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MORTALITY OF SEABIRDS IN THE JAPANESE HIGH SEAS SALMON MOTHERSHIP FISHERY

1981 - 1984

by

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INTRODUCTION

Recent studies have demonstrated the susceptibility of seabirds to entanglement in gillnets. This form of seabird mortality is particularly evident in the northern hemisphere as exemplified by studies in the northeast Atlantic (Brun 1979, Whilde 1979, Myberget 1980), off of Greenland (Tull, Germain and May 1972, Evans and Waterston 1976, Christensen and Lear 1977, Piatt and Reddin 1984), in Newfoundland (Piatt et al. 1984), in California (Heneman 1982, King 1984), in British Columbia (Carter and Sealy 1984) and in the North Pacific Ocean and Bering Sea (Sano 1978, King et al. 1979, Ainley et al. 1981, King 1985, Ogi 1985).

Four drifnet fisheries currently operate in the North Pacific Ocean and Bering Sea: the recently developed Taiwanese and Japanese squid fisheries in the central and western North Pacific, the Japanese land based salmon fishery that operates south of 46°N and west of 175°E and the Japanese high seas salmon mothership fishery that operates north of 46°N. Little is known about the magnitude of seabird mortality in the former three fisheries, however, the latter fishery has gained increasing notoriety in recent years due to the thousands of seabirds killed in salmon nets during the brief two month long fishing season (Sano 1978, Ainley et al. 1981, King 1985, Ogi 1985).

Prior to this study, our knowledge of seabird mortality in the Japanese mothership fishery relied on data gathered by American and Japanese observers aboard Japanese Research Vessels from 1977 through 1979 (Sano 1978, Ainley et al. 1981). These vessels usually fished outside the commercial fishing zone

and used nets with variable mesh sizes. Ainley et al. (1981) showed that not only did catch rates of seabirds vary geographically, principally with distance from land, but also that catch rates of seabirds in nets of small and large mesh sizes were lower than catch rates in mesh sizes used by the commercial fishery. Because of these limitations in the existing data, we re-examined seabird mortality in the Japanese mothership fishery but from commercial catcherboats. This project was initiated at the request of the United States Congressional Committee on Merchant Marine and Fisheries. Personnel of the National Marine Fisheries Service collected seabird mortality data in 1981 incidental to others studies. In 1982, the U.S. Fish and Wildlife Service assumed responsibility for the study of seabird mortality under a cooperative work agreement with the National Marine Fisheries Service from 1982 through 1984. Observers of the National Marine Fisheries Service continued to gather data for this study under that cooperative agreement. Our goals were:

1. To improve estimates of the size, species composition and geographic distribution of mortality caused by foreign gillnet fisheries;

2. To identify colonies that are affected by the fisheries;

3. To determine the biological significance of fishery-caused mortality by considering mortality in relation to the probable number of birds originating at individual colonies, normal productivity of individual species, and other natural or anthropgenic sources of mortality.

THE FISHERY

The Japanese salmon mothership fishery in the North Pacific began in 1952 with three motherships and 57 catcherboats. The fleet attained its largest size in 1959 when 16 motherships and 460 catcherboats fished about 355,000 km of net (Fredin et al. 1977). Since then the fleet has been reduced in size on 5 occasions, most recently in 1978, resulting in the present fleet of 4 motherships and 172 catcherboats.

Prior to 1956, the mothership fleet fished almost entirely to the west of 175°E, however in 1956 the fleet expanded its operations east of 175°E, and began fishing in the Bering Sea. Between 1959 and 1976 the fleet fished in an irregularly shaped area from 160°E to 175°W and north to 60°N. As a result of both Soviet and U.S. proclamations extending jurisdiction of their fishing zones to 200 nm, the area open to the mothership fleet was reduced in 1978 to a narrow band between 165°E and 175°E in the North Pacific but still extending to 175°W in a limited part of the Bering Sea (Figure 1).

The Japanese mothership fishing zone is divided into three regions: the U.S. Fishery Conservation Zone (U.S. FCZ) located roughly between 48°N and 56°N; the region south of the U.S. FCZ which extends south to 46°N; and the region north of the U.S. FCZ in the Bering Sea which extends to about 60°N and east to 175°W (Figure 1). The mothership fleet enters and begins fishing in the southern part of the fishing zone on 1 June but not until 10 June is the fleet allowed to enter the U.S. FCZ. The fleet usually spends most of the remaining fishing season in the U.S. FCZ although after 25 June they may go outside the U.S. FCZ in the Bering Sea (Figure 1). Most fleet

commanders opt to leave U.S. controlled waters in late June or early July for a week or more. They then return to the U.S. FCZ and fish until they fill their salmon quotas or until 31 July, whichever comes first.

Each of the four motherships currently operating in the North Pacific is associated with forty-three catcherboats. With the exception of 6 catcherboats which are designated as scoutboats, all fishing vessels return to the mothership daily to offload salmon. Scoutboats frequently range far from the motherships searching for salmon, and do not return everyday to offload fish.

Movements of the fleets on the fishing grounds are dictated by the fleet commanders and their staffs on the motherships. As a rule the fleets change position each day. Each catcherboat is positioned in an orderly set array and all nets are set in parallel usually in a heading of 20° (Figure 2). One or more scoutboats are occasionaly included in the catcherboat array. Nets are set in late afternoon or just before dark and retrieval occurs about nine hours later, in daylight. Running times from the fishing site to the mothership range from 1 to 6 hours. Generally, catcherboats fishing closest to the mothership on one day are the first to unload their catches and therefore are assigned new fishing sites the farthest from the mothership for the next set.

Gillnets used in the mothership fishery are about 16.5 km long and are composed of 330 fifty meter sections (tans) that are laced together. The nets hang in the water like a curtain from the surface and are 8 m deep. The single strand monofilament nets are composed of 121 mm and 130 mm stretched mesh. At two equally spaced intervals in the net, the tans are loosely tied

at the floatline and leadline rather than laced. These sections of equal length frequently break apart in rough to modertate seas, presumably to prevent the net from seriously tangling upon itself. Each section of net is marked with radio beacons to aid in its relocation. The beginning and end of each net are also marked with light buoys, radar buoys and flags. In 1982, 1983 and 1984 additional modifications were made on the nets of selected catcherboats. Some nets contained three rows of hollow fibers located horizontally in the center of the net along its entire length. The other boats used nets with nine sound generators equally spaced along its length. Both devices were being tested as means to reduce the catch of Dall's porpoises (Phoecenoides dalli). Their effects on seabird mortality were not measured but it was our impression that it was negligible.

METHODS

Each year from 1981 through 1984, twelve American observers were placed in the four mothership fleets to gather data on porpoise and seabird mortality. The twelve observers varied widely in their seabird expertise although a brief training period prior to the 1982-84 fishing season familiarized the observers with the bird species they were likely to encounter on the high seas. Undoubtedly, some problems with seabird identifications occurred on catcherboats, particularly between sibling species such as Thick-billed and Common Murres (Uria lomvia and U. aalge) and Short-tailed and Sooty Shearwaters (Puffinus tenuirostris and P. griseus). This was particularly evident in 1981 when no formal bird training occurred. With the

exception of 1981, we were generally pleased with the observers' abilities to discriminate among the species.

The twelve observers were divided equally among the four mothership fleets. They worked a staggered rotation of three days on the mothership followed by six days on salmon catcherboats thus at any one time there were two observers on catcherboats in each fleet.

Our coverage of the fishery in 1981 through 1983 was limited to waters within the U.S. FCZ. During the periods of time the fleets were outside the U.S. FCZ , American observers were not allowed on the commercial vessels. In 1984, however, one porpoise/seabird observer and one salmon observer per fleet were allowed on catcherboats while the fleets were outside the U.S. FCZ in the Bering Sea. Our data now include 68 gillnet sets from this little known area.

Aboard catcherboats, biologists observed gillnet sets and retrievals usually from the flying bridge. We observed 262 sets in 1981, 270 sets in 1982, 266 sets in 1983 and 344 sets in 1984. During net retrieval each observer watched closely for entangled seabirds and marine mammals. Dead seabirds that were normally brought on board and immediatley discarded were saved by the Japanese fishermen and later identified by the biologists. Seabirds that dropped from the net before being brought on deck and those released alive by Japanese fishermen were also recorded. When time permitted, some observers sorted birds by age groups, and examined them for sex and breeding condition.

Collections of entangled birds were made in 1982 and 1983. In 1982, all twelve observers haphazardly collected 530 specimens. In 1983, however, only one observer from each fleet collected birds and then on only the third and

sixth days aboard each catcherboat. This sampling scheme was hopefully more representative of the overall seabird kill than the previous year as it was spaced over both time and area. In addition, individual observers were prevented from making decisions on what and where to collect thereby eliminating some sampling bias. Four-hundred and three seabirds were collected in 1983. Seabirds were frozen aboard the mothership and later dissected in the laboratory.

Prior to the field season we established criteria for ageing the various species of seabirds. We relied primarily on plumage, feather condition, and the presence or absence of a bursa, which is an outpocketing of the dorsal surface of the cloaca. We determined in 1982 that, almost without exception, shearwaters undergoing primary molt did not have bursas and had more highly developed gonads than those not undergoing primary feather molt. We reasoned that those birds with new primaries, bursas and small testes or undifferentiated ovaries were hatching year (HY) birds that had recently grown wing feathers on the nesting grounds in Tasmania. Consequently birds with wing molt were designated as After Hatching Year (AHY). Wing molt was not used as an ageing criteria for alcids. Rather bill size and color, the presence of bill grooves and head plumes, the color of the face, body and legs, and the presence or absence of a bursa were important ageing criteria. Tufted (Fratercula cirrhata) and Horned Puffins (F. corniculata) were divided into three age groups: one-year olds, sub-adults and adults. Murres were divided into adults and sub-adults as were the small alcids. Breeding status was determined by the presence or absence of brood patches. Murres develop a single brood patch located centrally on the abdomen. Ancient Murrelets

(Synthliboramphus antiquum) have two circular brood patches on the abdomen. Other alcids have two elongate brood patches located laterally above the knee. Northern Fulmars (Fulmarus glacialis) and storm-petrels develop a single brood patch on the abdomen although its presence may not be a reliable criteria for breeding.

In addition to collecting data on seabird mortality, we also undertook surveys to assess densities of birds within the fishing zone . Transects of 10 or 15 min duration were made from the flying bridge and bridge wings of fishing boats or research vessels. During each transect, the observer counted all birds within 300 m of one forequarter of the ship. Periodic instantaneous counts of flying birds within the transect zone were made to avoid inflating density estimates (see Gould et al. 1982 for a discussion of this technique). The distance the ship travelled during the time period multiplied by 300 m provided an estimate of the surveyed area. The surveyed area divided into the number of birds counted provided an index of seabird density in birds/km^2 (Gould et al. 1982). Birds following the ship were not included in density estimates. Density indices for various sub-regions of the fishing area were obtained by calculating the number of birds/km^2 for each transect, adding these together, and then dividing by the number of transects. Data used in this study were from transects taken by us in 1982 and 1983 and by U.S. Fish and Wildlife Service personnel in previous years.

Seabird colonies of eastern Agattu Island were carefully enumerated in June 1982 by one of us (Forsell and Ambrose 1982). In addition to censusing colonies of Tufted Puffins, murres and Black-legged Kittiwakes (Rissa tridactyla), an attempt was made to band and color mark Tufted Puffins to

determine if breeding birds from Agattu Island were killed in the gillnet fishery. After color-marking about 40 puffins, the project was abandoned because of the difficulty in catching adequate numbers of birds and the disturbance to birds associated with capturing and color-marking which may have resulted in abandonmemt of nests. None of the color-marked birds were seen by American observers on Japanese fishing vessels.

The major Tufted Puffin colonies of Attu Island were examined in summer 1983. Time did not permit a careful census of these colonies but the islands were subjectively evaluated to see if numbers of burrows varied considerably from previous estimates.

RESULTS

Fishing Effort

Detailed information on fishing area and effort was available only for the U.S. FCZ from 1982-84 (Figures 3-5). For the areas south and north of the U.S. FCZ we were able to obtain information on the number of fishing days per fleet and therefore fishing effort, but not detailed information on the location of effort. In addition, for the area north of the U.S. FCZ we were unaware of the locations of scoutboats. For this study we assumed that scoutboats fished with the fleet when the latter was north of the U.S. FCZ although we know that frequently they fished in waters south of the Aleutian Islands at this time. Therefore our estimates of total mortality may err on the conservative side because our 1984 data suggest that cath rates of

seabirds for the area north of the U.S. FCZ were much lower than in the southern part of the U.S. FCZ.

In all years fishing effort was concentrated in the U.S. FCZ. In fact between 67% and 70% of all sets occurred within the American zone each year. The area of least fishing was consistently the region south of the U.S. FCZ. From 13 to 16% of the total sets were made in this region each year. During each year of our study, all four fleets moved north into the U.S. FCZ on 10 June, the first day possible. In all years the fleet commanders of all motherships exercised their options to move their vessels outside the FCZ in the Bering Sea. The duration of each fleets' stay in this region varied but it usually was at least 8 days.

Within the U.S. FCZ fishing was concentrated south of the Aleutian Islands in all years (Figures 3-5). Over 95% of all gillnet sets made in the U.S. FCZ were made in the southern area. Another feature of fishing effort which was consistent among years was the tendency of the fleets to concentrate fishing effort on the eastern side of the U.S. FCZ south of the Aleutian Islands. Fishing effort was particularly concentrated in the 173°E and 174°E longitude blocks between 49°N and 52°N (Figures 3-5). In 1983 more fishing effort occurred in the Bering Sea section of the FCZ compared to 1982 and 1984.

Fishing effort data also reveals that little fishing effort occurs in the 52°N blocks in the vicinity of Agattu and Attu Islands. Fishing staff on the motherships advised us that strong currents in these waters frequently result in tangled nets, reducing fishing efficiency. Presumably strong currents would also increase the likelihood of losing portions of the gillnet,

a costly proposition for fishermen and wildlife alike (DeGange and Newby 1980).

Salmon fishing by the Japanese in the U.S. FCZ was widespread in all years. Our coverage of the commercial fleet was also widespread (Figures 3-5), especially in 1983 when we observed gillnet sets in 79% of the 1° latitude by 1° longitude blocks in which commercial fishing occurred. For 1982 and 1984 we obtained about 60% coverage. More important than the geographic extent of our coverage is the fact that our coverage concentrates in the same geographic areas as does the commercial fleet, i.e. towards the eastern edge of the fishing zone south of the Aleutian Islands. For any 1° lat by 1° longitude block our coverage usually ranged from 0 to 8% of the gillnet sets. The percent coverage was occasionally much higher especially for those blocks in which few gillnet sets were made. It is our general impression that our coverage was fairly representative of the commercial fleet. We do not feel the Japanese were intentionally trying to keep us out of certain areas.

Catch Statistics

A total of 4510 birds in 1981, 6102 seabirds in 1982, 9669 seabirds in 1983 and 4127 birds in 1984 were recorded captured in gillnets by American observers. These birds were assigned to three capture categories: those dropping from the net during retrieval (lost), those escaping from the net during retrieval or brought on deck alive and released (alive) and those brought on deck dead. Birds that were tallied as lost were always dead and were therefore included with dead birds on deck in further analyses of

mortality.

