NOAA Technical Memorandum NMFS-AFSC-29

Estimation of Salmonid Bycatch in the 1989 Japanese Squid Driftnet Fishery

by
Steven E. Ignell, Laura J. Simon, and Michael L. Dahlberg

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The new NMFS-NWFSC series will be used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Ignell, S. E., L. J. Simon, and M. L. Dahlberg. 1994. Estimation of salmonid bycatch in the 1989 Japanese squid driftnet fishery. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-29, 45 p.

Reference in this document to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

NOAATechnical Memorandum NMFS-AFSC-29

Estimation of Salmonid Bycatch in the 1989 Japanese Squid Driftnet Fishery

by
Steven E. Ignell, Laura J. Simon, Michael L. Dahlberg

Auke Bay Laboratory
Alaska Fisheries Science Center
11305 Glacier Highway
Juneau AK 99801-8626

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary
National Oceanicand Atmospheric Administration
D. James Baker, Under Secretary and Administrator
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

January 1994

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

www.ntis.gov

Notice to Users of this Document

This document is being made available in .PDF format for the convenience of users; however, the accuracy and correctness of the document can only be certified as was presented in the original hard copy format.

ABSTRACT

Salmonid *(Oncorhynchus* spp.) bycatch data from the 1989 U.S., Canada, and Japan monitoring program for Japanese squid driftnet vessels were analyzed. Sampling effort was consistently less than expected by proportionate sampling between 170°E and 180° long., especially during the first part of the month when capture of salmonids would most likely occur. Salmonid incidence (the proportion of monitored operations encountering salmonids) was highest at the western and eastern boundaries of the fishery.

Fishing-effort data for the bycatch calculations were divided into three categories: a portion-represented by. observer data, an unrepresented portion that could be estimated by extrapolation of sampled data, and an unrepresented portion thatcould not be estimated. The observers reported a catch of 79 salmonids in 57 monitored operations (4% of total fishing effort). For the estimated portion (81% of total fishing effort), a bycatch estimator based on an extension of Aitchison's delta distribution produced a bycatch estimate of 2,648 salmonids. Although the unestimated portion of Japanese fishing effort is small, salmonid bycatches there may have been significant; a Republic of Korea research vessel operating in an unsampled portion of the fishing area and using 37 tans of driftnet caught 13 salmonids. This represents over 16% of the total salmon observed in 1,427,225 tans through the monitoring program.

The problem of unestimated strata may be unique to migratory species like salmonids which are found only within a small portion of the total fishing area. In addition, the warm ocean conditions of 1989 probably displaced salmonids northward, restricting the amount of fishing area intersecting salmonid waters, and inducing some of the estimation problems associated with our data.

CONTENTS

INTRODUCTION

In 1989, the United States, Canada, and Japan established a monitoring program aboard Japanese squid driftnet vessels operating in the North Pacific Ocean. This program was intended to secure information on the catch of neon flying squid (Ommastrephos bartrami) and the incidental take 'of salmonids (Oncorbynchus spp.) and other fishes... [and] to secure information on incidental take of marine mammals, seabirds, and other marine species of mutual interest.[1] The program was designed to provide initial data on the variability of bycatch rates in the fishery.[2] The 1989 data would be used to design a 1990 observer program to obtain fishery-wide bycatch estimates.

The need for immediate information on levels of bycatch in these fisheries led scientists from the participating nations to develop bycatch estimates based on 1989 data rather than waiting for 1990 data. Despite the limited amount of monitoring effort in 1989, expansion of observer data to provide fishery-wide bycatch estimates was theoretically feasible, given certain assumptions. Validity of these assumptions depends on estimation methodology. If the assumptions are false, an evaluation of possible estimation biases is required.

Methodology for estimating the number of salmonids caught in the 1989 Japanese flying squid driftnet fishery is developed and evaluated in this paper. First, the distribution of observer sampling effort relative to the reported fishing effort is examined. Second, the temporal and spatial patterns of salmonid incidence' are evaluated. Finally, a salmonid bycatch estimator is developed and applied.

---

[1] Annex to the 2 May 1989 letter from Kazuo Shima, Councillor to the Fisheries Agency of Japan, to Richard Smith, Deputy Assistant Secretary, U.S. Department of State.

[2] The reader should note that a U.N. sponsored moratorium on large-scale driftnet fishing was implemented beginning in 1993.

ANALYSIS OF OBSERVER SAMPLING EFFORT

Data. Collection

The 1989 monitoring program was implemented in two parts (Int. North.Pac. Fish. Comm. 1990): 1) a July-August program to collect data on the incidental catch of salmonids and other species near the recently modified northern boundary of the fishery, and 2) a June-December program to collect. data fishery-wide. The July-August program consisted of 22 Japanese, 5 Canadian, and 4 U.S. observers aboard 22 driftnet vessels. The July-December program consisted of 5 U.S. and 810 Japanese observers aboard 10 driftnet vessels. Canadian and U.S. observers were always paired with Japanese observers; 'thus, vessels included in the program were either monitored by a single Jgpanese observer or jointly by Japanese and North American observers.

Distribution of sampling effort was not controllable. Although the Fisheries Agency of Japan (FAJ) randomly selected vessels from each fishing port to host the observers, the -observers exerted no influence over areas fished. The vessels fished in accordance with directions from the fishing master (Int. North Pac. Fish. Comm. 1990).

The observers monitored driftnet operations 5 days at a time, resting each 6th day. For each observed fishing operation, they recorded the month, day, latitude, longitude, sea surface temperature, number of standardized effective tans. (50 m of driftnet) deployed; and the bycatch counts of various species. Observers monitored retrieval operations from an unobstructed vantage point, usually atop the pilot house or on the bridge wing. Because retrieval operations commonly lasted up to 12 h, one of every four net sections was randomly selected for a work break. Total catch by species was recorded on standardized data forms. Catch and: fishing effort for the entire fleet was provided by the FAJ and summarized by 10-day periods and by 1^o latitude by 1^o longitude statistical areas.

Analytic Methods

Distribution of observer monitoring 'effort relative to fishing effort by the fleet was examined. Fishing and observer effort data were stratified by time and area: nine approximately 10-day periods (1-10, 11-20, and 21 to end of month) in June, July, and August and between-10 and 13 areas depending on the time. If observer effort were proportional to fleet effort in the stratum, then the expected observer. effort for the jth area in the ith period is computed as

$$E(Obs)_{ij} = \sum_{j=1}^{n} Obs_{i,j} * \left(\frac{FE_{i,j}}{\sum_{k=1}^{n} FE_{ik}} \right) ,$$

where ***Obs*** is the number of operations observed and FE is the number of operations fished.

These statistical areas were formed from a combination of 1) five longitudinal categories--four 10° intervals between 170°E and 150°W long. and one 5° interval between 150°W and 145°W long.; 2) three latitudinal categories for July and August data east of 170°W long.--within 1°, between 1° and 2°, and more than 2° south of the northern boundary; and 3) two latitudinal categories for areas not covered in 2)--one above and one below the 1° line of latitude south of the northern fishing boundary (Fig. 1). Data from the July-August and June-December programs were combined.

The statistical areas were designed to divide observer and fishing effort data into strata reflecting possible differences in salmonid densities. For example, near the southern limit of salmonid distribution, a 2°C change in ocean temperatures--the expected monthly temperature change for a given latitude near the northern boundary of the squid fishing area--can lead to a marked change in salmonid abundance (Ogura and Takagi 1987). Selection of 10-day periods in the analyses were thus used-to minimize these changes.

Results

Observers monitored 1,402 Japanese squid driftnet operations from June through October 1989, observing the retrieval of 1,427,225 tans (71,361 km) of driftnet. These observations represent a 4.17% coverage of fishing operations and a 4.15% coverage of deployed tans (Fisheries Agency of Japan 1990). Although the program called for the monitoring of 32 driftnet vessels, data from only 27 vessels proved useful (Int. North Pac. Fish. Comm. 1990).

Distribution of Sampling Effort

The observer sampling effort was generally not proportional to reported commercial fishing effort (Fig. 2; Table 1), as observer effort was relatively more intense in the summer months. Deviations from proportional effort were related to longitude. Sampling effort was consistently greater than expected between 160°W and 150°W long. near the northern boundary, and between 170°W and 160°W long. in the southern portion of the fishery. Sampling effort was less than expected between 170°E and 180° long. for both latitudinal categories (Table 2).

The deviations also differed by time period between and within strata (e.g.; compare figures in Appendix Fig. 1). For the northern strata defined by 170°E-180° long. and 170-160°W long., sampling effort increased, by period; for adjacent strata located east of these two strata, sampling effort decreased by period (Figs. 3, 4). Within the extreme northwestern stratum (northern 1°, latitude of 170°E-180° long.); observed vessels were east of the fleet average toward the first of the month; toward the end of the month, they were located similarly (Fig. 5).

Differences between reported fishing effort and observed effort may be affected by the experimental design of the observer monitoring program. Observer placement was randomized over vessels, not over time and area. Vessel movements. are nonrandom; vessels may fish in an area for an extended period, or move great distances to fish in a new area.

ANALYSIS OF SALMONID INCIDENCE

Analytic Methods

Consider a random variable Y_i, such that $Y_i = 1$ if. salmonids are present and $Y_i = 0$ if salmonids are absent in,, the ith fishing operation. Assume that Y_i is distributed binomially. The likelihood function for a set of N driftnet operations is, then,

$$L(\pi) = \prod_{i=1}^{N} \pi^{y_i} (1 - \pi)^{1-y_i}.$$

Using the logit function,

$$g(\mu) = \ln[\frac{\pi}{1 - \pi}] ,$$

and fitting a linear predictor composed of a p-dimensional vector of independent variables (X_1, X_2,..., X_p), leads to the familiar logistic regression model where the conditional probability of salmonid incidence is-given as

$$\pi_i = \frac{\exp(\beta_0+\beta_1 x_1+\beta_2 x_2+...+\beta_p x_p)}{1+\exp(\beta_0+\beta_1 x_1+\beta_2 x_2+...+\beta_p x_p)}.$$

The independent variables used in the analyses consisted of spatial factors (latitude and longitude), month, time period, and sea surface temperature. Model parameters B_i of the linear predictor were estimated by the method of maximum likelihood.

Model selection employed a stepwise regression algorithm. Design variables for categorical variables were constructed using "reference cell coding," where the lowest group of a categorical variable serves as a referent group (Table 3). Model significance was assessed by likelihood ratio statistics which are formed from the logarithm of the ratio of two likelihoods (hereafter called the deviance). For a particular step, the deviance provides a test for whether the term entered (or removed) at that step significantly improves model prediction. Model adequacy was assessed by the Hosmer goodness-of-fit test (Hosmer and Lemeshow 1989), which compares the observed and predicted frequencies within strata defined by a grouping of the 'estimated probabilities.

Results

Only 57 of the 1,402 (i.e., 4.07%) observed operations encountered salmonids, resulting in a total observed catch of 79 salmonids during the 1989 monitoring program. 'As a result, the frequency distribution of salmonid bycatch rates was highly skewed, largely composed of zeros and ones (Fig. 6).

Catches of salmonids were sporadic in location (Fig. 7, for example) but generally highest at the western and eastern boundaries of the fishery (Tables 4, 5). The area of greatest incidence was between 145°W and 150°W long., where 22% (12/55) of the fishing operations located in the upper 1° latitude of the monitored fishery encountered salmonids. East of 180° long. (180°-170°W), 42 of the 44 operations encountering salmonids were within the northern 1° latitude of the fishery. West of 180° long. (180°-170°E), the incidence rate (the proportion. of monitored operations encountering salmonids) decreased more gradually with distance from the northern boundary. For example, if we consider the area 1° or more below the northern boundary,. 8 of 222 driftnet operations west, of 180° long. encountered salmonids, as compared with 2 of 476 operations eastward, an 8.6-fold increase over the incidence rate eastward (Table 4).

Model Fitting

Based on these results, we divided, the data-into two sections--west and east of 180° long.?-and fit separate logistic regression models to each set of data. This division eliminated the need to include interaction terms; such as longitude x latitude, thereby enabling a 'more straightforward interpretation of -parameter coefficients. For each section, regression models were first fit to the entire data set. Regions south of the northern boundary with very low incidence rates were then removed and the model refitted to clarify 'relationships among factors affecting the incidence measure.

For data. east of 180° longitude, two covariates were selected by the stepwise algorithm--longitude and distance from the northern boundary. The Hosmer test indicated that the model performed satisfactorily '(Table 6). Coefficients for the three longitude design variables, ***were*** negative. This means that for a given distance from the northern boundary of the fishery, the likelihood of salmonid incidence in strata west of 150°W long. was less than that from 145-150°W long. The other estimated coefficients in the model indicate that salmonid incidence was greatest 'during July and August, least during. September ‘and October, and least one or more-degrees south of the northern' boundary (Table 6).

When data were constrained further to within 0-1° of the northern boundary, both month and longitude entered into the model. Estimated coefficients for longitude were similar to those for the full data set; salmonid incidence was greatest during July and August and along the eastern portion of the fishery.

For data west of 180° long., only one variable (month) was selected by the stepwise algorithm (Table 7). Salmonid incidence was greatest in July, and greater in June than August. When restricted to data 0-20 south of the northern boundary, period replaced month in the regression mode-l.

Trends in Incidence Rates

The logistic model indicated that the probability of salmonid incidence in the areas observed in the 1989 squid fishery was small. Areas of greatest probability were west of 180° long. or along the northern boundary east of 180° long. The incidence rates were related to time period west of 180° long., but not eastward. East of 180° long., salmonid incidence was least from 170°W to 160°W long. and greatest from 145°W to 150°W long.; salmonid incidence there usually varied by month, never by 10-day period within month, and always by longitude and the distance from the northern boundary. Incidence rates for some months (e.g., July and August) and for some areas (e.g., 160-170°W long., and 170°W-180° long.), however, were similar.

Results from these models could be affected by the distribution of sampling effort in some areas. For example; salmonid incidence west of 180° long. was low during August. There was no observer coverage, however, reported along the northern boundary of this stratum during the first two periods of the month. In other months, salmonid incidence west of 180° was highest during the first of the month; thus the low August incidence is probably affected by these sampling patterns. This possibility is supported further by analyses of research vessel data which show that this area typically exhibits a high probability of salmonid incidence during early August (Ignell 1989).

SALMONID BYCATCH ESTIMATION

Analytic Approach

Assume each fishing operation is independent and selected at random. Also, assume that the fishing operations can be stratified into i regions and periods with relatively homogeneous rates of salmonid bycatch. Assume, within each stratum i that there is a p_i proportion of zero salmonid bycatch rates, and that nonzero salmonid bycatch rates are distributed log-normally.

