RESULTS OF 1985 RESEARCH ON THE HIGH-SEAS SQUID DRIFTNET FISHERIES OF THE NORTH PACIFIC OCEAN

by

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INTRODUCTION

High-seas driftnet fisheries for North Pacific squid have grown since 1978 to involve about 700 vessels from Japan, Taiwan, and the Republic of Korea (ROK). Each vessel fishes from 18 to 40 km of monofilament gill net nightly, and the fisheries are conducted from June through November each year. In so doing, these squid fisheries may entrap marine mammals and seabirds in their nets, incidentally catch salmon, and generate significant amounts of marine debris which contributes to the mortality of living marine resources and poses a threat to human safety as a result of fouling vessels. Because these squid fisheries are outside the U.S. E.E.Z. and not subject to any international treaty to which the U.S. is a party, it has not been possible to routinely place U.S. observers in these fisheries. Therefore, the extent of entanglement of marine species in squid driftnets is not known. Qualitative evidence, however, discussed at the Workshop on the Fate and Impact of Marine Debris, in Honolulu (November, 1984), suggests that it may be substantial for certain species.

Widespread public concern over entanglement of marine mammals, seabirds, and commercial fishes by these fisheries prompted the U.S. Congress, this year, to fund a study of this problem. This study was conducted by the National Marine Fisheries Service (NMFS) in cooperation with the United States Coast Guard, 17th District. The following report presents the initial findings of this research.

The NMFS recently concluded 36 days of research on the high-seas squid gill-net fisheries of Japan, Republic of Korea, and Taiwan in the Central North Pacific. The USCG provided the USCGC STORIS as a research platform for the NMFS scientific party. The objective of our research was to examine the gill-net vessels and determine if they incidentally catch marine mammals, seabirds, and salmon. Since little is known about these fisheries, we desired information on the vessels, fishing techniques, equipment, and schedules, in addition to catch information. Taiwanese and Republic of Korea fishing vessels were determined too far south and west so our survey concentrated on Japanese vessels. Although we planned to survey the entire squid regulation area, a SAR event and rough weather in the west kept most work within the eastern segment of the study area.

The NMFS scientists observed 4 deployments and 11 retrievals of gill nets and the USCG boarded 15 gill-net vessels. We found that it took 3 to 4 hours to deploy a net and 6 to 9 hours to retrieve it. Different size boats fished different lengths of gill net ranging from 7 nm to 35 nm of net set each evening. The retrieval usually began 3 to 4 hours before sunrise and continued through the morning.

ESTIMATING CATCHES AND DROPOUTS

Net retrievals were observed, and sample counts of gill-net catches were made from the bridge wing of the USCGC STORIS and from a motor launch. We used the bridge wing of the STORIS as an observation platform to make sixty-three 5-minute sample counts of gill-net catches by three Japanese squid boats. Counts were made in both daylight and darkness. These counts sampled 40% of the total time for retrieval of three nets. We used a motor launch to make one hundred forty-eight 5-minute sample counts of gill-net catches by seven Japanese squid boats. All of these small boat counts were made in daylight. These counts sampled 24% of the total time for retrieval of seven nets. Counts of dropout fish were also made in 5-minute increments.

Observations from the motor launch were vastly superior to observations from the bridge of the STORIS because of the closer viewing distance. We were able to recognize birds in the gill net, and we could confidently distinguish tuna from pomfrets. No salmon were seen, but we believe we could have distinguished salmon from tuna if any salmon had been caught.

Catch estimates were determined from the 5-minute sample counts. Total catch was then estimated by using the number of squids, sharks, pomfret, etc., which were counted per 5-minute sample, the number of 5-minute samples, and the total time of retrieval (Table 1). The data show that a single day's catch ranges from 871 to 8,256 squid and 5 to 530 tuna (Table 2). Average CPUE/nm for squid, tuna and yellowtail, and pomfret was 127, 9.4, and 78.9, respectively.

More than 90% of the squid were flying squid based on their large size and red color. The Masters of squid boats said that all squid were flying squid. Less than 10% may be other species based on smaller size and grayish color. Our counts are totals of all squid caught.