As the number of dead birds recorded on deck by American observers increased so did the number of birds lost or released alive. In fact the number of birds lost or released alive was positively correlated with the number dead for all years of the study. Nevertheless the number of birds recorded lost or alive were few in comparison to the number dead. Birds that were lost from the net during retrieval accounted for only 0.5%, 2.2%, and 0.8% of the birds caught in 1982-1984 respectively. These values are considerably lower than the 5-13% drop-out rate recorded by Ainley et al. (1981) on research vessels. The lower drop-out rates recorded in this study may result from birds becoming more thoroughly entangled in meshes of 121 and 130 mm used on commercial vessels compared to the variable mesh gillnets of research boats. Few observers in 1981 recorded the number of birds lost or released from nets so that year was excluded from these analyses.

Consistent with the higher mortality of seabirds in 1983 than 1982 or 1984, significantly more birds were lost per set in 1983 than either 1982 or 1984 (Mann-Whitney U Test; p .001). Short-tailed Shearwaters and Tufted Puffins were the species most frequently lost from the nets during this study.

All birds caught in gillnets and brought on deck alive were released immediately by the Japanese fishermen. Released birds accounted for only 1.1%, 6.3% and 2.9% of the total birds caught for 1982, 1983 and 1984 respectively. The number of birds brought on board alive increased almost 10-fold from 1982 to 1983, rising from .25 birds per set to 2.30 birds per set. Significantly more birds were released alive in 1983 than 1982 or 1984 (Mann-Whitney U Test, p .001). Short-tailed Shearwaters were the species most

frequently released alive, comprising 58% of 67 birds in 1982, 80.0% of 611 birds in 1983 and 76% of 123 birds in 1984. An additional 10% of the birds released alive in 1983 were unidentified shearwaters and the majority of these were probably Short-tails as well. Northern Fulmars accounted for 10.4%, 6.2% and 13.0% of the number of birds released per year. These values are higher than what we expected based on the percent composition of fulmars in the overall kill and reflect not only the tendency of this species to get caught at the surface while feeding on entangled fish and birds but their abilities to survive after entanglement.

The majority of released birds were caught at the floatline although a few alcids, obviously caught moments before being landed on deck, were as deep as 5m in the net. The fate of released birds is unknown. Many of the birds we examined were thoroughly wet and often lethargic. It seems unlikely that they could survive in the cold subarctic waters of the North Pacific and Bering Sea. Regardless of the fate of these birds, we excluded these data from further analyses of mortality.

The number of dead birds in each set including the few birds lost from the net varied from 0 to 101 birds in 1981, 1 to 191 birds in 1982, 0 to 457 birds in 1983 and 0 to 103 birds in 1984. Frequency distributions of the number of seabirds caught in each set in the North Pacific and Bering Sea for all years were significantly skewed to the left indicating that large numbers of birds were taken in relatively few gillnet sets and that in most gillnet sets, the number of birds taken was below the mean.

Overall mortality rates of seabirds caught in gillnets varied considerably among years. Mortality was highest in 1983 when about 34.1 birds

were killed per gillnet set, intermediate in 1981 and 1982 when 17.2 and 22.3 birds were killed per set respectively, and lowest in 1984 when about 11.6 birds were killed per set. Pair-wise comparisons between years revealed that overall mortality rates were significantly different for all combinations of years with the exception of 1982-83 (Mann-Whitney U test, p .001).

Catch rates of seabirds varied geographically. In general, catch rates of seabirds were highest in the U.S. FCZ south of the Aleutian Islands and lowest in the Bering Sea (Table 1). We found significant differences in catch rates between the southern part of the U.S. FCZ and the Bering Sea in 1983 and 1984, the only years for which sufficient data exist for the latter area (Mann-Whitney U test, p .03, 1983; p .001, 1984). Although considerable fishing effort usually occurs each year outside the U.S. FCZ both in the North Pacific and Bering Sea, limited data exist from which to assess seabird mortality. For the region south of the U.S. FCZ, limited data from 1982 and 1984 suggest that mortality rates were lower than for areas closer to the Aleutian Islands (Table 1). For the region north of the U.S. FCZ in the Bering Sea, data collected in 1984, albeit a year of comparatively low mortality, similarly suggest that catch rates of seabirds were lower there than for other areas in the fishing zone (Table 1).

A striking feature of the seabird bycatch data for most years and areas is the large variation in catch rates. Standard deviations for most years and areas frequently exceed the mean (Table 1). Catch rates of seabirds south of the Aleutian Islands were more variable than catch rates of seabirds in the Bering Sea. Coefficients of variation for catch rates of seabirds south of the Aleutian chain for the four years of study ranged from 114 to 161 (X=129)

compared to a range of 51 to 101 (X=71) for the fishing areas north of the Aleutian Islands.

Twenty-one species were entangled in gillnets during the four years of study including several Black-legged Kittiwakes, Pomarine Jaegers (Stercorarius pomarinus), and Rhinoceros Auklets (Cerorhinca monocerata), a lone Harlequin Duck (Histrionicus histrionicus) and a Dovekie (Alle alle). The remaining fifteen species were caught more frequently as a result of their abundance and behavior (Table 3, see Ainley et al. 1981).

In all years of the study in the U.S. FCZ, the area for which we have the best data, shearwaters, particularly Short-tailed Shearwaters, were the most common seabirds killed in nets in terms of percent of total birds killed and birds caught per set (Tables 2,4). Short-tailed Shearwaters also occurred more frequently in gillnet sets than any other species except for Tufted Puffins in 1982 (Table 3). Most shearwaters in 1981 were not identified to species but based on results in successive years it seems likely that these were also predominantly Short-tailed Shearwaters. Catch rates of shearwaters were consistent in 1981 and 1982 at about 9-10 birds per set, however, in 1983 catch rates of shearwaters rose sharply to over 24 birds per set (Table 4) when Short-tailed Shearwaters accounted for over 72% of the birds killed in the U.S. FCZ and occurred in 84% of all gillnet sets (Tables 2,3). Catch rates of shearwaters in the U.S. FCZ decreased to about 9 birds per set in 1984.

Tufted Puffins (Lunda cirrhata) were the second most numerous species killed in Japanese salmon gillnets in the U.S. FCZ in all years of the study (Tables 2,4). Catch rates of Tufted Puffins in the U.S. FCZ increased from

3.6 birds per set in 1981 to a high of about 8 birds per set in 1982. In that year, Tufted Puffins comprised over 38% of the overall kill and occurred in almost 100% of the sets (Tables 2,3). Tufted Puffin mortality in the U.S. FCZ decreased in 1983 to 4.5 birds set and decreased further still in 1984 to about 2 birds per set. Despite lower mortality in 1983 and 1984, Tufted Puffins were caught in a comparatively high percentage of sets attesting to their widespread abundance in the fishing area (Table 4).

Of the remaining species, only Horned Puffins and Thick-billed Murres were taken in substantial numbers, although compared to Short-tailed Shearwaters and Tufted Puffins, their mortality was low. Mortality of Horned Puffins within the U.S. FCZ followed the same pattern as Tufted Puffins, i.e., a sharp increase in catch rates in 1982 followed by declines in 1983 and 1984 (Table 4). Catch rates of Thick-billed Murres (*Uria lomvia*) increased from 1981 to a high of about 1.2 birds per set in 1983 and then decreased in 1984 (Table 4).

Five small alcids were occasionally caught during all four years of the study (Table 2). Of these, Ancient Murrelets and Crested Auklets (*Aethia cristatella*) were most frequently taken. Ancient Murrelets were usually caught individually, however, Crested Auklets were sometimes caught in flocks. On 22 June 1983 199 Crested Auklets were caught in one gillnet set.

Information on catch statistics of seabirds outside of the U.S. FCZ were from 6 gillnet sets south of the U.S. FCZ in 1982, 5 sets south of the U.S. FCZ in 1984 and 68 sets north of the U.S. FCZ in 1984. The data from south of the FCZ in 1984 were used in computations of mortality but not in a descriptive summary of the seabird bycatch because some of the bird

identifications were suspect.

Six species were recorded in sets from south of the U.S. FCZ in 1982 (Table 5). Tufted Puffins predominated in the catch occurring in all six sets and comprising over half of the birds taken. Short-tailed Shearwaters were second most abundant in the bycatch. For the region north of the U.S. FCZ in 1984, nine species were recorded. Catch statistics of seabirds for the area north of the U.S. FCZ were similar to those from within the U.S. FCZ although Short-tailed Shearwaters and Tufted Puffins did not dominate the catch as they did in the latter area (Table 6). Thick-billed Murres were proportionally more common in the seabird bycatch north of the U.S. FCZ in the Bering Sea than within the U.S. FCZ.

The large increase in mortality of seabirds that occurred in 1983 was entirely the result of an increase in Short-tailed Shearwater mortality. Short-tailed Shearwaters are a gregarious species and are frequently found in large flocks on their wintering grounds in the North Pacific (Gould et al. 1982). Most of the large individual kills of seabirds in Japanese salmon gillnets were of this species and although large kills were comparatively rare, they were often impressive. For example, on 29 June 1983 409 Short-tailed Shearwaters were caught in a single set.

A factor which may have influenced the number of Short-tailed Shearwaters caught in gillnets was the presence of Steller sea lions (Eumetopias jubata) feeding on entangled salmon. Sea lions would first remove salmon from the net and tear them apart at the surface. Shearwaters attracted to this activity occasionally initiated feeding frenzies near the net, resulting in massive entanglements. If the feeding frenzies formed near the catcherboat, many

shearwaters came aboard alive. For example on 1 July 1983, DeGange observed a retrieval in which 106 out of 270 shearwaters caught in the net were released alive. If the entanglements occurred far from the vessel, most of the shearwaters were dead by the time they were removed from the net.

We doubt that the shearwater - Steller sea lion interaction was the primary factor responsible for increased mortality of shearwaters in 1983. Such incidents were infrequent and were observed by only a few biologists . In addition, sea lions were observed near the nets during retrieval only slightly more often in 1983 than 1982 or 1984. The percent of gillnet retrievals observed by Americans during which Steller sea lions were counted was consistent among years, ranging from 18.4% in 1984 to 22.7% in 1983. We suspect the high catch rates of Short-tailed Shearwaters in 1983 relative to other years was a result of their increased abundance in the fishing zone.

In 1982 we estimated the depth in the net of entangled birds (Table 7, Figure 6). About 91% of entangled birds were in the upper half of the net and 68% were in the upper quarter. We reject the null hypothesis that seabirds were entangled equally at all depths (X^2=1864; p .001). Many of the birds caught in the upper meter were caught at the surface. This was especially evident for shearwaters and surface feeders such as fulmars and Fork-tailed Storm-Petrels. Diving birds such as the alcids were also caught frequently at the surface but also at deeper depths (Table 7).

Salmon also tended to be caught in the upper sections of the net (Figure 6). Over 92% of the salmon recorded were caught in the upper half of the net and about 61% were caught in the upper quarter of the net. We similarly reject the null hypothesis that salmon were equally caught at all depths

(X^2=1300; p .001).

The results of our study suggest that catch rates of seabirds vary geographically at least on a broad scale, with higher catch rates south of the Aleutian Islands compared to the Bering Sea. Ainley et al. (1981) found a strong negative correlation between catch rates of seabirds and distance from land south of the Aleutian Islands which led us to look for a similar relationship using correlation anlaysis. We also observed a significant negative correlation between the number of birds killed per set and distance from land in 1981, 1982, and 1983 for the fishing area south of the Aleutian Islands. The correlation coefficients, however, were weak (1981: r=-.49,p .001; 1982: r=-.33,p .001; 1983: r=-.34, p .001) undoubtedly reflecting the variability in our data. The correlations between catch rates of seabirds and distance from land for 1982 and 1983 were improved only slightly by using a natural log transformation of one or both of the variables. We observed no relationship between the same variables in 1984.

Figure 7 shows the relationship between catch rates of seabirds and distance from land in 1981, 1982 and 1983. Because of the variablity in our data, it was impossible to discern the relationship from a scattergram of all data points. Therefore, we stratified the catch rate data by 50 nautical mile zones which eliminated much of the variablity and reduced the number of plottable points to 5 in 1981 and 1982 and 4 in 1983. The correlation coefficients presented in the figure, however, are the same as those presented in the text.

At a recent meeting between officials of the United States and Japan, Japanese scientists argued that catch rates of seabirds in the mothership

fishery will decline over time as increasing numbers of birds are killed in gillnets. This hypothesis assumes that populations of seabirds in the fishing zone are static with little or no movemnet in or out of the area. In order to test this hypothesis we examined the variation in catch rates of seabirds over time. Catch rate data from 1982 to 1984 were stratified by seven day periods starting on 11 June and continuing until 30 June. The seven day periods were constant between years even though fishing ended on different days each year. Because both catch rates and fishing effort vary geographically, we examined a limited portion of the U.S. FCZ where fishing effort was concentrated throughout the fishing season; specifically the region south of the Aleutian chain bounded on the north by 52°N, on the west by 172°E and on the east by 175°E.

In 1982 and 1984 shearwater mortality was bimodal with peaks in mortality in mid to late June and mid to late July (Figure 8). This is in sharp contrast to 1983 when one sharp peak in mortality occured in late June (Figure 8). Shearwaters are highly mobile organisms and it seems possible that the peaks in mortality coincided with movements of shearwaters into the fishing zone. It appears that shearwater mortality does not necessarily decrease over the course of the fishing season but is dependent on movements of shearwaters into and out of the zone.

Birds of the family alcidae are not as proficient flyers as shearwaters. Because they are less mobile than shearwaters, their population in a given area may be more susceptible to repeated fishing in that area and therefore exhibit decreasing mortality over time. For the three years of data used in this analysis, Tufted Puffin mortality was highest during mid to late June and

early July and declined thereafter (Figure 9). In 1983 the decline in Tufted Puffin mortality continued until the end of the fishing season supporting the view that seabird mortality decreases during the fishing season as a result of removing birds from the population at sea with little or no replacement. In 1982 and 1984, however, mortality did decline in early July but during the last two weeks of the season Tufted Puffin mortality increased (Figure 9). These data suggest an increase of Tufted Puffins into the study area during the latter part of the fishing season. Breeding puffins liberated from incubation duties may be partly responsible for this influx of birds although the region used in this analysis is outside what we believe is the normal foraging range of breeding puffins.

