Exxon Valdez Oil Spill
State/Federal Natural Resource Damage Assessment Final Report

Impacts of the *Exxon Valdez* Oil Spill on Bottomfish and Shellfish in Prince William Sound

Fish/Shellfish Study 18
Final Report

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Study History: Fish/Shellfish Study 18 was initiated in 1989 to survey demersal bottomfish and shellfish in Prince William Sound and adjacent outside waters to estimate stock abundances and assess oil exposure. The project included 2 years of trawl surveys and was concluded in 1990.

Abstract: Trawl surveys were conducted in Prince William Sound and adjacent waters in 1989 and 1990 to 1) determine abundance of important bottomfish and shellfish species and 2) assess the incidence of oil contamination. Surveys in 1989 compared catch per unit effort (CPUE) with a 1978 survey and estimated biomass by random sampling. Compared to 1978, CPUE was greater for seven species and lower for four species. Biomass was generally greatest in heavily oiled areas. Significant oil contamination was detected in fish bile in both 1989 and 1990, and contamination was more widespread in 1990 than in 1989. In 1989, five of six species tested and 29% of bile samples were contaminated or possibly contaminated. In 1990, all six species tested and 39% of bile samples were contaminated. Contaminated fish were mostly from oiled areas in 1989, but were from throughout Prince William Sound in both oiled and non-oiled areas in 1990. Although relating hydrocarbon metabolites in bile to effects on bottomfish populations may be impossible, the persistent contamination of demersal fishes 1 year after the spill indicates that effects of the oil spill may be long term and should be monitored closely.

Key Words: *Exxon Valdez*, oil spill, Prince William Sound, trawling, bottomfish, shellfish, bile.

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Impacts of *Exxon Valdez* Oil Spill on
Bottomfish and Shellfish in Prince William Sound

Executive Summary

Trawl surveys were conducted in Prince William Sound and adjacent waters in 1989 and 1990 to assess impacts of the *Exxon Valdez* oil spill on commercial species of bottomfish and shellfish. The surveys 1) determined abundance, distribution, and year-class strength of important bottomfish and shellfish species and 2) assessed the incidence and distribution of oil contamination in fish bile.

Abundance of bottomfish and shellfish was determined in two surveys in 1989. The first survey compared catch per unit effort (CPUE) with a 1978 survey; the second survey estimated biomass by random sampling. Compared to 1978, CPUE was greater for seven species (arrowtooth flounder, flathead sole, rex sole, halibut, sablefish, Pacific cod, and sidestripe shrimp) and lower for four (tanner crab, walleye pollock, eulachon, and skates). Biomass of bottomfish and shellfish was generally lowest in non-oiled areas and greatest in heavily oiled areas.

Significant oil contamination was detected in fish bile in both 1989 and 1990. In 1989, hydrocarbon metabolites were detected in five of six species tested: herring (100%), flathead sole (42%), walleye pollock (100%), halibut (9%), and Pacific cod (50%); 29% of all bile samples were contaminated or possibly contaminated by oil. In 1990, hydrocarbon metabolites were detected in all six of the common bottomfish species: Pacific cod (91%), flathead sole (81%), walleye pollock (26%), Dover sole (21%), sablefish (19%), and halibut (9%); 39% of all bile samples were contaminated by oil. Contamination in 1990 was more widespread than in 1989. In 1989, contaminated fish were mostly from oiled areas, but in 1990, contaminated fish were distributed throughout Prince William Sound in both oiled and non-oiled areas.

Presence of hydrocarbon metabolites in bile in 1989 and 1990 shows that many fish in Prince William Sound were exposed to petroleum hydrocarbons from the *Exxon Valdez* spill. Although relating hydrocarbon metabolites in bile to effects on bottomfish populations may be impossible, the persistent contamination of demersal fishes 1 year after the spill indicates that effects of the oil spill may be long term and should be monitored closely.

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Introduction

The impact of the *Exxon Valdez* oil spill on the fish and shellfish of Prince William Sound was of great concern in the days after the spill. Pelagic fishes might have been exposed to waterborne hydrocarbons, contaminated prey, or for a short time, coating of oil. In contrast, demersal fishes were vulnerable to long-term effects from persistent oil in sediments, as well as ingestion of oil-contaminated prey during vertical feeding migrations. Demersal species are good indicators of chronic degradation of benthic sediments (Malins et al. 1988).

The purpose of this study was to assess the extent of oil contamination of trawl-caught species in Prince William Sound (PWS) after the *Exxon Valdez* oil spill. The NOAA vessel *John N. Cobb* conducted two trawl surveys in 1989 to determine species distributions, biomass, and year-class strength, and to collect tissue samples. One survey was conducted in 1990 to collect tissues to determine incidence of oil contamination persisting 1 year after the spill.

Oceanographic profiling was included in this study because subsurface water properties influence the distribution of benthic organisms and the dispersion of oil. Prince William Sound is a fjord-type estuarine system (Muench and Schmidt 1974). Mixing and circulation are strongly influenced by seasonal changes in temperature and freshwater runoff. Oceanographic processes influence the fate of oil and, thus, determine the long-term effects on fish and shellfish.

Objectives

1. Determine abundance of Tanner crab, sidestripe shrimp, halibut, sablefish, and other commercially important species in 1989;

2. Determine age composition of primary species in 1989;

3. Determine profile of water characteristics with a Conductivity-temperature-depth (CTD) instrument throughout the sampling area in 1990;

4. Determine the incidence of tar balls in the demersal environment and in stomachs of bottomfish from oiled and non-oiled areas in 1989; and

5. Determine the incidence of hydrocarbon metabolites in bile in commercial species from oiled and non-oiled areas in 1989 and 1990.

Methods

Prior Trawl Surveys

Various NOAA and chartered vessels surveyed PWS with otter trawls, beam trawls, and shrimp trawls in 1954, 1959, 1962, and 1970. These surveys, however, were not systematic; the gear used and the area sampled often differed. Therefore, most can not provide baseline data for assessing effects of the *Exxon Valdez* oil spill. The only previous systematic survey was conducted by the RV *Oregon* in 1978.

