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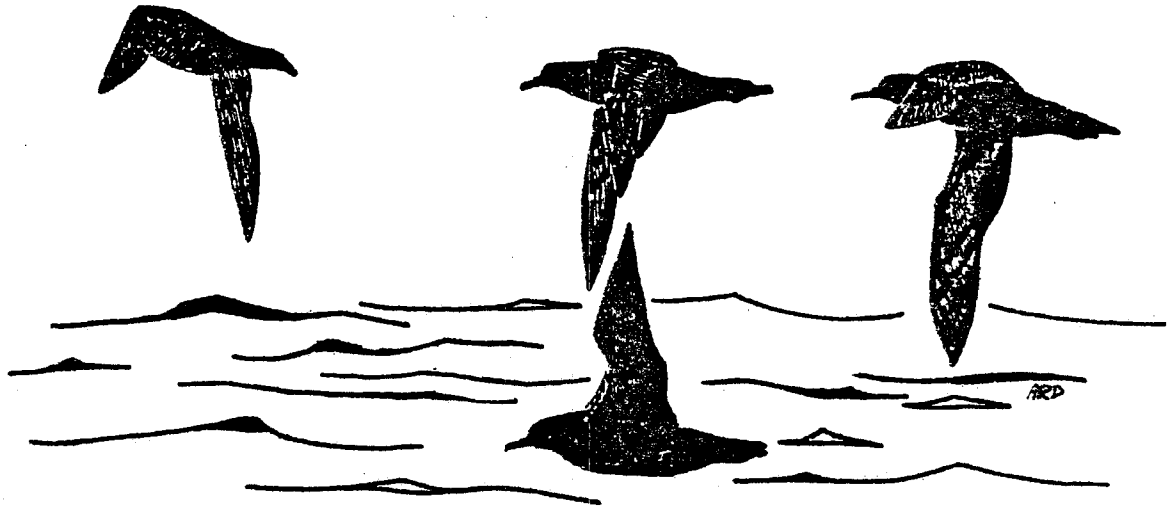
OBSERVATIONS ON THE MORTALITY OF SEABIRDS IN JAPANESE SALMON GILLNETS MADE FROM THE OSHORO MARU AND HOKUSEI MARU, SUMMER 1978



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INTRODUCTION

In recent times two large commercial salmon fisheries have operated on the high seas; the Danish fleet in the North Atlantic from 1965 - 1975 and the Japanese fleet in the North Pacific and Bering Sea from 1952 to the present. The Republic of Korea also operated a small fleet in the Bering Sea during 1969 and 1970 but their effort was relatively small.

Although Bourne (1972) briefly discussed the incidental kill of seabirds in fishing nets, not until publication of Tull, Germain and May's (1972) paper on the mortality of Thick-billed Murres (Uria lomvia) in the West Greenland fishery did the ornithological community become aware of a large incidental kill of seabirds in high seas salmon fishing operations. Tull et al. estimate that 500,000 ± 250,000 Thick-billed Murres were killed annually in the Danish fishery. This, together with natural mortality and a high annual kill by hunters, exceeded the estimated annual production of those populations of Thick-billed Murres affected by that fishery.

As the Japanese fleet was taking approximately 100 times the quantity of salmon as the Danish fleet, concern was expressed that this fishery was also killing large numbers of seabirds.

The problem of the incidental mortality of seabirds in the North Pacific Ocean was initially addressed by King at the International Council for Bird Preservation Congress in 1974 and by Sowl and Bartonek (1974) at the Thirty-ninth North American Wildlife and Natural Resources Conference. Later King et al. (1978), in a paper presented at an international symposium on the conservation of marine birds in northern North America in 1975, estimated that between 214,500 and 750,000 birds were killed annualy in the Japanese North Pacific salmon fishery.

Considerable publicity has been generated on this issue including brief reports in the Auk (1975, Report of the Committee on Conservation), International Council of Bird Preservation Bulletin (King, 1975), Pacific Seabird Group Policy Statement No. 2 (Scott, 1975) Smithsonian Magazine (Ripley, 1975), International Wildlife (March/April, 1977) and numerous newspapers.

Recently, the Japanese Fishery Agency has estimated the 1977 incidental seabird kill at 350,000 birds (unpubl. data), a figure within the range given by King et al. (1978).

In order to learn more about the incidental mortality of seabirds in the Japanese high seas salmon fishery, I participated in cruises aboard the University of Hokkaido, Faculty of Fisheries Training Vessels OSHORO MARU and HOKUSEI MARU during the summer of 1978. In addition to studying the entanglement of seabirds in gillnets, I made extensive

observations of the distribution and abundance of seabirds in the areas of the western North Pacific and Bering Sea transited by the vessels. This report is primarily concerned with my observations of high seas salmon fishing techniques, the mortality of seabirds during the cruises of the OSHORO MARU AND HOKUSEI MARU, and the overall mortality of seabirds in the Japanese high seas salmon fishery. Funding for this study was provided by the U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Washington, D.C., and would not have been possible without the cooperation of the Japanese Fishery Agency and the University of Hokkaido.

METHODS

This project was comprised of two different studies necessitating different methods. The first, seabird mortality in gillnets, was best approached from an observer's point of view. The following information was collected for all gillnet sets: location, time of initiation of net deployment, time of completion of net deployment, time of initiation of retrieve and time of completion of retrieve.

During retrieval of the gillnet, all entangled birds were removed from the net and put aside until the operation was completed. I attempted to determine the mesh size in which all birds were caught; however, due to a communication problem, I did not get this information for all birds during the initial two sets on the OSHORO MARU. When possible, I noted whether each bird was entangled in the upper 1/3, middle 1/3 or lower 1/3 of the gillnet.

After completion of the fishing operation, the birds were injected with isopropyl alcohol to preserve their stomach contents and frozen. The birds were brought back to Hakodate where they were measured, sexed and dissected. The stomachs were removed and preserved in 10% formalin for later analysis.

The food habits of these birds are being studied by Dr. Haruo Ogi, a very capable scientist of the University of Hokkaido, Hakodate, Japan. Dr. Ogi, although having little time to work on the thousands of samples he has obtained through gillnetting, has already published two papers on the feeding ecology of Thick-billed and Common Murres (see Ogi and Tsujita, 1973, 1977). Although several studies concerning the feeding ecology of seabirds are underway in Alaska, few scientists have concerned themselves with pelagic areas. Ogi's work should help fill this glaring gap in our knowledge.

I obtained the entire catch statistics of the 1978 summer cruise for the OSHORO MARU prior to my leaving Japan.

The second part of the study concerned itself with the distribution and abundance of seabirds in the North Pacific Ocean and Bering Sea. Standard transects, developed by personnel of the USFWS/OBS-CE, Anchorage, Alaska were taken whenever the research vessels were underway and observing conditions were suitable. Each transect was 10 minutes long

and all birds within 300 m of one side of the vessel were identified to lowest taxon. Birds that followed and circled the ship were recorded but not included in density calculations. For each transect, depth of water, surface water salinity, surface water temperature and weather conditions were recorded if possible. Depths were taken from charts or electronic depth sounders. On the OSHORO MARU, water temperature and water salinity were recorded mechanically from engine intake. The HOKUSEI MARU's equipment was malfunctioning thus water samples were taken every hour during periods of observation. Salinity was analyzed by Seiji Sasaki, 2nd Officer aboard the HOKUSEI MARU.

During periods of observation, I attempted to adhere to a 10 minute on, 10 minute off schedule. However, due to weather, rough seas and stopping at oceanographic stations, this schedule was not strictly adherred to.

During the OSHORO MARU cruise, I completed 445 transects, while on the HOKUSEI MARU, I completed 300 transects. A detailed analysis of the transects is beyond the scope of this report. A brief analysis of 177 transects taken in the Bering Sea from the OSHORO MARU and 159 transects taken south of the Aleutian Islands from the HOKUSEI MARU are included. These transects were taken in the approximate locale of the gillnet sets.

Description and History of the Japanese Commercial Fleets

The commercial salmon gillnetting fleets of Japan include a mothership fleet and a land based fleet. The mothership fleet is made up of large processing boats, each of which is associated with between 32 and 43 catcher boats. Catcher boats usually make nightly gillnet sets and deposit their catch at the mothership daily.

Prior to 1978, the mothership fleet ranged east to 175°W, west to 160°E and south to 46°N (Figure 1). At its inception in 1952, the fleet included only 57 catcher boats. The fleet increased to 460 catcher boats in 1959 and stabilized at 369 catcher boats and 11 motherships during the 1960s. Between 1972 and 1976, 332 catcher boats and 10 motherships were active. As a result of agreements between Japan and the Soviet Union, the western limit of the mothership fleet was pushed east to approximately 170°E. As a result, only 245 catcher boats and 6 motherships fished in 1977. In 1978, the fleet was further reduced to 172 catcher boats and four motherships as a result of a new agreement between Japan and the United States that further restricted the fishing area. In 1978, the fleet was allowed to operate in an irregular shaped area north of 46°N but only to 175°E in American waters (Figure 2).

The Japanese manufacture gillnets in units of 50M called tans. To give an indication of fishing effort of the mothership fleet, I include the total length of net fished for several years: 1956, 9.3 million tans (465,000 km); 1974, 5.4 million tans (270,000 km); 1977, 3.9 million tans (195,000 km) and an estimated 2.95 million tans (147,500 km) in 1978. Typically, the fishing season of the mothership fleet lasts as long as it takes the fleet to fill its salmon quotas or up to 65 days.

The land based fishery can be further divided into boats between 40 and 90 tons that operate south of 46°N and to the eastern limit (pre 1978 to 175°W; 1978 to 175°E) and boats under 7 tons that fish west of 160°E. The larger boats make infrequent landings in Japan and must preserve their catch. The small boats probably make daily landings in Japan.

At present, I have little information on the size and fishing effort of the land based fleet. In 1975, 371 vessels in the 40 - 90 ton class and 1,120 vessels of less than 7 tons were active. Approximately 6.0 million tans of net (300,000 km) were fished by the larger vessels in 1975 (Fredin et al., 1977). In 1977, the larger vessels of the land based fleet fished an estimated 3.72 million tans (185,950 km).

In addition to the commercial fleet, 14 Japanese research vessels were conducting fishery studies, oceanographic studies and training students in 1977. All 14 vessels conducted experimental gillnetting during that summer season, and a total of 65,040 tans of net (3252 km) were fished.

Description of fishing and fishing gear

The two training vessels of the University of Hokkaido have two primary functions: 1) to train students of the university in navigation and fishery techniques and 2) to conduct research on the physical and biological characteristics of the ocean. To accomplish their goals, both the OSHORO MARU and HOKUSEI MARU utilize various fishing techniques including gillnetting, vertical long lining, horizontal long lining, otter trawling, purse seining and squid jigging.