Age and Sex Composition of The Kill

Because the mothership fishery occurs over a wide geographic area, including both nearshore and offshore habitats, and because seabirds are long-lived and may spend several years at sea before returning to land to breed, we examined a portion of the catch in 1982 and 1983 for age and sex composition. In both 1982 and 1983, HY Short-tailed Shearwaters, i.e., those birds recently fledged from colonies in the southern hemisphere dominated the catch, comprising at least 73% of the take of shearwaters in both field and lab samples (Table 8). In 1983, HY SHort-tailed Shearwaters comprised over 91% of 4700 shearwaters aged by wing molt on catcherboats (Table 8). We suggest two hypotheses to account for the predominace of HY shearwaters in the shearwater kill. First, HY shearwaters may be less efficient predators than

older birds, and following their long migration to the North Pacific, they may be atrracted to gillnets to scavenge on dead fish. Second, and probably most important, HY shearwaters may be more abundant in the fishing zone. The lack of older, molting shearwaters in the seabird bycatch suggests that these birds may winter elsewhere in the North Pacific Ocean and Bering Sea. Guzman (1981) postulates that shearwaters migrate in waves from their colonies in the southern hemisphere with older birds leaving in late March and HY birds leaving 4-6 weeks later in early May. Guzman collected 166 Short-tailed Shearwaters from the eastern Bering Sea and Kodiak region and found all in some stage of wing molt, suggesting that older birds were abundant in these areas. Perhaps the peaks in shearwater mortality we observed represent waves of migrant HY shearwaters that summered in the western North Pacific and Bering Sea.

The sex of 86 Short-tailed Shearwaters was determined in 1982 and there were no significant differences in the proportion of males and females (X^2=.18; p .50). Five hundred and nine shearwaters were examined in the field in 1983 and the ratio of males to females was highly skewed towards females (X^2=18.4; p .005). We cannot explain the disparity in sex ratios of male and female shearwaters. Perhaps some sexual segregation occurs at sea or perhaps shearwaters migrate in waves of birds of similar age and sex.

For Tufted Puffins our data suggest pronounced shifts in the proportion of age classes taken in the fishery in 1982 and 1983 (Table 8). Results of autopsies performed in the lab in 1982 and 1983, however, may not be comparable as a result of different collecting schemes. In addition, results of ageing of alcids done on catcherboats are clouded by the varying abilities

of the observers, the sometimes subtle ageing criteria employed in this study, and the fact that several observers each year either lacked the time to examine birds or chose not to do so.

In 1982 sub-adult Tufted Puffins accounted for over 50% of the birds examined by us in the laboratory or by observers on catcherboats (Table 8). One-year old birds were second most numerous in our samples accounting for about 25% of the kill, and adults were least abundant comprising less than 25% of the field and lab samples (Table 8). Only 2% of the 223 Tufted Puffins examined in the lab had brood patches. In 1983 adult Tufted Puffins comprised about 50% of the birds aged in the field and lab. The percentage of sub-adults and one-year old birds decreased in the samples compared to 1982. Twenty-four percent of the Tufted Puffins examined in the field and 32% of the Tufted Puffins examined in the lab had brood patches.

We also examined the variation in the age distribution of Tufted Puffins by latitude in the study area. This analysis revealed that the majority of birds collected in 1982 and 1983 were from different areas. In 1982 over 65% of the Tufted Puffins were collected from between 49°N and 51°N, whereas in 1983 only 16% of the Tufted Puffins were collected in that area. In 1983 the majority of the collections of Tufted Puffins came from between 51°N and 53°N. Such differences in collection area probably had an important influence on the relative proportions of age classes in the collections assuming that adults and breeding birds were distributed closer to the Aleutian Islands which lie between 52°N and 53°N. The results of our 1983 collections of Tufted Puffins clearly suggest that such was the case for Tufted Puffins (Table 9). In 1983 over 60% of the Tufted Puffins collected

between 51°N and 53°N were adults and half of these were breeding birds. Immature Tufted Puffins predominated in all other latitude blocks (Table 9). In 1982, immature Tufted Puffins predominated in all latitude blocks (Table 10), even in those closest to the Aleutian Islands. The differences between years in the proportion of various aged Tufted Puffins in the latitude blocks nearest the Aleutian Islands are difficult to explain although in 1982, observers made individual decisions on which birds to collect and there may have been a tendency to collect immature birds which often had unusual plumages and bill shapes.

Despite the difficulties in comparing the two years of data, the results clearly indicate that immature Tufted Puffins form a significant portion of Tufted Puffin kill and that breeding Tufted Puffins are frequently taken in some years. In addition there may be considerable variation in the age compsition of the kill depending on the locations of fishing effort each year.

For Tufted Puffins examined in the field in 1982 (N=108) and 1983 (N=242) and in the lab in 1982 (N=223), the proportion of males to females was not significantly different (X^2 test: p .25). However in our lab sample in 1983 (N=172) the sex ratio was significantly skewed towards males (X^2=5.96; p .01). Again, a skewed sex ratio is difficult to explain. If egg laying is highly synchronous, it is possible that a preponderance of breeding birds of one sex could be incubating the egg or feeding offshore at one time. More difficult to explain is a segregation of sub-adult or immature birds of one sex at sea. We have one collection of 11 young male puffins from a single gillnet set in mid July, 1983 which suggests that such segregation may occur.

Ageing Horned Puffins was more difficult than Tufted Puffins because of the often subtle differences between the sub-adult and adult classes. Because the same two people always aged and dissected birds in the lab (ARD and DJF) we feel those data are more consistent than data from the field. There was also a greater degree of disconcordance between field and lab samples of Horned Puffins than Tufted Puffins which possibly relates to the difficulty in assigning birds to age groups. Using only the lab samples, variation in the proportion of age classes of Horned Puffins between years exhibited a similar trend as Tufted Puffins, i.e. a decreasing percentage of young birds in the catch and an increasing percentage of adult birds betwen 1982 and 1983 (Table 8). Young Horned Puffins comprised about 88% of the lab sample in 1982 and about 65% of the lab sample in 1983. Breeding birds were not observed in the catch in 1982, however, 20% of the Horned Puffins examined in the lab in 1983 had brood patches (57% of adults).

Fewer Horned Puffins than Tufted Puffins were collected in 1983 thus analysis of the geographic distribution of age cohorts of Horned Puffins suffered from small sample sizes. Generally, subadult and one year old Horned Puffins predominated in all latitude blocks except between 51° and 52°N where breeding and non-breeding Horned Puffins made up about 53% of the collections (Table 11). The lone breeding Horned Puffin taken north of 54° was unexpected but perhaps was a failed breeder.

Immature birds comprised over 90% of the Thick-billed Murres (Uria lomvia) autopsied in the lab in 1982 and 1983 (Table 8). There was strong concordance between the lab and field samples in 1982 and the lab sample in 1983. We suspect that many dark-headed Thick-billed Murres were classified as

adults in the field in 1983 regardless of whether or not they had bursas. We found in the lab that many Thick-billed Murres with dark heads still had bursas and therefore, according to our criteria, were sub-adults. Few of the Thick-billed Murres taken in 1982 or 1983 were breeding. We found only one bird with a brood patch in our 1982 lab sample (2%) and two individuals with brood patches in our 1983 lab sample (3.8%). Sex ratios of Thick-billed Murres in our lab samples for both years were not significantly diffferent (X^2 test; p .25).

Of the small alcids, only Ancient Murrelets and Crested Auklets were taken in sufficient numbers to warrant further attention here. In 1982, 33% of the Ancient Murrelets examined in the lab were immatures or sub-adults and 67% were adults. Thirty-two percent (10) of the 31 birds examined in 1982 had brood patches (48% of adults). In 1983, 50% of the birds examined in the lab were immatures or sub-adults and 50% were adults. Twenty-five percent (7) of the 28 birds examined in the lab in 1983 had brood patches (50% of adults). The sex ratios of Ancient Murrletes for both years were even (X^2 test; p .10).

For Crested Auklets, 55% of the birds examined in the lab in 1982 were immatures or sub-adults and 45% were adults. Thirty-two percent of the birds examined in the lab in 1982 had brood patches (84% of adults). In 1983, 63% of the birds examined in the lab were immature or sub-adults and 37% were adults. Thirty percent of the birds examined in the lab had brood patches (81% of adults). The sex ratios of Crested Auklets dissected in the lab were not significantly different (X^2 test; p .10).

In waters south of the Aleutian Islands, observers classifies 329 birds of 10 species as breeding based on the presence of brood patches. Over 64% of these were Tufted Puffins, 13% were Crested Auklets and 9% were Horned Puffins. Catch rates of breeding seabirds were negatively correlated with distance from land ($r = -.58$, p .025). The correlation was improved by taking the natural log of breeding birds caught per set ($r = -.65$, p .005). Catch rates of seabirds fell off sharply as distance from land increased (Figure 10). Breeding birds were infrequently taken outside of 60 nm.

Mortality Estimates

Mortality estimates were calculated for seabirds taken in the U.S. FCZ for each year of the study by multiplying the catch rates of seabirds for the portions of the FCZ north and south of the Aleutian Islands by the number of gillnet sets in each region (see bracketed regions in Table 12). The estimates of mortality for the northern and southern portions of the U.S. FCZ were then summed. Estimates of seabird mortality in the U.S. FCZ were 107,314 birds in 1981, 138,417 birds in 1982, 204,270 birds in 1983 and 79,769 birds in 1984. Based on these estimates of mortality and the species composition of the kill for each year, we calculated mortality estimates for each species for each year in the U.S. FCZ (Table 13).

Because over 2,000 additional gillnet sets occur each year outside of the U.S. FCZ, we also estimated overall mortality for the mothership fishery each year. These estimates were calculated in a similar fashion as those already presented but with the addition of those areas both north and south of the

U.S. FCZ. Only in 1984 do we have catch data for both regions. In 1982 we have data from the region south of the U.S. FCZ. For the region north of the U.S. FCZ in 1982 we used the same mortality rate data as for the northern portion of the FCZ (Bering Sea). In 1981 and 1983 we have data for only the U.S. FCZ. For the region north of the U.S. FCZ in 1981 and 1983 we used the same mortality rates as for the northern FCZ. For the area south of the U.S. FCZ, we calculated catch rate data for the 49°N latitude block, the southernmost part of the fishing zone for which we have sufficient data to calculate a mean. Attempts to further stratify the data by time and area resulted in only minor reductions in overall mortality estimates but greatly widened the 95% confidence intervals.

Overall mortality estimates varied from 95,093 in 1984 to 245,268 in 1983 (Table 12). An average of 162,749 birds were killed in Japanese salmon gillnets per year. Based on overall mortality estimates and the species composition of the kill, we calculated overall mortality estimates for each species by year (Table 14). Comparison of overall estimates of mortality and estimates of mortality from the U.S. FCZ suggest that about 82.2% of the seabirds killed in 1981, 76.8% of the seabirds killed in 1982, 83.3% of the seabirds killed in 1983, and 83.9% of the seabirds killed in 1984 were from the U.S. FCZ.

Only one other estimate of seabird mortality based on data from commercial catcherboats is available for the Japanese mothership fishery. Ogi (1984) estimates that between 120,000 and 130,000 seabirds were killed in the mothership fishery in 1981 which agrees favorably with our estimate of 134,000. Based on data from from research vessels, Ogi estimates that between

128,401 and 142,249 seabirds were taken in the mothership fishery between 1978 and 1980. Ainley et al. (1981), also using data from research vessels, argue that when consideration is given to variation in catch rates in various mesh sizes of research gear and the effects of distance from land, a more accurate estimate of mortality for 1978 is over 200,000 seabirds. Given the variation in catch rates we observed in the four years of this study, it seems likely that we have yet to experience either the low or high extreme in seabird mortality in the mothership fishery.

In addition to estimating the overall mortality of seabirds in the fishery we attempt to estimate the number of breeding birds of various species taken in the fishery in 1983. For Ancient Murrelets and Crested Auklets we multiplied the total number of birds killed in the mothership fishery by the proportion of breeding birds in our lab samples. We restricted the analysis to the U.S. FCZ because of the unlikely chance of finding breeding birds outside of this area. We estimate that about 544 breeding Ancient Murrelets and 3,937 breeding Crested Auklets were killed in the mothership fishery in 1983. For Tufted Puffins and Horned Puffins we estimated overall mortality per latitude block and multiplied this value by the proportion of breeding birds in each latitude block as determined in an earlier analysis (Tables 10, 12). Breeding puffins began to decrease in the 51°N latitude block, therefore we divided that block into three 20' zones and determined the proportion of various age groups of Tufted Puffins from the 1983 lab samples in each zone. The results reveal that breeding Tufted Puffins were common in the northern and middle portions of the 51°N latitude block but are absent in the southernmost portion where almost 50% of the commercial sets occurred

(Table 15). We estimate that about 5,087 breeding Tufted Puffins were killed in 1983. When field data from two reliable observers are included in this analysis the estimate of breeding Tufted Puffins decreases to 4,202 birds. Because of limited lab samples of Horned Puffins we were unable to stratify the 51°N latitude block. We estimate that about 1,209 breeding Horned Puffins were killed in 1983.

Impact of the fishery

Despite our current understanding of the magnitude of seabird mortality in the Japanese mothership fishery it is difficult to assess the impact of this fishery on seabird populations in the subarctic North Pacific Ocean and Bering Sea. Four factors complicate this task: 1) the origins of seabirds taken in this fishery are little understood; 2) estimates of nesting seabird populations in the western Aleutian Islands prior to the inception of the fishery are crude; 3) the difficulty in monitoring populations of nesting seabirds in the remote western Aleutian Islands and detecting real changes in populations; and 4) the lack of data on net related mortality from other driftnet fisheries in the North Pacific.

The lack of data on seabird mortality from the other driftnet fisheries is particularly frustrating as it is impossible to assess the collective impacts of driftnet fisheries on seabirds in the North Pacific when only one component of that mortality is known. Given the large populations of seabirds inhabiting the subarctic North Pacific (Gould et al. 1982, DeGange amd Sanger in press, Sanger in prep.) and the low annual mortality most species

experience in the mothership fishery, it is unlikely that the mothership fishery is harming these species, when viewed in isolation. Two species, however, the Short-tailed Shearwater and Tufted Puffin, are taken in far greater numbers than the other species of seabirds.

The world population of Short-tailed Shearwater is about 16 million birds (Naarding 1980). On the average about 98,000 Short-tailed Shearwaters are killed each year in the Japanese mothership fishery (assuming that most unidentified shearwaters are Short-tailed Shearwaters), most of which are HY birds. Prior to leaving their nesting grounds, HY Short-tailed Shearwaters are subjected to a commercial and non-commercial harvest which in recent years has taken between 663,000 and 849,000 nestlings (Naarding 1980). Therefore, on the average, losses in the mothership fishery and muttonbird harvest each year account for about 814,000 HY birds, or about 15% of the annual production. Naarding (1980) demonstrated that colonies of Short-tailed Shearwaters can sustain enormous harvests of young. Furthermore, estimates of survival used by Naarding in constructing life tables for Short-tailed Shearwaters in a commercially exploited colony were from Serventy (1967) and were based on data collected when the mothership fishery was considerably larger than today. Several band recoveries from the western North Pacific suggest that some banded birds were taken in Japanese gillnet fisheries (Guzman 1981) thus presumably these estimates of survival take into account losses from the mothership and land-based salmon fisheries. Although Tasmanian authorities feel that populations of Short-tailed Shearwaters have not diminished, intensive recreational "birding" at some colonies may be having some impact. Ultimately, destruction of shearwater nesting habitat

through erosion from livestock grazing and "birding, and mortality from domestic cats (Felis catus) may have a greater impact on Short-tailed Shearwater populations than the mothership fishery. Additional mortality from the squid driftnet fisheries, of which we know little, may exacerbate destruction of nesting habitat in Tasmania.