Our tuna and yellowtail counts included yellowtail and albacore. Pacific bonito may have been included because a Coast Guard boarding party reported mackerel-like tuna on a squid boat. The large pectoral fins of the albacore were easily visible only when profiled against a light background. Live yellowtail were found attached to a log by a piece of gill-net debris. The log and entangled net fell out of a squid net during retrieval.

The shark counts were composed of blue sharks, hammerhead sharks, and possibly one salmon shark. Although some individual sharks were recognizable to species, we could not identify these makes rapidly enough to justify the effort. We observed a high rate of dropout for sharks. Many of the dropouts were intentionally shaken or rolled out of the net by the fishermen. Dogfish sharks, and small blue sharks could not have been distinguished from each other as we viewed them. We confirmed the presence of blues from specimens caught in a piece of derelict gill net. We did not obtain specimens to confirm the presence of dogfish sharks. Blue sharks and possibly other unidentified sharks 3 to 4 feet long dominated the shark catch and they were quickly discarded.

Pacific pomfrets were recognized by their silvery color, round shape, and small size relative to other fish in the catch. They could be confused with small ocean sunfish when viewing distance exceeded 200 meters. Pomfrets appeared to be caught in the net by their pectoral fins and characteristically could be seen actively flipping as the net was pulled aboard the vessel. Many of the smaller pomfrets were tossed overboard soon after they were caught. A high percentage of those released in this manner could have been viable.

Other fish that were recognized in the catches included lancetfish, pelagic armorhead, swordfish, and marlin. Small ocean sunfish can be confused with pomfrets at distances greater than 200 meters.

Effects of the Squid Fisheries on Other Species

Salmon

No salmon were observed caught by the squid boats. The vessel masters' response to the question "Have you caught any salmon?" was always "no."

It has been noted that the 15°C isotherm is mentioned in some reports as a line of separation between salmon and the squid fisheries (Takagi 1983; Burgner and Meyer 1983). The squid boats observed were actively fishing were in water warmer than 16°C. The 15°C isotherm was crossed at about 47°30'N on the way south from Kodiak and between 47° and 48°N on the way north to Kodiak. Water temperatures were above 15°C throughout the study area. Water temperatures may have been relatively warm in the squid fishery area this year, and if so, this may have reduced the chances of finding salmon.

Birds

Effective monitoring of seabird entanglement was only possible from the small boat. Since birds were fairly infrequent, all observations were noted. Therefore, seabird observations during the total count samples and the dropout count samples can be combined.

A total of 27 birds (26 shearwaters and 1 black-footed albatross) were seen in the net (Table 3). The shearwaters were either sooty or short-tailed shearwaters, but except for one instance, they could not be closely examined to determine species. In one case, two birds were discarded from the ship after being observed in the net. These birds were recovered; one was confirmed as the only black-footed albatross observed caught and the other as a short-tailed shearwater. It is suspected that most, if not all the other shearwaters, were short-tailed shearwaters, but since these birds are essentially indistinguishable

without close examination, identification is not positive. Three of the shearwaters were released unharmed. Birds were easily seen and identified (at least to genus) in the net since they tended to be fully stretched out, with their wings extended. All the birds were seen near the corkline, sometimes solitary, but in one case, in a group of six.

Marine Mammals

During the total and dropout counts, as well as casual observations between counts and observations from the STORIS, the net was examined for marine mammals, but none were seen. The Master of one squid boat, the HATSUE MARU #68, acknowledged that he had caught four or five dolphins on one occasion this season. The Masters of all the other squid boats were queried about marine mammals and stated they had caught none. Marine mammals were seen close to a gill net only once when a fur seal was observed near the port side forward of the beam of a squid boat while the boat was retrieving gill net. The fur seal was not entangled in the net. Officers on the STORIS frequently supplemented our own efforts to observe incidentally caught marine mammals, and none were seen.

TRANSECTS CONDUCTED DURING THE CRUISE

Transects were conducted during the cruise for a better understanding of the distributions of marine mammals, birds, and discarded fishing nets. The cruise tracks were not designed for population surveys, since the transects were conducted on an opportunistic basis, and no estimates of abundance are made.