Under the above assumptions, Pennington's (1983) extension of Aitchison's (1955) delta-distribution methodology can be used to construct a bycatch estimator that treats zeroes in the data- separately. Separate treatment: of zeroes provides a more efficient bycatch estimator statistically. The minimum-variance unbiased estimator of the mean, ***k,*** of the delta distribution is

$$k = \frac{n_1}{n} * \exp(\bar{y}) * G_{n_1}(0.5 * s^2) \qquad \text{if } n_1 > 1,$$

$$k = \frac{x_1}{n} \qquad \text{if } n_1 = 1,$$

$$k = 0 \qquad \text{if } n_1 = 0,$$

where

n_1 = the number of nonzero values,
n = the sample-size,
$\bar{y}$ = the sample mean of the natural logarithm of the nonzero salmonid bycatch rates,
G_{n_1} = an infinite series (Pennington 1983),
s^2 = the sample variance of the natural logarithm of the nonzero salmonid bycatch. rates, and
x_1 = the actual salmonid bycatch rate of the one nonzero value.

The estimated variance of the mean k, $\text{var}_{est}(k)$, is approximated by (Berrien et al. 1981)

$$var_{est}(k) = \left(\frac{\left(\frac{n_1}{n} * k\right)^2}{n} \right) * \left(\frac{n_0 * n}{n} + \frac{n_1}{n} \left(s^2 + \frac{s^4}{2} \right) \right) \qquad \text{if } n_1 > 1,$$

$$var_{est}(k) = \left(\frac{x_1}{n} \right)^2 \qquad \text{if } n_1 = 1,$$

$$var_{est}(k) = 0 \qquad \text{if } n_1 = 0,$$

where

n_0 = **the number of zero values.**

For each observed stratum *i* of the squid fishery, an estimate of the mean; k_i, and variance of the estimated mean, $var_{est}(k,)$, were derived. Weighting the estimated means k_i by the amount of fishing effort in each stratum *i*, (w_i), and summing over all strata, provides an estimate of the number of salmonids incidentally caught in 1989. A 95%-confidence interval of the total number of salmonids caught can be calculated by assuming that this weighted sum of the k_i is approximately normally distributed with standard-error $(\Sigma_i (w_i^2 * var_{est}(k_i)))^{1/2}$.

Sampled data were extrapolated into the unsampled cells based on the results of the logistic regression analysis. We used incidence data rather than catch rates because the mode of the catches was one and because our efforts to develop a regression model for catch per unit effort (CPUE) proved unfruitful. Accordingly, the following guidelines--derived from examinations of model statistics and parameter coefficients--were established to guide this extrapolation: 1) For data along the northern boundary east of 180° long., first look for data from adjacent periods (period was not significant for this region); 2)if there were no sampling in the stratum for that month, use data from an adjacent longitude stratum, but only if the parameter coefficientsfor the two strata were similar (e.g.,, the two strata between 160°W and 180° long.); 3) for data east of 180° long. but at least 1^o south of the northern boundary, expand over time period, or adjacent longitudinal strata; and 4) do not extrapolate for data west of 180° long. (time period was important in the model, and observer effort was irregular by time and area), or for data in October (insufficient data to determine bycatch patterns).

Results

The observed data set was stratified into the same 10-day periods and statistical areas as for the Chi-square analysis of the sampling distribution. Because of the limited number of positive values in each stratum (<8), we were unable to test the assumption of log-normality of the data.

For each stratum containing observed fishing operations, the mean salmonid bycatch rate (per 1,000 standardized effective tans), k_i, and its. standard error were estimated (Table 8). Weighting each estimated stratum mean by the number of 1,000 standardized effective tans in the stratum, and summing over all strata, provided an estimate of 2,635 salmonids (S.E. =675.997) and a 95% confidence interval of 1,310 to 3,959 salmonids.

Given the foregoing rules, we extended observer data into 28 -unsampled strata providing an estimate of 13.08 salmonids (S.E. of 9.01) (Table 9): 'Combining these two estimates yields a total estimate of 2,648 salmonids in 27,934,788 tans of fishing effort (81%of total fishing effort).

For unsampled strata meeting none of the foregoing criteria, or when period of fishing exceeded the period of sampling. (10 October), we did not estimate the salmonid bycatch. The nonsampled regions represent 0.25% of the fishing effort for June through August and 19% of the overall effort. In some strata, however, salmonid catch would be likely and perhaps even large. For example, between 1 and 10 August, none of the 20 fishing operations in the northwestern block of the fishery (the 44,-45°N lat. and 170°E-180° long. block) were observed. Yet, we know that salmonids were present then; a Republic of 'Korea (ROK) research vessel[3] caught 13 salmon on 5 August 1989 at

---

[3] Cruise report of the ROK vessel Pusan 851, Daniel Cheng, NOAA, National, Marine Mammal Laboratory, Seattle, Washington.

45°N lat. and 170°E. long. using 1.85 km of variable mesh-size driftnet. This is equivalent to a bycatch rate of 351.4 salmon per 1,000 standardized effective tans, and it occurred in an unsampled stratum containing 24,960 tans of commercial fishing effort.

CONCLUSIONS

Observer monitoring effort was generally not proportional to reported commercial fishing effort. Deviations from the expected proportions varied by longitude and period, but they were consistently less than expected between 170°E and 180° long. 'Some (an unknown amount) of these deviations may be an artifact of the experimental design of the observer monitoring program as this was the first year of wide-scale sampling-of the fishery.

Nonproportional sampling, however, is consequential only if it results in fishing areas that are not represented by sampling effort. This is most likely to occur in areas in which expected observer effort is small. One of these areas was the extreme northwest portion of the fishery; for some periods, sampling effort was either absent or observed vessels were spaced east of the fleet average (where salmonid catches, would probably be lower).

Salmonid incidence was highest at the western and eastern boundaries of the fishery. The area of greatest incidence was between 145°W and 150°W long., where 22% of the monitored fishing operations located in the upper 1^{o} latitude of the fishery encountered salmonids. When salmonids were encountered, CPUEs were highest 'west of 180° long., even though observer sampling effort there was generally located south of sampling effort in the eastern portion of the fishery.

Fishing effort data for the bycatch calculations was divided into three sections: a portion represented by observer data, an unrepresented portion that could be estimated by extrapolation of sampled data, and an unrepresented portion that could not be estimated. For the estimated portion (81% of total fishing effort), a bycatch estimator based on an extension of Aitchison's delta distribution--proposed by Pennington (1983)--produced -a bycatch estimate of 2,648 salmonids.

Only a small part of the portion of the fishery that could not be estimated is likely to have any significance in terms of salmonid bycatch. For these data, the central problem is how to extrapolate observer data from a sampled region of low salmonid abundance to an unsampled region of historical high abundance. Unsampled effort in this region represents less than 1% of the total fishing effort; however, on 5 August 1989, a ROK research vessel in one unsampled area using 37 tans of driftnet caught over 16% of the total amount of salmon observed in 1,427,225 tans of monitored fishing effort. Thus, despite the extremely small amount of fishing effort, bycatch in this region may be significant.

We note, however, that these estimation difficulties may be unique to species like salmonids which are vulnerable to only a small portion of the fishery and thus are more affected by sampling variations. There is significant zonal: variability in the density of salmon across the northern. boundary of the squid driftnet area (Ignell. 1991). Salmonids are most likely to be caught near the northwestern boundary of the fishery during the first part of the month. Moreover, the extent of thisvulnerability varies yearly, depending on ocean conditions (Ignell 1989). Surface and subsurface temperatures near the squid driftnet fishing area were warmer than normal in 1989, and the subarctic frontal zone wasprobably displaced northward that summer (Ignell 1990): Because of the role ocean conditions play in determining salmonid distributions in the North Pacific Ocean! salmonids were also probably displaced northward, restricting the amount of fishing area intersecting salmonid-inhabited waters. These phenomena probably induced some of the estimation problems encountered in the 1989 data.

In conclusion, our estimation difficulties point out the need to carefully consider some of the inherent problems of sampling a highly skewed population. Such a population contains extreme values which, -although rare; can affect-the results of even moderately large samples (Kish 1965). Many of these effects (decreased precision, increased variance, and invalidation of the normal approximation) are well known.'

From an applied perspective, however, the most crucial effect is that a single sample generally provides a point estimate that underestimates the true population mean, particularly as in our case, where the sampling fraction is greater than the expected probability of extreme events. In such cases, it is good sampling practice to segregate these events (e.g., high catch rates) in the sampling design, especially when concentrations of the events correspond to other factors such as temperature or geographic area.

ACKNOWLEDGMENTS

We are indebted to Dr. Jerry Pella of the National Marine Fisheries Service, Dr. Terry Quinn of the University of Alaska, and -Dr. Bruce Lindsay of Pennsylvania State University for advice regarding the statistical methodology. We also thank Jim Murphy and Susan Fowler for assistance with the figures.

CITATIONS

Aitchison, J. 1955. On the distribution of a positive random variable having a discrete probability mass at the origin. J. Am. Stat. Assoc. 50: 901-908.

Berrien, P. L., N. A. Naplin, and M. R. Pennington. 1981. Atlantic mackerel, Scomber scombrus, egg production and spawning population estimates for 1977 in the Gulf of Maine, Georges Bank, and Middle Atlantic Bight. P.-V. Reun. Cons. Int. Explor. Mer 178: 279-288.

Fisheries Agency of Japan. 1990. Catch and effort statistics for the Japanese squid driftnet fishery in the North Pacific in 1989. Int. North Pac. Fish. Comm. document, 44 p.

Hosmer, D. W., Jr., and S. Lemeshow. 1989. Applied logistic regression. John Wiley and Sons, New York. 307 p.

Ignell, S. E. 1989. Annual variability in salmonid incidence and near-surface ocean temperatures in the central North Pacific Ocean, 1978-1988. (Document submitted to annual meeting of the International North Pacific Fisheries

Commission, Seattle, September, 1989;) Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 11305 Glacier Hwy., Juneau, AK99801-8626, 22 p.

Ignell, S. E. 1990. Diagnostic indices of oceanographic and atmospheric conditions in the central North Pacific Ocean. (INPFC Doc.) Auke Bay Laboratory, Alaska' Fisheries Science Center, NMFS, NOAA, 11305 Glacier Hwy., Juneau, AK,99801-8626, 14 p.

Ignell, S. E. 1991. Zonal variability in salmonid driftnet catch rates in the central North Pacific Ocean, p. 89-95. *In* J. E. Wetherall (editor),, Biology, oceanography, and fisheries of the North Pacific transition zone and subarctic frontal *zone.* U.S. Dep. Commer., NOAA Tech.. Rep. NMFS 105.

Int. North Pac. Fish. Comm. 1990. Final report of squid and bycatch observations in the Japanese driftnet fishery for neon flying squid *(Ommastrephes* bartrami), June - December, 1989 Observer Program. (INPFC Doc:) Joint report by the National Sections of Canada, Japan and the United States. (Available from Driftnet Program Coordinator, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., BIN C15700, Seattle, WA 98115-0070.), 111 p.

Kish, L. 1965. Survey sampling. John Wiley and Sons, New York., 643 p.

Ogura, *M.,* and K. Takagi. 1987. Differences in area of distribution between salmon and flying squid based on data collected by Japanese salmon 'research vesseles [sic], 1983-1986. (INPFC Doc.) Fisheries Agency of Japan, Tokyo, Japan 100, 21 p.

Pennington, M. 1983. Efficient estimators of abundance, for fish and plankton surveys.., Biometrics 39: 281-286.

Table 1.--Chi-square (x^2) tests of whether observer effort is proportional to fishing effort in the Japanese squid driftnet defined fishery. Data are stratified by statistical areas and by time period for months with significant observer effort.

Period	Month	Days	x^2 test statistic	***P***
1	June	1-10	7.124	0.6242
2		11-20	15.509	0.0778
3		21-30	27.693	0.0005
4	July	1-10	66.418	0.0000
5		11-20	116.702	0.0000
6		21-31	99.399	0.0000
7	August	1-10	102.517	0.0000
8		11-20	20.483	0.0391
9		21-31	31.467	0.0017

Table 2.--Distribution of observer effort by time period and area compared to the expected reported fishing effort of the Japanese squid driftnet fishery. Minus signs = observer effort less than expected; + = greater than expected; NA = no reported fishing effort; and 0 = no observer effort.

		June			July			August		
Latitude	**Longitude**	**1-10**	**11-20**	**21-30**	**1-10**	**11-20**	**21-31**	**1-10**	**11-20**	**21-31**
Upper 1°	**170°E-180°**	**0**	**-**	**-**	**-**	**-**	**-**	**0**	**0**	**+**
	180°-170°W	**-**	**-**	**+**	**+**	**+**	**-**	**+**	**-**	**-**
	170-160°W	**-**	**-**	**-**	**+**	**+**	**+**	**-**	**+**	**+**
	160-150°W	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
	150-145°W	**+**	**0**	**0**	**NA**	**+**	**+**	**-**	**-**	**+**
Below 1°	**170°E-180°**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	180°-170°W	**-**	**+**	**-**	**+**	**-**	**-**	**-**	**-**	**+**
	170-160°W	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
	160-150°W	**+**	**+**	**+**	**+**	**-**	**+**	**+**	**-**	**-**
	150-145°W	**0**	**0**	**NA**	**NA**	**-**	**-**	**+**	**-**	**-**

Table 3.--Specification of the design variables for the four categorical variables used in the stepwise logistic regression. analysis of salmonid incidence in the Japanese squid driftnet fishery, 1989.

		Design variables		
Variable	**Stratum**	**D_1**	**D_2**	**D_3**
Longitude	**145-150°W**	**0**	**0**	**0**
	150-160°W	**1**	**0**	**0**
	160-170°W	**0**	**1**	**0**
	170°W-180°	**0**	**0**	**1**
Month	**June**	**0**	**0**	**0**
	July	**1**	**0**	**0**
	August	**0**	**1**	**0**
	Sept.-Oct.	**0**	**0**	**1**
Distance in degrees from northern boundary	**0°-1°**	**0**	**0**	
	1°-2°	**1**	**0**	
	2°-3°	**0**	**1**	
Time period in days	**1-10**	**0**	**0**	
	11-20	**1**	**0**	
	21-31	**0**	**1**	

Table 4.--The number of Japanese squid driftnet operations encountering salmonids stratified by longitudinal stratum and time period, and distance from the northern boundary of the fishery.

Longitude	Time period	0-1° from northern boundary: Absent	0-1° from northern boundary: Present	1-2° from northern boundary: Absent	1-2° from northern boundary: Present	>2° from northern boundary: Absent	>2° from northern boundary: Present
145-150°W	1-10	8	2	11	0	0	0
	11-20	17	7	1	0	0	0
	21-30	18	3	0	0	0	0
	Total	43	12	12	0	0	0
150-160°W	1-10	104	10	39	0	28	0
	11-20	71	6	24	0	7	0
	21-30	77	5	21	0	1	0
	Total	252	21	84	0	36	0
160-170°W	1-10	29	1	50	0	26	0
	11-20	84	3	74	1	21	0
	21-30	88	2	63	0	7	0
	Total	201	6	187	1	54	0
170°W-180°	1-10	37	3	29	0	20	1
	11-20	16	0	22	0	9	0
	21-30	35	0	21	0	0	0
	Total	88	3	72	0	29	1
180°-170°E	1-10	6	0	33	5	52	0
	11-20	20	2	54	0	24	2
	21-30	47	3	40	1	11	0
	Total	73	5	127	6	87	2

Table 5.--The number of Japanese squid driftnet operations encountering salmonids stratified by longitudinal stratum, month, and distance from the northern boundary of the fishery.