In April 1978, NMFS used the RV *Oregon* to systematically survey PWS to determine if bottomfish resources were sufficient to keep processing plants busy between other fisheries (Parks and Zenger 1979). The *Oregon* used a 400-mesh Eastern bottom trawl rigged with 1¼-inch mesh codend liner to retain small animals. Trawl doors were 5 x 7 ft V-type, with bridles 20 fathoms long and ½-inch diameter. The horizontal spread was 38 ft, and the vertical opening was 6-8 ft. NMFS divided PWS into four sampling quadrants, and completed 53 hauls.

Biomass and Age Composition

The first 1989 survey (Survey 1; 17 May-23 June) was used to collect tissue samples of bottomfish and shellfish for hydrocarbon analysis and to provide data for developing a stratified random sampling design to estimate bottomfish biomass in a subsequent survey (Survey 2). Survey 1 made 61 successful hauls (Figure 1), closely duplicating the stations sampled by the RV *Oregon* in 1978 to minimize search time for trawlable bottom and provide maximum coverage of PWS. Results of Survey 1, along with ADFG data on commercial catch and Tanner crab surveys, were used to develop a sampling design for Survey 2. Survey 2 (7 August-3 September and 13-18 September) collected data on biomass, population size, and year-class strength. Survey 2 made 63 successful hauls (Figure 2) with the final gear configuration.

Sampling gear differed between Surveys 1 and 2 in 1989. Survey 1 used a standard trawl that was the same size as the RV *Oregon*'s in 1978. The trawl was of proven design and had been used by the RV *John N. Cobb* in many surveys. Because this trawl was worn, it was replaced for Survey 2 with a new 400-mesh Eastern otter trawl, which at first was unsatisfactory. Changes were made to the ground rope, number of floats, and attachment of bridles to the doors to increase catch efficiency. Only data from the final configuration are included in this report.

The catch was processed according to methods of the Resource and Conservation Engineering Division (RACE) of the NMFS Alaska Fisheries Science Center (7600 Sand Point Way NE, Seattle, WA 98115), as detailed in Wakabayashi et al. (1985). Use of RACE methods allowed the data to be included in the RACE database for editing and processing. Wakabayashi et al. (1985) describe methods for sorting, counting, weighing, sexing, and other processing of the catch.

Catch data from Survey 2 were analyzed with the RACE BIOMASS computer program based on the method described in Wakabayashi et al. (1985). The BIOMASS program uses catch weight, distance trawled, net width, and stratum size of a given area to calculate biomass (total population weight), total population number, and size composition (population number by length interval). The BIOMASS program also gives variance, mean CPUE, and confidence intervals. Survey 1 was not designed to estimate biomass; its data were used only to compare CPUE with the 1978 survey. Because Tanner crab inhabit mostly trawlable bottom, total stratum area would overestimate the total population; therefore, we also computed Tanner crab biomass for trawlable bottom only.

Oceanography

Conductivity-temperature-depth (CTD) casts were made at each trawling station with a self-contained CTD recorder (Sea-Bird Model 19). The instrument was lowered at a rate of 35-45 m/min to within 10 m of the bottom. Temperature-salinity diagrams and depth profiles of temperature, salinity, and density were made for each successful cast. Survey 1 made 56 CTD casts, and Survey 2 made 37 CTD casts.

The sampling design for trawling was not suitable for synoptic analysis of water structure in PWS. Some stations, however, were close enough in time and space for a view of water structure along four transects: two each in Survey 1 and 2. In Survey 1, one transect extended from Hinchinbrook Entrance to Orca Bay; the other extended from south of Cape Puget through Montague Strait to between Eleanor and Smith Island (Figure 3). In Survey 2, one transect extended from Hinchinbrook Entrance to Glacier Island; the other duplicated the Survey 1 transect through Montague Strait (Figure 4). All stations along each transect were sampled within 7 days of each other.

Tissue Samples

Tissue samples were collected in 1989 and 1990 according to guidelines of the Damage Assessment Program. Procedures were developed on shipboard (SOP No. 1) and are described in the Project Operational Plan for the 1989 summer trawl survey (available from Tom Rutecki, Auke Bay Laboratory).

In 1989, fish and crab for tissue samples were collected by trawl at 24 stations in Survey 1 between 17 May and 23 June. The number of hauls from which bile samples were collected from oiled and non-oiled areas was proportional to the area's size (Table 1). Oiled areas comprised 64% of PWS, and 62% of the hauls were sampled; non-oiled areas comprised 36% of PWS, and 38% of the hauls were sampled. Tissue samples were collected from six species of fish and two species of shellfish: halibut (*Hippoglossus stenolepis*), flathead sole (*Hippoglossoides elassodon*), walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus* *macrocephalus*), sablefish (*Anoplopoma fimbria*), herring (*Clupea harengus*), sidestripe shrimp (*Pandalopsis dispar*), and Tanner crab (*Chionoecetes bairdi*).

A total of 452 hydrocarbon samples from various tissues were collected in 1989 (Table 2). Blanks were taken periodically and included with the frozen samples. Only bile samples were analyzed for hydrocarbons (fluorescent aromatic compounds). Samples for histopathology also were collected from flathead sole and sidestripe shrimp by combining 2-20 specimens from the same haul (Table 3); the samples were not processed and were archived.

Many 1989 bile samples could not be used because they deteriorated from delayed freezing. Chromatogram peaks can shift if bile is obtained from fish that have been dead for several hours. The peaks shift from a normal distribution of several peaks (7-16 min) to one large tailing peak (6-7 min). In Survey 1, some fish were not sampled for up to 4 h after capture, and some bile samples were at ambient temperature for another 4 h. To improve the data in 1990, bile samples were taken from live animals and immediately iced until frozen within 2 h.

In 1990, fish and crab were collected between 13 and 23 June with trawls of the same design as the one used in Survey 1 and by jigging with sportfishing gear. Trawling and jigging were done at 12 sites, and jigging for Pacific cod was done at one site (Zaikof Bay) (Figure 5). At each trawled site, we tried to sample 15 specimens from six fish and one shellfish species: (halibut, Dover sole (*Microstomus pacificus*), flathead sole, Pacific cod, walleye pollock, sablefish, and Tanner crab). Sometimes enough samples could be obtained from a single haul, but often too few animals were caught for a sample. A second haul was sometimes made, and jigging augmented the catch. Walleye pollock and Pacific cod rarely survived trawl capture; jigging provided live fish for hydrocarbon samples. Each haul was processed separately, except that hauls 10 and 11 were combined because of low catch. Bile and muscle were sampled from all six fish species, hepatopancreas was sampled from Tanner crab, and fish stomach contents were examined for oil or tar balls. A total of 1,117 samples of various tissues were taken from 409 animals (Table 4); only the bile samples were analyzed.