An estimated 4 million Tufted Puffins nest in Alaska (Sowls et al. 1978). The overall population of Tufted Puffins in the North Pacific is considerably larger than that when consideration is given to birds nesting in Asia and elsewhere in North America and to large numbers of young birds remaining at sea. Even excluding these birds, the average annual mortality of Tufted Puffins of 36,412 birds (Table 14) only comprises 0.9% of the Akaska breeding population. We conclude that the annual loss of Tufted Puffins in the Japanese mothership fishery is having a negligible impact on Tufted Puffin numbers in the subarctic North Pacific and Bering Sea.

Although mortality of seabirds from nets in the mothership fishery has a negligible impact on seabirds Pacific-wide, it is probably more appropriate to examine the impacts of the fishery more locally, such as on at-sea populations of seabirds in U.S. waters and on breeding populations in the western Aleutian Islands.

Populations of seabirds in the U.S, FCZ were estimated from 892 transects conducted from 1975 to 1984. Too few transects were conducted each summer to stratify the transect data by year thus all transect data were lumped to represent an average year. These data were stratified into seven geographic zones (Figure 11) as follows: zones 1 and 2 follow the 200 m and 2000 m isobaths respectively; zones 3 through 5 extend 30 nm beyond the previous zone

although zones 4 and 5 do not extend north of 53°N; zone 6 extends to the southern edge of the U.S. FCZ and north to 53°N and zone 7 includes all waters of the U.S. FCZ north of zone 3 or 53°N.

Mean densities of seabirds and catch rates of seabirds within each zone were calculated (Table 16). Catch rates of seabirds and densities of seabirds for the seven zones were positively correlated (p .05) for Ancient Murrelets, Tufted Puffins and Horned Puffins. Densities for most alcid species were highest in zones 1 and 2, corresponding to shelf and shelf break waters and progressively decreased in offshore zones. Murres seemed particularly dependent on nearshore waters and were infrequently seen offshore. The seeming dependence of murres on nearshore habitats in the western Aleutian Islands, where few gillnet sets occurred, most likely explains their low rates of mortality and the dearth of breeding birds taken in the fishery. Tufted Puffins on the other hand remained relatively more abundant than murres in the outer zones of the U.S. FCZ. Northern Fulmars, shearwaters, and Fork-tailed Storm-petrels, clearly three of the most proficient flyers of all seabirds in the study area, maintained comparatively high densities both inshore and offshore of the Near Islands.

We compared overall mortality estimates for seabirds in the U.S. FCZ (Table 13) with estimated population sizes for the most common seabirds in the study area affected by the gillnet fishery (Table 17). The comparisons suggest that about 0.2% of the Northern Fulmars, 5.1% of the shearwaters, 4.6% of the murres, and 1.7% of the Ancient Murrelets in the U.S. FCZ were killed in an average year in the Japanese fleet. In contrast, about 10.4% of the Crested Auklets, 18.9% of the Horned Puffins, and 28.7% of the Tufted Puffins

in the U.S. FCZ are killed in an average year. Such high percentages are clearly cause for alarm especially if all puffins were from one or two colonies in the western Aleutian Islands. It is more likely, however, that many of the immature alcids taken in the fishery were from numerous colonies both in North America and Asia.

Lastly, we attempt to estimate the impact of the gillnet fishery on breeding populations of seabirds nesting in the western Aleutian Islands. Over 5 million seabirds nest in the region west of and including Kiska Island (Figure 12, Table 18). It is unlikely that seabirds nesting on Kiska Island (180 km east of the U.S. FCZ) or the Commander Islands (200 km west of the U.S. FCZ) are killed in the mothership fishery unless they are failed breeders that have moved into the fishing zone. An exception may be the Northern Fulmars nesting on Mednyy Island (Markov 1963) although the overall number of fulmars killed annually is insignificant. Seabirds nesting on Buldir Island (60 km east of the U.S. FCZ) and Agattu Island (within the U.S. FCZ) probably are more heavily affected by the fishery than seabirds nesting on Attu Island, Shemya Island, and Alaid-Nizki Islands.

Restricting our analysis to 1983 data, for which we have the best sex and age information, we compared the estimated mortality of breeding birds with the annual breeding populations on Buldir Island and the Near Islands (Table 19). Insignificant numbers of Northern Fulmars, storm-petrels, and Crested Auklets were killed relative to their overall populations, however, much larger percentages of breeding Ancient Murrelets, Tufted Puffins and Horned Puffins were killed in 1983.

Seabirds generally are long lived animals (Ashmole 1971) although

estimates of survival are not known for alcids in Alaska. In the eastern North Atlantic, Atlantic Puffins (F. arctica) experience high survival, ranging from 94 - 96% annually (Ashcroft 1979, Harris 1983, Mead 1974). We geuss that puffins in Alaska have similarly high survival. If so, then estimated losses of Tufted and Horned Puffins in the mothership fishery triple and double respectively, annual mortality to these species from natural causes. Thus for each 1000 pairs of Tufted Puffins breeding in the western Aleutian Islands, 220 birds must be replaced for the population to remain stable when natural mortality of breeding birds is 4% and gillnet mortality is about 7%. Based on average production values of Tufted Puffins in the Gulf of Alaska (DeGange and Sanger in press), we estimate that 1000 pairs of Tufted Puffins will produce 416 fledglings. For the breeding population to remain stable, more than 50% of those fledglings must survive to breeding age. If annual mortality of breeding birds in the gillnet fishery is 8.7% then survival of immature puffins must exceed 60%. These values are high compared to estimates of survival for young alcids in the North Atlantic which range from 20 - 41% (Harris 1983).

In 1982, we censused seabird colonies on eastern Agattu Island. For murres and Horned Puffins, the only species for which historical data are available, we cautiously conclude that no appreciable changes have occurred in their populations in the last 10 years. Unfortunately, there were no similar data for Tufted Puffins. It was our subjective impression that the few islets on which Tufted Puffins nest were saturated with puffins. If natural mortality coupled with losses in the gillnet fishery is greater than the annual production of Tufted Puffins in the western Aleutian Islands, perhaps

populations of Tufted Puffins are maintained through immigration. Harris (1983) suggests that such a phenomenon may have been partly responsible for the increase in Atlantic Puffins on the Isle of May in the last few decades.

Recommendations

Despite an annual mortality of over 160,000 seabirds in the Japanese mothership fishery, we feel that this fishery, when viewed in isolation, is not causing significant harm to seabird populations in the North Pacific. We stress, however, that we know little of the impacts of the other driftnet fisheries on seabirds in the North Pacific. The collective impacts of all these fisheries may be significant.

It is clear that in some years thousands of breeding birds are killed in the mothership fishery although we have been unable to demonstrate that these losses are decreasing populations of breeding birds in the western Aleutian Islands. We recommend that a no fishing zone be established around the western Aleutian Islands. This fishing-free zone would decrease the mortality of both breeding and non-breeding seabirds in the U.S. FCZ. Based on the results of our research, we suggest that a closure out to 50-60 nm may be appropriate.

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Table 1. Catch rates of seabirds (+ 1 SD) from four regions of the Japanese salmon mothership fishing zone.

Region	1981	1982	1983	1984
South of U.S. FCZ	No Data	16.0 ± 8.7 (6)	No Data	10.1 ± 4.2 (8)
South U.S. FCZ	17.3 ± 20.9 (260)	22.6 ± 26.9 (257)	37.2 ± 59.9 (232)	14.5 ± 16.6 (261)
North U.S. FCZ	11.0 ± 5.7 (2)	15.5 ± 8.0 (14)	12.3 ± 9.8 (34)	2.1 ± 1.2 (7)
North of U.S. FCZ	No Data	No Data	No Data	1.4 ± 1.5 (68)

Table 2. Species composition of seabirds killed in Japanese salmon gillnets within the U.S. FCZ from 1981 - 1984.

SPECIES	PERCENT OF TOTAL				
	1981 N=4510	1982 N=6035	1983 N=9058	1984 N=3983	1981-84
Laysan Albatross	0.2	0.0	0.0	0.1	tr[1]
Northern Fulmar	2.4	1.0	1.1	1.6	1.5
Sooty Shearwater	0.1	0.4	0.2	0.5	0.3
Short-tailed Shearwater	8.3	43.3	72.5	65.9	47.5
Unid. shearwater	45.7	1.6	0.7	0.0	12.0
Fork-tailed Storm-Petrel	1.2	0.4	0.4	0.7	0.7
Leach's Storm-Petrel	0.1	0.0	tr	0.1	tr
Pomarine Jaeger	tr	tr	0.0	0.0	tr
Black-legged Kittiwake	0.1	tr	tr	0.0	tr
Thick-billed Murre	0.6	1.7	3.5	2.5	2.1
Common Murre	1.4	0.9	0.6	1.1	1.0
Unid. murre	2.2	1.4	0.3	0.1	1.0
Pigeon Guillemot	tr	0.0	tr	0.0	tr
Dovekie	0.0	tr	0.0	0.0	tr
Ancient Murrelet	0.4	1.3	0.8	1.2	0.9
Crested Auklet	7.6	1.5	3.3	0.3	3.2
Least Auklet	tr	0.1	0.1	0.2	0.1
Parakeet Auklet	0.2	0.5	0.4	0.6	0.4
Cassin's Auklet	0.2	0.1	0.2	0.1	0.2
Unid. small alcid		0.2	0.1	0.2	0.2
Rhinoceros Auklet	tr	tr	0.0	0.0	tr
Horned Puffin	4.5	6.8	2.6	6.7	5.2
Tufted Puffin	21.0	38.3	13.1	18.1	22.6
Unid. bird	0.5	0.1	tr	0.0	0.2

[1] tr = trace

Table 3. Frequency of occurrence of seabirds in Japanese salmon gillnets within the U.S. FCZ from 1981 through 1984.

SPECIES	PERCENT OF SETS OCCURING				
	1981 N=262	1982 N=271	1983 N=266	1984 N=268	1981-84 $\bar{X}$
Laysan Albatross	3.4	0.0	0.0	1.4	1.2
Northern Fulmar	20.9	16.2	22.6	16.7	19.1
Sooty Shearwater	1.1	2.9	2.3	3.6	2.5
Short-tailed Shearwater	16.0	73.1	83.5	84.4	64.3
Unid. shearwater	67.6	4.4	3.4	0.0	18.9
Fork-tailed Storm-Petrel	14.9	7.7	9.4	8.0	10.0
Leach's Storm-Petrel	1.5	0.0	1.5	1.4	1.1
Pomarine Jaeger	0.4	0.4	0.0	0.0	0.2
Black-legged Kittiwake	2.3	1.1	0.8	0.0	1.1
Thick-billed Murre	7.6	21.4	49.2	18.8	24.3
Common Murre	15.3	12.9	13.5	9.8	12.9
Unid. murre	20.2	8.5	4.5	1.4	8.7
Pigeon Guillemot	0.4	0.0	0.4	0.0	0.2
Dovekie	0.0	0.4	0.0	0.0	0.1
Ancient Murrelet	6.1	17.7	16.2	11.6	12.9
Crested Auklet	11.8	8.5	12.0	2.9	8.8
Least Auklet	0.4	2.9	2.2	1.8	1.8
Parakeet Auklet	3.8	10.3	8.3	6.2	7.2
Cassin's Auklet	1.5	2.6	5.3	0.4	2.5
Unid. small alcid	6.5	2.6	1.5	1.4	3.0
Rhinoceros Auklet	0.8	0.4	0.0	0.0	0.3
Horned Puffin	39.3	65.7	39.5	46.0	47.6
Tufted Puffin	68.7	98.2	80.1	72.5	79.9
Unid. Bird	3.8	2.6	1.1	0.0	1.9

Table 4. Catch rates of seabirds killed in Japanese salmon gillnets within the U.S. FCZ from 1981 - 1984.

SPECIES	BIRDS PER SET				
	1981	1982	1983	1984	1981-84
Laysan Albatross	0.03	0.00	0.00	0.02	0.01
Northern Fulmar	0.42	0.22	0.38	0.22	0.31
Sooty Shearwater	0.01	0.09	0.06	0.07	0.06
Short-tailed Shearwater	1.43	9.65	24.68	9.29	11.26
Unid. shearwater	7.87	0.36	0.25	0.00	2.12
Fork-tailed Storm-petrel	0.21	0.10	0.13	0.10	0.14
Leach's Storm-petrel	0.02	0.00	0.02	0.01	0.01
Pomarine Jaeger	tr[1]	tr	0.00	0.00	tr
Black-legged Kittiwake	0.02	0.01	0.01	0.00	0.01
Thick-billed Murre	0.10	0.39	1.18	0.36	0.51
Common Murre	0.23	0.20	0.22	0.16	0.20
Unid. murre	0.37	0.31	0.09	0.01	0.19
Pigeon Guillemot	tr	0.00	tr	0.00	tr
Dovekie	0.00	tr	0.00	0.00	tr
Ancient Murrelet	0.06	0.29	0.27	0.16	0.19
Crested Auklet	1.31	0.34	1.14	0.05	0.71
Least Auklet	tr	0.03	0.04	0.02	0.02
Parakeet Auklet	0.04	0.11	0.12	0.08	0.09
Cassin's Auklet	0.04	0.03	0.07	0.01	0.04
Unid. small alcid	0.18	0.04	0.03	0.03	0.07
Rhinoceros Auklet	0.01	tr	0.00	0.00	tr
Horned Puffin	0.78	1.52	0.88	0.95	1.03
Tufted Puffin	3.62	8.53	4.47	2.54	4.79
Unid. Bird	0.09	0.03	0.01	0.00	0.03

[1] tr = trace

Table 5. Species composition, frequency of occurrence, and catch rates of seabirds killed in six gillnet sets south of the U.S. FCZ in 1982.

Species	No.	Percent of Total	Frequency of Occurrence	Birds Per Set
Northern Fulmar	1	1.0	16.7	.17
Sooty Shearwater	8	8.3	50.0	1.33
Short-tailed Shearwater	29	30.2	83.3	4.83
Ancient Murrelet	1	1.0	16.7	.17
Tufted Puffin	51	53.1	100.0	8.50
Horned Puffin	6	6.3	66.7	1.00

Table 6. Percent of total, frequency of occurrence and catch rates of seabirds killed in 68 gillnet sets north of the U.S. FCZ in 1984 (N = 94 birds).

Species	Percent of Total	Frequency of Occurrence	Birds Per Set
Northern Fulmar	9.6	13.2	0.13
Short-tailed Shearwater	30.9	27.9	0.43
Pomarine Jaeger	1.1	1.5	0.01
Common Murre	5.3	7.4	0.07
Thick-billed Murre	14.9	14.7	0.21
Unidentified murre	2.1	2.9	0.03
Least Auklet	4.3	5.9	0.06
Parakeet Auklet	1.1	1.5	0.01
Unidentified small alcid	3.2	4.4	0.04
Tufted Puffin	17.0	17.6	0.24
Horned Puffin	10.6	13.2	0.15

Table 7. Depth in salmon gillnet where seabirds were caught (n = 1370).