		Number of driftnet operations with salmonids either present or absent					
		0-1° from northern boundary		1-2° from northern boundary		>2° from northern boundary	
Longitude	Month	Absent	Present	Absent	Present	Absent	Present
145-150°W	June	3	0	0	0	0	0
	July	28	4	1	0	0	0
	August	12	8	11	0	0	0
	September	0	0	0	0	0	0
150-160°W	June	100	0	40	0	16	0
	July	59	7	19	0	0	0
	August	92	14	25	0	20	0
	September	1	0	0	0	0	0
160-170°W	June	65	0	25	0	1	0
	July	85	4	89	1	19	0
	August	26	2	62	0	26	0
	September	25	0	11	0	8	0
170°W-180°	June	35	0	16	0	2	1
	July	43	3	25	0	14	0
	August	9	0	20	0	0	0
	September	1	0	11	0	13	0
180°-170°E	June	12	0	18	1	2	0
	July	38	5	36	5	4	0
	August	13	0	44	0	38	2
	September	10	0	29	0	43	0

Table 6.--Output from the stepwise regression model. Data are from monitored driftnet operations of the Japanese squid driftnet fishery, 1989, -east of 180° longitude.

	Model statistics			Maximum likelihood statistics			
Data	Deviance	D.f.	Hosmer p.	Effect	Level*	Coeff.	S.E.
All	**54.182**	**7**	**0.883**	**Constant**		**-1.295**	**0.326**
				Distance	**(1)**	**-2.937**	**1.019**
					(2)	**-1.759**	**1.025**
				Longitude	**(1)**	**-1.234**	**0.397**
					(2)	**-2.152**	**0.506**
					(3)	**-1.865**	**0.608**
0-1° south of northern boundary	**56.096**	**6**	**0.875**	**Constant**		**-10.877**	**0.384**
				Month	**(1)**	**9.435**	**0.358**
					(2)	**10.001**	**0.000**
					(3)	**-4.260**	**827.000**
				Longitude	**(1)**	**-0.908**	**0.416**
					(2)	**-1.639**	**0.537**
					(3)	**-1.489**	**0.685**
0-1° south of boundary 150-170°W	**30.556**	**3**	**0.971**	**Constant**		**-11.914**	**0.313**
				Month	**(1)**	**9.342**	**0.000**
					(2)	**9.916**	**0.411**
					(3)	**0.000**	**75.790**

---

* Levels of model effects are defined as follows.

Distance: (1) is 1-2°,
(2) is 2° or more south of the northern boundary.

Longitude: (1) is 150-160°W,
(2) is 160-170°W,
(3) is 170°W-180°.

Month: (1) is July,
(2) is August.
(3) is September-October;

Table 7,. --Output from the stepwise regression model. Data are from monitored driftnet' operations of the Japanese squid driftnet fishery, 1989, west of 180° long.

	Probability			Maximum likelihood statistics			
Data	**Deviance**	**D.f.**	**Hosmer p**	**Effect**	**Level***	**Coeff.**	**S.E.**
All	15.877	3	1.000	Constant		-3.466	1.016
				Month	(1)	1.374	1.069
					(2)	-0.405	1.242
					(3)	-8.712	48.700
0-2° south of northern boundary	3.923	2	1.000	Constant		-2.079	0.474
				Time period	(1)	-1.558	0.859
					(2)	-1.012	0.697

-Level of month effects are defined similar to those in Table 6. Level (1) of time period is defined as monthly days 11-20, and level (2.) of time period as monthly days 21 to end of month.

Table 8.--Estimation based on Pennington's (1983) method using 1989 Japanese squid observer data. Only strata with observed operations are shown. Per = period within the month (1 = days 1-10, 2 = days 11-20, 3 = days 21-31). Number of operations: n = total number; n = number of nonzero operations; and n_0 = number of zero operations. A tan is a standardized effective tan (50 m long).

Stratum			**Observed bycatch rate**					**Std.**	**Estimated bycatch rate**		
Mo	**Per**	**Location**	**Mean (ln)**	**Variance**	n	n_1	n_0	**1,000 tans**	**Mean**	**S.E.**	**Stratum weight**
Jun	1	<39°N, 170E-180°	0.000000	0.000000	4	0	4	67.412	0.000000	0.000000	0.000
Jun	2	<39°N, 170E-180°	0.000000	0.000000	6	0	6	116.833	0.000000	0.000000	0.000
Jun	3	<39°N, 170E-180°	0.084176	0.007086	11	1	10	270.499	0.084176	0.084176	22.770
Jun	1	<39°N, 180-170E°	0.185185	0.034294	5	1	4	74.986	0.185185	0.185185	13.886
Jun	2	<39°N, 180-170E°	0.000000	0.000000	9	0	9	67.288	0.000000	0.000000	0.000
Jun	3	<39°N, 180-170E°	0.000000	0.000000	5	0	5	91.668	0.000000	0.000000	0.000
Jul	1	42-43°N, 170-160W°	0.207641	0.043115	14	1	13	194.569	0.207641	0.207641	40.401
Jul	2	42-43°N, 170-160W°	0.029797	0.000888	40	1	39	442.609	0.029797	0.029797	13.188
Jul	3	42-43°N, 170-160W°	0.225901	0.261741	36	2	34	431.401	0.079050	0.062255	34.102
Jul	1	42-43°N, 160-150W°	0.320752	0.824651	5	2	3	49.111	0.754236	0.708476	37.041
Jul	2	42-43°N, 160-150W°	0.110990	0.481500	23	3	20	309.555	0.183092	0.128033	56.677
Jul	3	42-43°N, 160-150W°	-0.018359	0.345076	37	2	35	801.539	0.062725	0.051545	50.277
Jul	2	42-43°N, 150-145W°	0.405371	0.395708	14	2	12	86.668	0.256916	0.209599	22.266
Jul	3	42-43°N, 150-145W°	0.472137	0.490129	18	2	16	279.669	0.223940	0.193881	62.629
Jul	1	41-42°N, 170E-180°	0.000000	0.000000	5	0	5	128.222	0.000000	0.000000	0.000
Jul	2	41-42°N, 170E-180°	0.480226	0.932262	12	2	10	594.744	0.407662	0.427574	242.454
Jul	3	41-42°N, 170E-180°	0.108027	0.100307	28	3	25	1,269.877	0.125270	0.072259	159.078
Jul	1	41-42°N, 180-170W°	0.520153	0.426628	33	3	30	255.621	0.187846	0.129542	48.017
Jul	2	41-42°N, 180-170W°	0.000000	0.000000	10	0	10	185.520	0.000000	0.000000	0.000
Jul	3	41-42°N, 180-170W°	0.000000	0.000000	2	0	2	108.397	0.000000	0.000000	0.000
Jul	1	41-42°N, 160-150W°	0.000000	0.000000	36	0	36	597.605	0.000000	0.000000	0.000
Jul	2	41-42°N, 160-150W°	0.036677	0.001345	35	1	34	305.949	0.036677	0.036677	11.221
Jul	3	41-42°N, 160-150W°	0.000000	0.000000	19	0	19	95.463	0.000000	0.000000	0.000
Jul	1	<41°N, 170E-180°	1.072851	0.640063	16	5	11	843.241	1.227090	0.679326	1,034.733
Jul	2	<41°N, 170E-180°	0.000000	0.000000	21	0	21	899.887	0.000000	0.000000	0.000
Jul	3	<41°N, 170E-180°	0.000000	0.000000	9	0	9	185.835	0.000000	0.000000	0.000
Aug	2	45-46°N, 170-160W°	-0.197683	0.079456	15	2	13	226.758	0.113541	0.078223	25.746
Aug	3	45-46°N, 170-160W°	0.000000	0.000000	13	0	13	234.891	0.000000	0.000000	0.000
Aug	1	45-46°N, 160-150W°	-0.044087	0.282194	59	8	51	578.247	0.149002	0.057381	86.160
Aug	2	45-46°N, 160-150W°	-0.014863	0.008740	26	3	23	404.966	0.114161	0.062299	46.231
Aug	3	45-46°N, 160-150W°	-0.032432	0.063455	21	3	18	303.261	0.142535	0.079044	43.225
Aug	1	45-46°N, 150-145W°	0.164452	0.163005	7	2	5	253.674	0.360937	0.240853	91.560
Aug	2	45-46°N, 150-145W°	0.600163	0.428542	10	5	5	279.875	1.101427	0.497564	308.262
Aug	3	45-46°N, 150-145W°	0.911993	0.831731	3	1	2	137.553	0.911993	0.911993	125.447
Aug	1	<44°N, 170E-180°	0.000000	0.000000	28	0	28	1,222.415	0.000000	0.000000	0.000
Aug	2	<44°N, 170E-180°	0.033198	0.199624	36	2	34	934.930	0.063267	0.048266	59.150
Aug	3	<44°N, 170E-180°	0.000000	0.000000	21	0	21	673.060	0.000000	0.000000	0.000
										Total:	**2,634.524**
										Standard error:	**675.997**

Table 9.--Estimation based on Pennington's (1983) method using 1989 Japanese squid driftnet observer data. Only unsampled strata that were filled in with extrapolations of observed operations are shown. A tan is a standardized effective tan.. NA = not able to be estimated.

Stratum			Std.	Estimated bycatch rate		
Month	10-day period	Location	1,000 tans	Mean	S.E.	Stratum weight
Jun	1	39-40°N, 170°E-180°	6.590	NA	NA	NA
Jun	1	<39°N, 150-145°W	8.828	0.000000	0.000000	0.0000
Jun	2	39-40°N, 150-145°W	20.594	0.000000	0.000000	0.0000
Jun	2	<39°N, 150-145°W	6.958	0.000000	0.000000	0.0000
Jun	3	39-40°N, 150-145°W	7.135	0.000000	0.000000	0.0000
Jul	1	<41°N, 160-150°W	5.031	0.000000	0.000000	0.0000
Jul	2	<41°N, 170-160°W	7.648	0.000000	0.000000	0.0000
Jul	2	<41°N, 160-150°W	1.376	0.000000	0.000000	0.0000
Jul	3	41-42°N, 150-145°W	5.687	0.000000	0.000000	0.0000
Jul	3	<41°N, 180°-170°W	6.112	0.000000	0.000000	0.0000
Aug	1	45-46°N, 170-160°W	115.220	0.113541	0.078223	13.0822
Aug	1	44-45°N, 170°E-180°	24.960	NA	NA	NA
Aug	1	<44°N, 180°-170°W	44.833	0.000000	0.000000	0.0000
Aug	1	<44°N, 150-145°W	39.214	0.000000	0.000000	0.0000
Aug	2	44-45°N, 170°E-180°	27.018	NA	NA	NA
Aug	2	44-45°N, 180°-170°W	18.068	0.000000	0.000000	0.0000
Aug	2	44-45°N, 150-145°W	6.570	0.000000	0.000000	0.0000
Aug	3	44-45°N, 150-145°W	12.306	0.000000	0.000000	0.0000
Aug	3	<44°N, 150-145°W	4.524	0.000000	0.000000	0.0000
Sep	1	45-46°N, 160-150°W	21.204	NA	NA	0.0000
Sep	1	<45°N, 160-150°W	3.960	0.000000	0.000000	0.0000
Sep	1	45-46°N, 150-145°W	2.388	NA	NA	0.0000
Sep	2	45-46°N, 180°-170°W	4.605	0.000000	0.000000	0.0000
Sep	2	<45°N, 150-145°W	6.930	0.000000	0.000000	0.0000
Sep	3	45-46°N, 170°E-180°	8.620	NA	NA	0.0000
Sep	3	<45°N, 180°-170°W	162.045	0.000000	0.000000	0.0000
Sep	3	45-46°N, 160-150°W	1.824	NA	NA	0.0000
Sep	3	<45°N, 150-145°W	2.970	0.000000	0.000000	0.0000
					Total:	13.0822
					Standard error:	9.0129

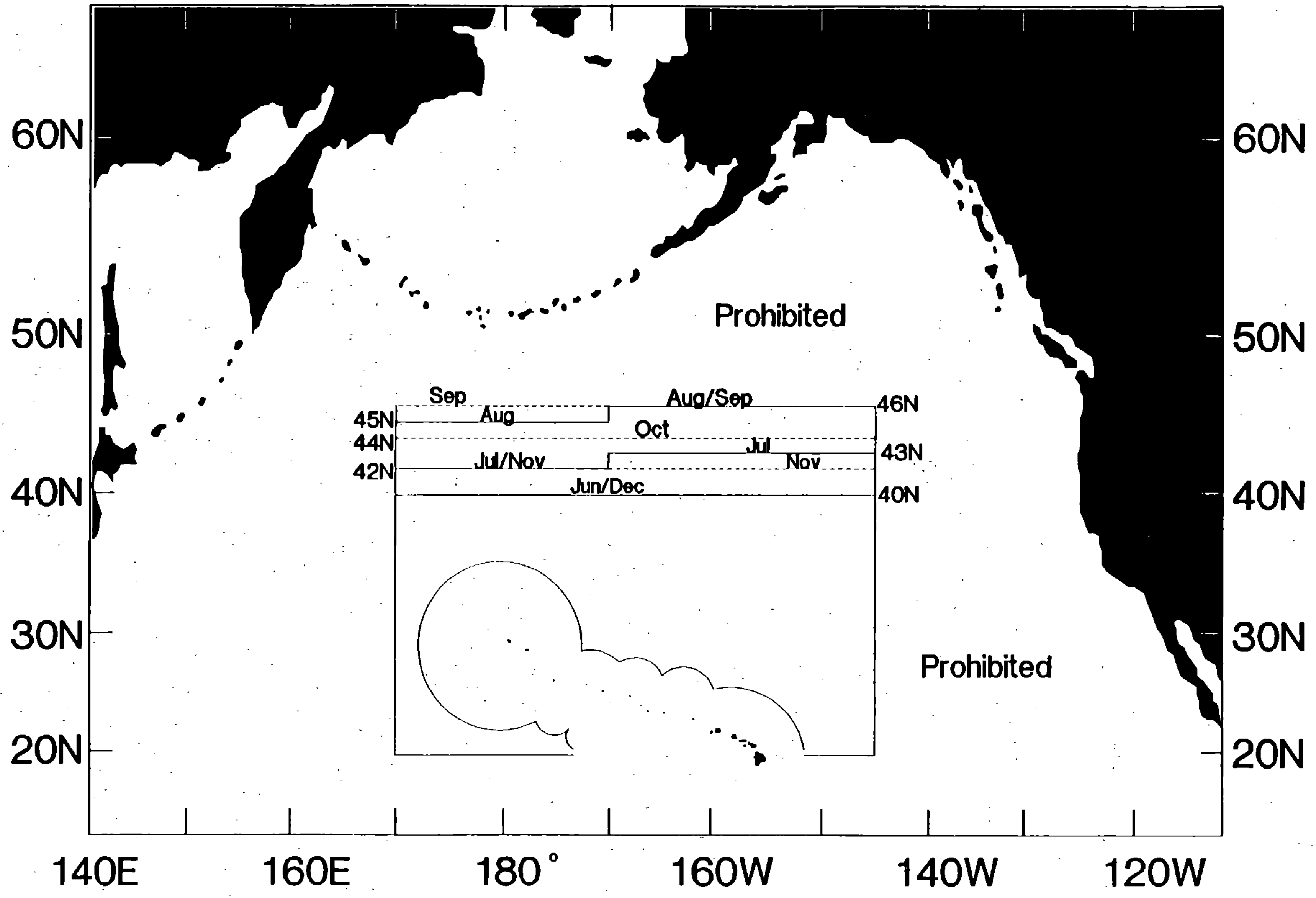


Figure 1.--Monthly location of the permitted fishing area for Japanese squid driftnet vessels during the 1989 fishing season.