Two of the above fishing procedures resulted in seabird mortality while I was aboard the vessels: horizontal long lining and gillnetting. What follows is a description of the gear and procedures involved with both fishing techniques.

Horizontal Long lining

This procedure was only used while I was aboard the OSHORO MARU. The purpose of horizontal long lining is to live catch salmon for tagging. This operation was conducted three times from the OSHORO MARU in the Bering Sea.

During this operation, a long length of line, similar in size to purse seine cord, was laid on the surface of the water with several orange floats interspersed along its length. Also interspersed along the line were short pieces of monofilament with baited hooks and styrofoam floats. This gear, which stays at or near the surface, was deployed at approximately 0230 and retrieved immediately after completion of gillnetting (05:15 - 06:30).

On 14 June, 1978, four Short-tailed Shearwaters (Puffinus tenuirostris), apparently attracted to the small fish bait, were entangled in the hooks and line. All four were alive and released. Two of these were healthy and flew when released, however the other two were badly soaked and probably died later from exposure.

Salmon gillnetting

Salmon gillnetting was the principal fishing technique used by both the OSHORO MARU and HOKUSEI MARU during the two cruises. While I was aboard, four sets were made from the OSHORO MARU and nine sets from the HOKUSEI MARU. In addition, 13 sets were made from the OSHORO MARU after I left the vessel in Kodiak.

The gillnets used by both the Japanese commercial and research fleets are made of single strand monofilament. They have a lead line at the bottom and a float line at the top to keep them vertical while fishing. The lead line and float line are nylon, one with lead weights and the other with styrofoam floats equally spaced along their entire length.

Commercial boats use nets with a stretched mesh of approximately 110 mm to 130 mm as these are the most effective for catching salmon. Typically, catcherboats in the mothership fleet use nets of 121 mm and 130 mm while the land-based fleet uses nets of 110 mm and 115 mm (Fredin et al., 1977). Research boats, however, interested in species in addition to salmon, use nets of variable mesh size (Table 1).

Monofilament nets from Japan are manufactured in units of 50m x 6m. These units, called tans, are laced together to form a net of variable length. The OSHORO MARU used a net of 130 tans (6.5 km) while the HOKUSEI MARU used a net of 115 tans (5.8 km). Commercial boats, however, typically use nets of up to 330 tans (16.5 km).

During deployment, 4 marker buoys, consisting of bamboo poles with large, orange styrofoam floats are attached to the net. In addition, a radio beacon, and a blinking light buoy are attached to the end of the net.

On the research boats, gillnets are set while the vessel moves at half speed, on a straight course. On commercial boats, the nets are set at a much faster speed (Dave Ambrose, pers. comm.). The duration of net deployment for four sets on the OSHORO MARU ranged from 57 min. to 61 min. ($\bar{X}$ = 59.5 min.) (Table 2). Gillnet deployment from the HOKUSEI MARU ranged from 27 min. to 53 min. ($\bar{X}$ = 40.4 min) for 9 sets. The 27 min. set was for a short, experimental set of 75 tans.

Typically, gillnet sets are made in the early evening at approximately 18:00 and retrieved between 03:00 and 04:00 (Table 2). Net retrieval ranged from 1 hour, 8 min. to 3 hours, 35 min. for all 13 sets. The length of time needed to retrieve the net was highly dependent on the fishing success. The duration of the gillnet set, here defined as the period of time between initiation of deployment and completion of retrieve ranged from 10 hours, 58 min. to 12 hours, 30 min. on the OSHORO MARU and from 7 hours, 48 min. to 13 hours, 50 min. on the HOKUSEI MARU (Table 2). Fredin et al. (1977) report that the gillnets of catcher boats are set in late afternoon and retrieved shortly after midnight with the actual fishing time ranging from 9-12 hours or more.

Gillnets are always set from the stern. Both the OSHORO MARU and HOKUSEI MARU have stern ramps which are useful but not necessary for setting gillnets. The R/V HOKUHO MARU lacks a stern ramps, but still gillnets successfully. Gillnets are retrieved from the port side of the forward deck. The lead line is mechanically hauled with the vessel's hydraulics. The float line is pulled by hand. Usually a line of 4 or 5 men stand on each side of the net, passing it from one to another. As the net is pulled aboard, these men remove the entangled fish, squid and birds. The net is then pulled through a funnel on the starboard side by a hydraulic winch and passes down a long net conveyor tube on the starboard side. The net is deposited on the stern deck just forward of the stern ramp, ready for the next operation.

On the research vessels, all salmon are weighed, cleaned, salted and frozen. The gonads are weighed and the eggs are salted. Albacore (Thunnus alalunga) and skipjack (Katsuwonus pelamis) are handled in a similar fashion, but smaller fish and squid are frozen whole without cleaning.

RESULTS

Figure 3 depicts the cruise tracks for both the OSHORO MARU and HOKUSEI MARU. Not depicted is the track of the OSHORO MARU from Kodiak, Alaska to Hakodate, Japan.

Four gillnet sets were made from the OSHORO MARU in the Bering Sea (Figure 4). In addition, 13 sets were made from the OSHORO MARU south of Alaska, en route to Japan. Although I did not participate in the latter part of the OSHORO cruise, the data were obtained from Dr. Haruo Ogi. These data are included in Table 3.

Pelagic Distribution of Birds

The densities of seabirds observed on 177 transects in the gillnetting area of the Bering Sea ranged from 0 - 149 birds/km^2 ($\bar{X}$ = 11.3, $S\bar{x}$ = 1.4) (Figure 4). On seventy three percent of the transects, I found less than 10 birds/km^2. Of 14 transects with over 25 birds/km^2, nine were on the continental shelf near the Pribilof Is.

Two highly pelagic species, the Northern Fulmar (Fulmarus glacialis) and Fork-tailed storm petrel (Oceanodroma furcata), both infrequently caught in gillnets, were observed on 76.8% and 59.9% of the transects respectively. These were the most frequently observed species in the Bering Sea. Both Black-legged (Rissa tridactyla) and Red-legged Kittiwakes (Rissa brevirostris), were observed on 35.0% of the transects in the study area. Other species seen on the transects include murres (18.6%), Horned Puffins (Fratercula corniculata, 1.7%), Tufted Puffins (Lunda cirrhata, 22.0%) and Short-tailed Shearwaters 21.5%). Although less frequently seen, these species made up a much larger percentage of the incidental kill (Table 3).

Figure 5 shows the location of 9 gillnet sets from the HOKUSEI MARU in the western North Pacific, the location of 159 transects in the study area, and the densities of seabirds observed on these transects. Seabird densities in this region were also generally low but more variable than in the Bering Sea. Densities ranged from 0 - 2034 birds/km^2 ($\bar{X}$ = 36.9, $S\bar{x}$ = 16.2) (Figure 5). On seventy-six percent of the transects, I observed less than 10 birds/km^2. Densities of over 25 birds/km^2 were observed on only 13 transects in this study area. Whereas in the Bering Sea, I observed densities of over 100 birds/km^2 on two occasions, in the Emperor Seamount area I observed such densities on five occasions, of which three were over 1000 birds/km^2.

As in the Bering Sea, great variability in densities is attributable to the absence or presence of Short-tailed and Sooty Shearwaters (Puffinus griseus). These were the most frequently observed group of birds in the Emperor Seamount area and occurred on 51% of the transects. Laysan Albatross (Diomedea immutabilis) and Northern Fulmars were observed on 39.0% and 31.0% of the transects respectively. Horned and Tufted Puffins, both of which reach the southern limits of their range in the northern part of the study area were infrequently observed on transects (1.9%, 7.5%). Murres were not observed.

While on the HOKUSEI MARU, we traveled in a northerly direction from 39°N to 50°N in the central North Pacific. This brought us past the southern edge of the distribution of puffins, Northern Fulmars and Fork-tailed Storm Petrels. Sooty and Short-tailed shearwaters, both southern hemisphere breeders wintering in the North Pacific, were infrequently observed during the southern part of the cruise. The species seen in the southern area included Harcourt's Storm Petrel (Oceanodroma carbo), Sooty Storm Petrel (Oceanodroma tristrami), Solander's Petrel (Pterodroma solandri), Kermadec Petrel (Pterodroma neglecta), Bonin Island Petrel (Pterodroma hypoleuca), Stejneger's Petrel (Pterodroma longirostris), Cook's Petrel (Pterodroma cooki), and Wedge-tailed Shearwater (Puffinus pacificus). These species primarily feed by air dipping, contact dipping, surface feeding and more rarely by scavenging and thus are expected to be caught in gillnets infrequently (Ashmole and Ashmole, 1967; Gould, 1971).

Gillnet Mortality

Fifty-four seabirds were killed in the gillnets of the two vessels during 26 sets (Tables 3, 4 and 5). All but 11 of these were killed in the Bering Sea.

Considerable variation is shown when comparing the percent species composition of the gillnet kill with other studies (Table 3). This is not unexpected considering the variation in areas and level of fishing effort. The species composition of the combined gillnet kill from the OSHORO MARU and HOKUSEI MARU in 1978 was most similar to the 1972 gillnet mortality from the OSHORO MARU in the Bering Sea. Considering that 87% of the 54 birds from the two cruises in 1978 were taken on the OSHORO MARU in the Bering Sea, these results are not surprising. The study most representative of the commercial catch is probably the 1977 gillnetting by 14 Japanese research vessels in the North Pacific Ocean and Bering Sea in 1977. The catch on the 14 vessels totalled 3,279 birds, most of which were in or near areas that commercial boats fished.

The data clearly show that those species of seabirds that dive for their food e.g. shearwaters, murres, puffins and other members of the family Alcidae, are most frequently entangled in gillnets. Surface feeders such as Laysan Albatross, Northern Fulmars and Fork-tailed Storm Petrels are infrequently caught despite their abundance in the North Pacific and Bering Sea. During my cruises, Laysan Albatross, Northern Fulmars, Black-legged and Red-legged Kittiwakes were attracted to the nets and research vessels. It was apparent that albatross and fulmars were entangled only when attempting to feed on fish caught in the gillnets, notably Saury (Cololabis sauria). For example on 31 July, one dead Laysan Albatross was observed floating next to the gillnet. Apparently, the bird became entangled, drowned, and floated free after its body relaxed. On 1 August, another Laysan Albatross was caught but managed to free itself after a brief struggle. Over 70 albatross were attracted to the net on that day. On 4 August, a Northern Fulmar was caught while feeding on an entangled salmon. This bird was taken aboard alive and released. On 5 August, 1 dead Laysan Albatross, 6 dead Northern Fulmars and 1 living Northern Fulmar were found entangled in an old drifting gillnet (see Appendix).

