-billed murre	572	3	30	0.05	1	1	0.02	0	0	0.00
Black-legged kittiwake	545	402	120	2.04	1	1	0.02	0	0	0.00
Others		1251			0			0		
In N = 5875 observed retrievals:		1955			62	57	0.97 %	53	48	0.82 %

Encounter = bird observed within 10m of active driftnet (incl. entanglements)
Entanglement = bird contacted net (includes incidental deaths)
Incidental death = serious injury or death resulting from entanglement

n = number of birds involved, s = number of sets involved, %sets = per cent of observed retrievals (N = 5875) involved in each interaction

Table 14. Weekly summary of the number (n) and extrapolated estimate (est) of marine bird species found dead or seriously injured in PWS driftnets, 1991.

	MARINE BIRD SPECIES																							
	RtLoon		SShear		UnAlc		UnMur		ComMur		UnMrlt		MarMrlt		KzMrlt		Total killed							
Week	n	est	n	est	n	est	n	est	n	est	n	est	n	est	n	est	n	est	(95%CI)					
May 12 - 18			1	14.9					1	14.9							2	29.8	(2-85)					
19 - 25									4	85.9			1	21.5			5	107.4	(22-223)					
26 - 01							1	34.2					1	34.2			2	68.3	(6-192)					
Jun 02 - 08									8	171.9			1	21.5	2	43.0	11	236.4	(114-399)					
09 - 15									8	140.3							8	140.3	(57-256)					
16 - 22							1	19.5	1	19.5							2	39.0	(3-110)					
23 - 29					1	29.6											1	29.6	(1-110)					
Jul 30 - 06	1	21.0															1	21.0	(1-79)					
07 - 13													1	19.5	3	58.6	4	78.2	(19-174)					
14 - 20	2	31.6											9	142.0	2	31.6	13	205.1	(105-335)					
											1	13.8					1	13.8	(1-52)					
21 - 27																								
Aug 28 - 03													2	11.4			2	11.4	(2-34)					
04 - 10													1	12.6			1	12.6	(1-48)					
11 - 17																								
18 - 24																								
25 - 31																								
	3	52.6	1	14.9	1	29.6	2	53.7	22	432.5	1	13.8	16	262.7	7	133.2	53	992.9	(334-2097)					

Species: RtLoon = red-throated loon, SShear = sooty shearwater, UnAlc = unid. alcid, UnMur = unid. murre, ComMur = common murre, UnMrlt = unid murrelet, MarMrlt = marbled murrelet, KtzMrlt = Kittlitz's murrelet

n = number of observed mortalities; est = point estimate of weekly mortality, assuming a negative binomial distribution

Table 15. Distribution and comparison of the frequency of marine bird entanglement and mortality within driftnet districts and habitat zones of Prince William Sound, 1991.

MARINE BIRD TAKE BY DISTRICT

		BR		CR		CG		ES		UN	
% OBS RETRIEVALS (N = 5875) :		0.68%		70.86%		5.62%		22.37%		4.80%	
	N	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp
Bird entanglement	62	0	0.4	57	43.9	1	3.5	4	13.9	0	0.3
Bird mortality	53	0	0.4	48	37.6	1	2.8	4	11.9	0	0.5

Chi-square (d.f. = 4) entanglement: 12.8 ($p < 0.05$)
mortality: 10.1 ($p < 0.05$)

MARINE BIRD TAKE BY DISTRICT

		CHANNEL		BAR		SURF		NEARSHORE		OFFSHORE		FIORD	
% OBS RETRIEVALS (N = 5875) :		26.30%		2.90%		1.90%		29.90%		33.10%		6.00%	
	N	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp	obs	exp
Bird entanglement	62	4	16.3	2	1.8	1	1.2	27	18.5	27	20.5	1	3.7
Bird mortality	53	3	13.9	2	1.5	1	1	27	15.8	19	17.5	1	3.2

Chi-square (d.f. = 5) entanglement: 17.3 ($p < 0.01$)
mortality: 18.2 ($p < 0.01$)

PWS Districts: BR = Bering River, CR = Copper River, CG = Coghill, ES = Eshamy, UN = Unakwik

% obs retrievals: percentage of 5875 observed complete retrievals that occured within each district or habitat zone

Obs = number of interactions observed, exp = expected number of interactions based on proportion of sampling effort in each category

Table 16. Species, condition, location, and apparent cause of death of marine mammals found during surveys for beachcast carcasses on the Copper River Delta, 15 May-26 September 1991.