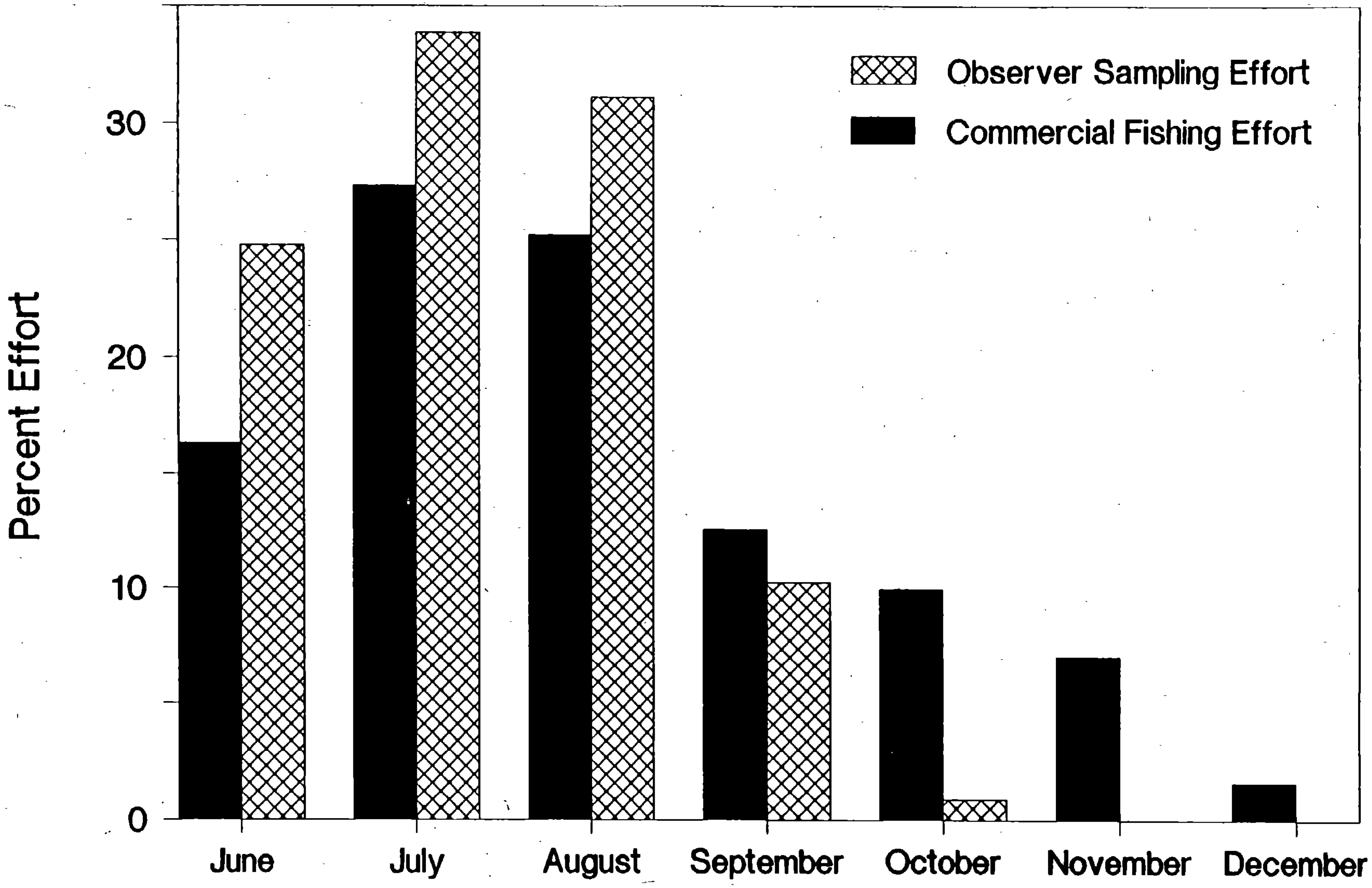


Figure 2.--Comparison of the distribution of commercial fishing effort and observer monitoring effort by month for the Japanese squid driftnet fishery, 1989.

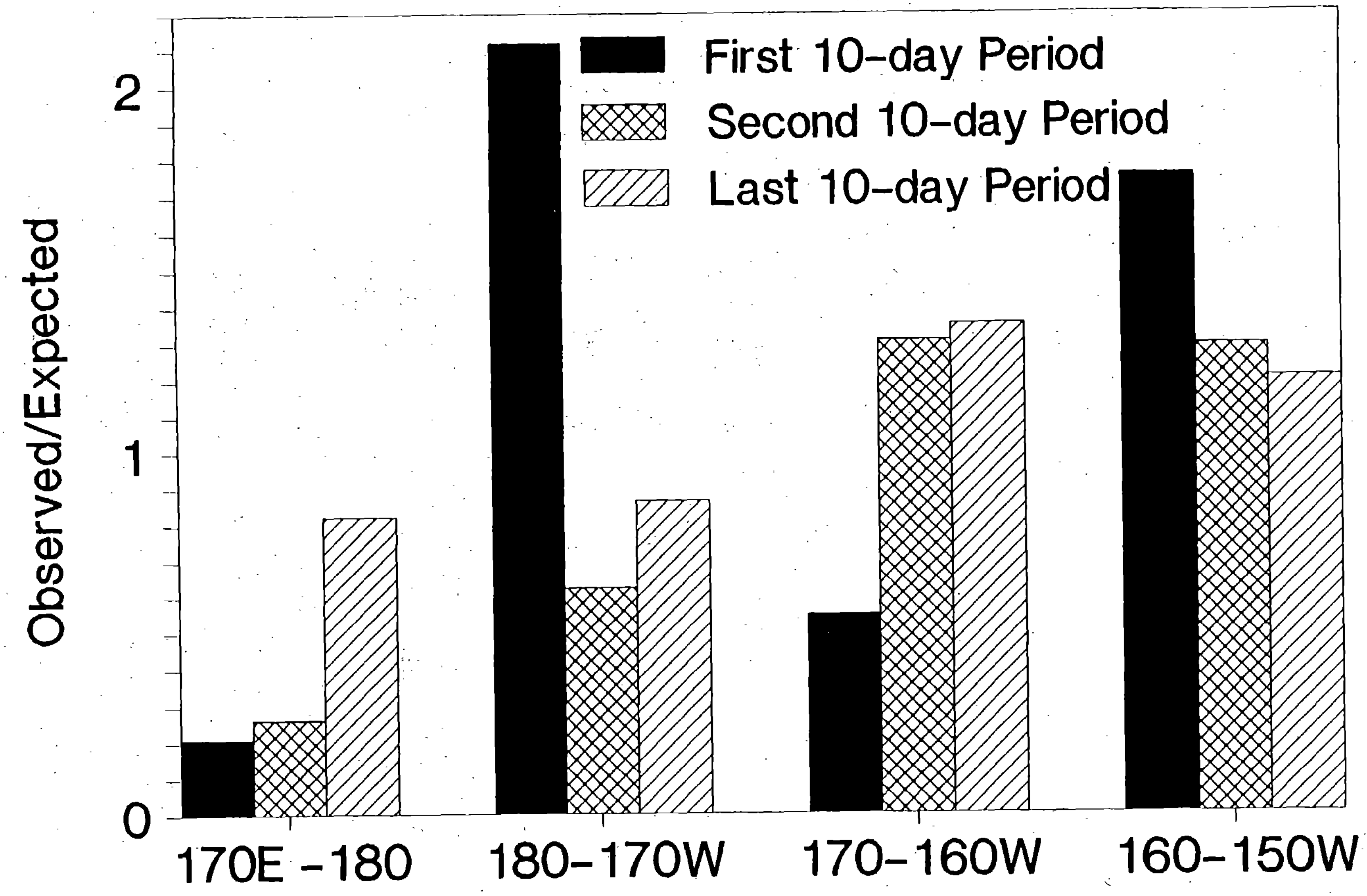


Figure 3. --Temporal and spatial variability in the ratio of observed to expected sampling-effort averaged over the fishing season for four longitudinal strata located within 1° of the northern boundary of the Japanese squid driftnet fishery.

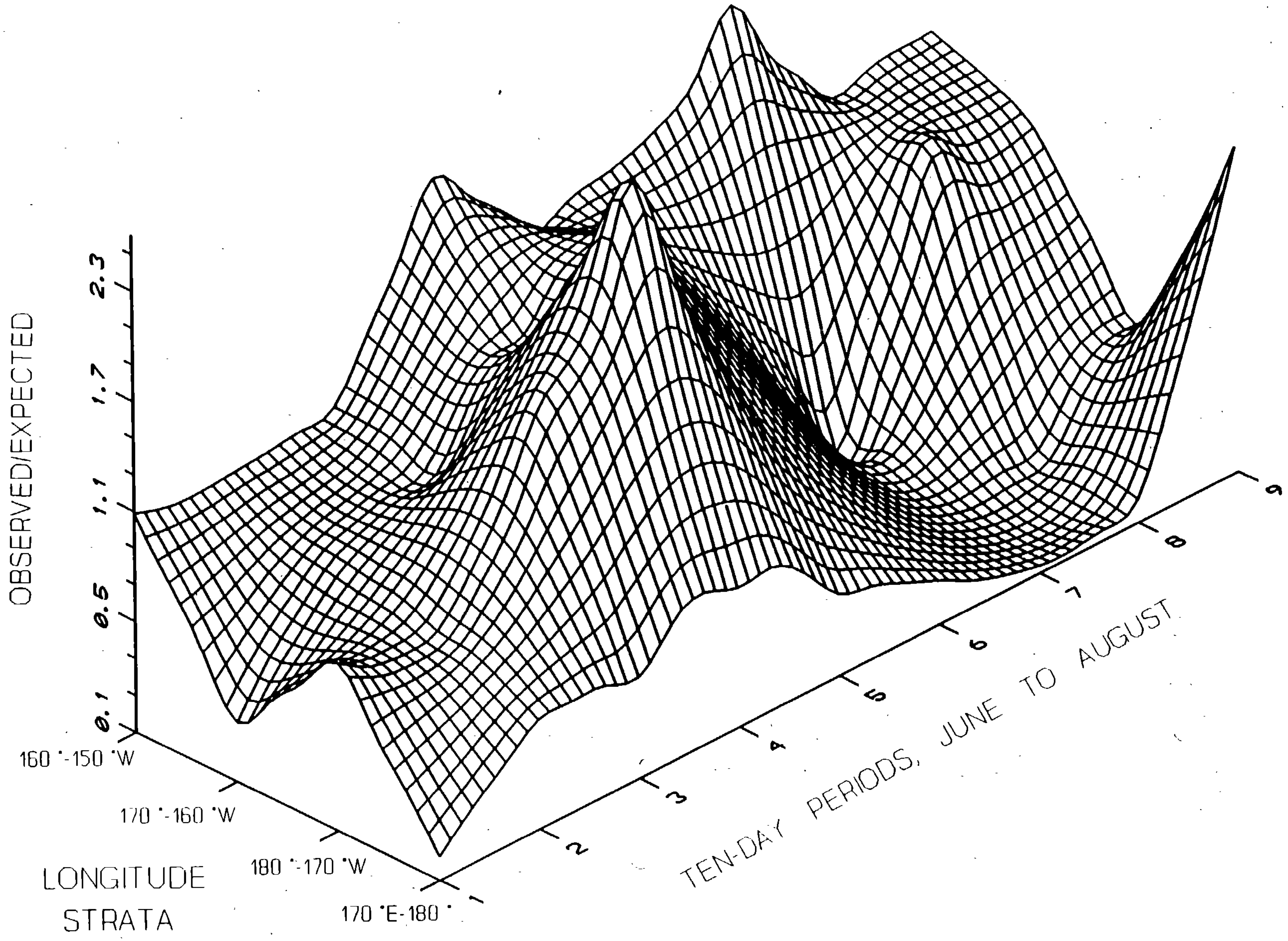


Figure 4.--The distribution of the ratio of observed to expected-sampling effort (z-axis) for four longitudinal strata located within 1° of the northern boundary of the Japanese squid driftnet fishery (y-axis) and nine sequential 10-day periods (x-axis) from June through August 1989.