Marine Mammal Surveys

Observations for marine mammals were conducted by the lookout on watch on the flying bridge, bridge personnel, and researchers with the identification of species made exclusively by the researchers. Search effort was conducted during daylight hours when the ship was underway, winds were no more than 15 knots, and visibility was at least 2 nm. These observations were considered "on effort" sightings, and observations of marine mammals during other conditions were considered "off effort" sightings. Observations were also made during the deployment and retrieval of nets.

A total of 1113 nm (111 hrs.) of marine mammal surveys were conducted in the study area (south of 47°N.). An additional 383 nm (37 hrs.) were conducted north of 47°N. Results of the surveys are given in Tables 4 and 5. No marine mammals were seen during the deployment or retrieval of the nets. However, one observation of Dall porpoise was made within 1 nm of the beginning of a net which had been deployed earlier in the day. Numerous species were present in the research area, particularly species that are, at least partially, squid eaters. These include sperm whales, pilot whales, beaked whales, Dall porpoise, Pacific white-sided dolphins, and northern right whale dolphins. Additionally, one group of unidentified dolphins was likely Risso's dolphin, based on behavioral characteristics, but identification was not confirmed due to unfavorable sea conditions.

Bird Surveys

Bird surveys were conducted opportunistically when the ship was underway, winds were less than 25 knots, and visibility was greater than 5 nm. Surveys were conducted by research personnel from the bridge wing of the ship. A 90 degree sector, extending 300 m from the ship and originating at 0 degrees in front of the ship and extending to abeam of the ship, was surveyed. Counts were conducted over 10-minute sample periods.

A total of 69 transects (118.3 nm over 11.5 hrs) were conducted south of 47°N, and an additional 18 transects (31.8 nm over 3.0 hrs) were sampled north of 47 N. Results of the surveys are given in Table 6.

Observations were also conducted during the deployment and retrieval of the gill nets. Birds tended to aggregate in the vicinity of the fishing vessels during both deployment and retrieval of the nets, but only black-footed albatross were observed actively feeding from the net. Black-footed albatross were also the most numerous bird in the vicinity of the fishing boats as nets were retrieved, occasionally numbering over 100 individuals directly astern of the ship. Fork-tailed storm- petrels and occasionally Leach's storm-petrels, northern fulmars, and long-tailed skuas were common during net retrieval. Buller's shearwater, Laysan albatross, kittiwakes, arctic terns, and some unidentified skuas were also observed near fishing vessels.

Dark shearwaters (scooty or short-tailed) were infrequently seen near the fishing vessels. An exception to this was during two retrievals when they were observed feeding behind the ships. Twenty-three of the 26 shearwaters observed in the nets were caught in these 2 retrievals.

Net Debris Surveys

Net debris surveys were conducted principally by the lookouts on the flying bridge and usually ran concurrent with marine mammal surveys. However, since net debris is usually seen only when it is close to the ship (discussions with the lookouts suggested an effective half-width perpendicular distance from the trackline of 100 m), transects were valid if the visibility was at least 1 nm. Additionally, vessel speed changes did not appear to disrupt the transects, so periods of variable speed were not invalidated.

Net survey was conducted south of 47°N. over 1312 nm (145 hrs) in good sighting conditions with wind speed no more than 15 knots. An additional 1044 nm (114 hrs) survey was conducted in marginal sighting conditions with winds of 16-25 knots.

Ten fragments of net were sighted, nine of which were pieces of gill net (Table 7). A sample of each piece of net was labeled with date and location. The samples were delivered to the NMFS Auke Bay Laboratory. Five gill-net fragments were recovered in good sighting conditions, but one of these was observed released from the net during net retrieval and is therefore not part of the transect data. An additional four gill-net fragments were recovered in marginal sighting conditions. The one piece of trawl gear was recovered in rough seas when effective transects could not be conducted.

Since there is no decrease in the rate of sighting net fragments in good sighting conditions (3.05 sightings/thousand nm) and marginal sighting conditions (3.83 sightings/thousand nm), the data can be pooled. This yields a survey of 2356 nm (259 hrs) and a rate of sighting discarded gill net of 3.40 net fragments per 1000 mi surveyed.