Bile samples from 1989 were analyzed by the Environmental Conservation Division, Northwest Fisheries Center, NOAA, by methods in the Detailed Study Plan; bile samples from 1990 were analyzed by the Geochemical and Environmental Research Group at Texas A&M University. Fluorescent aromatic compounds were measured at naphthalene (NPH) and phenanthrene (PHN) wavelength pairs (Appendix 1). Based on NPH and PHN concentrations and chromatographic patterns, bile samples were conservatively classified by Technical Services Study #1 (Manen et al. in prep.) into one of five categories: 1) contaminated (metabolites of aromatic hydrocarbons present); 2) possibly contaminated (hydrocarbon metabolites likely present above background level); 3) uncontaminated (no hydrocarbon metabolites); 4) degraded (peak characteristic of hydrocarbon degradation); and 5) insufficient bile for processing.

Results

CPUE, Biomass, and Populations

The similarity between the RV *Oregon*'s survey in 1978 and Survey 1 in 1989 allowed a comparison of CPUE (kg/h) for the most common species of bottomfish and shellfish. Although differences between years were not tested statistically, the sample mean CPUE for PWS as a whole was less for walleye pollock, skates (Rajidae), eulachon (*Thaleichthys pacificus*), and Tanner crab in 1989 than in 1978 (Figure 6). Most noteworthy was a 67% decrease in the sample mean of Tanner crab CPUE, from 144 kg/h in 1978 to 48 kg/h in 1989. The decrease in Tanner crab occurred in three of four quadrants; the southwest quadrant was similar in the two years. Sample mean CPUE of all other species (arrowtooth flounder, flathead sole, rex sole (*Glyptocephalus zachirus*), halibut, sablefish, Pacific cod, and sidestripe shrimp) was greater in 1989 than in 1978. The southwest quadrant had the greatest increase in sample mean CPUE for all species except sidestripe shrimp, which had its greatest increase in the southeast quadrant.

Arrowtooth flounder and walleye pollock were the most abundant species of bottomfish (Figure 7). Arrowtooth flounder made up the greatest proportion of total biomass at every site except Central Basin and Port Wells. It accounted for 67% of total biomass in the area of Knight Island/Montague Strait and 65% of total biomass in the area outside PWS. Walleye pollock were 27% of the total biomass at Orca/Fidalgo, 19% at Hinchinbrook, and 19% at Central Basin. Variability in catch, however, was great, as indicated by coefficient of variation, which ranged from 9 to 100% (Table 5). Mean biomass of arrowtooth flounder was 50,000 mt, and the 95% confidence interval was 6,000-90,000 mt (Figure 8). The 95% confidence interval for walleye pollock biomass was 6,000-13,000 mt, only slightly greater than that of flathead sole. Mean biomass of the other species was within the 95% confidence interval for sablefish (1,000-8,000 mt). On a percentage basis, Tanner crab biomass based on trawlable area was similar to biomass based on total area (Table 6). Mean biomass of Tanner crab based on trawlable area was 2,263 mt.

Total biomass was greatest in the heavily oiled Knight Island/Montague Strait area (Figure 9). Although not tested statistically, the sample mean biomass was greatest in this area for 13 of the 15 species. The most concentrated biomass was that of eulachon: 97% in Knight Island/Montague Strait. Because eulachon school, however, such a concentration may not reflect its real distribution. Alaska skate was noteworthy in that none of its biomass was in the Knight Island/Montague Strait area; all its biomass was in the Outside (81%) and Hinchinbrook (19%) areas. For PWS as a whole, the Knight Island/Montague Strait area contained 53% of the total biomass, followed by the Outside area with 19%. All 15 species had lowest biomass in the Port Wells area, which made up only 0.3% of the total biomass in PWS.

Species composition based on number of individuals differed from composition based on biomass (Figure 10). Arrowtooth flounder comprised the greatest proportion of individuals in the Outside and Knight Island/Montague Strait areas (49% and 32%, respectively). Sidestripe shrimp was next, with 38% in the Port Wells area and 30% in the Central area. Flathead sole led in the Orca/Fidalgo area (27%), and rex sole led in the Hinchinbrook area (19%).

Arrowtooth flounder was the most abundant bottomfish in PWS. Its total population was nearly 50 million fish, followed by flathead sole, northern shrimp, and Tanner crab with 20-30 million each (Figure 11). Because of wide variability in catch, the 95% confidence limits for arrowtooth flounder ranged from 10 million to 85 million fish. This wide range included the entire range for flathead sole, northern shrimp, and Tanner crab, and most of the range for rex sole and walleye pollock. Other species contributed less than 10 million individuals each to the survey area.

Length Frequencies

Comparisons of length frequencies between 1978 and 1989 could be made for flathead sole, sablefish, and halibut (Figures 12 and 13). Frequency distributions for flathead sole were comparable only for the two southern quadrants. For these quadrants, females were clearly larger than males, and modes for both sexes in 1989 were similar to the modes in 1978. Sablefish mean length (sexes combined) was greater in 1989 (55 cm) than in 1978 (43 cm). Similarly, halibut mean length (sexes combined) was greater in 1989 (74 cm) than in 1978 (60 cm).

The frequency distributions for arrowtooth flounder, walleye pollock, and flathead sole from Survey 2 (Figures 14-16) show that larger individuals generally occupied greater depth. This distribution was evident in each area, and it was especially pronounced in flathead sole. This pattern was not evident in the other species (Figures 17-20).

Tanner crab also showed a distinct size distribution by depth (Table 7). Small crab (indicated by high number/kg) were most common at shallow depth (<100 fm). Mean kg/haul was greatest at 101-250 fm, reflecting capture of adults. High variation in catches (from 0 to >4000 crab) indicated a patchy distribution.