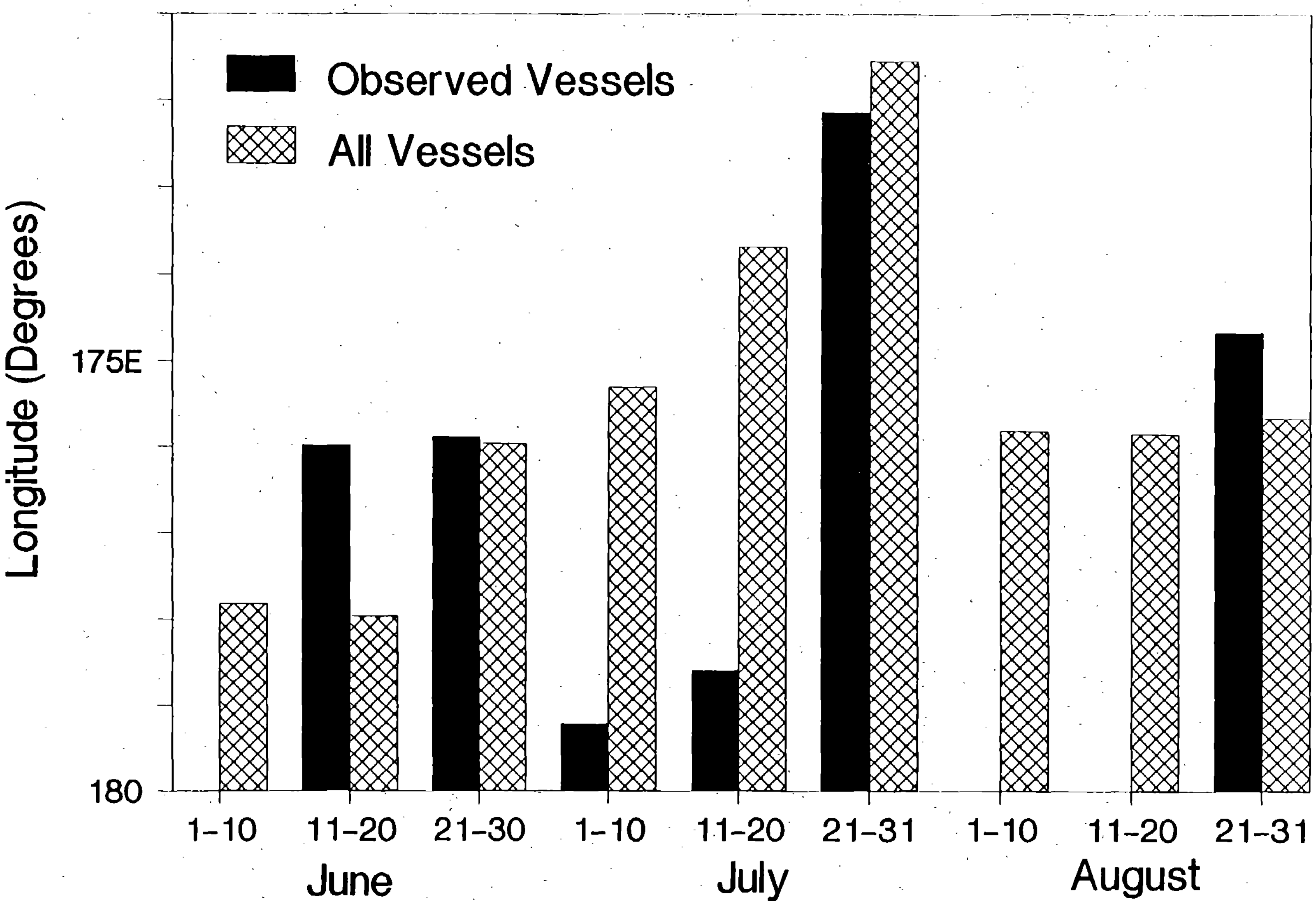


Figure 5.--Average longitude of observed vessels compared to the average longitude of all fishing vessels located within 1° latitude of the northern boundary and between 170°E and 180° long. in the Japanese squid driftnet fishery, 1989.

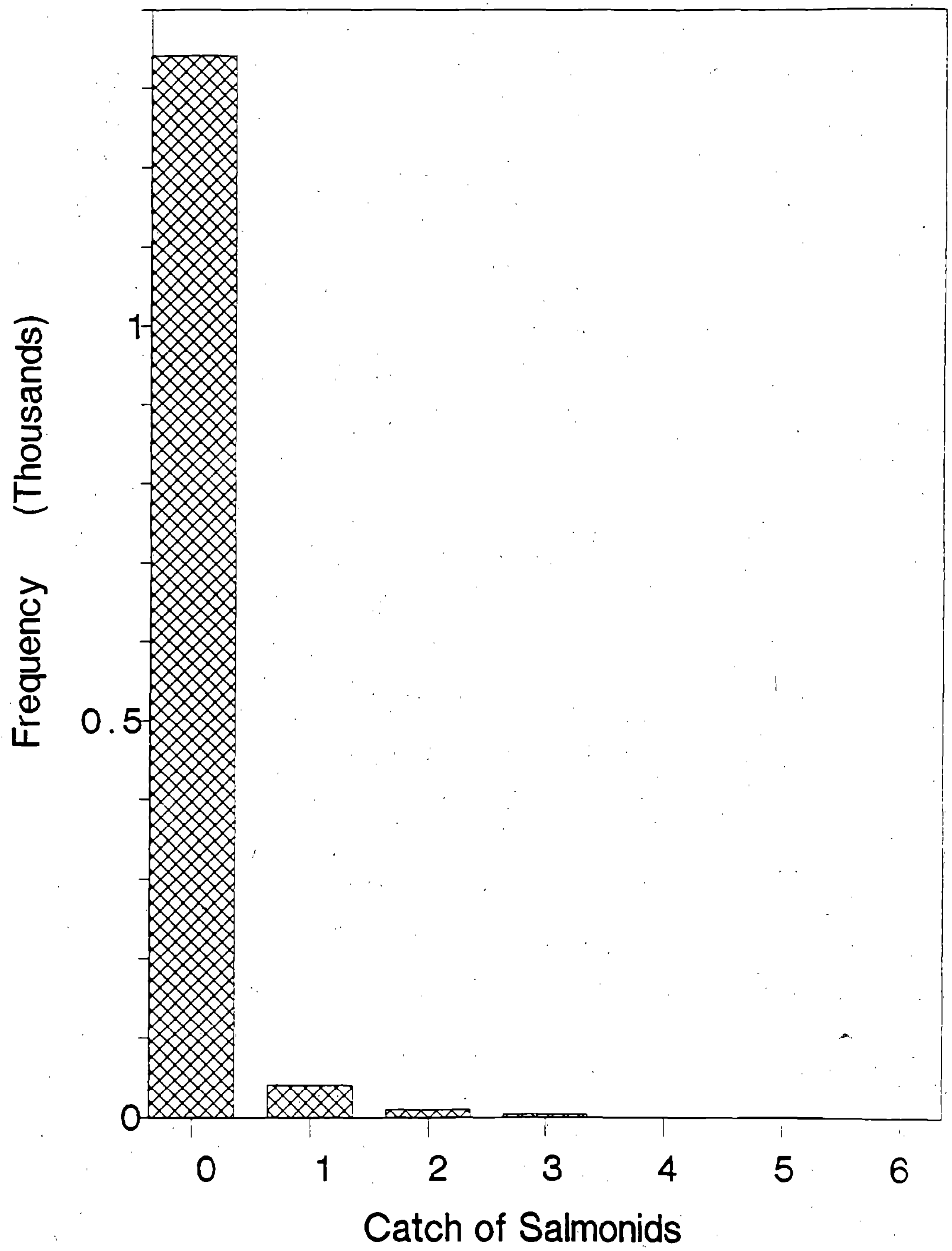


Figure 6. --Frequency distribution of the number of salmonids observed caught in 1,402 monitored operations of the 1989 Japanese squid driftnet fishery.

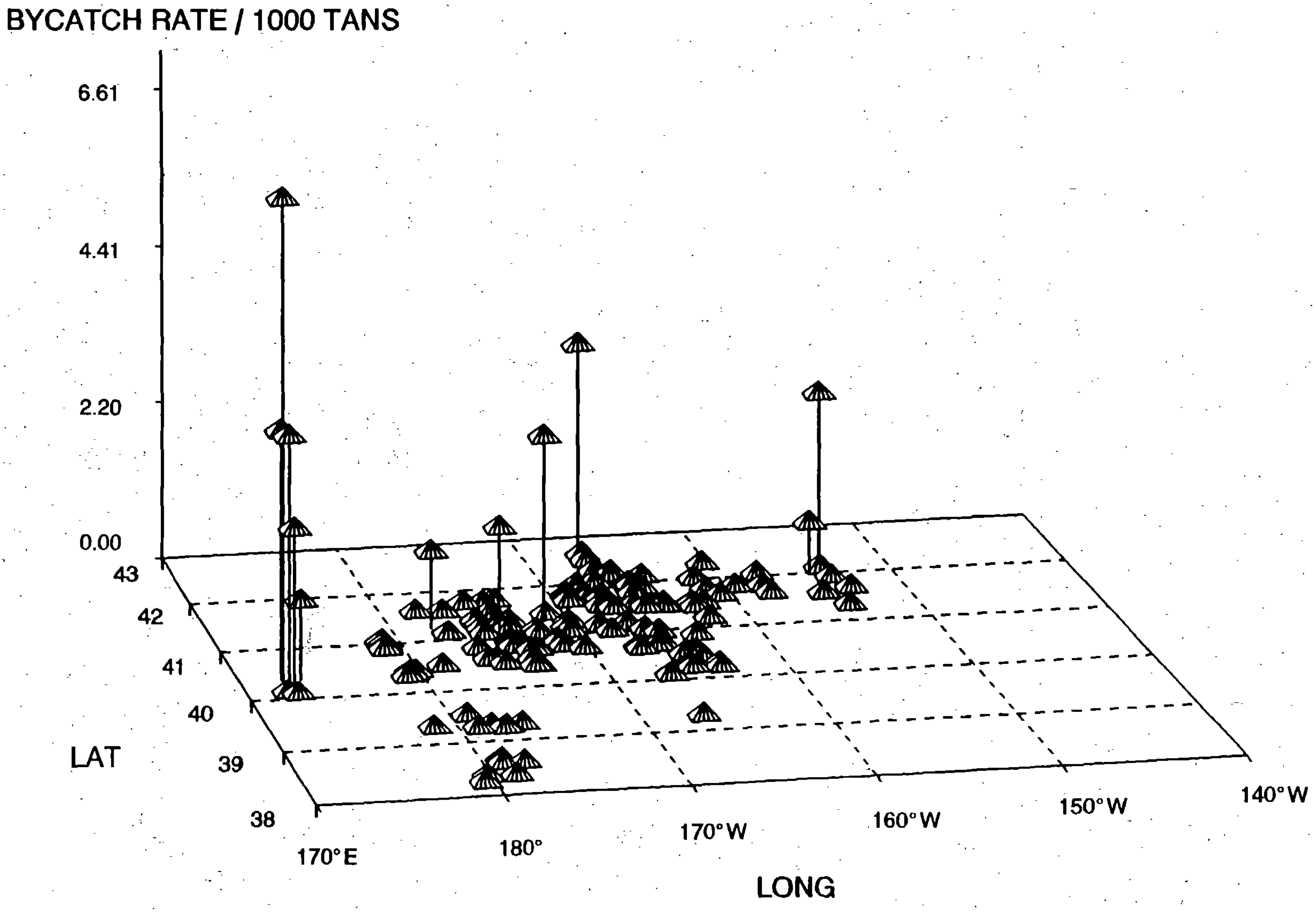
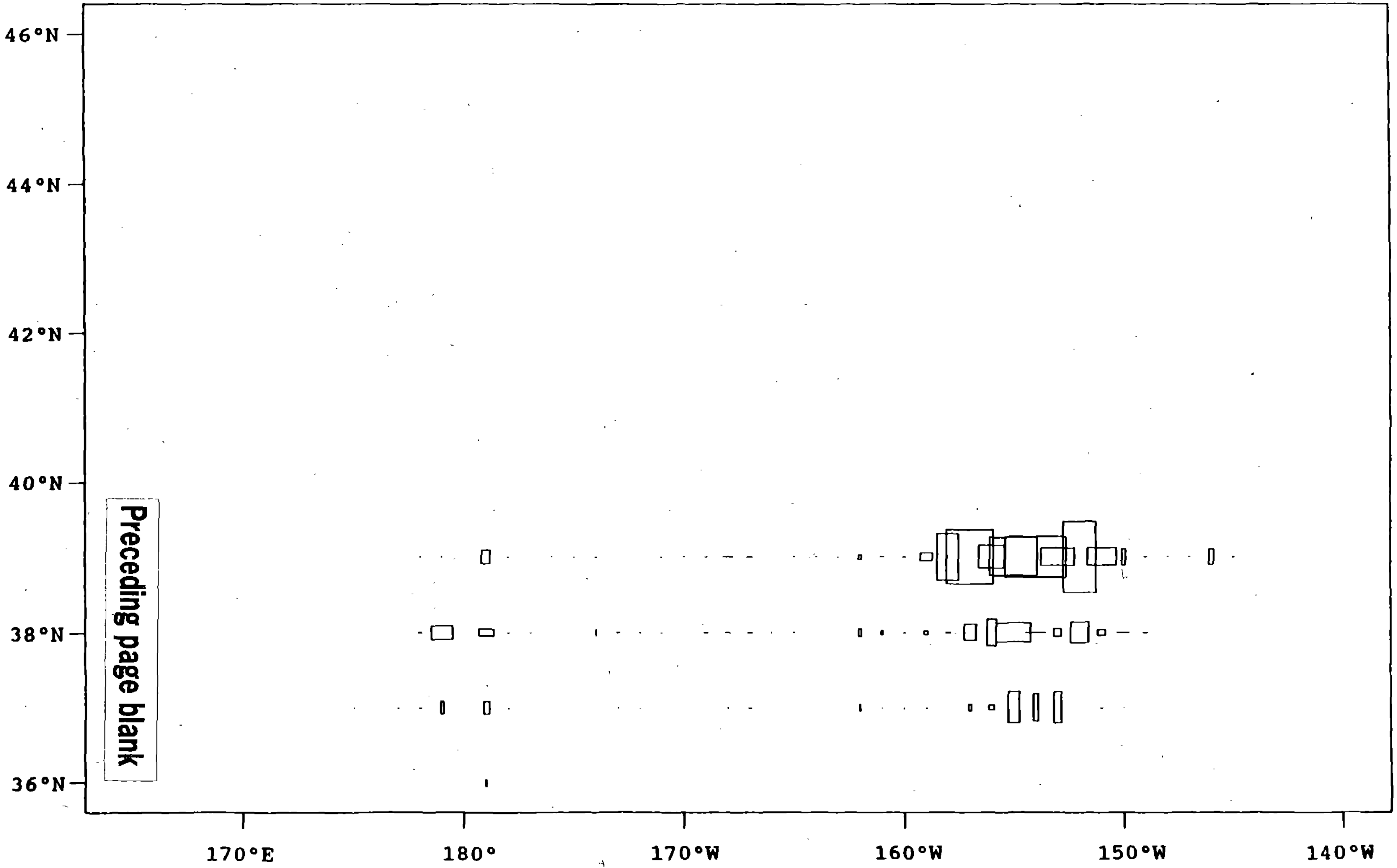


Figure 7.--Distribution of salmonid bycatch by latitude and longitude for 1-10 July 1989. The salmonid catch rate per 1,000 standardized effective tans for each observed operation appears on the z-axis. Pyramids on the surface represent zero bycatch of salmonids.