DISCUSSION

Our preliminary observations generally support results of previous research by Japanese, Canadian, and U.S. scientists involved in INPFC research. For example, we found that the CPUE rates of squid and of various species of fish change with sea surface temperature (SST) which is influenced by the latitude of the fishing location. A difference of two degrees latitude may translate into a difference of two or more degrees (C) in SST and thus significantly affect the numbers of fish or squid in the catch. For example, the MIYAGI MARU fishing 27 miles of net at 46N 154W caught over 4 times the average catch of squid for two boats, EIKYU MARU 12 and HATSUE MARU 68, fishing about 100 miles, farther south; each of the latter boats fished 30 miles of net at about 43°50'N 152°W. Similarly, the KAIRYU MARU #5, fishing 15 miles of net at 46°48'N 153°30'W caught more squid per mile of net than the average for the two boats further south. The boats fishing further south contended with 8 to 10 times as many incidentally caught fish such as pomfrets, tunas, sharks, and lancets. All tunas and the largest pomfrets and sharks were retained.

The lack of salmonid catch compares favorably with observations by a U.S. observer aboard a Japanese squid driftnet fishing vessel in 1982 (Cary and Burgner 1982). However, observations in 1982 identified 19 entrapped cetaceans in 11 gill-net sets whereas our research observed no marine mammals in 6 gill-net sets. No information on seabird entrapment was taken in 1982. The major differences between our data and the 1982 data are in SST and time of year; in 1982 the data were collected a month later than our data and in SST's of 12°-15°C. Perhaps SST contributes to these differences in entrapment rates or marine mammal distribution. Four of the 11 sets, in 1982, occurred in SST's of at least 15°. Of these four, entrapment of marine mammals occurred in only one set. Entrapment of marine mammals was observed in 4 of the remaining 7 sets, and these sets accounted for 17 of the 19 entrapped mammals.

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Cary, Frank and Robert L. Burgner. 1983. Observations aboard a Japanese squid driftnet fishing vessel in September-October 1982. 23 pp. University of Washington, Fisheries Research Institute, FRI-US-8307. Seattle.

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Table 1. Conversion of timed 5-minute counts of catch to approximate length of net sampled, assuming each net was retrieved at a relatively constant speed. Data, unless otherwise stated, were collected from the motor launch.

Ship	Net (nm)	No. Sect.	Length of each Sect. (nm)	Av. Time/ Section (min/sect)	Retrieval Rate (min/nm)	Total of 5-minute Sample Counts (min)	Sample Time Counting Drop-Outs (min)	Total Sample Time (min)	Length of net sampled for Total Count (nm)	Length of net sampled for Distance Drop-Out Count (nm)	Total Length of Net Sampled (nm)
EIKYU MARU #12[a/]	30	9	3.3	38.9	11.8	85	0	85	7.20	0	7.20
HATSUE MARU #68	30	10	3.0	41.4	13.8	90	55	145	6.52	3.99	10.51
KAIRYU MARU #5[a/]	15	5	3.0	54.3	18.1	50	5	55	2.76	.28	3.04
MIYAGI MARU	27	7	3.9	66.0	16.9	115	80	195	6.79	4.71	11.47
KIYO MARU #8[a/]	13	4	3.3	65.2	20.1	180	0	180	8.97	0	9.38
KIYO MARU #8	13	4	3.3	--[b/]	--[b/]	60	50	110	2.99	2.60	5.73
KASHIMA MARU #58	20.3	7	2.9	47.0	16.2	105	100	105	6.48	6.17	6.48
SANKICHI MARU #23	21.6	10	2.2	47.3	21.5	135	135	135	6.28	6.28	6.28
WAKASHIO MARU #22	23.8	8	3.0	60.5	20.2	100	100	100	4.95	4.95	4.95
HOKUTATSU MARU #88	30	11	2.7	48.0	17.1	135	135	135	7.89	7.89	7.89

[a/] Counted from the bridge wing of the STORIS.

[b/] These data were collected on the STORIS.