Because Tanner crab do not have structures for ageing, carapace width was used to indicate year class. Width frequencies of Tanner crab in May and June showed peaks at 18 and 28 mm (Figure 21). Modes beyond 40 mm were indistinct. Based on criteria of Donaldson et al. (1981), the mode at 28 mm was the 1987 year class, the mode at 18 mm was the 1988 year class, and the incomplete frequency at <10 mm was the 1989 year class. In the August-September survey, the modes had shifted upward: the <10-mm frequency became a mode at 18 mm, and the 18-mm and 28-mm modes became modes at 27 and 37 mm, respectively. If these shifts reflect growth, the 1988 and 1987 year classes grew 3 mm/month between the surveys. Tanner crab smaller than 95 mm had soft or recently molted exoskeletons in both 1989 surveys, whereas adults were in this condition only in spring (Figure 22). Molting in Tanner crab is similar to many decapods in that instar periods are initially short and gradually lengthen until, as adults, molting occurs once a year (Lipcius 1985).

Sidestripe shrimp occurred in 53 of 61 tows of Survey 1. The top 10 catches were made at 200-250 fathoms. Smaller catches in deeper water may reflect decreased gear efficiency rather than shrimp distribution. A few sidestripe shrimp were parasitized by the isopod *Bopyroides hippolytes* (Table 8). Sidestripe shrimp in PWS can be aged from length frequencies (Figure 23) by comparing with Butler's (1964) data for British Columbia. The May/June mode at 17 mm represents immature males 13 months old (assuming April hatching). They begin maturing in their second fall, 18 months after hatching. Sex changes the next spring at age 2. By the third fall, shrimp become females and extrude eggs. We observed eggs in both spring and fall (Table 8). In spring, they probably were fully developed embryos; in fall, they probably were recently extruded. Because samples of sidestripe shrimp were not collected throughout the year, these ages should be viewed with caution. Data for distinguishing year classes (i.e., length of sternal spines) were not collected.

Northern shrimp (*Pandalus borealis*), a circumpolar species with a varied life history (Haynes and Wigley 1969), showed marked differences in length frequencies of males between Surveys 1 and 2 (Figure 24), which makes ageing unreliable. The wide range in female carapace length indicates more than one year class (Table 8). As with sidestripe shrimp, a few northern shrimp were parasitized by *Bopyroides hippolytes* (Table 8).

Oceanography

The water of PWS was stratified in three distinct layers: a shallow upper layer, an intermediate layer characterized by a temperature minimum, and a slightly warmer bottom layer (Figures 25-28). The upper layer may be considered a surface pycnocline that gradually deepens as heat and fresh water accumulate in summer. The upper layer (0-50 m deep) was isothermal (6-8°C, 30-31 ppt salinity) in mid-May; by August, temperature increased to 13-14°C and salinity declined to less than 20 ppt at many stations. In winter, the upper layer is cooled by convection after freshwater input diminishes.

The intermediate layer (50-200 m deep) had a thermal minimum of 4.2°C that increased to 5.2°C by the end of summer. Salinity was consistently 31.5-32.8 ppt. The intermediate layer probably formed locally in response to winter cooling and convective mixing. Its warming in late summer may be by diffusive mixing (Muench and Schmidt 1974).

The bottom layer (200-500 m deep) was nearly isopycnal (5.2-5.5°C, 32.8-33.0 ppt). The source of this water was probably the Gulf of Alaska at 160-180 m. Renewal probably is nearly continuous, but most intense in fall.

Oil Contamination

No tar balls or other obvious oil was visible on sampling gear, on catches, or in fish stomachs.

Of 122 bile samples in 1989, 43 (35%) were degraded (Table 9). Degraded samples were from both oiled (23) and non-oiled (20) areas, indicating no bias in lost samples (Table 1).

Bile samples showed limited oil exposure in 1989 (Table 9). Of 76 analyzable bile samples in 1989, 54 (71%) were uncontaminated, 14 (18%) were possibly contaminated, and 8 (11%) were contaminated. Of the six species sampled, five were contaminated or possibly contaminated by oil (Table 9). Walleye pollock was most contaminated; six of seven samples were contaminated. Halibut and herring each had one contaminated and one possibly contaminated sample. Flathead sole had 10 possibly contaminated samples, and Pacific cod had one possibly contaminated sample. All 18 usable (sufficient bile and distinct chromatogram) sablefish samples were uncontaminated.

The contaminated and possibly contaminated samples in 1989 were from seven stations (Table 10). Six of the stations were in the heavily oiled area of Knight Island/Montague Strait; the other station was in the non-oiled area in Montague Trench (Figure 1; Table 10). Contaminated or possibly contaminated bile samples were significantly ($P = 0.001$; Chi-square test) more frequent in oiled than in non-oiled areas (Table 11).

Contamination of bottomfish in 1990 was more widespread than in 1989. Of the 114 usable bile samples collected in 1990, 44 (39%) were contaminated (Table 12). All six species of bottomfish examined were contaminated. Almost all (91%) Pacific cod and most (81%) flathead sole were contaminated, and significant numbers of walleye pollock (26%), Dover sole (21%), sablefish (19%), and halibut (9%) were also contaminated.

Of the 13 locations sampled in 1990, six (stations 3, 6, 7, 8, 9, 12) had contaminated fish (Figure 5). Most (61%) of the contaminated fish came from non-oiled areas (stations 3, 6, and 12). Contaminated flathead sole were at four stations (3, 8, 9, and 12), contaminated walleye pollock were at two stations (6 and 8), and contaminated sablefish, halibut, Dover sole, and Pacific cod were at one station each (stations 7, 7, 12, and 12, respectively). Pacific cod from Zaikof Bay were uncontaminated but were diseased; some had lesions the size of silver dollars.

Discussion

Demersal fish in the route of the oil spill were definitely exposed to petroleum hydrocarbons in 1989. The exposed species included those in direct contact with possibly contaminated bottom sediments, such as halibut and flathead sole, as well as those with diel migrations in the water column, such as pollock and herring. Continued contamination in bile in 1990 indicates continued exposure, probably via ingestion of contaminated benthic prey. Oil held in the sediments would continue to be available to benthic fish and invertebrates, and hence, would be available to the rest of the food chain.