MARINE MAMMAL CARCASSES

Date	Spec. No.	Sex	Std length(cm)	Approx age	Location	Latitude	Longitude	C.O.D	Comments
Steller sea lion									
05-29-91	SL91-001	F	224	Ad(pg)	e. Grass	60°13.8'	145°17.5'	sGS	preg:95cm nearterm M fetus
06-05-91	SL91-002	F	203	Sub	e. CS	60°18.5'	145°28.5'	U	fresh
06-05-91	SL91-003	M	161	Juv	w. Grass	60°15.0'	145°21.0'	U	fresh
06-14-91	SL91-004	F	216	Ad (not pg)	mid Egg	60°21.5'	145°48.5'	sGS	sus hole above RF flipper
06-14-91	SL91-005	M	307	Ad	w. SB	60°22.0'	146°11.0'	U	HUGE! stomach empty
07-04-91	SL91-006	M	175	Juv	w.Grass	60°16.3'	145°24.0'	U	Skeletal remains
07-19-91	SL91-007	M	201	Sub	midGrass	60°14.5'	145°19.0'	U	Rotten;no samples
		(3F:4M)							
Harbor seal									
05-29-91	HS91-001	M	132	Sub	e.Grass	60°13.7'	145°51.5'	PrGS	probable bullethole
06-05-91	HS91-002	U	U	Sub	e.Grass	60°15.0'	145°15.0'	U	couldn't land; scavenged
07-04-91	HS91-003	M	155	Ad	e. SB	60°23.5'	146°05.0'	PrGS	shattered skull
07-12-91	HS91-004	M	145	Sub	e. CS	60°18.5'	145°28.0'	U	decomposed
07-30-91	HS91-005	M	84	Juv	e. Grass	60°15.5'	145°15.0'	U	possibly abandoned
07-30-91	HS91-006	M	102	Juv	w. Kok	60°14.2'	145°12.8'	GS	head shot; scavenged
07-30-91	HS91-007	M	153	Ad	e. Kok	60°12.5'	144°55.0'	GS	multiple bulletholes
08-07-91	HS91-008	F	116	Sub	midGrass	60°14.5'	145°19.5'	GS	shattered skull
		(1F:6M:1U)							

Table 16. Species, condition, location, and apparent cause of death of marine mammals found during surveys for beachcast carcasses on the Copper River Delta, 15 May-26 September 1991 (continued).

Harbor porpoise									
05-24-91	HP91-001	M	125	Sub	e.CS	60°18.5'	145°26.8'	D	net marks; afloat
05-29-91	HP91-002	U	U	U	e. Softuk	60°13.2'	145°51.5'	U	couldn't land
06-05-91	HP91-003	M	150	Ad	e. SB	60°23.0'	146°08.0'	D	net marks; scavenged
06-14-91	HP91-004	F	138	Sub	e. Kok	60°13.0'	145°02.0'	D	net marks
		(1F:2M:1U)							
Sea otter									
06-14-91	SO91-001	M	U	Juv	w. Egg	60°23.0'	145°56.3'	F	collected whole for FWS
07-19-91	SO91-002	F	130	Ad	e. Egg	60°20.5'	145°46.0'	F	collected whole for FWS
09-12-91	SO91-003	M	U	Ad	e. SB	60°24.0'	146°07.0'	U	rotten; no samples
09-26-91	SO91-004	U	U	U	mid-SB	60°23.0'	146°09.5'	U	skel only; bear-scavenged
		(1F:2M:1U)							
Gray whale									
06-18-91	GW91-001	F	1250	Ad	e. Egg	60°22.3'	145°47.5'	U	adrift sev days before beached

Approximate age: Ad = adult (A), Sub = subadult (S), Juv = juvenile (J), U = unknown

C.O.D. = apparent cause of death: GS = definite gunshot, sGS = suspected gunshot, PrGS probable gunshot, D = drowned, F = fractured skull, U = undetermined

Table 17. Summary of marine mammal carcasses found or examined during weekly aerial surveys of barrier islands of the Copper River Delta, 15 May-26 September 1991.

MARINE MAMMAL CARCASS CHARACTERISTICS

Species	No. (r)	Sex			Estimated age class				Cause of death				
		M	F (pg)	U	Juvenile	SubAd	Adult	Unknown	U	dGS	sGS	D	F
Steller sea lion	7 (0)	4	3 (1)	0	2M	1M:1F	2F:1M	0	5	0	2	0	0
Harbor seal	8 (0)	6	1	1	2M	2M:1F:1U	2M	0	3	3	2	0	0
Harbor porpoise	3 (1)	2	1	1	0	1M:1F	1M	1	1	0	0	3	0
Sea otter	4 (0)	2	1	1	1M	0	1M:1F	1	2	0	0	0	2
Gray whale	1 (0)	0	1	0	0	0	1F	0	1	0	0	0	0
Total:	23 (1) = 24	14M: 7F: 3U			5J: 8S: 9A: 2U				12U: 3dGS: 4sGS: 3D: 2F				

No. = number necropsied, (r) = number observed but not examined

M = male, F = female, U = undetermined; (pg) = number of pregnant females

Cause of death: U = undetermined, dGS = definite gunshot, sGS = suspected gunshot, D = drowned, F = fractured skull