A limited amount of data was gathered on the sex and breeding condition of the birds caught on the OSHORO MARU and HOKUSEI MARU. Of 26 short-tailed shearwaters for which sexes were obtained, 12 were female and 14 were male. The gonads of these birds were small and probably inactive. Too few data were gathered on the other species to say anything definitive at this time.

In cold northern waters, salmon occur primarily at the surface, therefore gillnets are only 6 m deep. Most of the salmon caught on the OSHORO MARU and HOKUSEI MARU were entangled in the upper 1/2 of the net. Seabirds were caught in similar depths of the net as salmon. Of 34 birds for which I have information, 32 (94%) were caught in the upper 1/3 of the gillnet. In fact, many of these were caught in the upper 1 meter of the net.

Aboard the OSHORO MARU and HOKUSEI MARU seabirds were caught in gillnets with mesh sizes ranging from 82 mm - 179 mm (Table 5). On the OSHORO MARU, the seabirds were caught in similar mesh sizes as salmon (Figure 6).

The data in Figure 6 suggest that both seabirds and salmon were most frequently entangled in mesh sizes ranging from 112 mm to 130 mm. This size range is the most efficient at catching salmon and is used in the commercial fishery. Although Figure 6 is based on a sample of over 2200 salmon, only 31 birds from 4 sets were used in the analysis. A larger sample size is needed to determine the catchability of seabirds in different mesh sizes. However, it appears that altering the mesh sizes used by the commercial fleet to one that may entangle fewer seabirds, would reduce the efficiency of the gillnet fishery.

The few seabirds entangled in the gillnets of the HOKUSEI MARU were also primarily caught in commercial sized gillnets (Table 5).

Although at present the gillnet fishery is limited to salmon, the nets are capable of catching several other species in large numbers including the squid (Ommastrephes bartrami), Pacific Pomfret (Brama rai), Saury (Cololabis saira), and Skipjack (Katsuwonus pelamis). These species are all found well south of the Aleutians in warmer waters. Whether a gillnet fishery ever develops for these species in the future is unknown. If it did, the fishery would have much less of an impact on seabirds than the present salmon fishery.

Other Animals Entangled

Variable mesh gillnets such as those used by Japanese research vessels are capable of catching a wide variety of marine life. Forty species were taken in gillnets on the OSHORO MARU (Table 6) including such notables as the Dall Poprpoise (Phocoenoides dalli), Leathery Turtle (Dermochelys coriacea), Ocean Sunfish (Mola mola) and Daggertooth (Anopterus pharao).

Only one Dall Porpoise was caught on the OSHORO MARU. This animal was taken aboard alive and released. On the HOKUSEI MARU, we caught one Dall Porpoise in gillnet set No. 4 and one large 140 kg. male Dall Porpoise in set No. 5. Both animals were frozen for later shipment to the USA. They are being studied by personnel of the National Marine Fisheries Service.

Northern Fur Seals (Callorhinus ursinus) may occasionally become entangled in gillnets. On 2 August 1978, a juvenile Fur Seal was caught in the gillnet of the HOKUSEI MARU but fought itself free prior to being hauled aboard. During the four sets in the Bering Sea, we commonly saw Fur Seals playing about the net and feeding on entangled salmon. There is one record of a Fur Seal, fouled in an old monofilament gillnet, washing up on a Unimak Island, Alaska beach (Ed Bailey, pers. comm.). In addition, Waldichuk (1978) reports that dead, emaciated seals, entangled in large fragments of polypropylene net have been found on the Pribilof Islands, but did not specifiy the type of net.

Estimate of Total Mortality

As the fishing effort and area of fishing for the mothership fleet was greatly reduced in 1978 due to the U.S. declaration of extended jurisdiction, it was necessary to recalculate an estimate of total seabird mortality. However, there were too few data from the OSHORO MARU and HOKUSEI MARU in 1978 to be of use. Therefore, I used the 1977 data from Japanese research vessels to estimate the 1978 mortality. Fourteen research vessels fished gillnets in the North Pacific and Bering Sea in 1977 and birds were caught at many locations (Figure 7).

The maximum estimated fishing effort of the 1978 mothership fleet in fleet days per 2° Lat. x 5° Long. blocks is shown in Figure 2. The number in each block refers to the number of days a mothership and its associated 43 catcher boats fished in a particular 2° x 5° block. Assuming each catcher boat deployed 16.5 km of net each evening (Fredin et al., 1977), then the total amount of net fished in each 2° x 5° block as well as the total amount of net deployed by the mothership fishery in 1978 can be calculated (Figure 8). To determine the number of birds caught per tan, I only used 1977 research vessel data from gillnet sets made in the same 2° x 5° blocks as the mothership fishery fished in 1978.

Sixty-one sets were made in these areas in 1977 by research vessels. Two calculations of birds caught per tan were made. In the first, data from all 61 sets were used to calculate a figure of .0346 ± .01 birds/tan (95% C.I.) for the entire mothership area. This figure was multiplied by the total number of tans fished (2,951,520) to derive an estimate of 102,000 ± 29,000 seabirds killed in the mothership fishery in 1978. In the second, estimates of mortality were made for each 2° x 5° block that the mothership fleet fished (Fig. 8). For each 2° x 5° block, a 95% C.I. of birds/tan was calculated using only 1977 research vessel data from sets made in that block (Figure 8). The same 61 sets used above were thus subdivided resulting in smaller sample sizes and larger variances. For those blocks fished in 1978, for which no research vessel data is available, I subjectively assigned it a value based on values of neighboring blocks. Using this method, the total mortality in the mothership fishery was 139,500 ± 75,000 seabirds in 1978.

I made no attempt to weight the data by time of fishing season because of a lack of data; however this may be important. Although the calculations both show considerable variation, they at least show the order of magnitude of the kill.

Due to a paucity of information on the fishing effort of the 1978 land based fleet, I again used 1977 research vessel data to calculate an estimate of mortality. In 1977, the land based fleet deployed 3,718,779 tans (185,939 km) (Japanese Fishery Agency, unpubl. data). The fishing effort of this fleet may have been reduced in 1978 as the eastern boundary of the fishing area was pushed westward to 175°E. However, at this writing, I have no indication that a reduction occurred. One hundred and ninety-seven experimental gillnet sets were made by Japanese research vessels west of 175°E and south of 46°N in 1977. Based on these gillnet sets, the number of birds caught per tan equals .0373 ± .0055 (95% C.I.). Therefore, the estimated mortality of seabirds in the land based fishery in 1977 was 139,000 ± 20,500.

Again, assuming an equal fishing effort by this fishery in 1977 and 1978 we can assume a similar mortality. Thus the estimated total mortality to birds for the 1978 Japanese salmon fishery is between 183,000 and 374,000 birds (278,500 ± 95,500).

DISCUSSION

To date, five estimates of seabird mortality in the Japanese salmon fishery have been made. Sanger, (memorandum to J.C. Bartonek and subsequently published by King, Brown and Sanger, 1978) supplied estimates of 214,500 and 715,000 based on cruises of American research vessels that used gear similar to the Japanese fleet. The estimate of 214,500 was based on 449 km of net set on 10 cruises west of 175°W. The estimate of 715,000 birds was based on 951 km of net set during 20 cruises east and west of 175°W. For the mothership fishery alone, Sanger estimated that between 75,000 and 250,000 birds were killed annually. To calculate the estimate of 715,000 birds, Sanger used a figure of .042 birds caught per tan (Table 7). His lower estimate of 214,500 birds was calculated from the low figure of .012 birds/tan.

Bakkala (NMFS, unpubl. data) estimated that 763,000 seabirds were killed annually. His estimate is based on 1,288 birds caught in 1,477 km of gillnets from Japanese research vessels. Bakkala calculated that .04362 birds were caught per tan (Table 7); a figure in close agreement with Sanger's larger estimate.

The Japanese Fishery Agency estimates of 350,000 birds in the combined mothership and land based fisheries is lower than Bakkala's but well within the range of Sanger's estimates. To determine an estimate for the land based fleet in 1977, the Fishery Agency used a figure of .045 birds per tan; also very close to Bakkala's and Sanger's figures (Table 7). As the Fishery Agency calculated the mortality in the mothership fleet by 2° Lat x 5° Long. blocks, no overall figure of birds caught per tan is available.

The overall drop in mortality suggested by the mortality estimates presented thus far may, in part, reflect the reduction in fishing effort of the Japanese Fleet between 1974 and 1977. The mothership fleet was again reduced in 1978. The Fishery Agency estimate of 183,000 birds for this fishery in 1977 and my estimate of 139,000 birds for 1978 were both calculated in the same fashion, using the same data base. Thus this difference is a reflection of the reduced fishing effort.

I used a figure of .0373 birds/tan to calculate an estimate of mortality in the land based fishery. This figure is only slightly lower than previous estimates.

Using data from research boats and applying it to the commercial fleet assumes that the nets on each type of boat catch birds at an equal rate. Research boats use two types of gear; commercial size gillnets and experimental, variable mesh gillnets. It seems possible that net of very small mesh size or very large mesh size may entangle fewer birds than intermediate size net. If so, then my estimates and those of the Japanese Fishery Agency may be underestimates. Another factor which may have resulted in an underestimate of mortality is the drop-out rate of seabirds from the net after death. There may be a considerable loss of salmon from the nets in this way (Branson, pers. comm.) and it is possible that birds may frequently drop out when their bodies relax after death.

Although the variations in the current estimates of seabird mortality in Japanese gillnets are large, the estimates still provide a reasonable picture of what is occurring in the North Pacific and Bering Sea. The mortality has been reduced considerably as a result of the reduction in fishing effort and area fished, yet despite this, up to 300,000 birds are killed each year. Part of the problem lies in the location of the fishery. The western Aleutians are an important locale for seabirds in Alaska.

The Near Islands, the westernmost islands in the Aleutians, have approximately 189,000 seabirds associated with them during the breeding season including 33,000 murres, 10,000 Horned Puffins, and 35,000 Tufted Puffins. Tiny Buldir Island, just east of the Near Islands, supports an estimated 1,826,000 seabirds during the breeding season. Estimated totals for those species susceptible to gillnets include 26,000 murres, 250,000 Crested Auklets, 100,000 Least Auklets, 20,000 Horned Puffins and 20,000 Tufted Puffins (Sowls et al. 1978). In addition, substantial numbers of non-breeding shearwaters and alcids are found in this region throughout the summer.