Fish that tested positive for hydrocarbon metabolites could have been exposed to oil by ingesting oil-contaminated or coated prey or by contact with contaminated benthos. The more widespread contamination in 1990 could have been caused by movement of fish or movement of oiled prey. Whether contaminated prey were carried to the fish by water currents, or the fish obtained oiled prey in an oiled area is not known.

Loss of samples from degradation in 1989 probably did not bias our results. The area-weighted sampling effort and similar number of degraded samples from oiled and non-oiled areas meant that samples from both oiled and non-oiled areas had the same chance of degradation. Although loss of samples probably did not bias comparisons between oiled and non-oiled areas, it reduced precision of the estimators and statistical power to discriminate differences between oiled and non-oiled areas.

Analysis of bile for petroleum hydrocarbons has become a common tool for monitoring exposure of fish to oil pollution. Bile analysis was used to scan many fish after the *Exxon Valdez* spill (Krahn et al. 1992). Lipophilic compounds of high molecular weight are excreted by the gallbladder into the intestine in bile, while compounds of low molecular weight are excreted in urine. Bile monitoring, therefore, does not address exposure to compounds of low molecular weight or hydrocarbon accumulation in tissues. Tissue samples were not analyzed for hydrocarbon accumulation or damage; thus, the impact of exposure to oil indicated by bile can not be assessed from our data.

Bottomfish are excellent indicators of the health of the benthos. Carcinomas (McCain et al. 1982) and delayed ovarian maturation (Johnson et al. 1988) have been found in bottomfish on sediments contaminated with aromatic hydrocarbons. Bottomfish can be used to assess impacts of toxicant-laden sediments long after the polluting event (Powers 1989).

Hydrocarbon metabolites in bile indicate potential impacts on bottomfish reproduction. Petroleum hydrocarbons accumulate in lipid-rich tissues before excretion in bile (Hodgson and Guthrie 1982). Lipids also can sequester hydrocarbons, making them available to the organism for months after exposure. Gonads of adult bottomfish are especially rich in lipids and particularly susceptible to bioaccumulation of hydrocarbons, leading to impacts on reproduction (Johnson et al. 1988).

The high abundance of demersal fishes in spill area in 1989, evidence of exposure to oil, and presence of contaminated bile throughout Prince William Sound in 1990 indicate that impacts of the oil spill on demersal resources of Prince William Sound are likely to be long term. Assessment of that impact on demersal fish populations or habitat would require determining long-term changes in year-class strength and reproductive viability. Further research is needed to assess restoration needs and alternatives.

Damage to bottomfish and shellfish from the *Exxon Valdez* oil spill are difficult to ascertain. Survey data for bottomfish and shellfish stocks in Prince William Sound are too limited and variable to provide a baseline for determining trends in biomass. Extensive trawl surveys for several years would be needed to be able to document even a major impact on the 1989 year class. Even with such survey data, lack of knowledge about fish movements would make it difficult to determine if a decrease in abundance was due to movement, rather than poor recruitment caused by the oil spill.

Although relating hydrocarbon metabolites in bile to effects on bottomfish populations may be impossible, the widespread contamination of bottomfish 1 year after the spill indicates that the *Exxon Valdez* oil spill may have long-term effects, and bottomfish and shellfish populations should be monitored closely.

Conclusions

1. Species abundance: Arrowtooth flounder and walleye pollock were the most abundant bottomfish. Biomass was greatest in the heavily oiled area of Knight Island/Montague Strait for 13 of 15 species. For PWS overall, the Knight Island/Montague Strait area contained 53% of the total biomass.

2. Age composition: Length frequencies for arrowtooth flounder, walleye pollock, and flathead sole showed that larger individuals generally occupied greater depth. Small tanner crab were most common at depths to 100 fm; adults were most common at 101-250 fm. Tanner crabs in May/June showed a carapace-width mode at 28 mm, (1987 year class), a mode at 18 mm (1988 year class), and an incomplete frequency at <10 mm (1989 year class). Sidestripe shrimp showed a May/June length mode at 17 mm, representing immature males 13 months old. Male northern shrimp showed differences in length frequencies between surveys, making ageing unreliable; female lengths indicated more than one year class.

3. Seawater profile: The water of PWS was stratified in three layers: a shallow (0-50 m deep) upper layer (6-8°C, 30-31 ppt salinity in May, 13-14°C, 20 ppt in August); an intermediate layer (50-200 m) that was cold (4.2-5.2°C) and had more stable salinity (31.5-32.8 ppt); and a nearly isopycnal (5.2-5.5°C, 32.8-33.0 ppt) bottom layer (200-500 m deep).

4. Tar balls: No tar balls or other obvious oil was visible on sampling gear, on catches, or in fish stomachs.

5. Hydrocarbon metabolites in bile: Presence of hydrocarbon metabolites in bile in 1989 and 1990 showed that bottomfish fish were contaminated by *Exxon Valdez* oil. The contamination not only persisted in 1990 but became more widespread throughout Prince William Sound.

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Table 1.--Size of oiled and non-oiled areas, number and percentage of trawl hauls made in each area, and distribution of degraded bile samples, 1989 Survey 1, Fish/Shellfish Study #18.

	Area		Trawl Hauls			
Areas	Square Miles	% of Total	No. of Hauls	% of Total	No Samples Degraded	All Samples Degraded
Oiled Areas						
Central Basin	505	25	4	17	1	1
Hinchinbrook Entrance	225	11	2	8	1	0
Knight Is./Montague St.	548	28	9	38	4	2
Subtotal	1,277	64	15	63	6	3
Non-oiled Areas						
Orca/Fidalgo	290	15	4	17	0	1
Port Wells	108	5	2	8	1	0
Outside PWS	314	16	3	12	0	0
Subtotal	712	36	9	37	1	1
Total	1,990	100	24	100	7	4

Table 2.--Hydrocarbon samples taken in 1989 Survey 1, Fish/Shellfish Study #18.

Species	Bile	Stomach	Muscle	Hepato-pancreas	Eggs	Total
Halibut	25	25	25			75
Flathead Sole	27	27	26			80
Sablefish	19	21	21			61
Walleye Pollock	28	28	28			84
Pacific Cod	21	21	21			63
Tanner Crab			22	22	17	61
Herring	2	4	4		2	12
Sidestripe Shrimp			15	1		16
Total	122	126	162	23	19	452

Table 3.--Histopathological samples taken in 1989 Survey 1, Fish/Shellfish Study #18.