	Depth in Net (m)							
Species	1	2	3	4	5	6	7	8
Northern Fulmar	10							
Short-tailed Shearwater	454	110	39	22	6	4	1	1
Fork-tailed Storm-Petrel	4	1						
Murres	22	7	5	6	3	3	1	
Tufted Puffin	122	142	103	105	31	40	16	4
Horned Puffin	21	17	14	16	7	7	1	1
Small alcids	14	7	2		1			
Total birds	647	284	163	149	48	54	19	6
Percent of Total	47.2	20.7	11.9	10.9	3.5	3.9	1.4	0.4

Table 8. Age composition of four major species of seabirds from the Japanese mothership fishery examined on catcherboats and in the laboratory.

Species	Field 1982		Lab 1982		Field 1983		Lab 1983	
	No.	%	No.	%	No.	%	No.	%
Short-tailed Shearwater								
Hatching Year	68	73.9	40	85.1	4314	91.7	13	81.3
After Hatching Year	24	26.1	7	14.9	391	8.3	3	18.8
Thick-billed Murre								
Immature or Subadult	11	100.0	48	94.1	40	57.1	53	89.8
Adult	0	0	3	5.9	30	42.9	6	10.2
Tufted Puffin								
One-year	127	24.9	57	25.6	81	8.3	9	5.2
Subadult	257	50.3	140	62.8	344	35.3	82	47.7
Adult	127	24.9	26	11.6	550	56.4	81	47.1
Horned Puffin								
One-year	8	16.3	11	12.8	14	8.2	3	7.5
Sub-adult	15	30.6	66	76.7	49	28.8	23	57.5
Adult	26	53.1	9	10.5	107	62.9	14	35.0

Table 9. Age cohorts of Tufted Puffins from collections made by four observers in 1983. Seabird colonies in the Near Islands occur between 52° N and 53° N.

Latitude	Birds Examined	PERCENT OF TOTAL PUFFINS			
		One-year Old	Subadult	Adults (Non Breeding)	Adults (Breeding)
49° - 50°	4	0.0	100.0	0.0	0.0
50° - 51°	36	2.8	63.9	25.0	8.3
51° - 52°	119	1.7	29.4	21.8	47.1
52° - 53°	51	0.0	33.3	13.7	53.0
53° - 54°	28	17.9	60.7	10.7	10.7
54° - 56° [1]	10	20.0	80.0	0.0	0.0

[1] 54°N and 55°N blocks lumped because of small sample sizes.

Table 10. Age cohorts of Tufted Puffins from collections made in 1982. Seabird colonies in the Near Islands occur between 52° N and 53° N.

LATITUDE	BIRDS EXAMINED	PERCENT OF TOTAL PUFFINS			
		ONE-YEAR OLD	SUBADULT	ADULTS (NON BREEDING)	ADULTS (BREEDING)
48° - 49°	4	0.0	100.0	0.0	0.0
49° - 50°	53	15.1	83.0	1.9	0.0
50° - 51°	71	32.4	56.3	9.9	1.4
51° - 52°	49	32.7	40.8	20.4	6.1
52° - 53°	3	33.3	66.7	0.0	0.0
53° - 54°	2	50.0	0.0	50.0	0.0
54° - 55°	7	14.3	71.4	14.3	0.0
55° - 56°	1		100.0		

Table 11. Age cohorts of Horned Puffins from collections made by four observers in 1983. The seabird colonies in the Near Islands occur between 52° N and 53° N.

Latitude	Birds Examined	PERCENT OF TOTAL One-year Old	Subadult	Adults (Non-breeding)	Adults (Breeding)
49° -50°	2	0.0	100.0	0.0	0.0
50° - 51°	16	6.2	56.3	12.5	25.0
51° - 52°	26	0.0	46.2	26.9	26.9
52° - 53°	5	0.0	100.0	0.0	0.0
53° - 54°	2	0.0	100.0	0.0	0.0
54° - 56° [1]	9	22.2	33.3	33.3	11.1

[1] 54°N and 55°N blocks lumped because of small sample sizes.

Table 12. Catch rates of seabirds (+ 95% confidence interval) and overall mortality estimates of seabirds (+95% confidence interval) in the Japanese mothership salmon fishery.

		Catch Rate	Mortality Estimate
1981	South of FCZ	7.20 ± 1.94	9922 ± 2673
	Southern FCZ	17.30 ± 2.56	106533 ± 15764
	Northern FCZ	11.00 ± 50.8	781 ± 3606
	North of FCZ	11.00 ± 50.8	13244 ± 61163
	Total		130480 ± 83206
1982	South of FCZ	16.00 ± 8.64	19264 ± 10403
	Southern FCZ	22.63 ± 3.31	133472 ± 19522
	Northern FCZ	15.50 ± 4.59	4945 ± 1464
	North of FCZ	15.50 ± 4.59	22475 ± 6656
	Total		180156 ± 38045
1983	South of FCZ	15.62 ± 6.48	21493 ± 8916
	Southern FCZ	37.24 ± 7.76	192047 ± 40018
	Northern FCZ	12.26 ± 3.45	12223 ± 3439
	North of FCZ	12.26 ± 3.45	19505 ± 5489
	Total		245268 ± 57862
1984	South of FCZ	10.10 ± 3.47	13898 ± 4775
	Southern FCZ	14.53 ± 1.99	79406 ± 10875
	Northern FCZ	2.14 ± 1.09	472 ± 241
	North of FCZ	1.38 ± 0.36	1840 ± 480
	Total		95616 ± 16371

Table 13. Total mortality of seabirds in the U.S. FCZ by year.

Species	1981	1982	1983	1984	$\bar{X}$
Laysan Albatross	215	0	0	79	74
Northern Fulmar	2575	1384	2247	1276	1870
Sooty Shearwater	107	554	408	399	367
Short-tailed Shearwater	8907	59935	148096	52568	67377
Unid. shearwater	49042	2215	1429	0	13171
Fork-tailed Storm-petrel	1288	554	817	558	804
Leach's Storm-petrel	107	0	tr	80	47
Pomarine Jaeger	tr	tr	0	0	tr
Black-legged Kittiwake	107	tr	tr	0	27
Thick-billed Murre	644	2353	7149	1994	3035
Common Murre	1502	1246	1226	877	1213
Unid. murre	2361	1938	613	80	1248
Dovekie	0	tr	0	0	tr
Ancient Murrelet	429	1799	1634	957	1205
Crested Auklet	8156	2076	6741	239	4303
Least Auklet	tr	138	204	160	126
Parakeet Auklet	215	692	817	479	551
Cassin's Auklet	215	138	408	80	210
Unid. small alcid	0	277	204	160	160
Rhinoceros Auklet	tr	tr	0	0	tr
Tufted Puffin	22536	53014	26759	14438	29187
Horned Puffin	4829	9412	5311	5345	6224
Unid. puffin	2254	0	1012	0	816
Unid. bird	537	138	tr	0	169

Table 14. Estimates of seabirds lost in the Japanese salmon mothership fishery by year and species.

Species	1981	1982	1983	1984	X
Laysan Albatross	261	0	0	95	40
Northern Fulmar	3131	1802	2698	1712	2336
Sooty Shearwater	130	721	491	475	454
Short-tailed Shearwater	10830	78007	177819	61906	82140
Unidentified Shearwater	59629	2882	1717	0	16057
Fork-tailed Storm-Petrel	1566	721	981	666	984
Leach's Storm-Petrel	130	0	tr	95	56
Pomarine Jaeger	tr	tr	0	tr	tr
Black-legged Kittiwake	130	tr	tr	0	33
Thick-billed Murre	783	3063	8584	2663	3773
Common Murre	1827	1621	1472	1141	1515
Unidentified Murre	2871	2522	736	190	1580
Dovekie	0	tr	0	0	tr
Pigeon Guillemot	tr	0	0	tr	tr
Ancient Murrelet	522	2342	1962	1046	1468
Crested Auklet	9916	2702	8094	285	5249
Least Auklet	tr	180	245	285	178
Parakeet Auklet	261	901	981	571	679
Cassin's Auklet	261	180	491	95	257
Unidentified small alcid	0	360	245	285	222
Rhinoceros Auklet	tr	tr	0	0	tr
Tufted Puffin	27401	68999	32130	17117	36412
Horned Puffin	5872	12251	6377	6466	7742
Unidentified puffin	2740	0	0	0	685
Unidentified bird	652	180	tr	0	208

Table 15. Age cohorts of Tufted Puffins caught in gillnets in three 20' zones of the 51°N latitude block.

Location	Age	Percent of Total
51°00' N - 51°20' N	Breeding Adult	0.0
	Non-breeding Adult	16.7
	Sub-adult	73.3
	One-year Old	10.0
51°20' N - 51°40' N	Breeding Adult	21.8
	Non-breeding Adult	33.3
	Sub-adult	30.8
	One-year Old	14.1
51°40' N - 52°00' N	Breeding Adult	54.1
	Non-breeding Adult	25.9
	Sub-adult	20.0
	One-year Old	0.0

Table 16. Densities (den) of seabirds (B/km^2) and number of birds killed per set (kill) in 6 zones south of 53°20 north within the fishery zone,

SPECIES	0-200 m	200-2000m		2000m-30nm		30.1-60nm		60-90nm		GREATER THAN 90nm	
	DEN	DEN	KILL	DEN	KILL	DEN	KILL	DEN	KILL	DEN	KILL
Northern Fulmar	4.67	16.67	0.00	6.63	0.60	2.32	0.39	1.02	0.20	1.87	0.23
Dark Shearwaters	8.98	15.25	18.57	2.06	33.86	12.24	20.91	9.90	15.40	8.44	10.51
Fork-tailed Storm-Petrel	4.52	20.01	0.00	10.91	0.47	1.19	0.58	2.63	0.09	2.56	0.03
Leach's Storm-Petrel	0.04	0.73	0.14	1.55	0.13	2.70	0.03	2.84	0.01	1.37	0.003
Murres	10.45	1.46	2.14	0.29	1.56	0.00	1.51	0.01	0.81	0.07	0.44
Ancient Murrelet	3.94	2.10	1.00	0.70	0.70	0.20	0.38	0.04	0.19	0.06	0.10
Cassin's Auklet	0.09	0.28	0.14	0.14	0.06	0.00	0.09	0.00	0.03	0.00	0.02
Parakeet Auklet	0.07	0.15	0.86	0.06	0.20	0.00	0.18	0.00	0.13	0.00	0.06
Least Auklet	0.39	0.32	0.00	0.31	0.09	0.10	0.06	0.00	0.01	0.00	0.02
Crested Auklet	0.53	0.33	0.14	0.31	4.46	0.00	0.23	0.08	0.07	0.11	0.02
Unidentified Small Alcid	1.01	5.89	0.00	0.17	0.04	0.08	0.03	0.01	0.04	0.03	0.03
Horned Puffin	0.18	0.13	2.00	0.07	1.73	0.10	1.51	0.07	0.89	0.06	1.01
Tufted Puffin	3.76	3.00	8.28	2.14	9.79	0.89	5.35	0.48	3.84	0.10	4.90
Steller's Sea Lion	0.12	0.04		0.02		0.00		0.00		0.00	
Sample Size	499	147	6	120	80	22	108	54	160	19	401

Table 17. Percent of estimated populations of seabirds in the U.S. FCZ killed in gillnets of the mothership fishery.

Species	Estimated Population	Estimated Mortality	Percent of Total Killed
Northern Fulmar	723,354	1,870	0.3
Dark Shearwaters	1,743,755	80,915	4.6
Murres	114,284	5,496	4.8
Ancient Murrelet	87,210	1,205	1.4
Crested Auklet	29,678	4,303	14.5
Tufted Puffin	108,094	29,187	27.0
Horned Puffin	35,354	6,224	17.6

Table 18. Population estimates of seabirds nesting in the western Aleutian Islands.

	AGATTU	ATTU SHEMYA ALAID-NIZKI	BULDIR	KISKA
Northern Fulmar	0	0	1,240	0
Fork-tailed Storm-Petrel	6,000	+	1,710,000	+
Leach's Storm-Petrel	6,000	+	1,290,000	+
Total Cormorants	12,500	46,000	500	1,200
Glaucous-winged Gull	6,000	10,200	5,000	1,900
BLack-Legged Kittiwakes	13,200	4,600	21,600	700
Red-Legged Kittiwakes	0	0	4,400	0
Common Murre	11,900 c	P-	2,400 c	0
Thick-billed Murre	2,500 c	-	24,600 c	0
Total Murre (estimates)	19,500	16,000	36,600	0
Pigeon Guillemot	300	300	300	910
Ancient Murrelet	3,000	P	10,000	+
Cassin's Auklet	100	P	400	0
Parakeet Auklet	P	+	12,000	4,000
Least Auklet	0	0	140,000	1,160,000
Whiskered Auklet	50	100?	3,000	+
Crested Auklet	0	0	280,000	232,000
Horned Puffin	400	1,100	20,000	8,500
Tufted Puffin	18,000	20,500	20,000	16,600
Steller's Sea Lion	11,000	6,900	6,300	6,200

c = actual count of birds or nests;
+ = presence confirmed; numbers unknown;
P = probably present;

Table 19. Estimated mortality of breeding birds in the Japanese mothership gillnet fishery and percent of total breeding populations in the western Aleutian Islands.