APPENDIX

THIS PAGE INTENTIONALLY LEFT BLANK

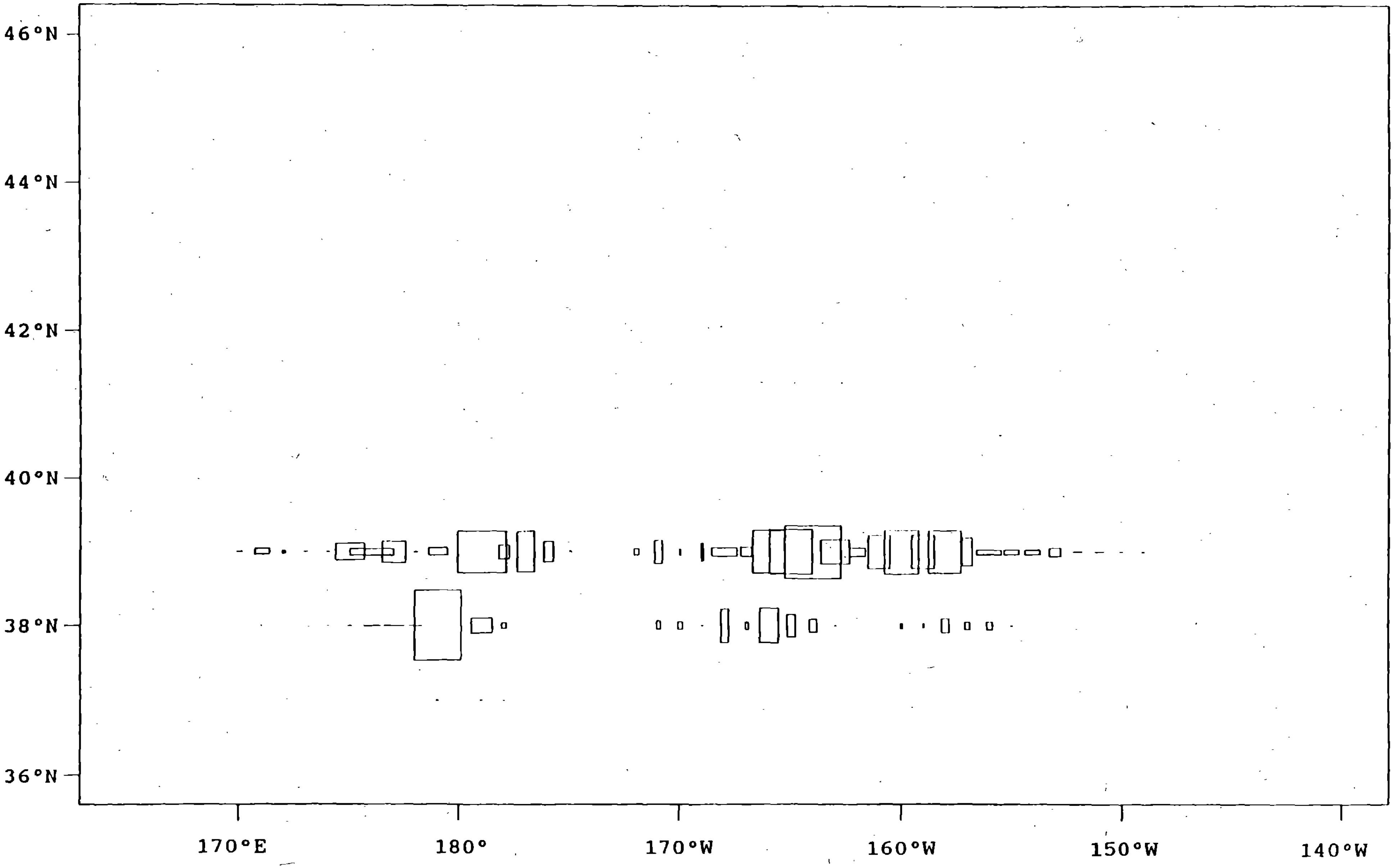
Appendix 1.--Distribution of observed and reported fishing effort in 1° by 2° statistical areas for the 1989 Japanese squid driftnet fishery. Width and height of rectangles are scaled to the percent of fishing effort and observer effort, respectively, located in the statistical area, 1-10 June 1989.



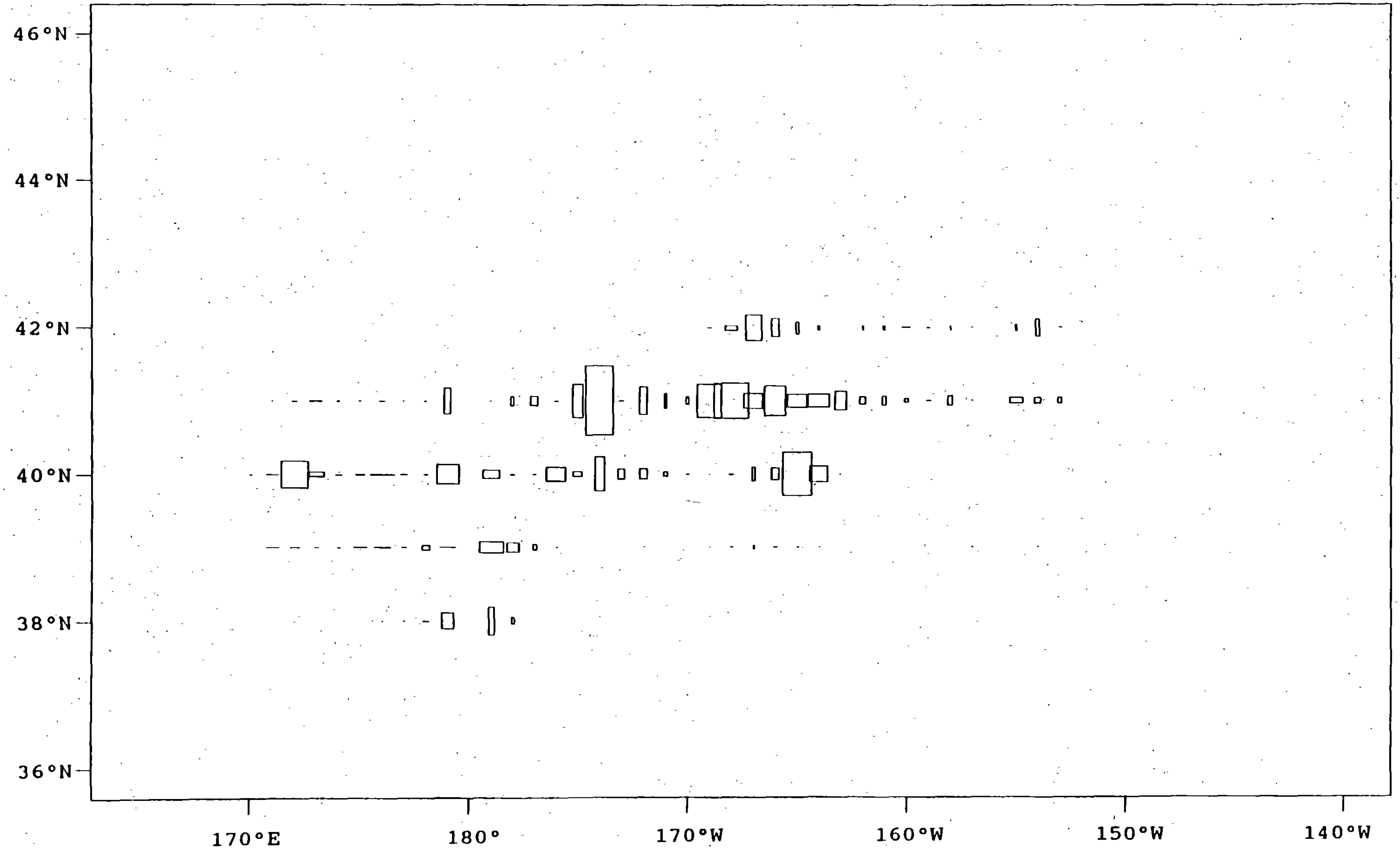
Preceding page blank

Appendix 1.--Continued. 11-20 June.

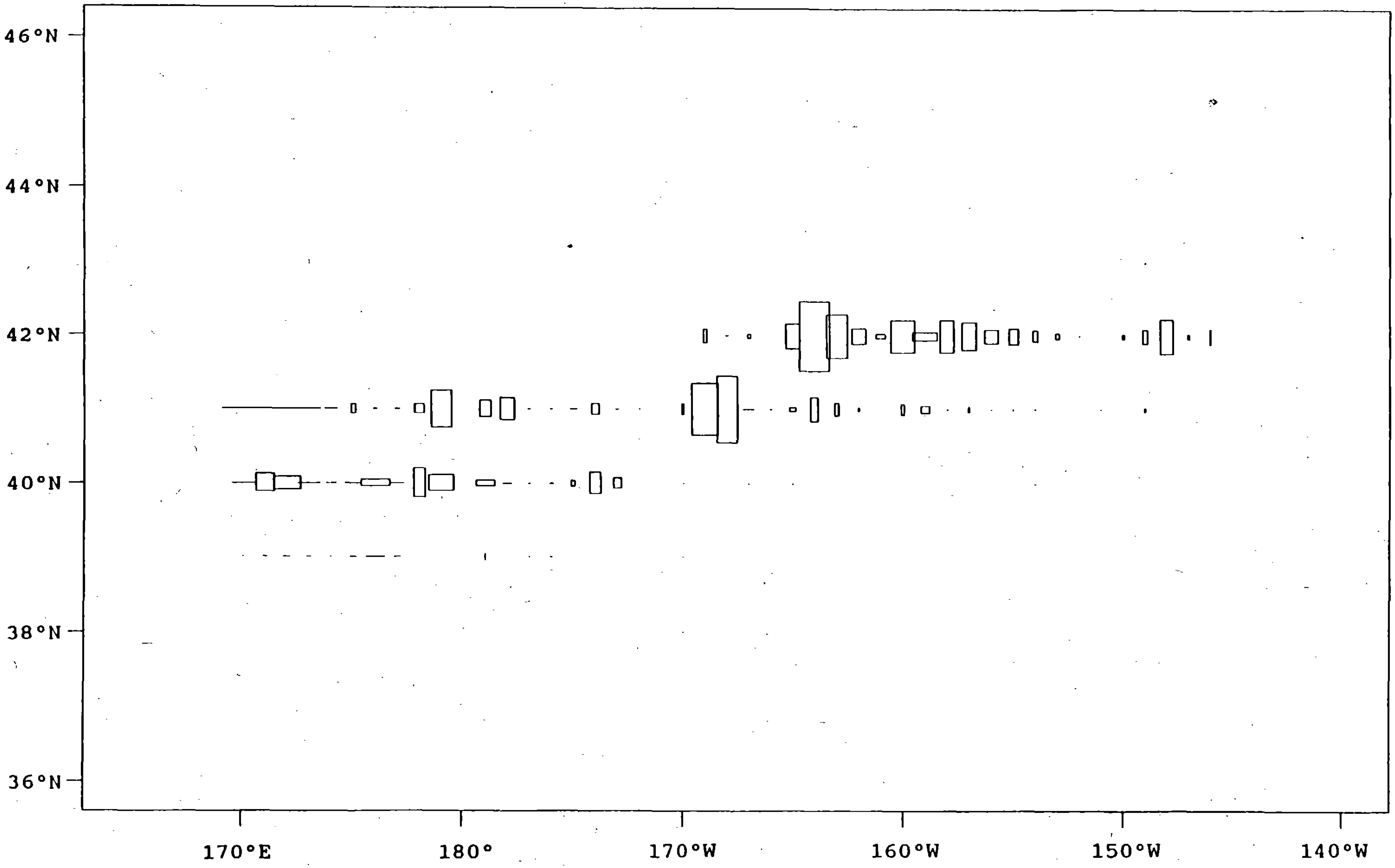
Appendix 1.--Continued. 21-30 June.



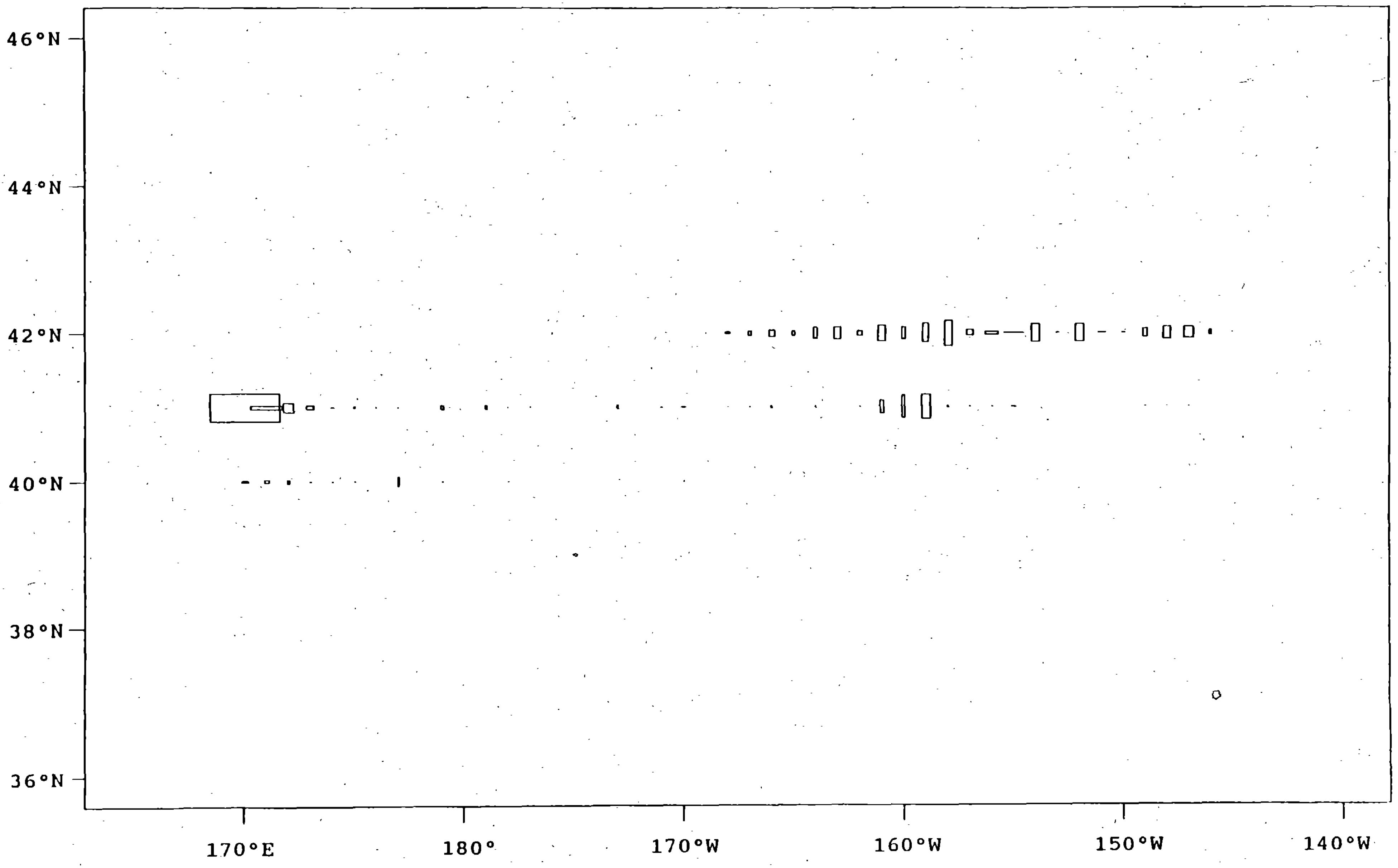
Appendix 1.--Continued. 1-10 July.