Date	Haul	Location	Species	Sample type	No. of specimens
5/25	20	Lower Montague	flathead sole	organs and tissues	20
5/30	27	Port Gravina	flathead sole	organs and tissues	20
			sidestripe shrimp	whole specimens	15
6/5	35	Naked/Glacier	sidestripe shrimp	whole specimens	20
6/6	36	Naked/Glacier	flathead sole	organs and tissues	2
6/6	37	Naked/Glacier	flathead sole	organs and tissues	9
6/6	38	Naked/Glacier	flathead sole	organs and tissues	6
6/7	41	Upper Montague	flathead sole	organs and tissues	8
6/17	54	Upper Montague	flathead sole	organs and tissues	2
			sidestripe shrimp	whole specimens	20
6/17	55	Upper Montague	flathead sole	organs and tissues	10

Table 4.--Hydrocarbon samples taken in 1990 by Fish/Shellfish Study #18.

Species	Bile	Muscle	Food	Liver	Hepato-pancreas	Total
Halibut	41	41	41	123		
Flathead Sole	58	58	58	174		
Sablefish	72	72	72	216		
Walleye Pollock	44	44	44	42	174	
Pacific Cod	45	45	45	135		
Dover Sole	73	73	73	219		
Tanner Crab	76	76				
Total	333	333	333	42	76	1,117

Table 5.--Coefficients of variation (standard deviation divided by mean, as a percentage) for mean biomass estimates by species in areas sampled in 1989 Survey 2, Fish /Shellfish Study #18.

Species	Hinchin-brook	Orca/ Fidalgo	Central Basin	Knight Is.	Port Wells	Out-side
Sablefish	82	30	47	89	-	43
Rougheye rockfish	36	48	91	36	-	98
Big Skate	80	90	100	81	-	88
Aleutian skate	24	38	22	20	42	10
Alaska skate	68	-	-	-	-	100
Walleye pollock	29	30	27	53	9	41
Pacific cod	25	26	26	40	-	42
Eulachon	94	-	-	42	-	-
Halibut	52	36	60	41	50	57
Flathead sole	38	30	39	29	57	76
Rex sole	35	29	41	53	75	37
Arrowtooth flounder	37	34	78	58	51	67
Tanner crab	26	32	29	26	79	62
Sidestripe shrimp	29	60	9	27	50	63
Northern shrimp	45	29	35	20	100	62

Table 6.--Percent of total biomass contributed by Tanner crab in different areas of Prince William Sound, based on trawlable area and total area.

	Trawlable	Total
Hinchinbrook	18	24
Orca/Fidalgo	16	13
Central	17	20
Knight Island	46	40
Port Wells	<2	2
Outside	<2	1

Table 7.--Catch of Tanner crab by depth, 1989 Survey 1, Fish/Shellfish Study #18.

Depth (fm)	Number of hauls	Maximum kg/haul	Mean no./kg	Mean kg/haul
≤50	4	3.0	22.7	1.4
51-100	22	94.8	42.1	1.8
101-150	14	55.8	2.9	11.0
151-200	5	31.8	1.3	14.3
201-250	12	21.5	2.4	12.9
>250	4	5.1	2.9	2.1

Table 8.--Life history data for sidestripe shrimp, *Pandalopsis dispar*, and northern shrimp, *Pandalus borealis*, collected in 1989 Survey 1, Fish/Shellfish Study #18. The parasite is the isopod *Bopyroides hippolytes.*

Species	Sex	Size range (mm)	Percent with eggs spring	Percent with eggs fall	Number of parasites
Sidestripe	male	12.5-31.5	--	--	8
	trans.	24.0-34.0	--	--	0
	female	25.5-38.5	1.8%	14.3%	0
Northern	male	8.5-21.0	--	--	1
	trans.	15.0-22.5	--	--	1
	female	13.5-27.5	0.0%	0.0%	0

Table 9.--Results of hydrocarbon analysis for oil contamination in bile samples taken in 1989 Survey 1, Fish/Shellfish Study #18.

Species	Degraded samples	Insufficient for analysis	Uncontaminated	Possibly contaminated	Contaminated	Total
Herring	0	0	0	1	1	2
Halibut	1	1	21	1	1	25
Flathead sole	2	1	14	10	0	7
Sablefish	1	0	18	0	0	9
Pacific cod	19	0	1	1	0	1
Walleye pollock	20	1	0	1	6	28
Total	43	3	54	14	8	122

Table 10.--Sites of contaminated and possibly contaminated bile samples, 1989 Survey 1, Fish/Shellfish Study #18.

Haul no.	Date	Location	Species	Bile analysis results
8	5/21/89	Knight/Green Is.	flathead sole	possible oil
8	"	"	"	"
10	5/22/89	"	halibut	"
10	"	"	"	oil present
10	"	"	pollock	"
10	"	"	"	"
10	"	"	"	possible oil
11	"	"	flathead sole	"
11	"	"	"	"
13	5/23/89	Lower Montague	"	"
13	"	"		"
22	5/26/89	Upper Montague	"	"
22	"	"	"	"
22	"	"	"	"
22	"	"	pollock	oil present
22	"	"	"	"
22	"	"	"	"
S-2	6/18/89	Knight/Green Is.	flathead sole	"
S-2	"	"	herring	"
S-2	"	"	"	oil present
S-2	"	"	pollock	"
58	6/19/89	Montague Trench	Pacific cod	possible oil

Table 11.--Number of uncontaminated, possibly contaminated, and contaminated bile samples from oiled and non-oiled areas of Prince William Sound, 1989 Survey 1, Fish/Shellfish Study #18. Only non-degraded samples with sufficient bile for analysis are included.

	Uncontaminated	Possibly Contaminated	Contaminated
Oiled Areas			
Central Basin	5	0	0
Hinchinbrook Entrance	6	0	0
Knight Is./Montague St.	16	13	8
Total	27	13	8
Non-oiled Areas			
Orca/Fidalgo	11	0	0
Port Wells	9	0	0
Outside PWS	7	1	0
Total	27	1	0

Table 12. Contamination in 1990 of the six species of bottomfish sampled by Fish/Shellfish Study #18.