Birds have been dying in gillnets in the North Pacific since 1952, yet an interest in the problem did not develop until the early 1970s. What affect the mortality has had on populations of northern and southern hemisphere seabirds is unknown. It is possible that upwards of 6.5 million seabirds have died thus far in the high seas Pacific salmon fishery. Conceivably this figure could be higher.

Populations of seabirds in Alaska have been studied intensively only since the mid 1970s. Most of the western Aleutians have been censused during the breeding season but most surveys have been of short duration and many estimates are crude. Except for Buldir Island, there have been few long term studies and intensive repetetive surveys. We also know very little of the pelagic distribution and abundance of seabirds in the western Aleutians and western North Pacific. Repetetive surveys in these areas are needed.

There are few ways to reduce the mortality of seabirds without crippling the salmon fishery. Both altering the mesh size and fishing the gillnet below the surface would reduce the efficiency of the fishery.

The 200 mile fishing limit excludes the Japanese fleet from gillnetting near all American soil except in the 2° Latitude X 5° Longitude block that includes the Near Islands. Preventing the fleet from fishing in this block may protect the breeding puffins and murres that nest in this area. The salmon fleet would have to pick up the slack in other areas but the pressure would fall primarily on non-breeders and not affect breeding birds and the eggs and chicks dependent on them.

Another method that may reduce mortality is related to the soaking time of the gillnets. Commercial boats deploy their nets in late afternoon and retrieve them in the early morning. The nets are usually in the water during several hours of daylight. Assuming that seabirds feed more actively during the day, mortality may be reduced by restricting the fishing to the period of darkness. This technique would have little benefit if seabirds feed frequently at night, and there is some evidence that some species do so (Gould, 1967). Such a technique would also decrease the number of salmon caught per set, thus lengthening the time needed to fill quotas and increasing the cost of the fishery.

SUGGESTIONS FOR FURTHER STUDIES

It appears to me that the fishing effort of the Japanese mothership fleet will stabilize at its present level for several years to come. If my estimates of mortality are reasonable, then we can expect over 200,000 northern and southern hemisphere seabirds to be killed annually in the Japanese gillnet fishery.

Through the present study, we have learned something of the gillnetting procedures on research boats which are undoubtedly very similar to those used in the commercial fleet. Based on data gathered in this study and furnished by the Japanese Fishery Agency, we have an accurate idea of seabird mortality rates on research boats. Although we directly applied these data to the commercial fleet, the validity of this procedure remains questioned simply because of the differences in the types of gear fished.

It would be very useful to have an observer aboard a mothership for part or all of the fishing season. This observer could board different catcher boats, observe the commercial fishing operation, and obtain mortality rates. Some good use could be made of the large number of seabirds taken in this fishery. This study could be in conjunction with the National Marine Fisheries Service/Marine Mammal Division which had observers aboard motherships in 1978 and will again do so in 1979. The bird observer could participate in the Dall Porpoise studies of NMFS and vice versa. Of course, a study of this sort would have to be approved by the Japanese.

A recent meeting of the United States - Japan Natural Resources Panel was held in Portland, Oregon on 19-20 October. Both the Japanese and American participants expressed great interest in joint studies on seabirds. Studies on the trophic relationships of seabirds and a study on the Short-tailed Albatross (Diomedea albatrus) were of particular interest to the Japanese delegation. The Japanese have a fleet of research boats which have been untapped as research platforms for marine bird and mammal studies. Summer cruises of these vessels are concentrated in the North Pacific while during the winter many have cruises to equatorial or southern hemisphere waters. I recommend that the use of these vessels for joint studies between the United States and Japan be explored.

Little is known of the distribution and abundance of seabirds in the central and western North Pacific Ocean. Published accounts include those of Austin (1958), Kuroda (1955, 1957, 1960), Nakamura (1975) and Nakamura and Tanaka (1977). Unpublished observations include those of Wahl (1976) from a cruise on the OSHORO MARU in 1975 and Gould (1977) on a cruise from Kodiak to Hawaii.

My observations aboard the OSHORO MARU and HOKUSEI MARU were extremely interesting as the cruises went to areas little studied by ornithologists. Both cruises were valuable as both passed through the zone of sub-arctic convergence providing distributional data on both warm and cold water species.

In 1979, the HOKUSEI MARU will again return to the Emperor Seamount Area. It would be valuable to place an observer aboard this vessel to gain one additional year's data from this interesting area, an area which may support an important fishery for Japan in the near future.

ACKNOWLEDGMENTS

Many individuals deserve thanks for making this study possible. In particular, I thank James C. Bartonek for providing his time, advice and logistic support and George Brakhage for providing funds.

In Japan, many contributed to make my stay extremely enjoyable. I thank Takeji Fujii, the officers, crew, and students of the OSHORO MARU for their friendship and hospitality on a most productive cruise. Dr. Haruo Ogi proved a ready source of advice both on the vessel and in Japan. On the HOKUSEI MARU, I thank Captain Shoichi Yamamoto, Officers Ishii, Sasaki, and Meguro, and the crew and students. Terry Newby and Tsuneyasu Hamanaka provided many valuable sightings of birds.

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Table 1. Number of tans of each mesh size and the linear order of tans for the gillnets of the OSHORO MARU and HOKUSEI MARU.

OSHORO MARU		HOKUSEI MARU	
MESH SIZE (mm)	NO. TANS	MESH SIZE	NO. TANS
115	15	112	10
48	3	115	10
93	3	118	10
157	3	121	10
106	3	112	10
63	3	115	10
121	3	118	10
72	3	233	3
138	3	204	3
82	3	179	3
55	3	82	3
121	20	157	3
130	15	72	3
121	20	63	3
115	15	42	3
130	15	106	3
		138	3
TOTAL TANS =	130	55	3
		93	3
		48	3
		33	3
		121	3
		TOTAL TANS =	115

Table 2. Location, deployment time, retrieval time and duration of gillnet sets for the OSHORO MARU and HOKUSEI MARU, summer 1978.

Set No.	Position	Deployment Time	Elapsed Time	Retrieval Time	Elapsed Time	Duration of Set
1 OM	55°00' N 177°59' W	17:57 - 18:58	1:01	03:00 - 05:43	2:43	11:46
2 OM	52°55' N 176°59' W	19:30 - 20:30	1:00	03:30 - 06:30	2:00	11:00
3 OM	54°59' N 175°29' W	18:40 - 19:37	:57	03:00 - 05:15	2:15	10:55
4 OM	54°00' N 178°00' W	18:00 - 19:00	1:00	03:40 - 06:30	2:50	12:30
1 HM	40°00' N 175°30' E	18:00 - 18:43	:43	04:15 - 07:50	3:35	13:50
2 HM	41°28' N 175°37' E	18:00 - 18:53	:53	03:58 - 07:15	3:17	13:15
3 HM	43°00' N 175°30' E	18:00 - 18:38	:38	04:00 - 06:00	2:00	12:00
4 HM	44°38' N 175°28' E	18:02 - 18:43	:41	04:00 - 05:44	1:44	11:42
5 HM	45°59' N 175°33' E	17:58 - 18:40	:42	03:53 - 06:08	2:15	12:10
6 HM	47°30' N 175°30' E	18:01 - 18:42	:41	03:55 - 05:58	2:03	11:57
7 HM	49°02' N 169°17' E	19:06 - 19:45	:39	04:18 - 06:21	2:03	11:15
8 HM	50°00' N 165°00' E	05:51 - 06:18	:27	12:31 - 13:39	1:08	7:48
9 HM	49°29' N 164°12' E	18:30 - 19:10	:40	04:44 - 06:56	2:12	12:26

Table 3. Total Number of Seabirds caught on the OSHORO MARU and HOKUSEI MARU, Summer 1978 and a comparison of the species composition of seabirds caught in the gillnets of various research vessels.

SPECIES	TOTAL BIRDS	% SPECIES COMPOSITION			
	This study	This study	Japanese R/V 1977	OSHORO MARU 1972	NMFS* 61-72
Unid. Albatross					0.2
Laysan Albatross			0.5		
Northern Fulmar	1	1.9	1.3	1.7	5.4
Sooty Shearwater	9	16.7	1.4		26.9
Short-tailed Shearwater	32	59.3	29.9	57.2	
Christmas Shearwater			17.4		
Unid. Storm Petrel					.4
Fork-tailed Storm Petrel	1	1.8	1.0		
Black-legged Kittiwake			tr		
Pomarine Jaeger			tr	0.2	
Common Murre			6.3	22.9	57.6
Thick-billed Murre	6	11.1	10.1	13.2	
Unid. Murre					
Pigeon Guillemot			0.1		
Marbled Murrelet				0.2	0.2
Ancient Murrelet	1	1.8	0.4	0.8	
Parakeet Auklet			3.9		
Least Auklet			tr		0.6
Crested Auklet			0.1		
Rhinoceros Auklet			1.8	0.2	
Horned Puffin	1	1.9	0.7	3.1	8.6
Tufted Puffin	3	5.6	17.1	0.6	
Unid. Bird			7.7		

*National Marine Fisheries Service

Table 4. Seabirds caught at individual gillnet sites for the OSHORO MARU and HOKUSEI MARU, Summer 1978.

Gillnet Set and Location	Seabirds
OSHORO MARU	
53°00'N 177°59'W	2 Thick-billed Murres, 3 Tufted Puffins
52°55'N 176°59'W	16 Short-tailed Shearwaters, 1 Fork-tailed Storm Petrel, 1 Ancient Murrelet
54°59'N 175°29'W	2 Thick-billed Murres, 1 Horned Puffin
54°00'N 178°00'W	2 Thick-billed Murres, 15 Short-tailed Shearwaters
45°36'N 173°25'W	None
44°03'N 174°58'W	None
43°00'N 175°00'W	None
41°59'N 175°00'W	None
40°58'N 174°58'W	None
39°59'N 174°59'W	None
38°59'N 174°59'W	None
38°58'N 177°43'W	None
38°59'N 179°59'W	None
40°25'N 179°55'E	None
42°00'N 179°57'W	None
43°30'N 180°00'	2 Sooty Shearwaters
44°58'N 179°58'E	2 Sooty Shearwaters
HOKUSEI MARU	
40°00'N 175°30'E	None
41°28'N 175°37'E	1 Sooty Shearwater
43°00'N 175°30'E	None
44°38'N 175°28'E	None
45°59'N 175°33'E	1 Sooty Shearwater
47°30'N 175°30'E	3 Sooty Shearwaters
49°02'N 169°17'E	1 Northern Fulmar
50°00'N 165°00'E	None
49°29'N 164°12'E	1 Short-tailed Shearwater

Table 5. Species and number of seabirds caught in the gillnets of the OSHORO MARU and HOKUSEI MARU, Summer 1978.