Species	Breeding Population	Estimated Mortality	Percent of Breeding Population
Murres	72,100	278	0.4
Ancient Murrelet	13,000 +	544	4.2
Crested Auklet	280,000	3,937	1.4
Tufted Puffin	58,500	4,202 [1] 5,087	7.2 8.7
Horned Puffin	21,500	1,029	4.8

[1] see text

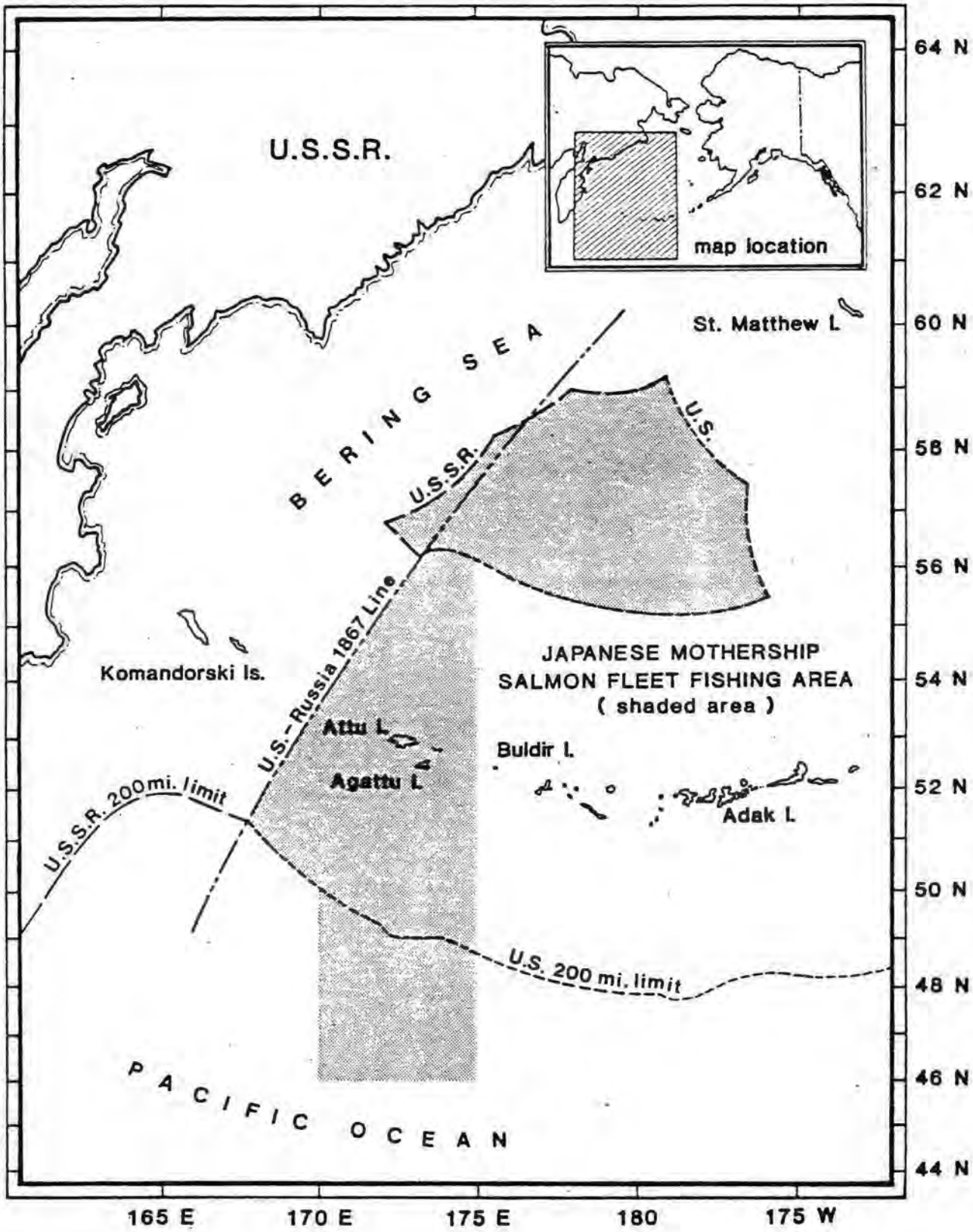


FIGURE 1. AREA open to the Japanese mothership salmon fishery.

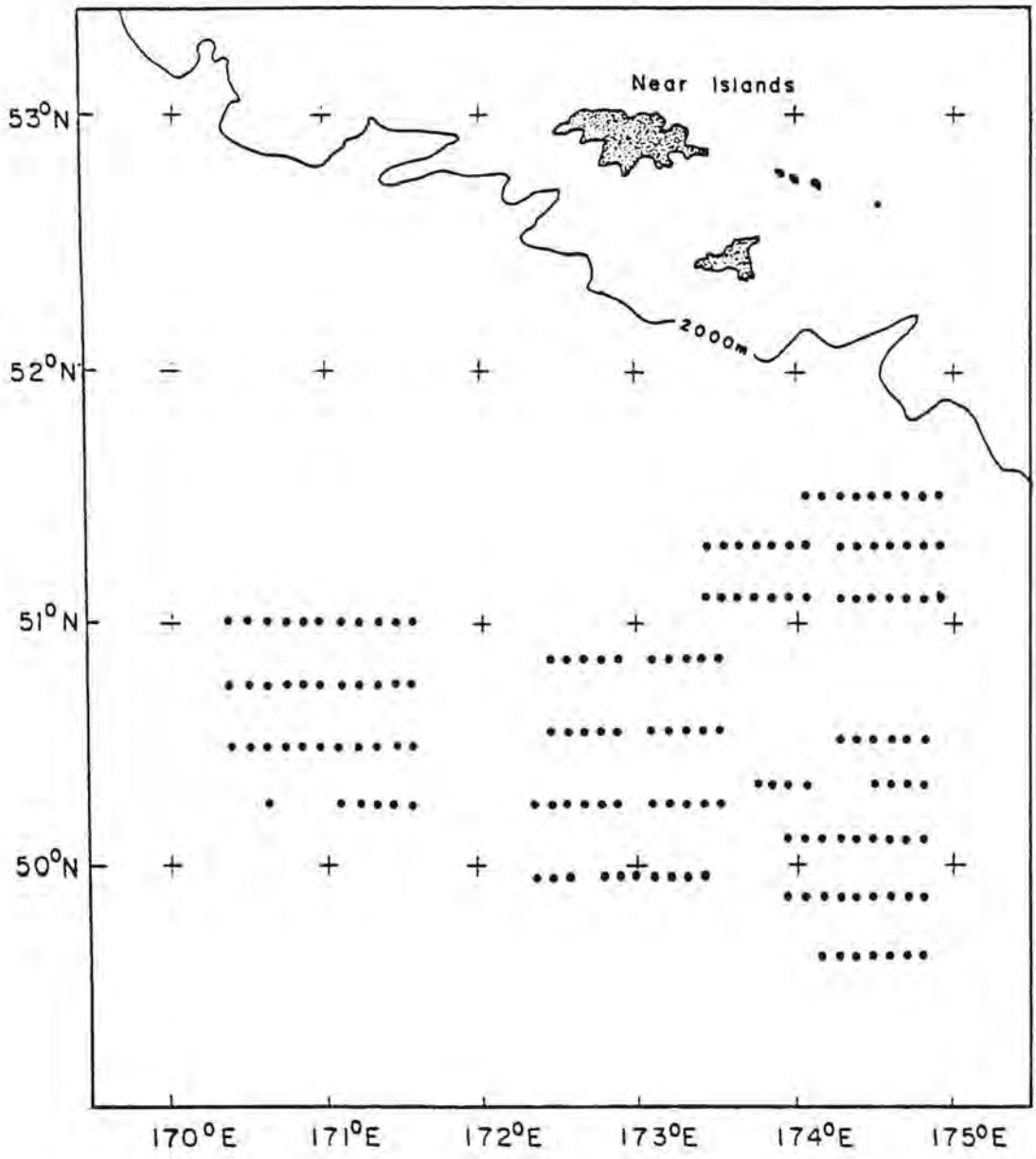


FIGURE 2. Typical set array of four mothership salmon fleets, 17 June 1985

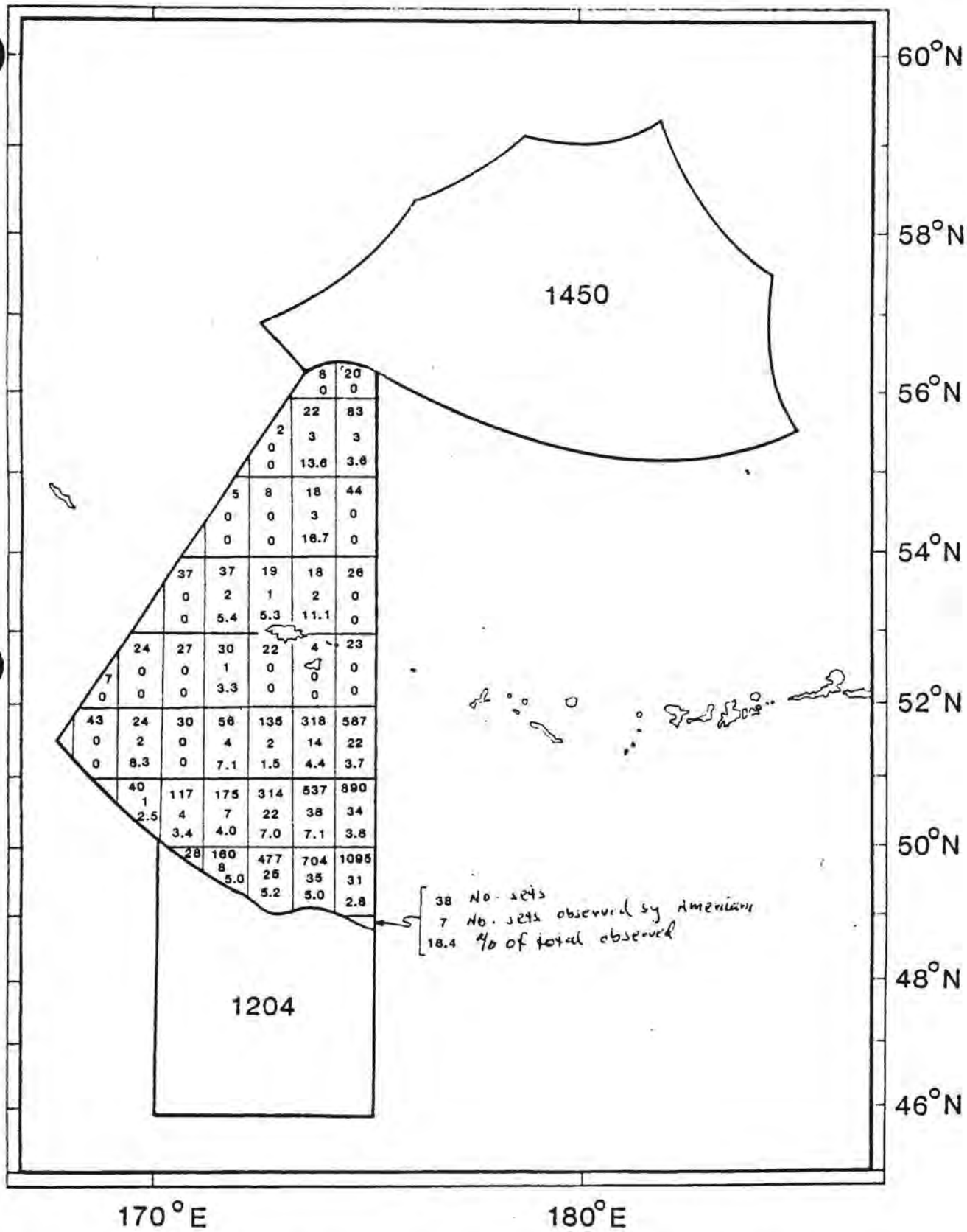


FIGURE 3. Fishing effort of salmon mothership fleets in 1982 and coverage by American observers.

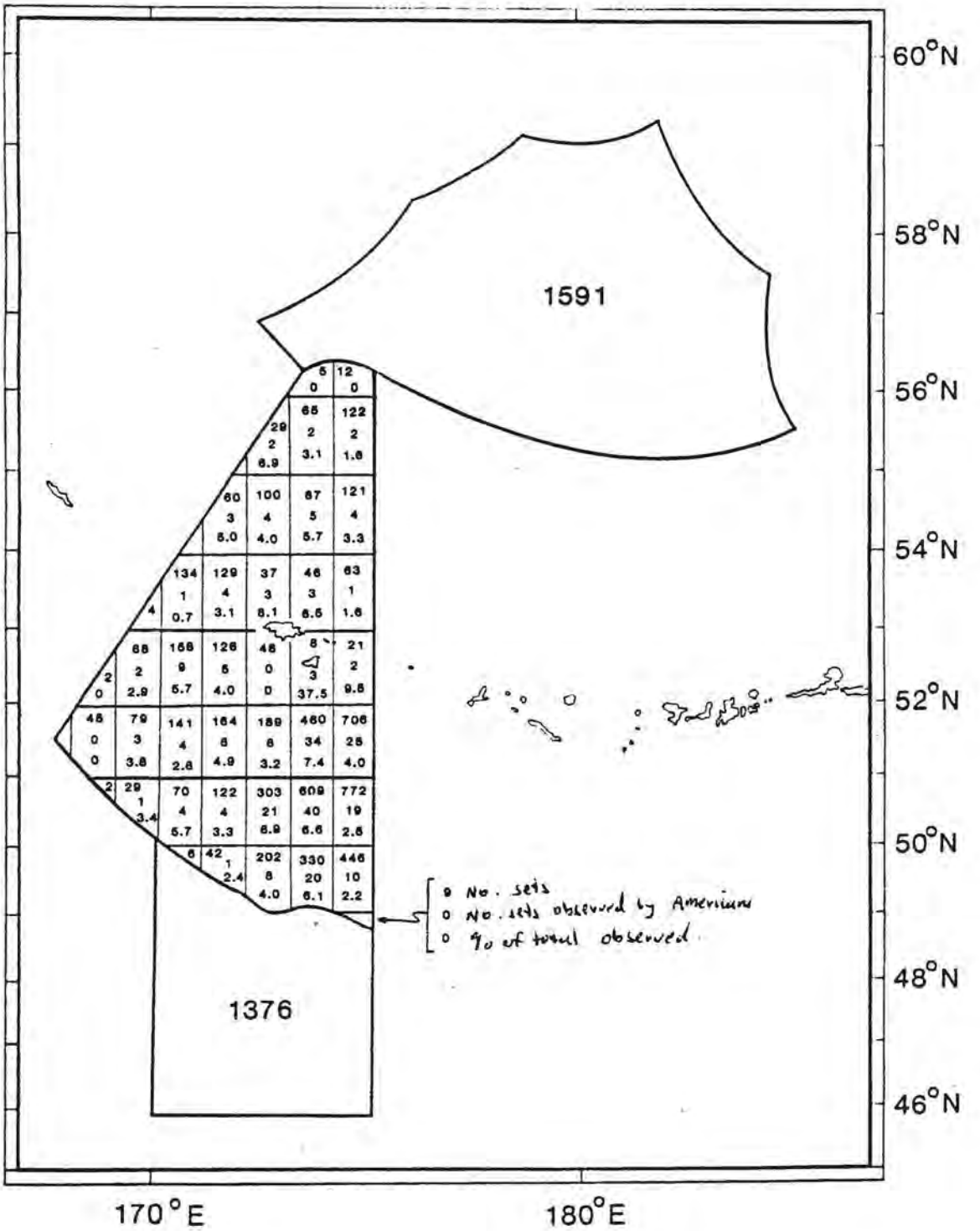


FIGURE 4. Fishing effort of salmon mothership fleets in 1983 and coverage by American observers ~~in 1983~~