Species	Number of samples	Number contaminated	Percent contaminated
Flathead sole	22	18	81
Sablefish	32	6	19
Walleye pollock	19	5	26
Dover sole	19	4	21
Halibut	11	1	9
Pacific cod	11	10	91
Total	114	44	39

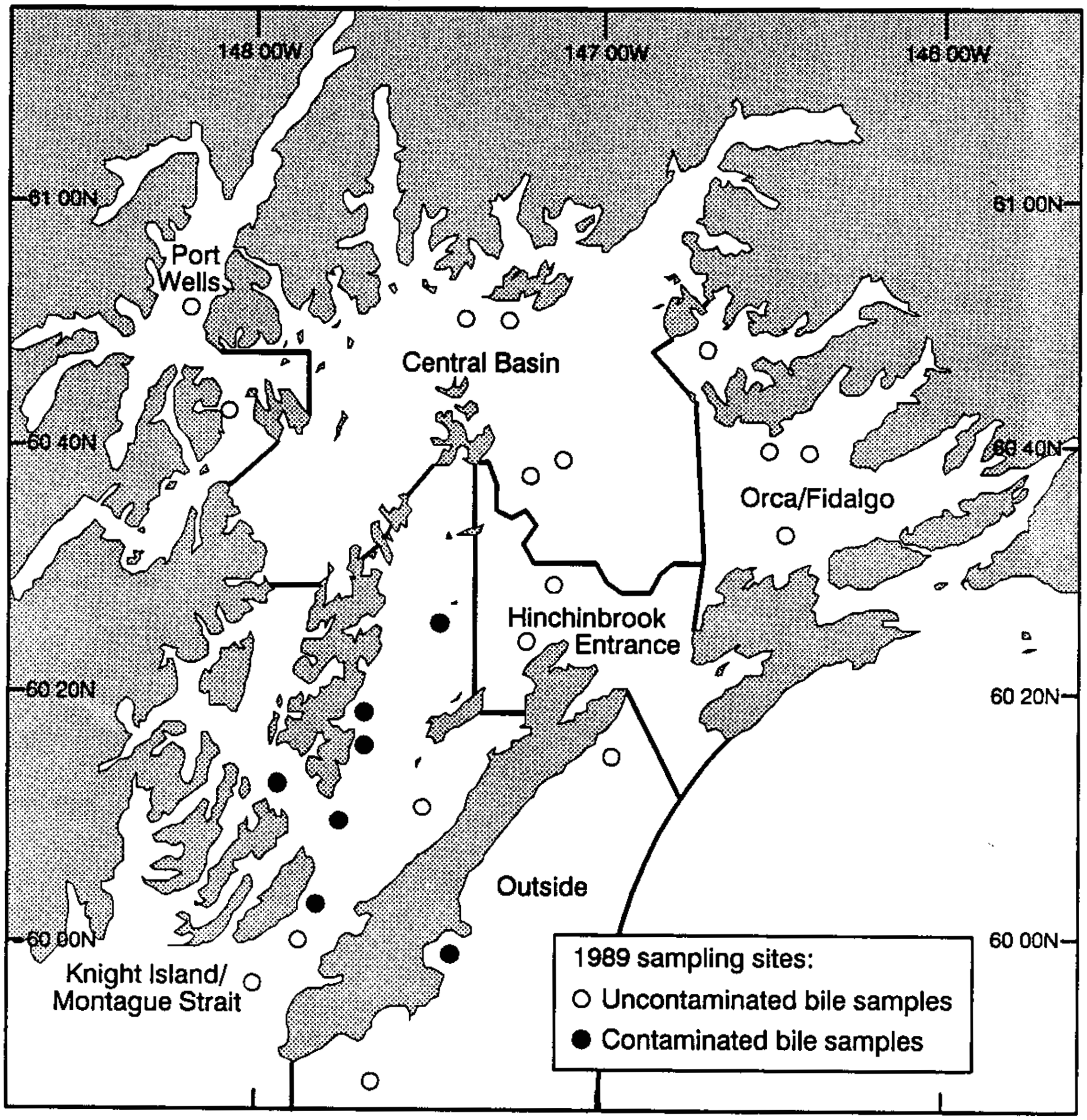


Figure 1. Map of sampling locations, 1989 Survey 1, Fish/Shellfish Study #18, showing distribution of contaminated bile samples.