Mesh Size (mm)	Species and Number
82	1 Horned Puffin
93	1 Sooty Shearwater*
112	1 Sooty Shearwater,* 1 Northern Fulmar*
115	1 Tufted Puffin, 3 Thick-billed Murres, 3 Short-tailed Shearwaters, 1 Sooty Shearwater*
118	1 Short-tailed Shearwater*
121	1 Ancient Murrelet, 1 Thick-billed Murre, 9 Short-tailed Shearwaters
130	1 Thick-billed Murre, 11 Short-tailed Shearwaters
138	1 Sooty Shearwater*
179	1 Sooty Shearwater*
Unknown Mesh Size	2 Tufted Puffins, 1 Thick-billed Murre 4 Sooty Shearwaters, 8 Short-tailed shearwaters 1 Fork-tailed Storm Petrel

*From the HOKUSEI MARU; all others from the OSHORO MARU

Table 6. Species and total numbers of animals caught in the gill nets of the OSHORO MARU in the Bering Sea and North Pacific, Summer 1978.

Species	Number
SQUID	
Gonatopsis borealis	56
Onychoteuthis borealijaponicus	115
Ommastrephes bartrami	1,482
Unid. Squid	18
FISH	
Oncorhynchus nerka	1,388
Oncorhynchus keta	148
Oncorhynchus gorbuscha	609
Oncorhynchus tshawytscha	20
Oncorhynchus kisutch	103
Theragra chalcogramma	458
Pleurogrammus monopterygius	4
Icosteus aenigmaticus	1
Icichthys lockingtoni	1
Hyperoglyphe japonica	4
Brama raii	3,879
Katsvwonus pelamis	459
Thunnus alalunga	98
Xiphias gladius	1
Seriola aureorittata	10
Coryphaena hippurus	1
Alepisaurus borealis	1
Anotopterus pharao	1
Cololabis saira	224
Exocoetidae	5
Naucrates indicus	2
Mola mola	2
Pseudopentaceros richardsoni	1
Tetragonurus cuvieri	5
SHARKS	
Lamna ditropis	10
Squalus acanthias	3
Prionace glauca	92
TURTLES	
Dermochelys coriacea	1

Table 6. (cont'd.)

MARINE BIRDS	
Puffinus griseus	4
Puffinus tenuirostris	31
Oceanodroma furcata	1
Uria lomvia	6
Synthliboramphus antiquum	1
Fratercula corniculata	1
Lunda cirrhata	3
MARINE MAMMALS	
Phocoenoides dalli	1

Table 7. Comparisons of Estimates of Seabird Mortality in the Japanese Salmon Gillnet Fishery

Data Source	Birds/Tan	Mortality	Total
Sanger (1973)			
Motherships	.04195	250,000	715,000
Land-based	.04195	465,000	
Motherships	.0120	139,500	214,500
Land-based	.0120	75,000	
Bakkala (1974)			
Motherships	.0436	255,000	763,000
Land-based	.0436	508,000	
Japanese Fishery Agency (1977)			
Motherships		183,200	350,500
Land-based	.0450	167,300	
This Study (1978)			
Motherships		139,500	278,500
Land-based	.0370	139,000	

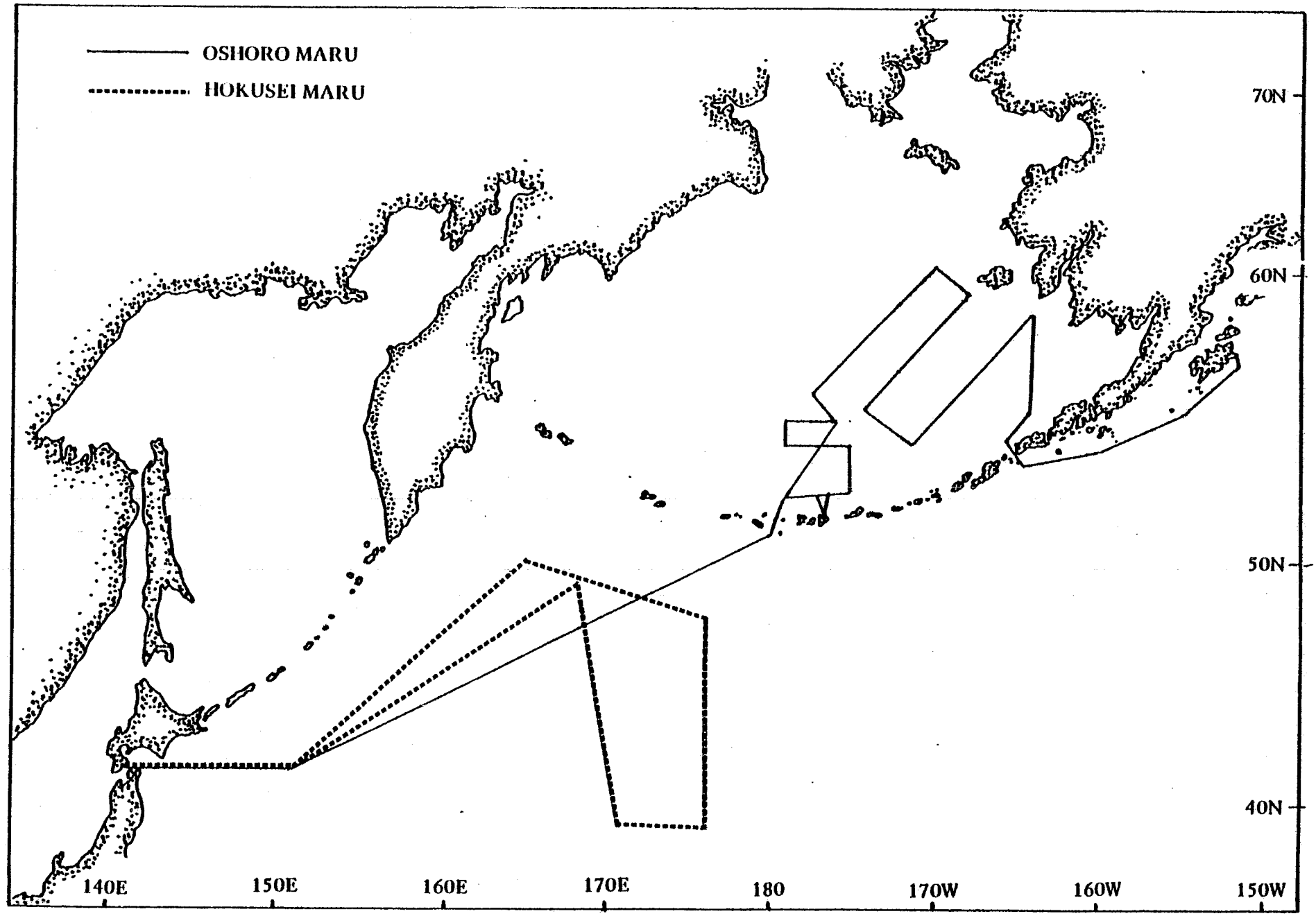


FIGURE 1. CRUISE TRACKS OF THE OSHORO MARU AND HOKUSEI MARU, SUMMER 1978

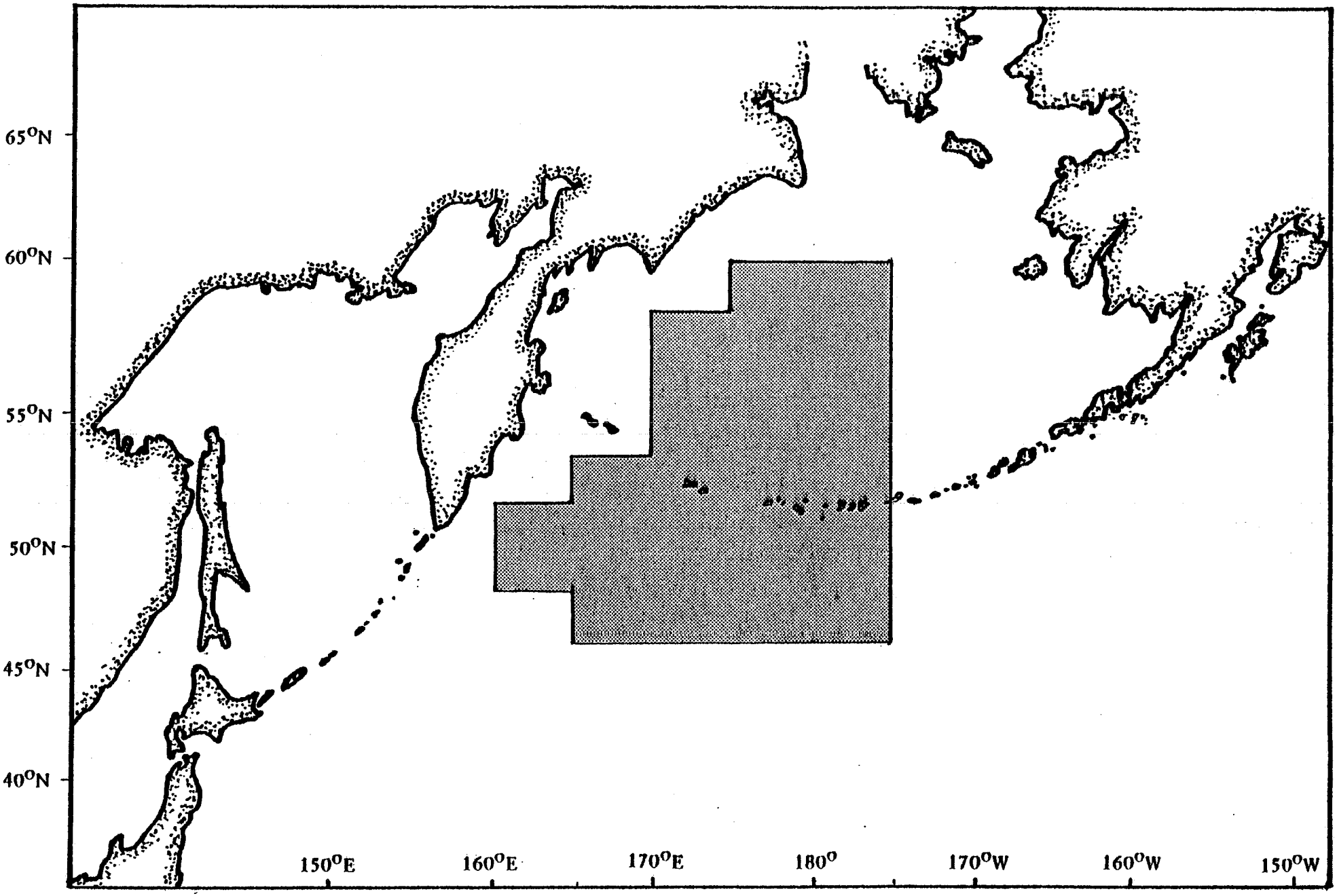


FIGURE 2. AREA OPEN TO FISHING BY THE JAPANESE MOTHERSHIP FLEET PRIOR TO 1977.