Table 2. Catch estimates from retrieval observations on Japanese squid boats. Fish counts were conducted from the motor launch unless stated otherwise.

Vessel	Length Net (nm)	CATCH									
		Squid		Tuna/Yellowtail		Shark		Pomfret		Other Fish	
		(No.)	(No./nm)	(No.)	(No./nm)	(No.)	(No./nm)	(No.)	(No./nm)	(No.)	(No./nm)
EIKYU MARU #12[a/]	30	2600	87.0	458	15.3	320	10.7			1214	40.5
HATSUE MARU #68	30	1734	57.8	143	4.7	156	5.2	402	46.7	14	0.5
KAIRYU MARU #5[a/]	15	1179	78.6	5	0.4	16	1.1	201	13.4	33	2.2
MIYAGI MARU	27	8256	305.8	20	0.7	16	0.6	509	18.8	87	3.2
KIYO MARU #8[a/]	13	871	67.0	-	-	-	-	-	-	-	-
KIYO MARU #8	13	900	69.2	87	6.7	148	11.4	826	63.5	9	0.7
KASHIMA MARU #58	20.3	1322	65.1	533	26.2	19	0.9	545	26.9	22	1.1
SANKICHI MARU #23	21.6	4406	217.0	224	11.0	206	10.2	151	7.5	31	1.5
WAKASHIO MARU #22	23.8	3327	139.8	125	5.3	476	20.0	3457	145.3	14	0.6
HOKUTATSU MARU #88	30	4259	141.9	430	14.3	186	6.2	11646	388.2	23	0.8

[a/] Counted from the bridge wing of the STORIS.

Table 3. Seabirds seen in the gill nets of Japanese squid boats by observers in a motor launch. The black-footed albatross (BFA), short-tailed shearwater (SW), and other unidentified dark shearwaters (also categorized as SW) were observed entrapped by gill nets.

Vessel	Net Observed (nm)	Birds Caught		Catch Rate (Birds/nm)		
		SW	BFA	SW	BFA	Combined
EIKU MARU #12[a/]	7.2					
HATSUE MARU #68	10.5	1	1	0.09	0.09	0.19
KAIRYU MARU #5[a/]	3.0					
MIYAGI MARU	11.5	0	0	0	0	0
KIYO MARU #8[a/]	9.4					
KIYO MARU #8	5.7	0	0	0	0	0
KASHIMA MARU #58	6.5	7	0	1.08	0	1.08
SANKICHI MARU #23	6.3	16	0	2.54	0	2.54
WAKASHIO MARU #22	5.0	1	0	0.20	0	0.20
HOKUTATSU MARU #88	7.9	1	0	0.13	0	0.13
Total	53.4	26	1			

[a/] Counted from the bridge wing of the STORIS.

Table 4. Results of marine mammal transects which were conducted while the USCGC STORIS was underway. Sightings are listed as A-B, where A is the number of animals and B is the number of sightings.

Species	South of 47°N		North of 47°N	
	On Effort Sightings	Off Effort Sightings	On Effort Sightings	Off Effort Sightings
Dall Porpoise	61-16	25-8	44-12	5-3
Pacific White-Sided Dolphins	50-2	135-3	350-1	—
N. Right Whale Dolphins	105-2	78-2	50-1	—
Minke Whale	1-1	—	—	—
Sei Whale	—	2-1	—	—
Fin Whale	6-2	8-3	—	—
Sperm Whale	3-3	—	—	—
Pilot Whale	15-1	30-1	—	—
Killer Whale	—	—	2-1	—
Curvier's Beaked Whale	3-1	—	—	—
Unidentified Beaked Whale	12-4	—	—	—
Unidentified Dolphin	22-1	—	2-1	4-1
Unidentified Whale	4-1	3-3	1-1	—
Northern Fur Seal	5-5	1-1	21-13	4-4
Northern Elephant Seal	1-1	—	—	—

Table 5. Range of sea surface temperatures (SST) in which marine mammals were observed.