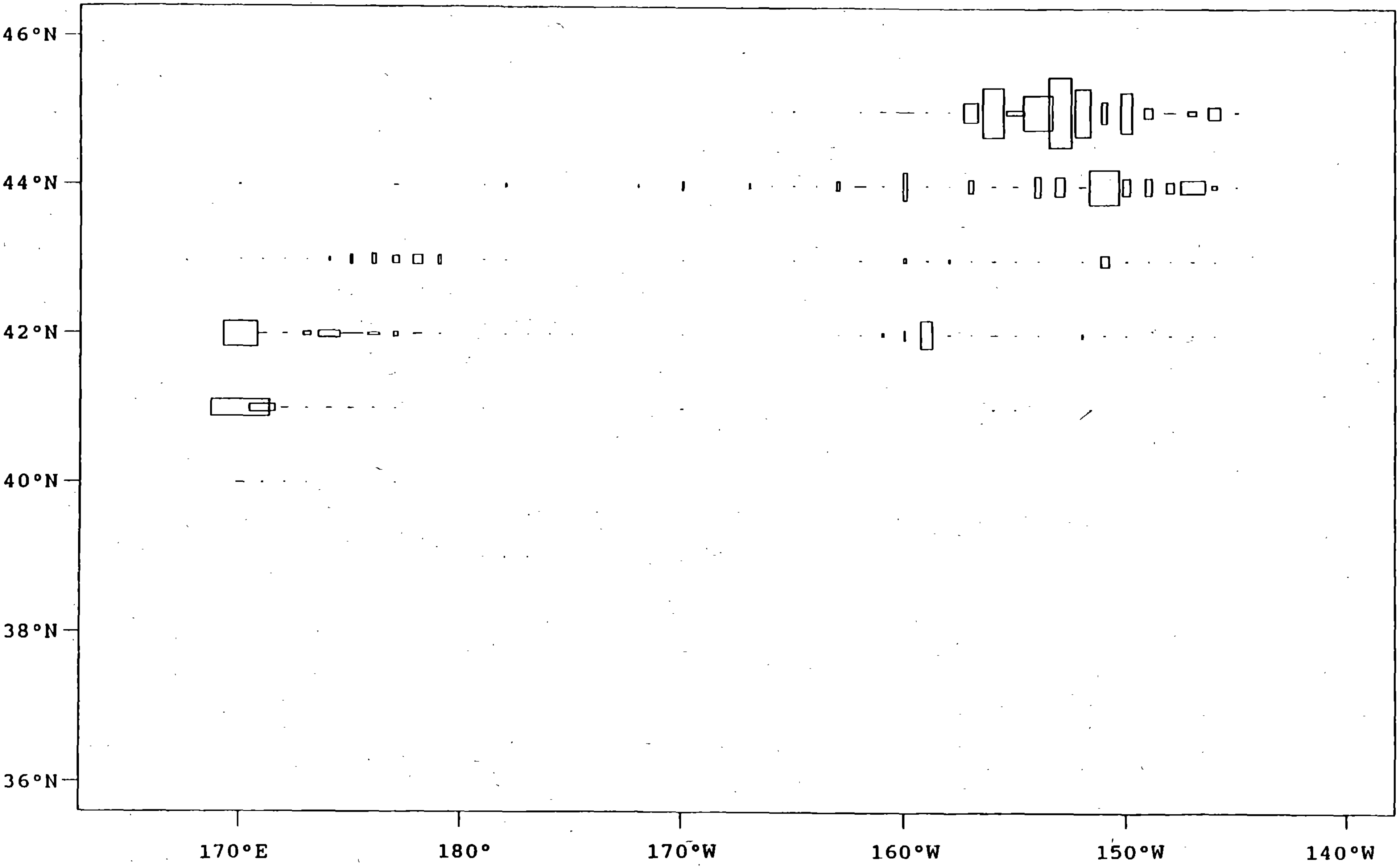
Appendix 1.--Continued. 11-20 July.



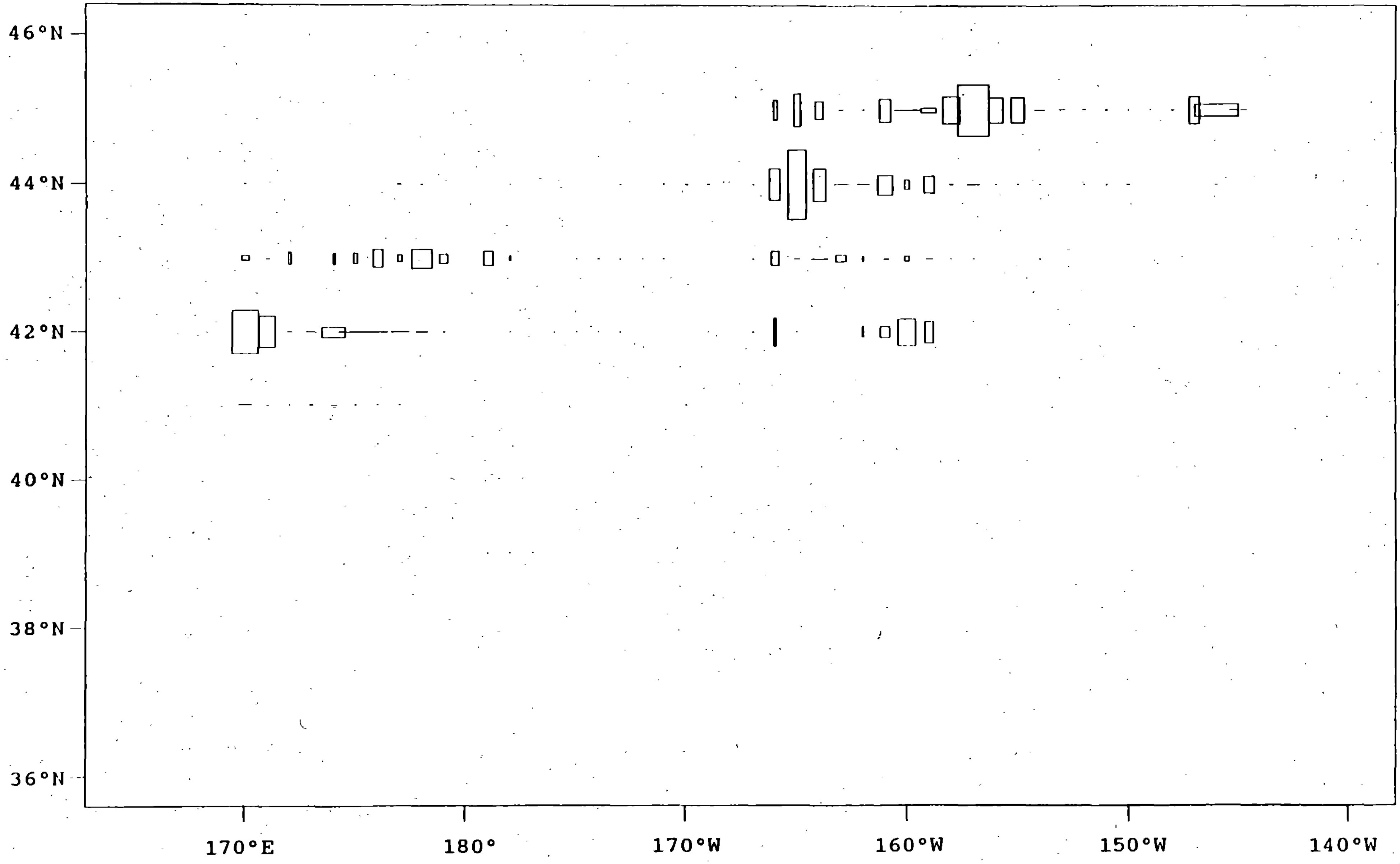
Appendix 1.--Continued. 21-31 July.



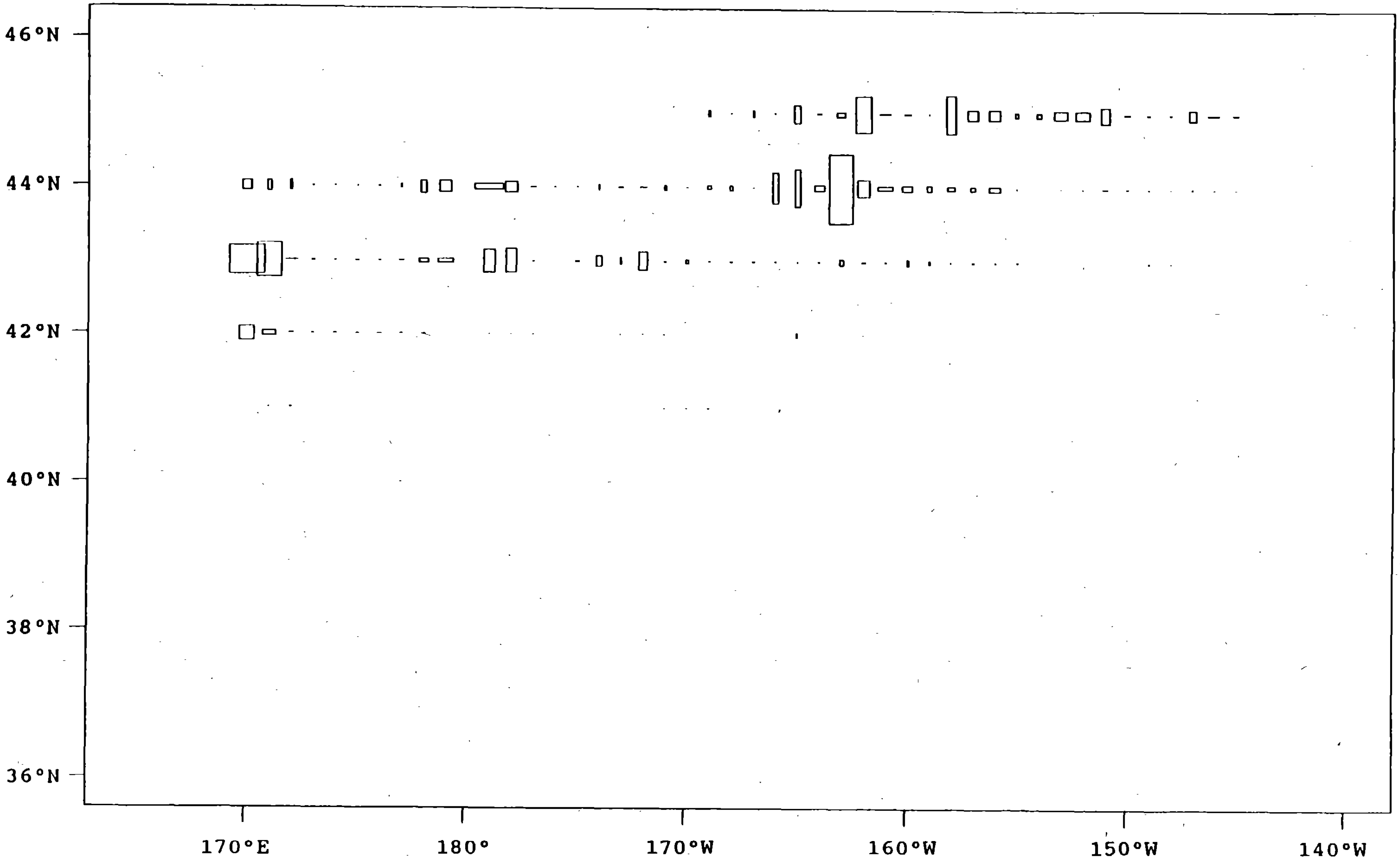
Appendix 1.--Continued. 1-10 August.



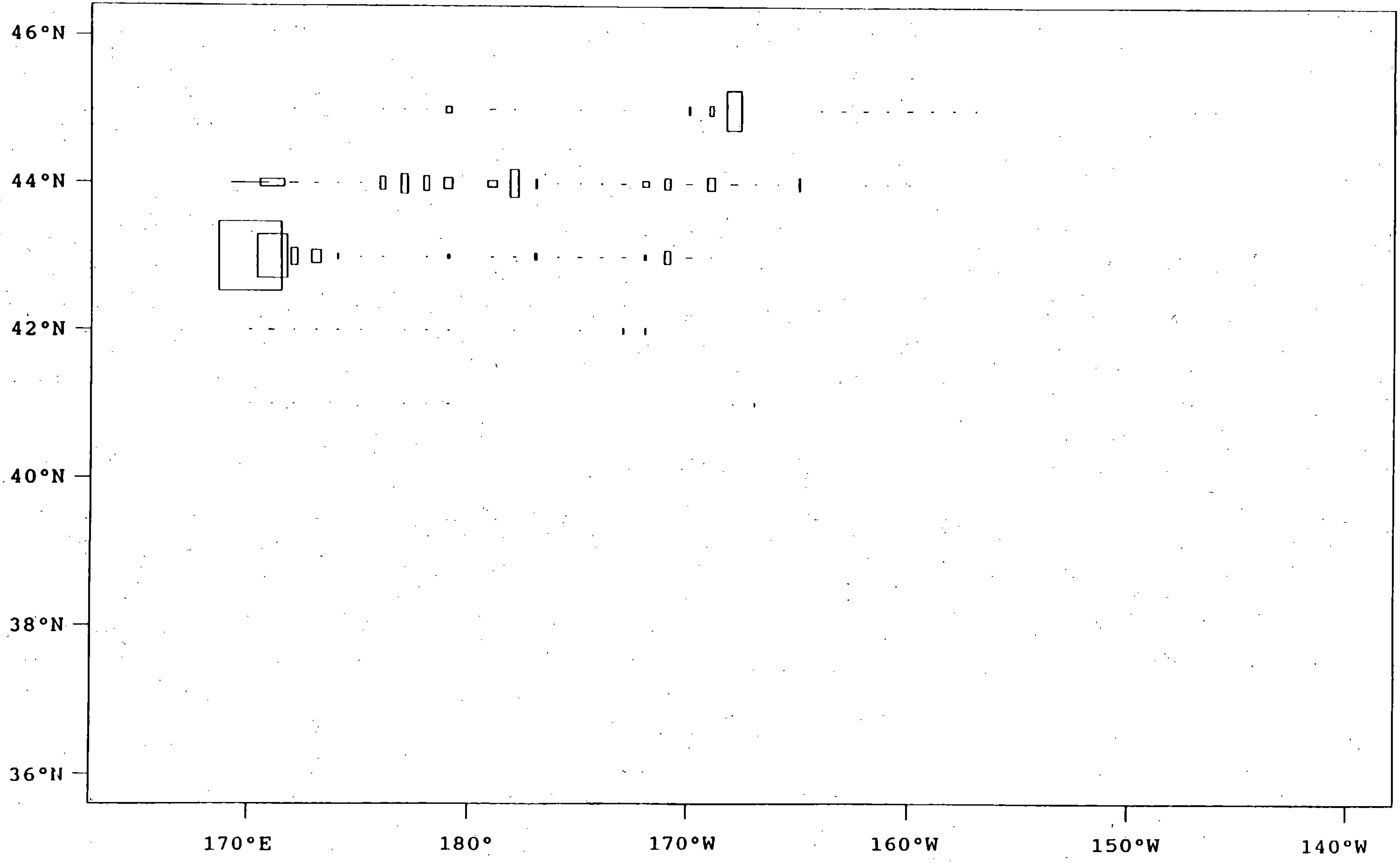
Appendix 1.--Continued. 11-20 August.