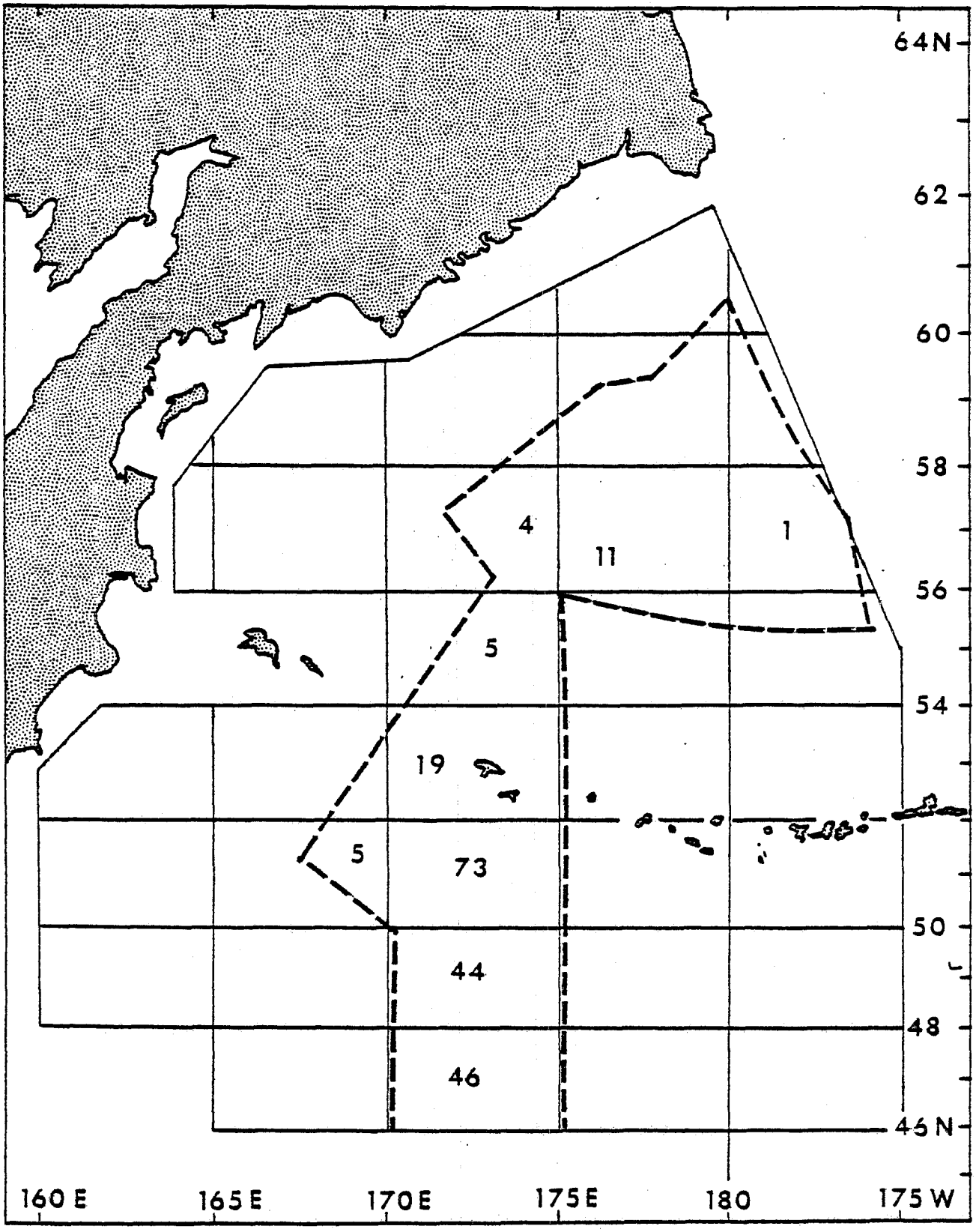


FIGURE 3. FISHING AREA OPEN TO THE JAPANESE MOTHERSHIP FLEET IN 1978 AND ESTIMATED FISHING EFFORT IN FLEET DAYS PER 2°LAT. x 5°LONG. BLOCK.

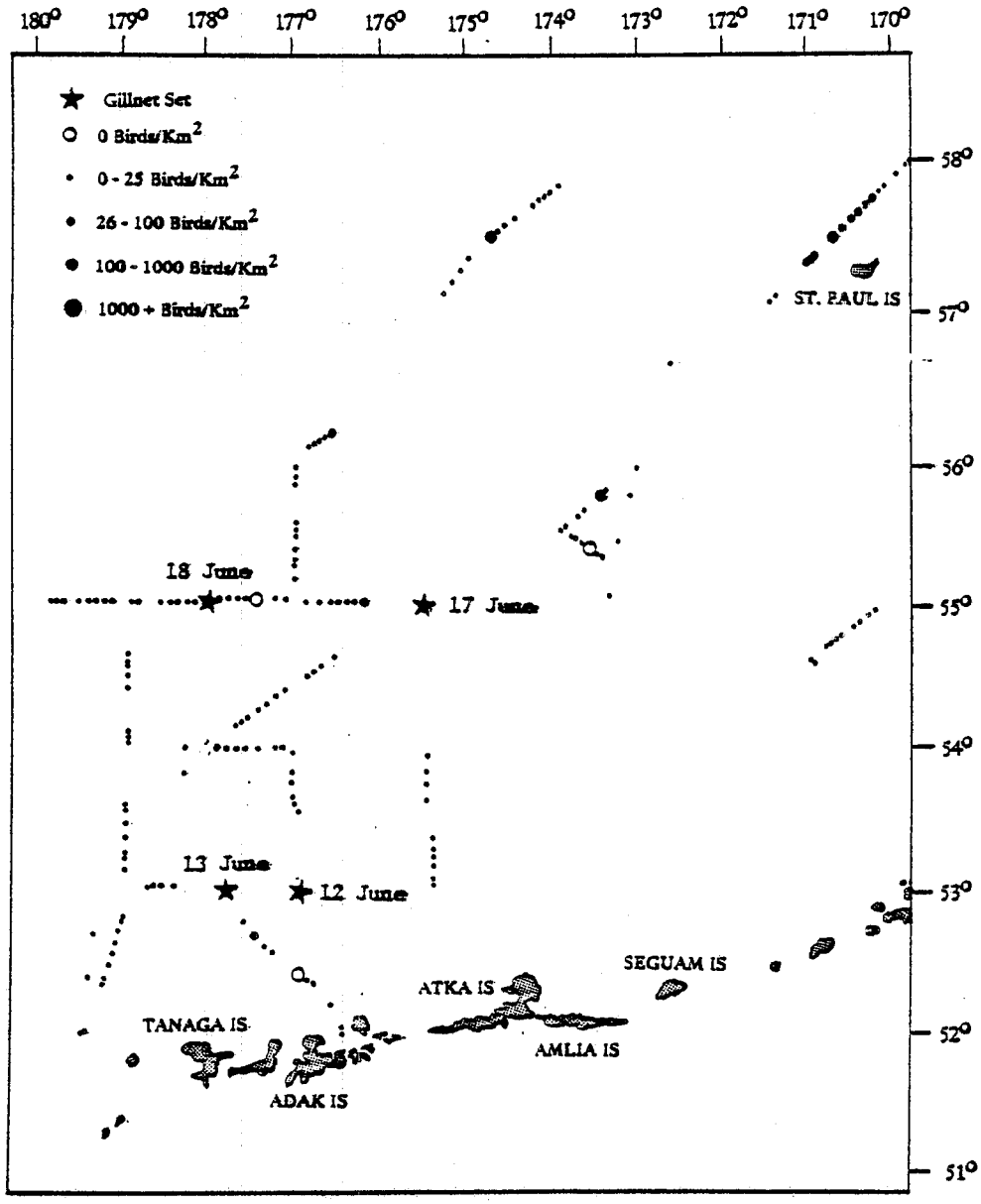


FIGURE 4. LOCATION OF GILLNET SETS; SEABIRD TRANSECTS, AND DENSITY OF SEABIRDS IN THE BERING SEA FOR THE OSHORO MARU CRUISE, 5 JUNE - 3 JULY, 1978.