Species	Minimum SST (C)	Maximum SST (C)
Dall Porpoise	11	19
Pacific White-Sided Dolphins	13	18
North Right Whale Dolphins	13	18
Minke Whale	18	18
Sei Whale	19	19
Fin Whale	16	17
Sperm Whale	16	16
Killer Whale	11	11
Pilot Whale	18	18
Cuvier's Beaked Whale	18	18
Unidentified Beaked Whale	18	18
Unidentified Dolphin	11	17
Unidentified Whale	11	19
Northern Fur Seal	11	18
Northern Elephant Seal	18	18

Table 6. Results of bird transects which were conducted while the USCGC STORIS was underway. The data is presented as the number of birds sighted by area.

Species	North of 47°	South of 47°N				Total
		46°N-47°N	45°N-46°N	44°N-45°N	43°N-44°N	
Black-Footed Albatross	1 (0.03)[a/]	13 (0.06)	5 (0.28)	17 (0.40)	3 (0.15)	38 (0.32)
Laysan Albatross	0 (0)	1 (>.01)	0 (0)	0 (0)	0 (0)	1 (>0.01)
Northern Fulmar	6 (0.19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Dark Shearwater Sp.	22 (0.69)	4 (0.02)	3 (0.17)	2 (0.05)	1 (0.05)	10 (0.08)
Pink-Footed Shearwater	0 (0)	0 (0)	0 (0)	1 (0.02)	10 (0.50)	11 (0.93)
Motked Petrel	55 (1.73)	3 (0.01)	1 (0.05)	1 (0.02)	0 (0)	5 (0.04)
Fork-Tailed Storm-Petrel	2 (0.06)	24 (0.11)	41 (2.26)	37 (0.86)	120 (6.06)	222 (1.88)
Leach's Storm Petrel	2 (0.06)	3 (0.01)	0 (0)	35 (0.82)	0 (0)	38 (0.32)
Long-Tailed Skua	0 (0)	1 (>0.01)	1 (0.05)	4 (0.09)	0 (0)	6 (0.05)
South Polar Skua	3 (0.09)	1 (>0.01)	0 (0)	0 (0)	0 (0)	1 (>0.01)
Skua sp.	0 (0)	10 (0.04)	4 (0.22)	8 (0.19)	2 (0.10)	24 (0.20)
Effort (nm)	31.8	37.6	18.1	42.8	19.8	118.3
Effort (hrs)	3.0	3.7	1.5	4.5	1.8	11.5

[a/] Numbers in parentheses are birds/nm of search effort.

Table 7. Recovered pieces of derelict gillnet from the 1985 squid gill-net study.

Date	Position	Length (m)	Mesh (mm)	Leadline?	Comments and Descriptions
8/21	43°48.0'N 152°00.2'W	>30	115	No	Around log, released from active fishing net. 3 yellowtails (2 dead, 1 alive).
8/23	44°17.4'N 156°27.1'W	18.5	120	No	Net gathered in vertical folds, not tangled. 18 floats. Depth = 4.3 m.
8/26	44°46.6'N 166°07.1'W	40	115	Yes	Dead fur seal (immature male) in net. Net very tangled. Depth (full stretch) = 9 m. Length measured at leadline.
8/27	45°05.6'N 162°21.3'W	13	115	No	16 floats, corks damaged as if cut by ship. Net very shallow.
9/1	45°38.9'N 158°11.1'W	>30	105	Uncertain	Wrapped around log. No obvious catch. Entire net not examined. 38-40 corks.
9/2	44°29.6'N 162°48.5'N	12 X 12	140	No	Not gill net, probably trawl net. Nylon cord, not monofilament. Length not stretch measure, mesh size is stretch measure. Net wadded at surface. Amphipods only present in net.
9/2	44°15.8'N 163°39.6'W	>30	None	No	Only corkline, no net. 28-30 floats knotted and tangled. Large concentration of barnacles. Estimated 12+ skillfish live in this structure.
9/6	46°02.2'N 169°18.0'W	Short	??	??	5 floats on surface, some net below but looked shallow. Not recovered due to seas.
9/7	46°00.2'N 165°39.7'W	75	115	No	1 dead pomfret, 2 pelagic armorhead, 1 dead, 1 alive. Decayed fish parts also present. 111 brown floats.
9/9	45°59.4'W 153°56.6'W	86	115	No	3 blue sharks, 1 tuna, 1 sunfish dead in net. All fish partly decayed. Depth = 2.28 m. Net not badly tangled.