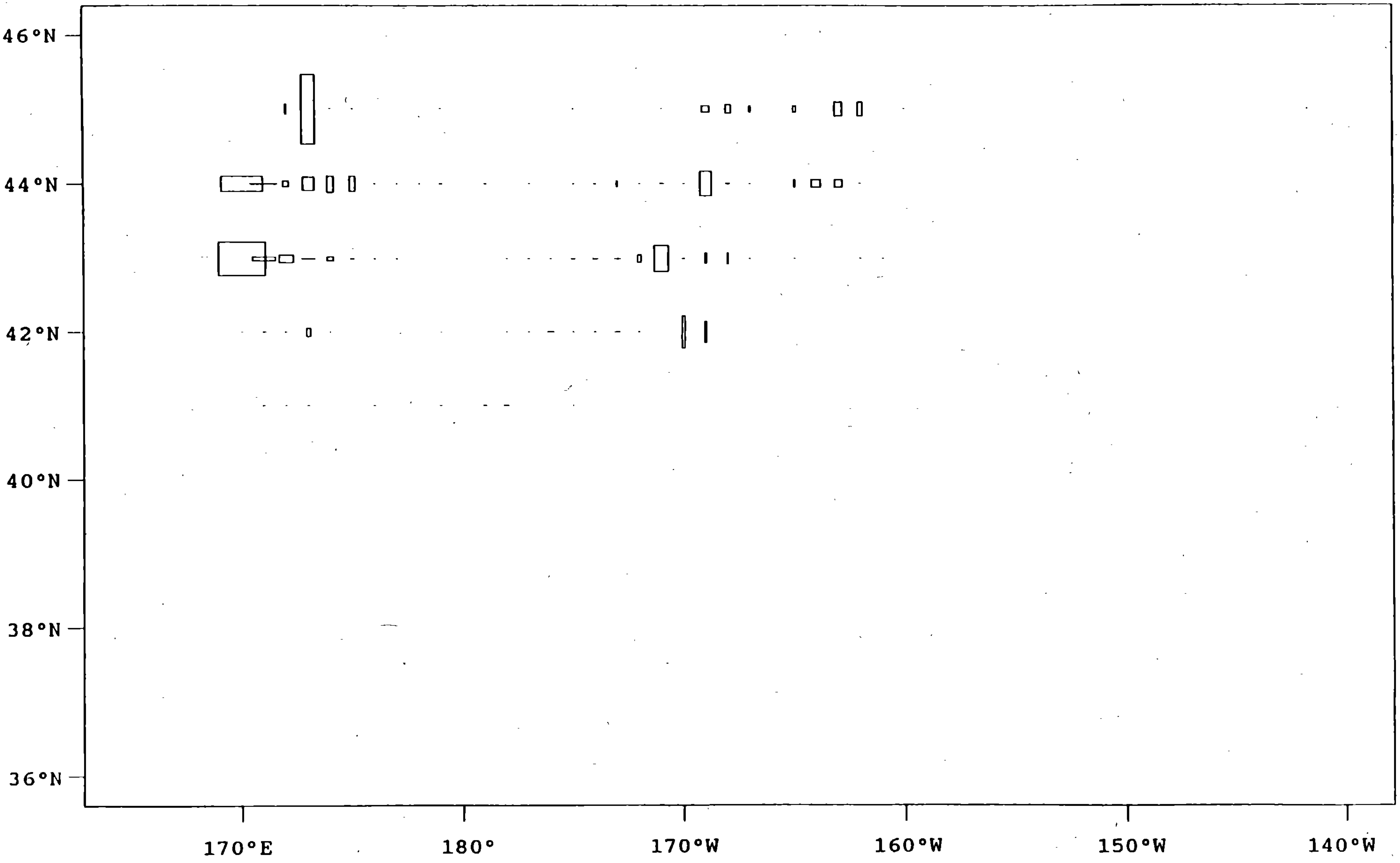
Appendix 1.--Continued. 21-31 August.



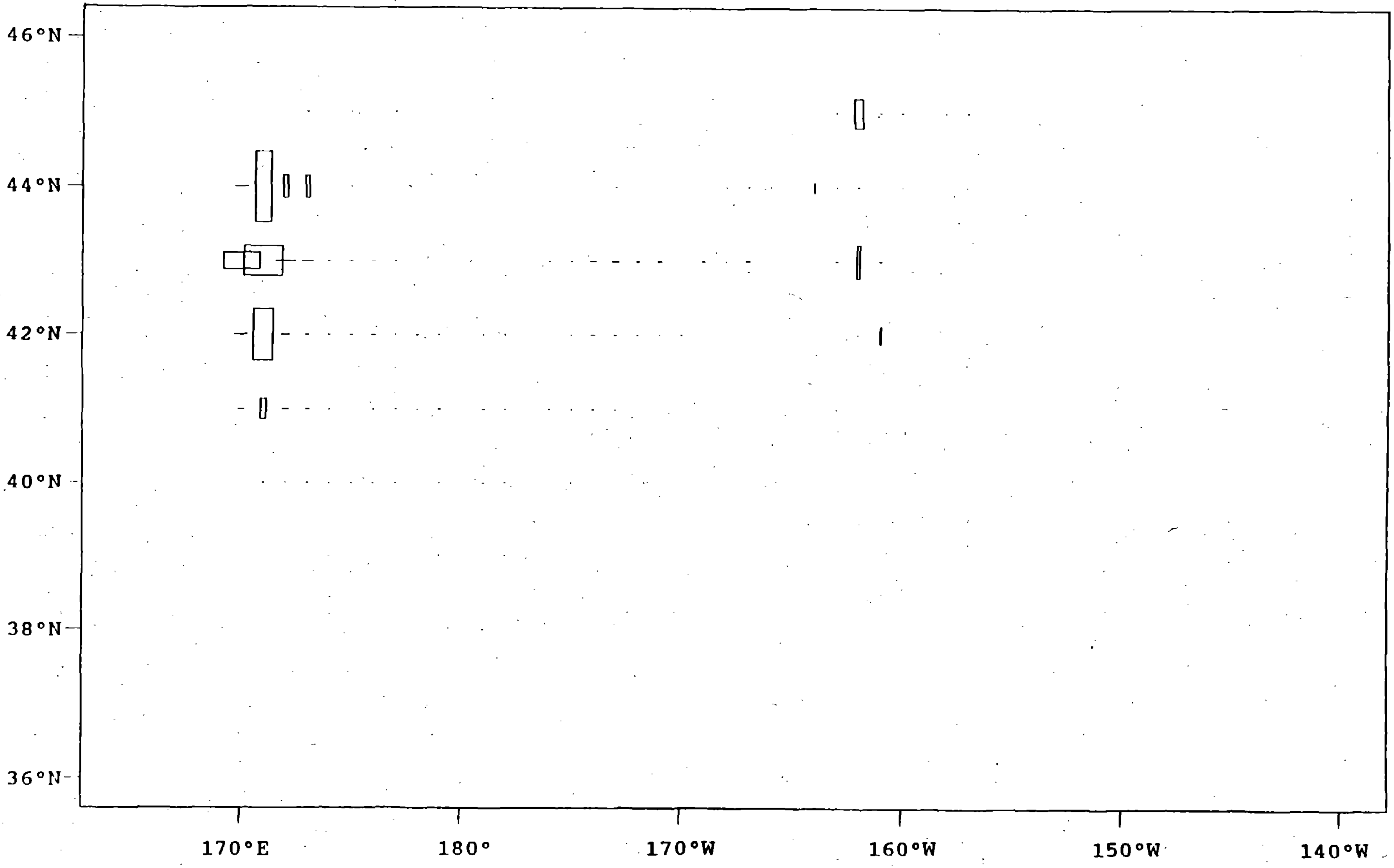
Appendix 1.--Continued. 1-10 September.



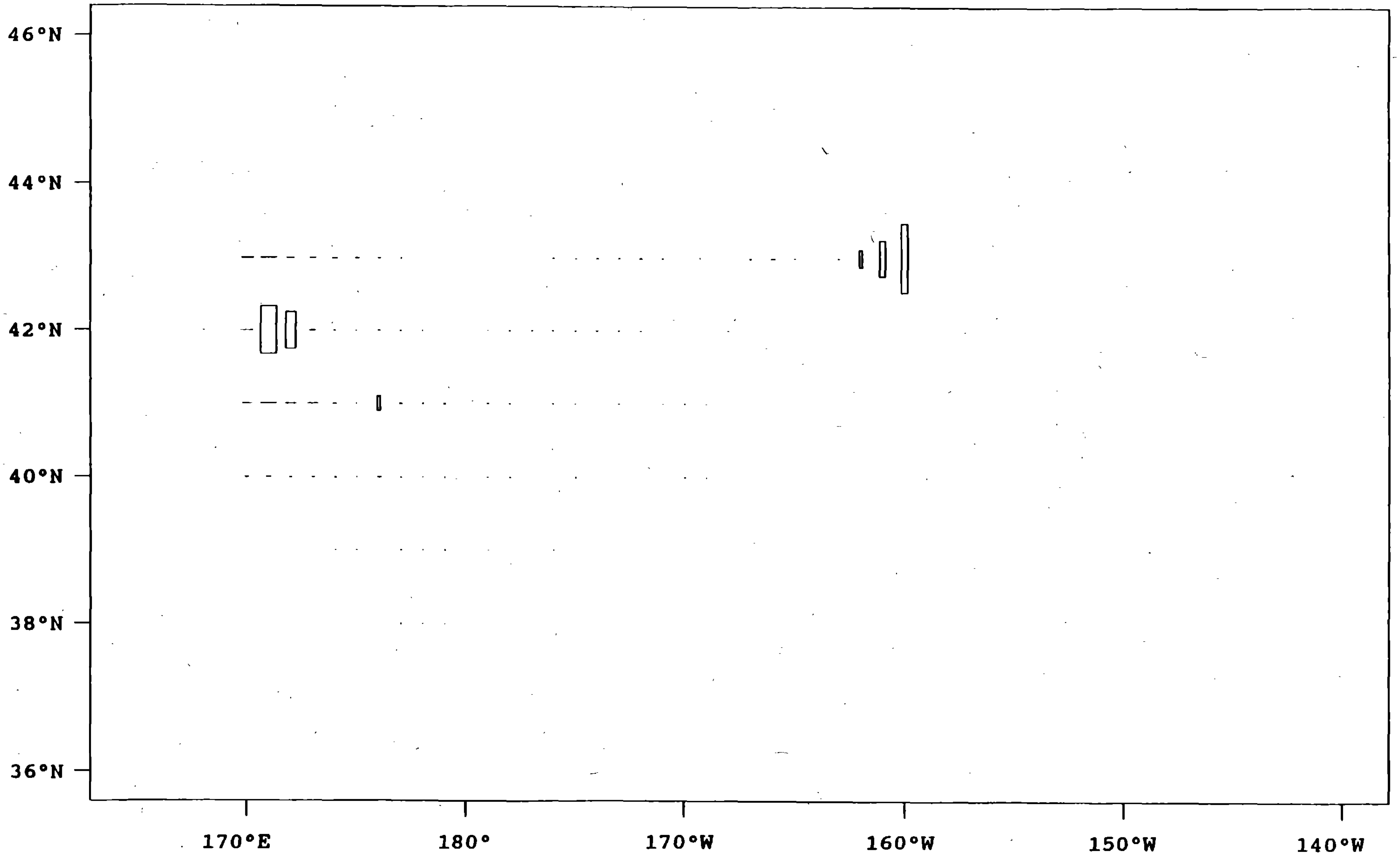
Appendix 1.--Continued. 11-20 September.



Appendix 1.--Continued. 21-30 September.



Appendix 1.--Continued. 1-10 October.



RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167 (web site: *www.ntis.gov)*. Paper and microfiche copies vary in price.

AFSC-

28 MORTENSEN, D. G., and H. SAVIKKO. 1993. Effects of water temperature on growth of juvenile pink salmon (Oncorhynchus gorbuscha), 12 p. NTIS No. PB94-145349.

27 LOW, L-L. (coordinator). 1994. Status of living marine resources off Alaska, 1993, 110 p. NTIS No. PB94-149846.

26 LOW, L-L. (coordinator). 1993. Status of living marine resources off the Pacific coast of the United States for 1993, 90 p. NTIS No. PB94-133733.

25 KINOSHITA, R. K., A. GREIG, J. D. HASTIE, and J. M. TERRY. 1993. Economic status of the groundfish fisheries off Alaska, 1992, 102 p. PB94-142759.

24 SINCLAIR, E. H. (editor) 1993. Fur seal investigations, 1991, 142 p. NTIS No. PB94-118171.

23 PARKS, N. B., F. R. SHAW, and R. L HENRY. 1993. Results of a 1988 trawl survey of groundfish resources of the upper continental slope off Oregon, 164 p. NTIS No. PB94-118163.

22 YANG, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 150 p. NTIS No. PB94-112463.

21 KINOSHITA, R. K., and J. M. TERRY. 1993. Oregon, Washington, and Alaska exports of edible fishery products, 1992, 52 p. NTIS No. PB93-226652.

20 REEVES, J. E. 1993. Use of lower minimum size limits to reduce discards in the Bristol Bay red king crab (Paralithodes camtschaticus) fishery, 16 p. NTIS No. PB93-228187.

19 SYRJALA, S. E. 1993. Species-specific stratification and the estimate of groundfish biomass in the Eastern Bering Sea, 20 p. PB94-103215.

18 PELLA, J., M. HOFFMAN, S. HOFFMAN, M. MASUDA, S. NELSON, and L. TALLEY. 1993. Adult sockeye and pink salmon tagging experiments for separating stocks in northern British Columbia and southern Southeast Alaska, 1982-1985, 134 p. NTIS No. PB93-226660.

17 SEASE, J. L., J. P. LEWIS, D. C. MCALLISTER, R. L. MERRICK, and S. M. MELLO. 1993. Aerial and ship-based surveys of Steller sea lions (Eumetopias jubatus) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1992, 57 p. NTIS No. PB93-226025.

16 FISCUS, C. F. 1993. Catalogue of cephalopods at the National Marine Mammal Laboratory, 183 p. NTIS No. PB93-226678.

15 KINOSHITA, R. K., A. GREIG, L. E. QUEIROLO, and J. M. TERRY. 1993. Economic status of the groundfish fisheries off Alaska, 1991, 94 p. NTIS No. PB93-197861.

14 PEREZ, M. A., and W. B. MCALISTER. 1993. Estimates of food consumption by marine mammals in the Eastern Bering Sea, 36 p. NTIS No. PB93-191195.

13 BERGER, J. D. 1993. Comparisons between observed and reported catches of retained and discarded groundfish in the Bering Sea and the Gulf of Alaska, 89 p. NTIS No. PB93-184711.