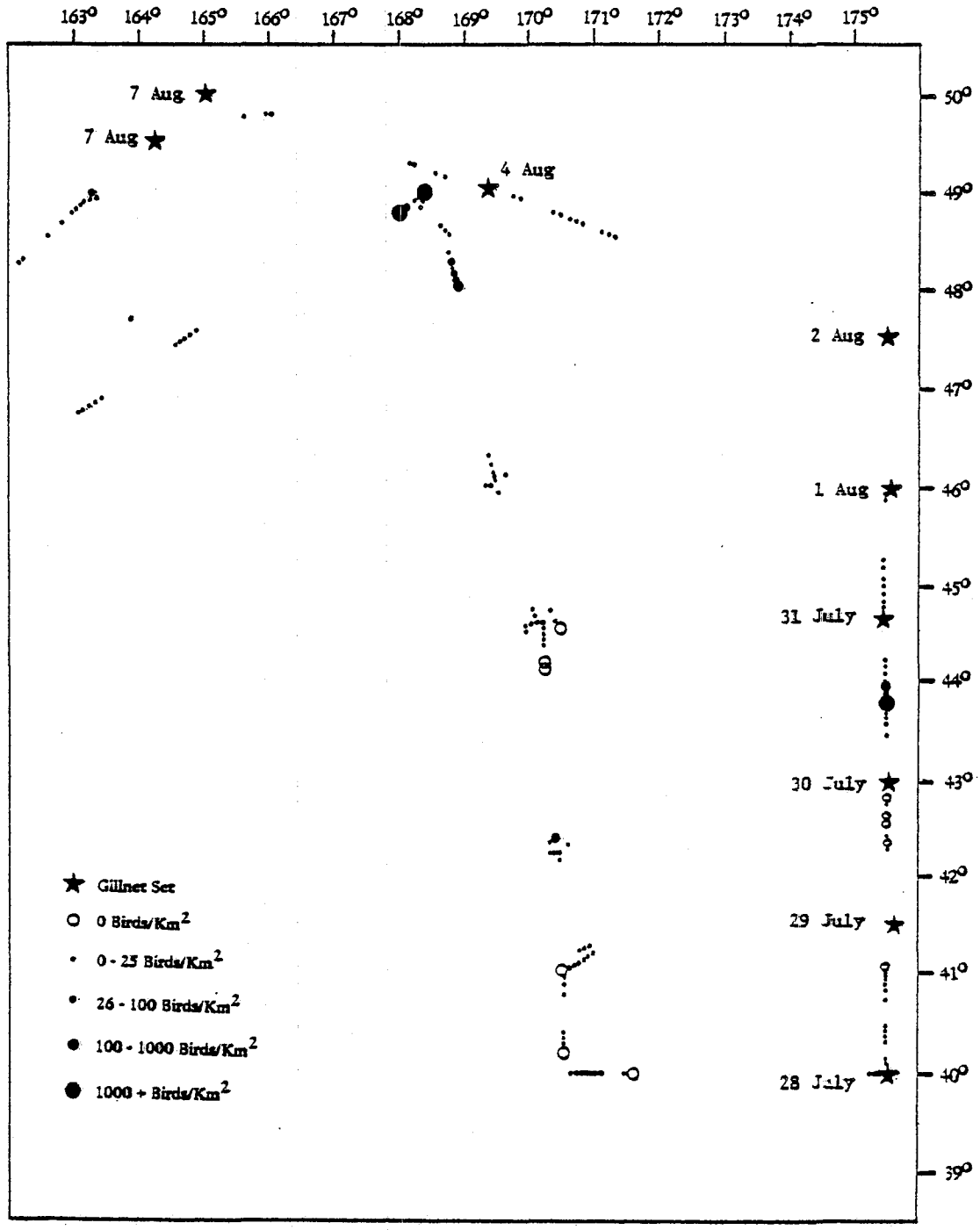


FIGURE 5. LOCATION OF GILLNET SETS, SEABIRD TRANSECTS, AND DENSITY OF SEABIRDS IN THE STUDY AREA OF THE HOKUSEI MARU, 16 JULY - 12 AUGUST, 1978.

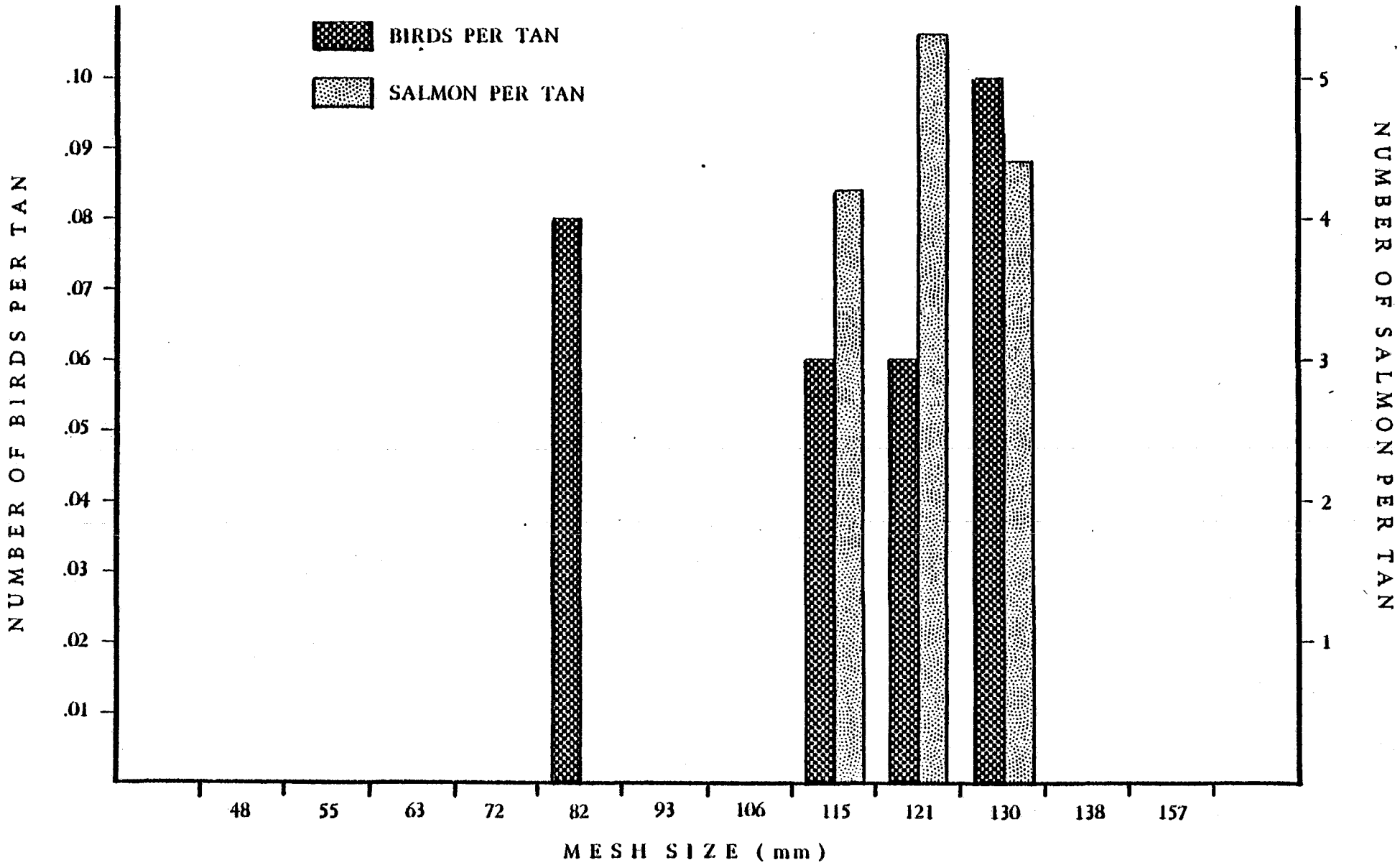


FIGURE 6. COMPARISON OF SEABIRDS CAUGHT PER TAN AND SALMON CAUGHT PER TAN IN THE GILLNET OF THE OSHORO MARU FOR FOUR GILLNET SETS IN THE BERING SEA, SUMMER 1978.

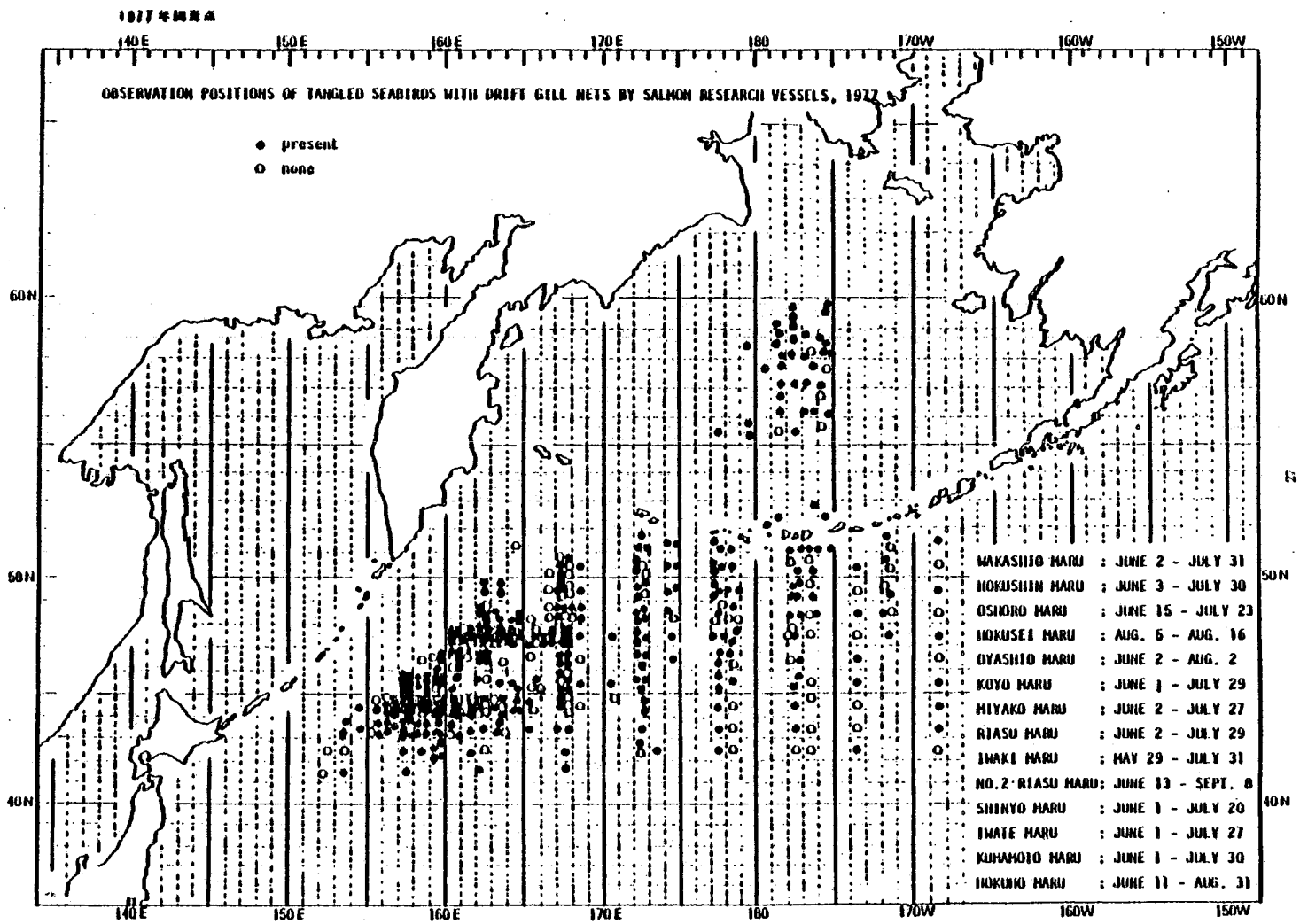


FIGURE 7. POSITIONS OF SEABIRD ENTANGLEMENT IN GILLNETS OF JAPANESE RESEARCH VESSELS IN 1977.