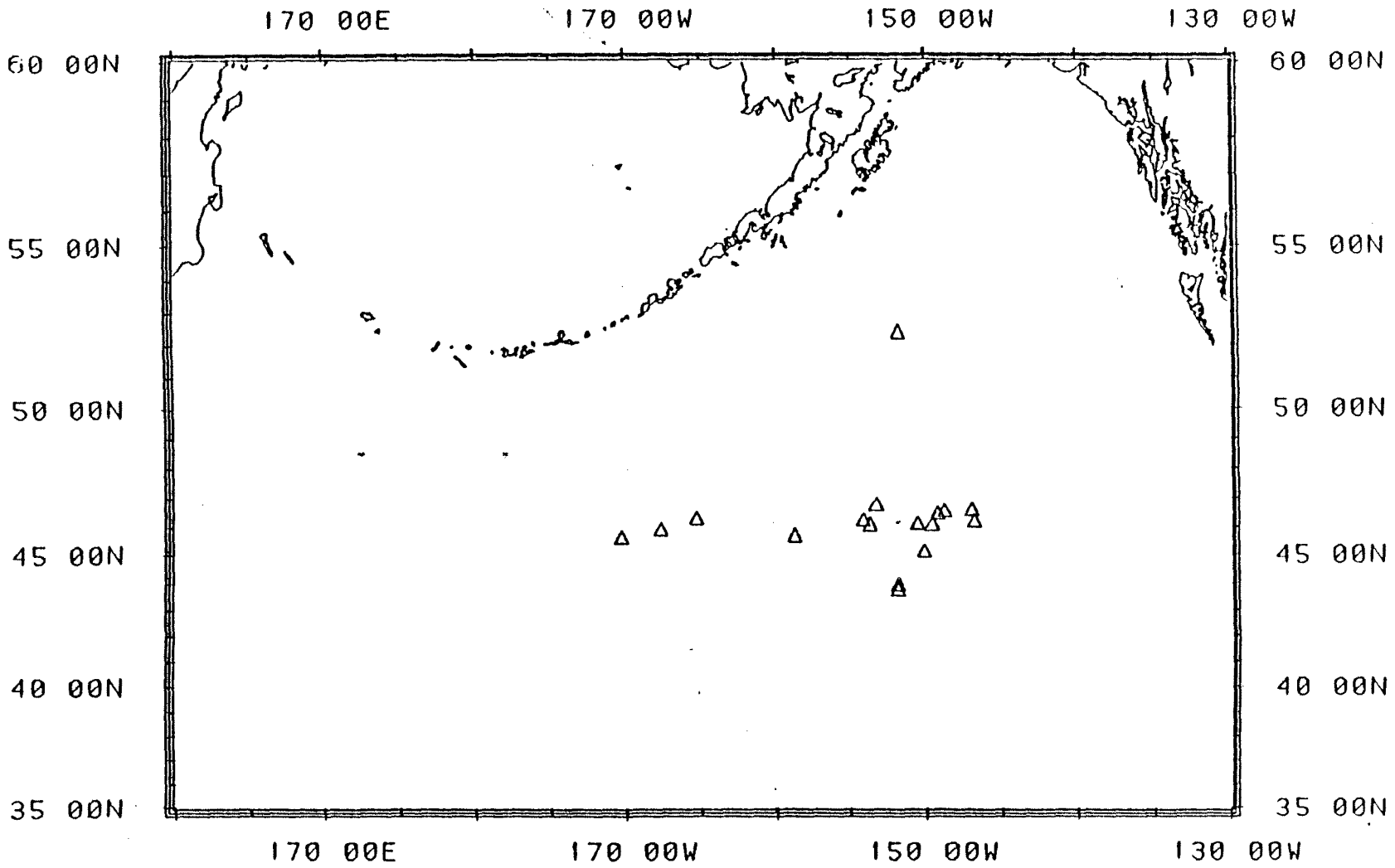

Figure 1. Locations of Japanese squid driftnet vessels which were either observed by NMFS scientists or boarded by USCG personnel.