170°E 1110

1983

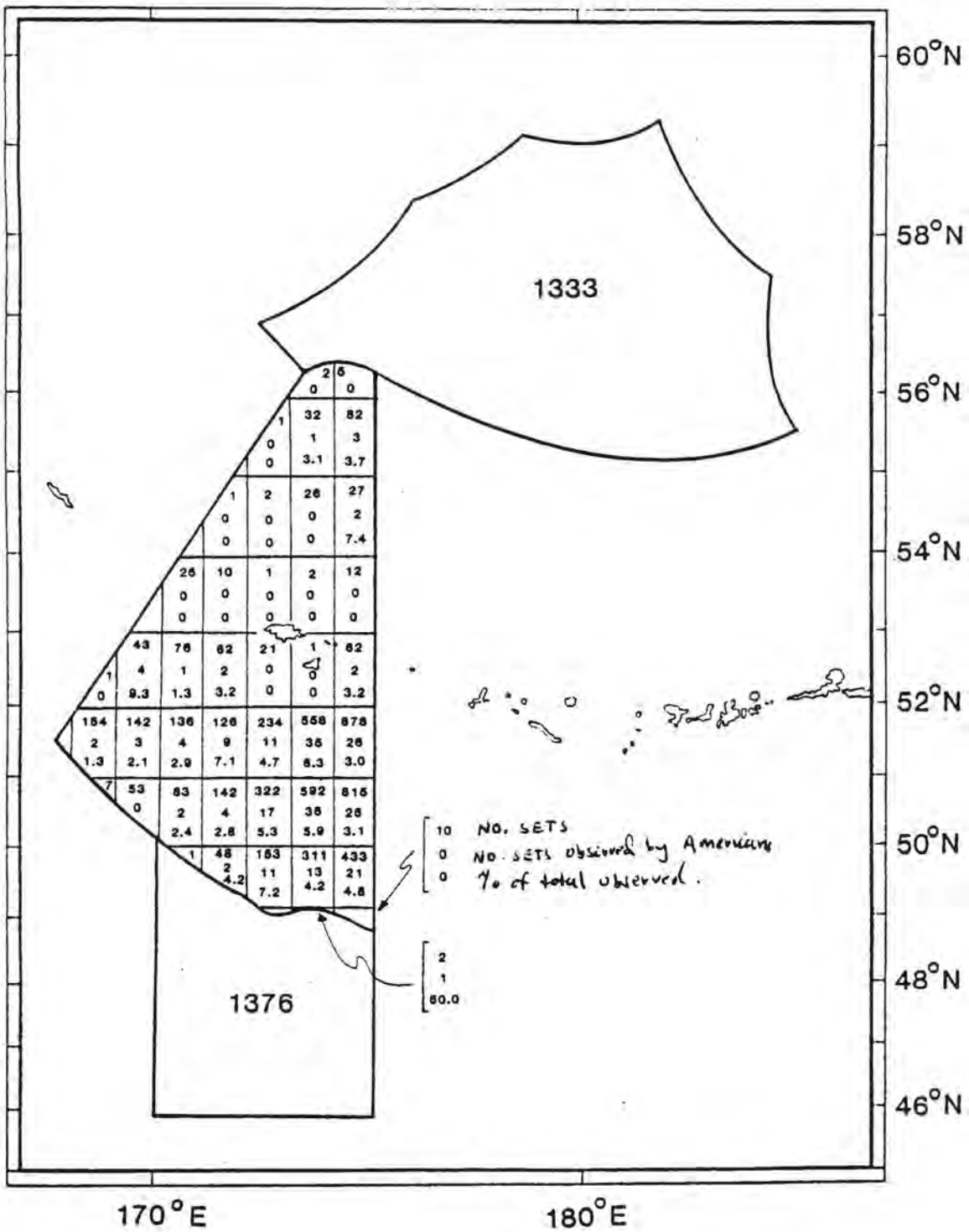


Figure 5. Fishing effort of salmon mothership fleets, 1984.

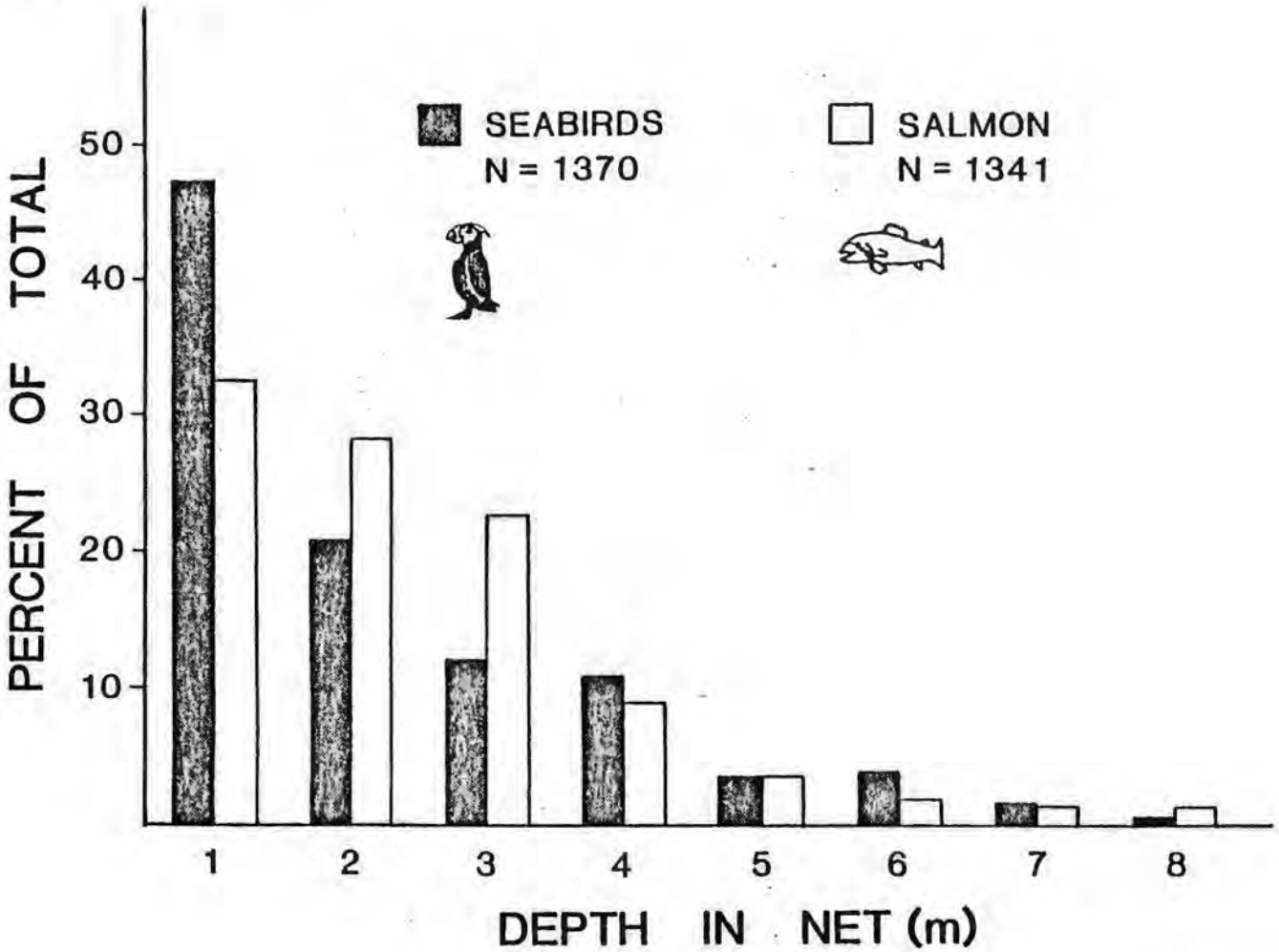


FIGURE 6. Comparison of depth of seabirds and depth of salmon caught in Japanese salmon gillnets

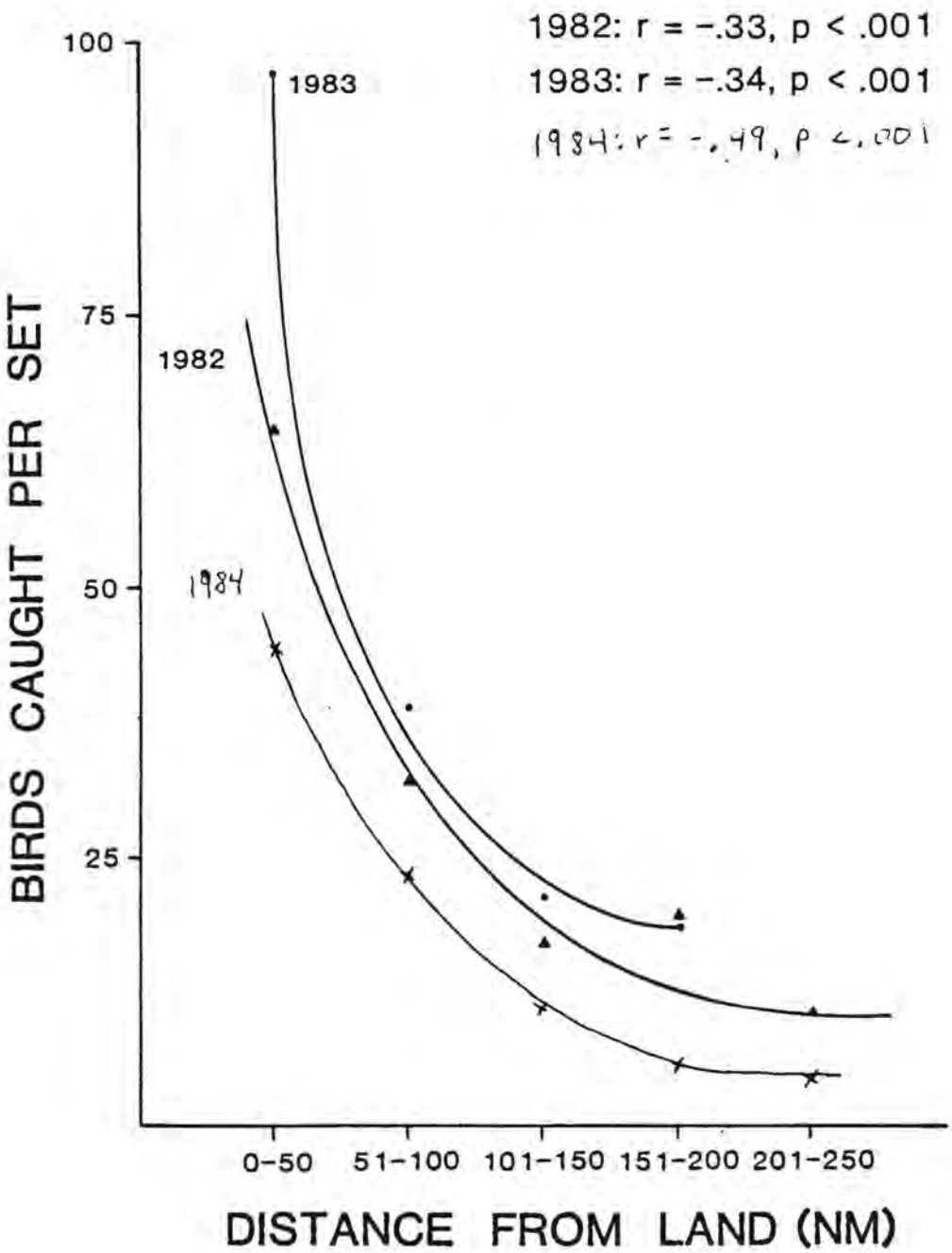


FIGURE 7. Relationship of catch rates of seabirds and distance from land, 1981-1983.

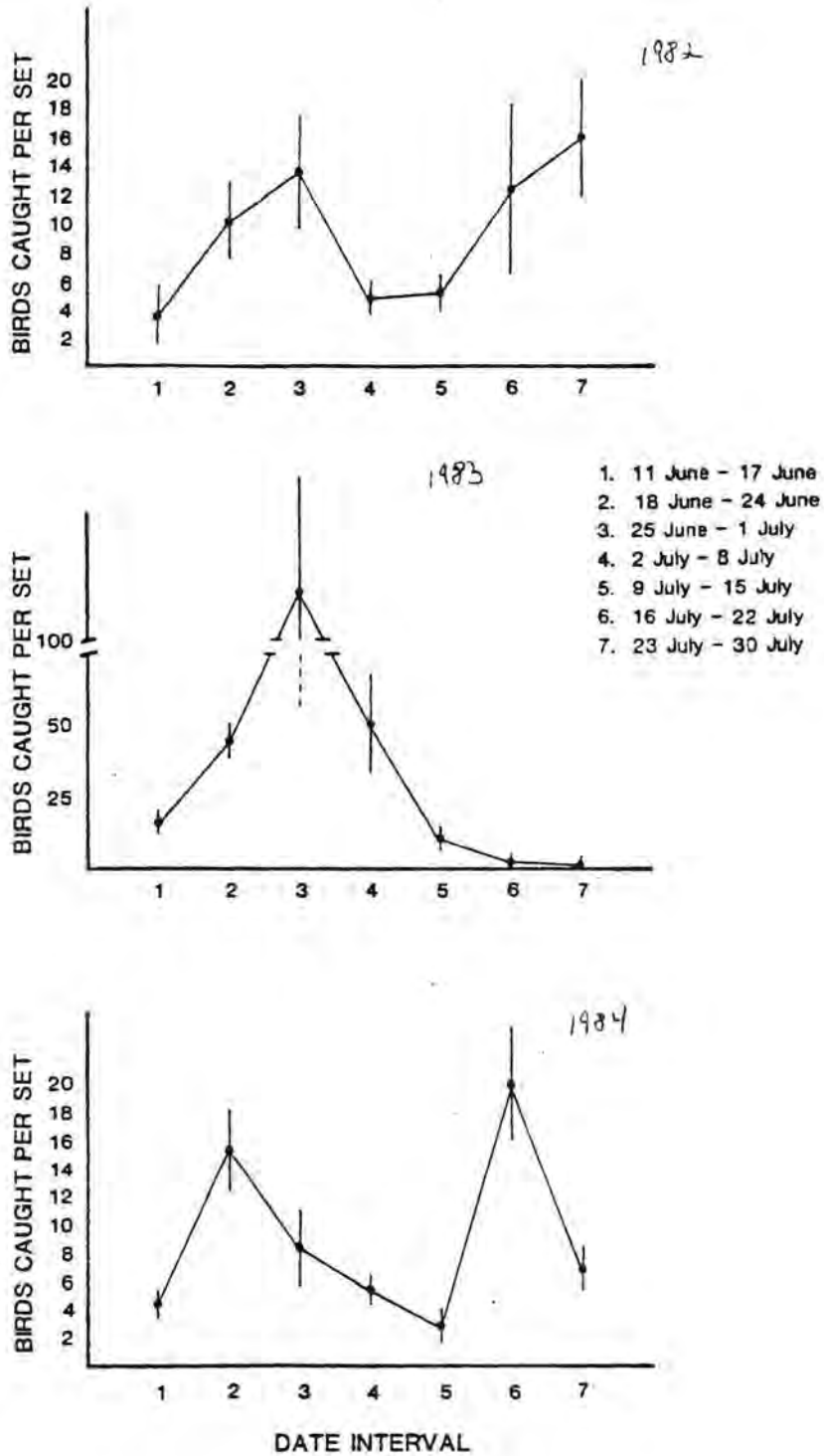


FIGURE 8. Catch rates of shearwaters for seven-day intervals south of the Aleutian Islands.