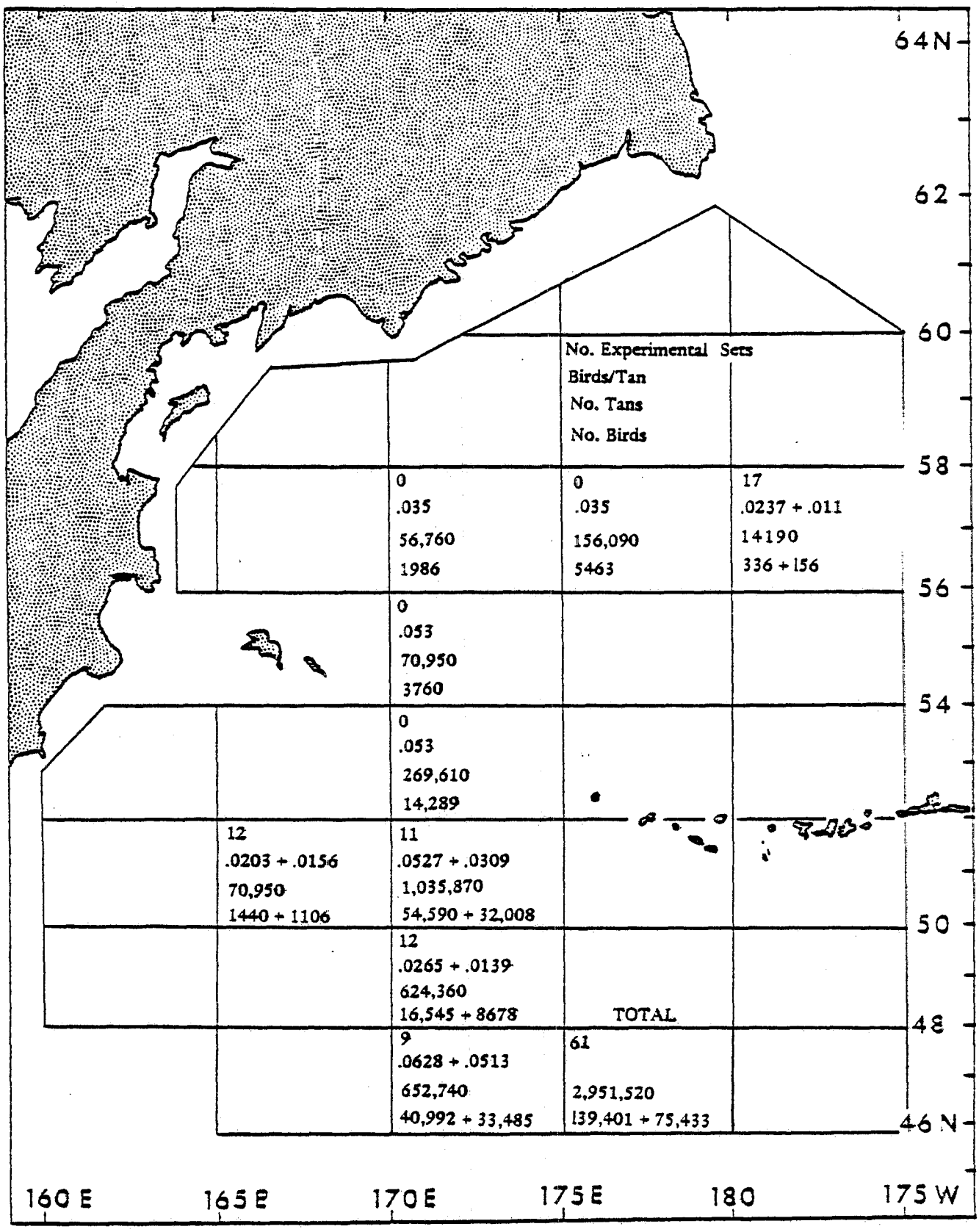
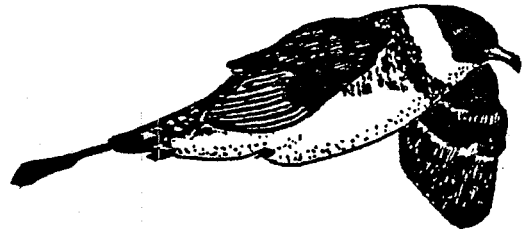
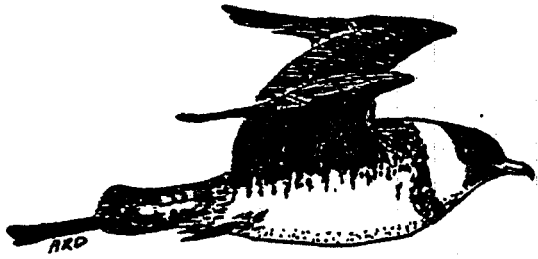


FIGURE 8. ESTIMATED FISHING EFFORT AND SEABIRD MORTALITY BY 2°LAT. x 5°LONG. BLOCK FOR THE JAPANESE SALMON MOTHERSHIP FISHERY IN 1978.

APPENDIX





The following draft of a manuscript on the mortality of marine fish and birds in an old untended gillnet will be submitted to a journal for publication in the near future.

Seabirds are frequently entangled in gillnets (Bourne, ICBP Bull. XI: 200-218, 1972; Sowl and Bartonek, Trans. Thirty-ninth N.A. Wildlife and Nat. Res. Conf: 117-126, 1974). Tull, Germain and May (Nature 237: 42-44, 1972) estimate that the 1965-1975 Danish gillnet fishery in the North Atlantic killed 500,000 ± 250,000 Thick-billed Murres (Uria lomvia) annually. King, Brown and Sanger (U.S. Fish and Wildlife Serv., Wildlife Research Report, In Press) estimate that between 214,500 and 715,000 seabirds were killed in Japanese salmon gillnets during each fishing season in the North Pacific Ocean and Bering Sea prior to 1974. A more recent estimate (Osamu Sano, Enyo 30: 1-4, 1978) put the incidental kill of seabirds in the Japanese fishery at approximately 350,000 birds.

The Japanese have operated a high seas salmon fleet in the North Pacific Ocean and Bering Sea since 1952. This fishery can be divided into both a mothership component and a land based component. The far ranging mothership fleet in 1977 included 245 catcher boats that deployed approximately 1170 sq. km of drifting gillnet. The fleet was reduced to 172 catcher boats in 1978 as a result of new agreements between Japan and the United States that further restricted the area open to fishing. In 1977, the Japanese land based fleet was composed of 832 vessels of less than 7 tons and 297 vessels of between 40 and 90 tons. The larger vessels fished approximately 1110 sq. km of gillnet in 1977.

Gillnet sets are made nightly from catcher boats, the duration of each set ranging from 9-12 hours. Bird entanglement, therefore can only occur during a defined although lengthy period of time. However, gear that has been lost or discarded without removal of the float line, continually fishes for near surface organisms. Bourne (Marine Poll. Bull. 8(4): 75-76, 1977) remarked that drifting fragments of gillnets may pose a hazard to seabirds. Such mortality increases the size and duration of the annual incidental kill but is difficult to quantify (Sowl and Bartonek, op. cit.).

Other than our observations, we know of few reports concerning the mortality of seabirds and other marine animals in lost or discarded gillnets. Waldichuk (Marine Poll. Bull. 9(8): 197, 1978) has recently commented on the increased number of Northern Fur Seals (Callorhinus ursinus) entangled in netting and plastics on the Pribilof Islands. Ed Bailey (Pers. comm.) found an entangled fur seal on a Unimak Island, Alaska beach in 1972. Sixty-six meters of monofilament gillnet containing the numerous feathers of seabirds and the skull of a seal were found on a beach in Lower Cook Inlet, Alaska in 1973 (Alaska Magazine 39(12): 25, 1973). In 1960, on Amchitka Island, Alaska, 3500m of monofilament gillnet containing 2 dead Dall Porpoise (Phocoenoides dalli), 3 dead Sea Otters (Enhydra lutris), 3 living Sea Otters, and 50 dead seabirds were recovered (Robert D. Jones Jr. pers. comm.). Other reports are limited to small numbers of birds entangled in fragments of net. This paper reports on the mortality of seabirds and fish from

an untended, drifting gillnet in the North Pacific Ocean.

On 5 August, 1978 while making observations of marine birds and mammals aboard the University of Hokkaido, Faculty of Fisheries Training Vessel HOKUSEI MARU, we discovered a long drifting gillnet of uncertain origin at 49° 15' N and 168° 14' E. The net was intact but lacked marker bouys, marker lights and a radio beacon. In a 2 hour period, 1500m of net were pulled aboard, leaving an estimated 2000m floating. The net was monofilament, had a stretched mesh of 110mm and was 6m deep. The float line was removed and the recovered net was subsequently thrown overboard with the intent of sinking the remaining floating net.

Approximately 75 recently entangled chum salmon (Oncorhynchus keta) and silver salmon (O. kisutch) were salvaged during the operation. However, for each salmon salvaged, at least two were too rotten to be used as food. In addition to salmon, one ragfish (Icosteus aenigmaticus) and two salmon sharks (Lamna ditropis) were entangled.

During the operation, four Laysan Albatross (Diomedea immutabilis), 75 Northern Fulmars (Fulmarus glacialis) and several Fork-tailed Storm Petrels (Oceanodrama furcata) were attracted to the net, apparently by net-entangled organisms. One entangled dark phase Northern Fulmar was taken aboard alive and released. Ninety-nine dead birds were recovered from the 1500m of net (Table 1). The majority of dead birds were caught in the upper one-third of the gillnet. As expected, many of the birds were in an advanced stage of decomposition. In some cases, only bones were present in the net. All 15 Tufted Puffins were immature, one year old birds, lacking both head plumes and white faces. Nine of eleven puffins showed primary molt and ten of these showed varying degrees of body molt.

Based on the decomposition of may fish and birds, it is apparent that the net has been soaking for a long period of time. Based on the appearance of the net and the degree of attached periphyton, Seiji Sasaki, 2nd Officer aboard the HUKUSEI MARU, estimated that the net had been floating 30 days. Based on ocean currents, Iori Tanaka (pers. comm.) suggested that this net may have drifted over 100km in that period of time.

Fragments of gillnet, both with and without floats are a common sight on beaches of the Alaska Peninsula and Aleutian Isalnd (Robert D. Jones Jr. pers. comm.). The observation presented herein show that lost or discarded intact fishing gear may have drastic consequences for organisms inhibiting the near surface zone. Similarly, net without floats or lead line may continually entangle benthic or nektonic organisms. Considering the durability of monofilament, lost or discarded gillnets may have serious consequences for wildlife for extended periods of time. With this in mind, in the future, fishermen must refrain from discarding gillnets and fragments of gillnets at sea.

Table 1. Seabirds Entangled in an Old, Drifting Gillnet in the North Pacific Ocean, 49° 15'N, 168° 14' E.

Species	Number
Diomedea immutabilis	1
Fulmarus glacialis - dark phase	6
Fulmarus glacialis - light phase	1
Puffinus griseus	14
Puffinus tenuirostris	40
Puffinus sp.	10
Unid. Seabird	12
Lunda cirrhata (immature)	15