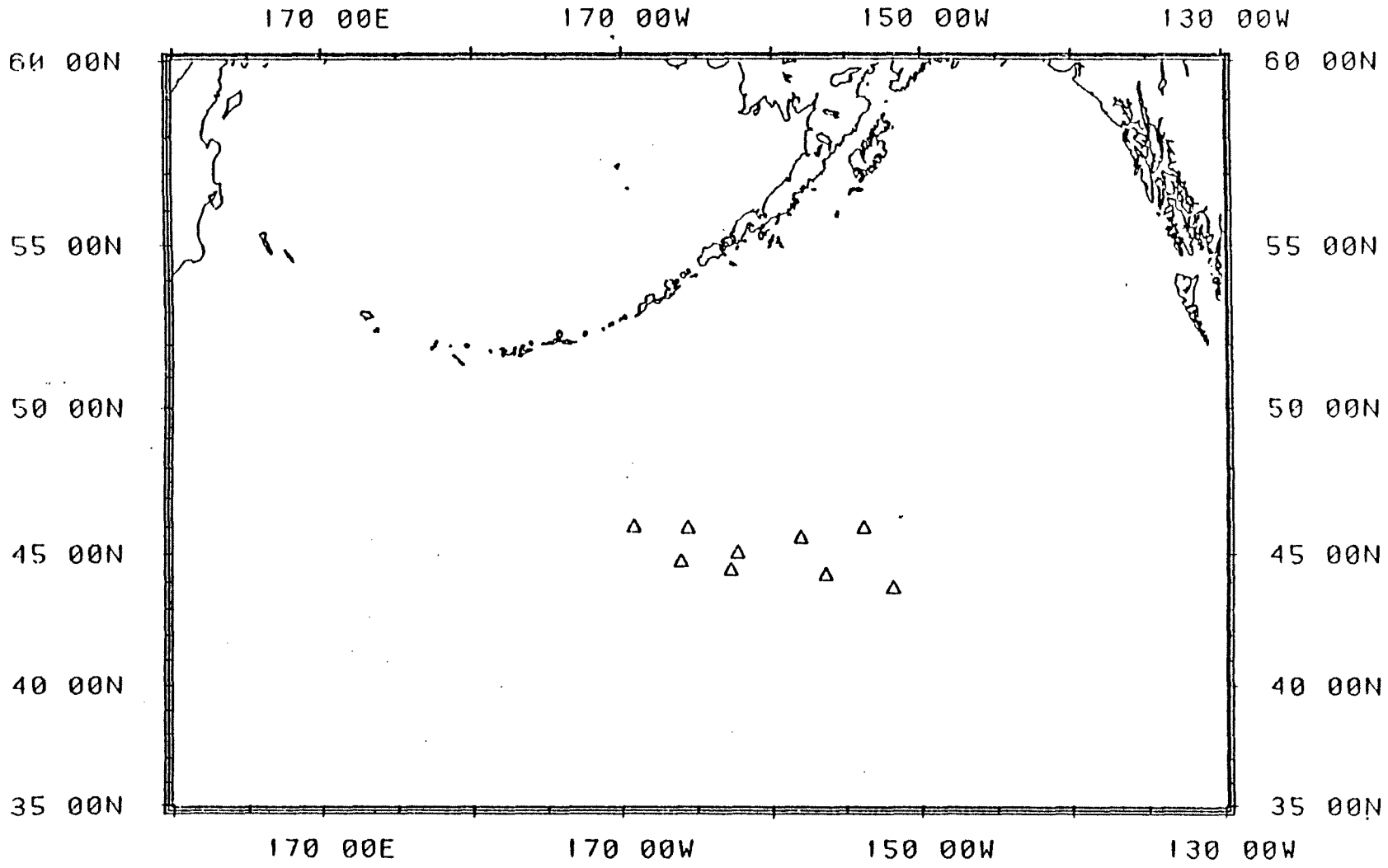

Figure 2. Locations of derelict gear found in survey area.