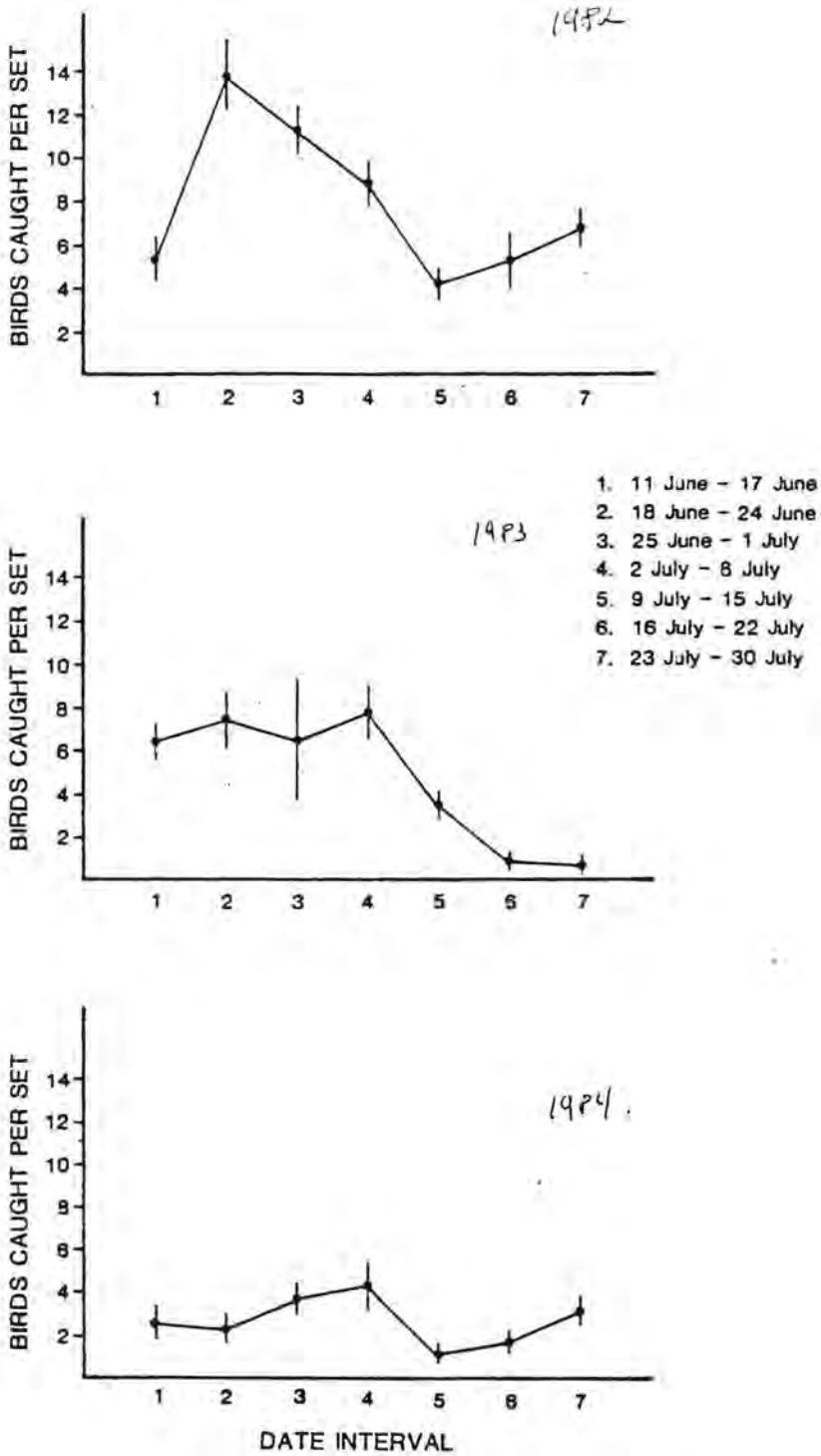


FIGURE 9. Catch rates of Tufted Puffins in salmon gillnets during seven-day intervals south of the Aleutian Islands.

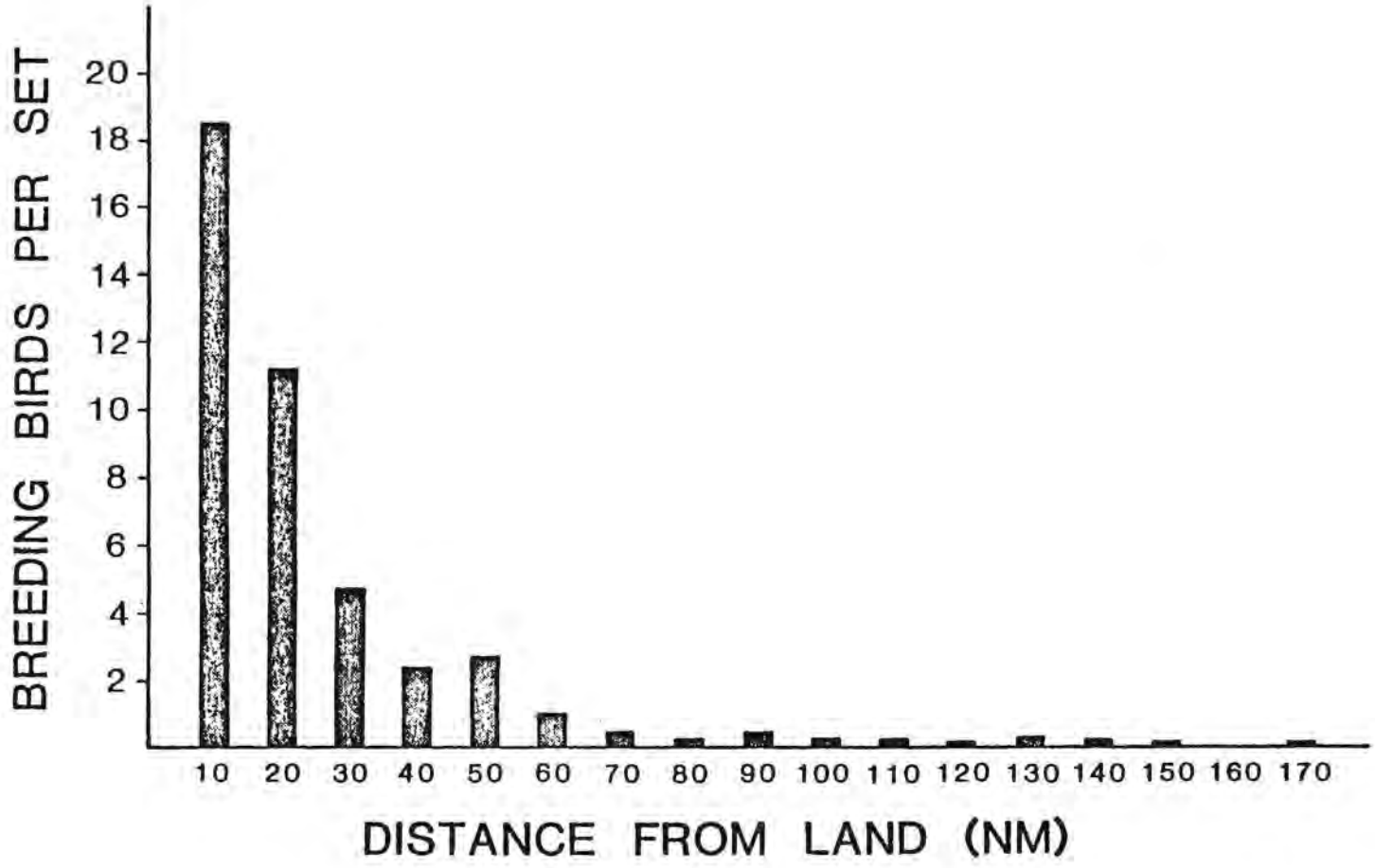


FIGURE 10. Catch rates of breeding seabirds in Japanese salmon gillnets and distance from land south of the Aleutian Islands

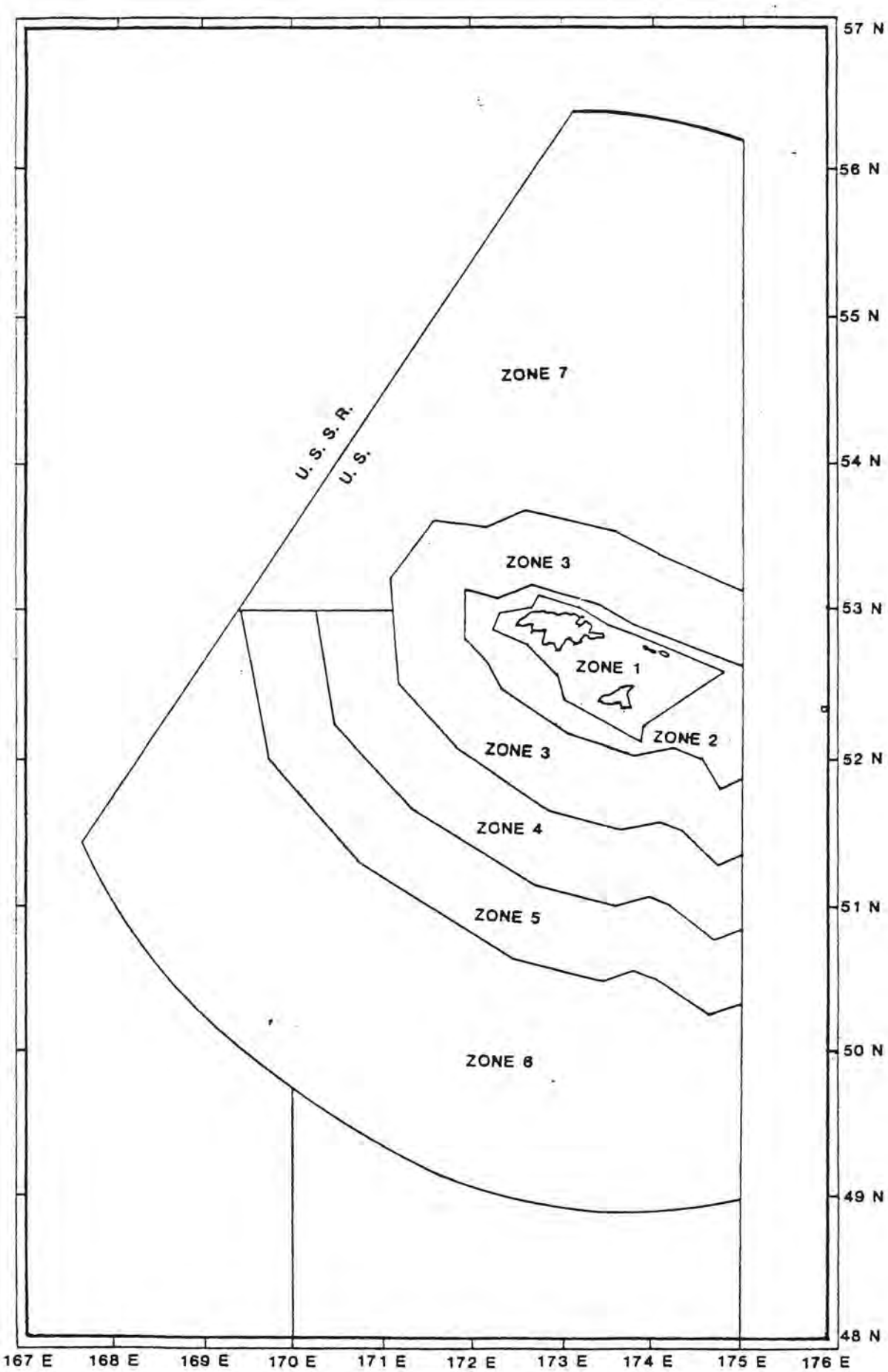
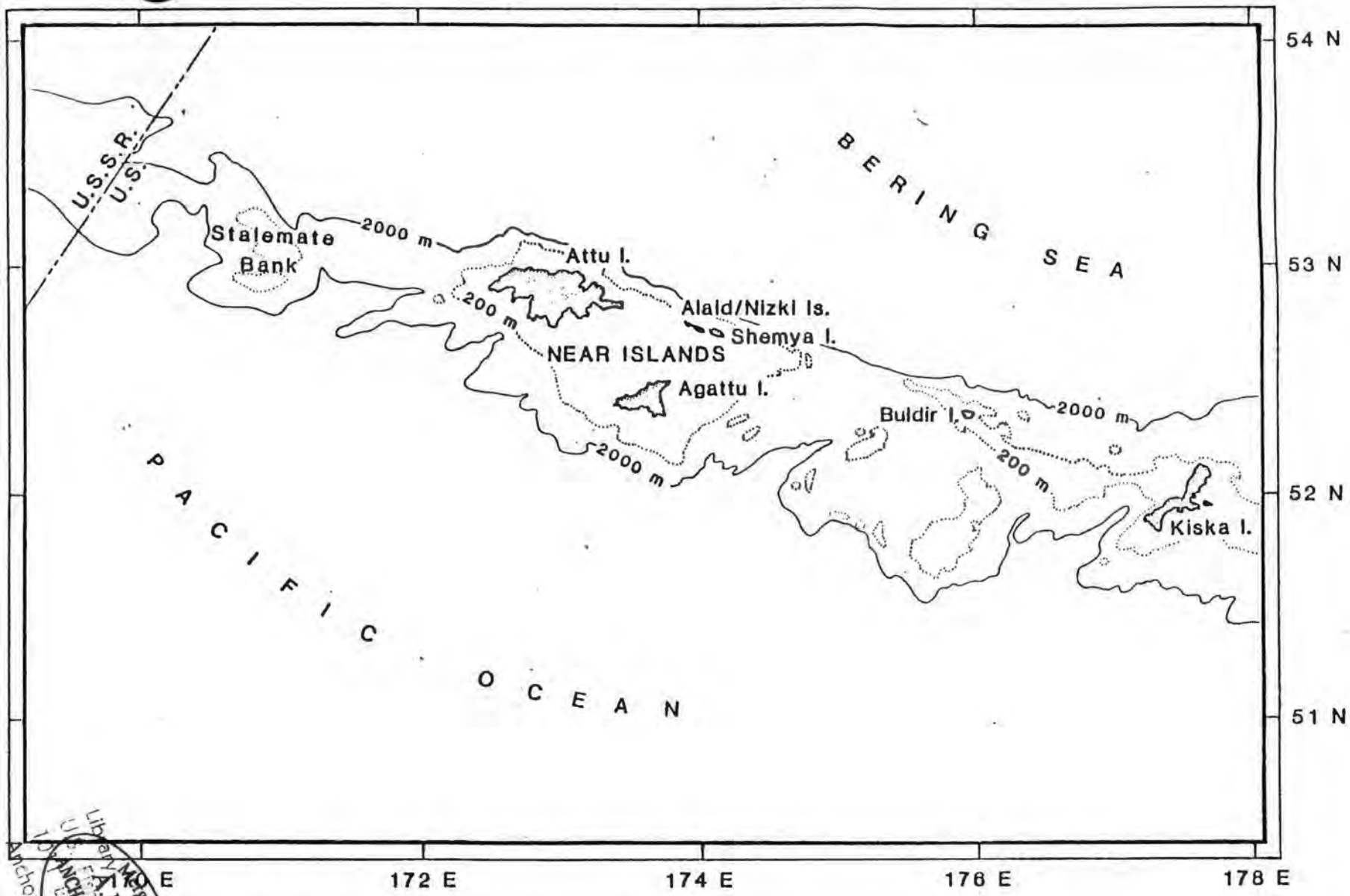


FIGURE 11. Zones used to establish populations of seabirds in the U.S. FCZ.



12. The western Aleutian Islands.

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