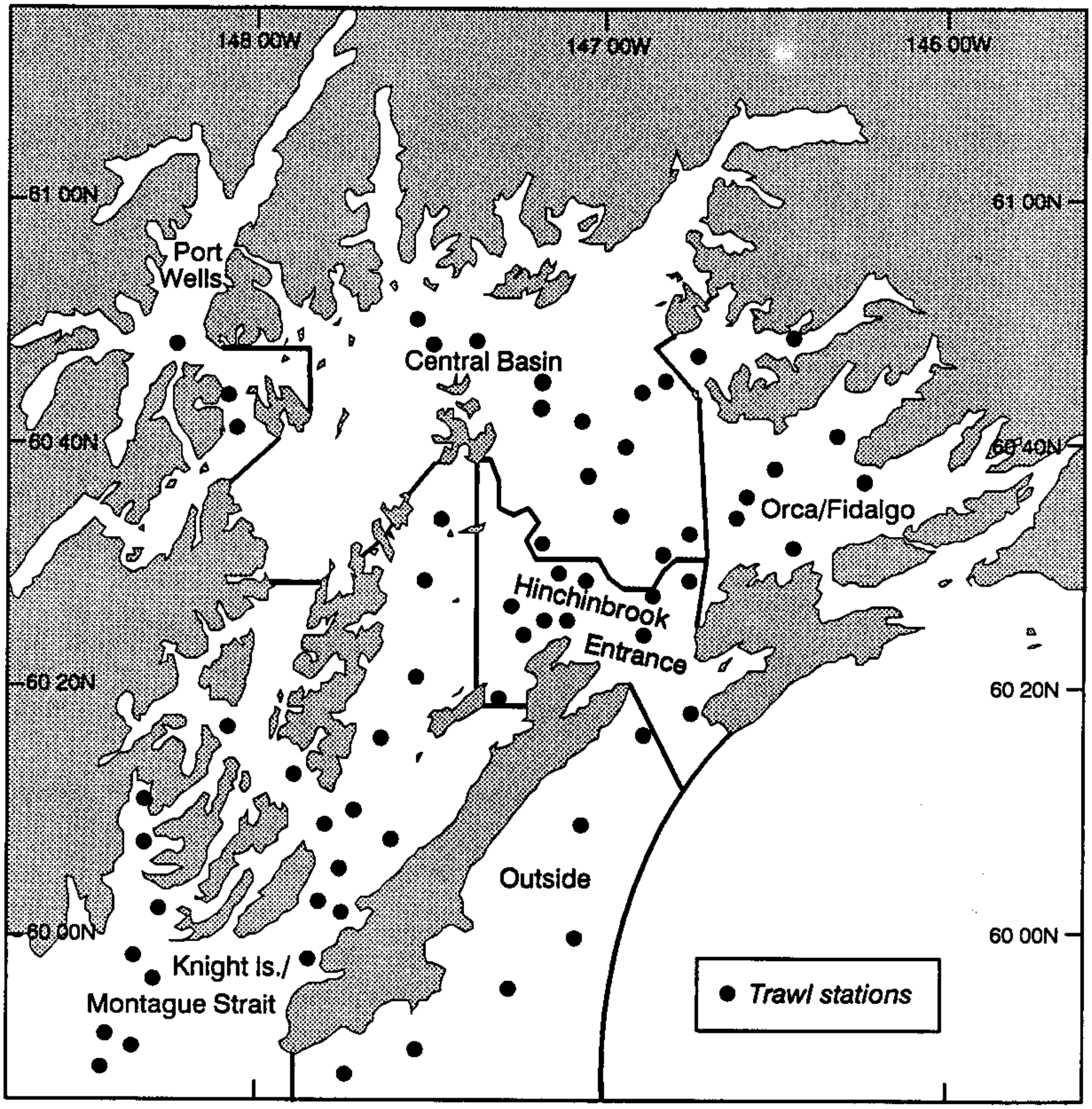


Figure 2. Map of station locations, 1989 Survey 2, Fish/Shellfish Study #18.

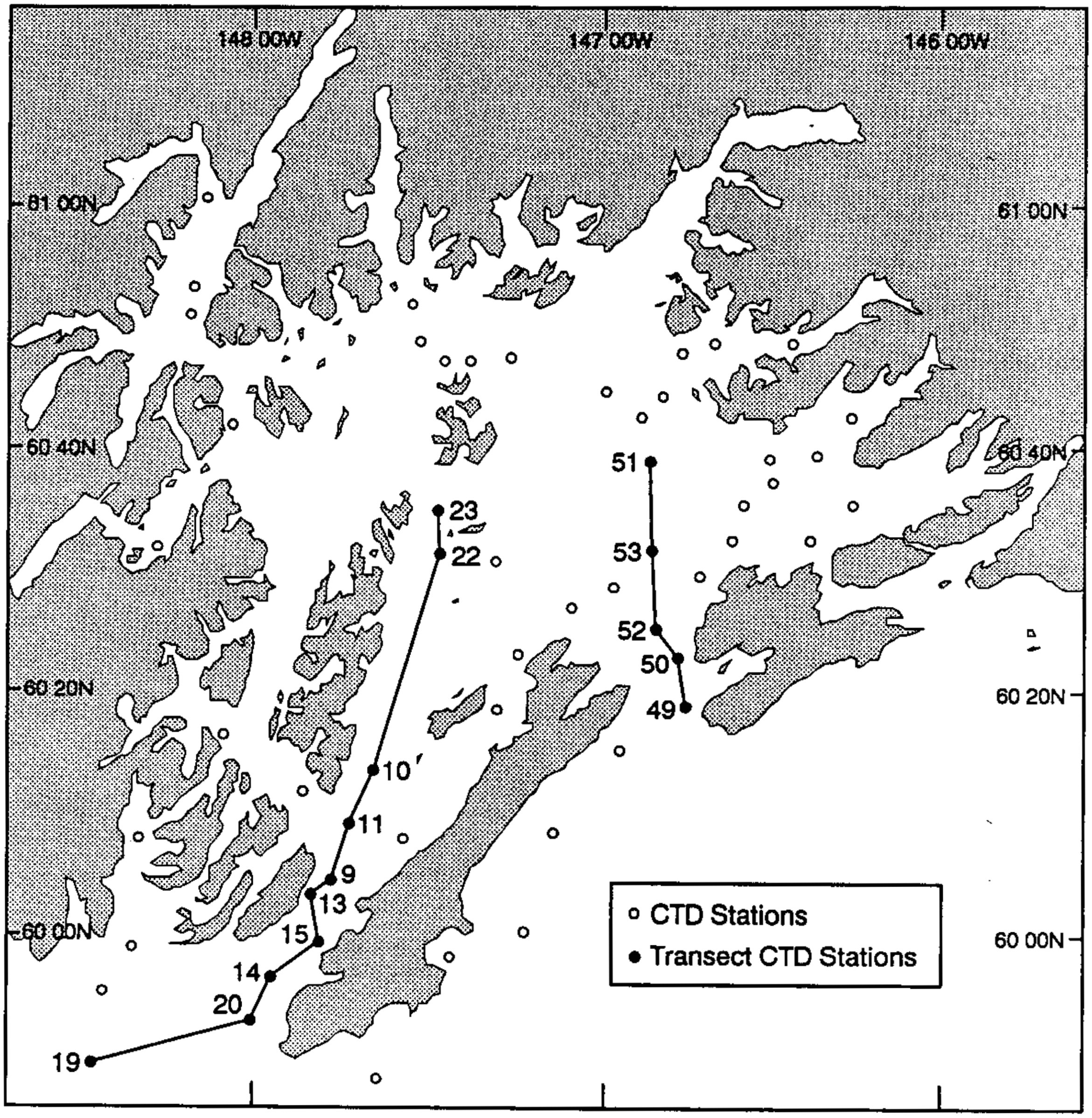


Figure 3. CTD stations and transects, 1989 Survey 1, Fish/Shellfish Study #18.

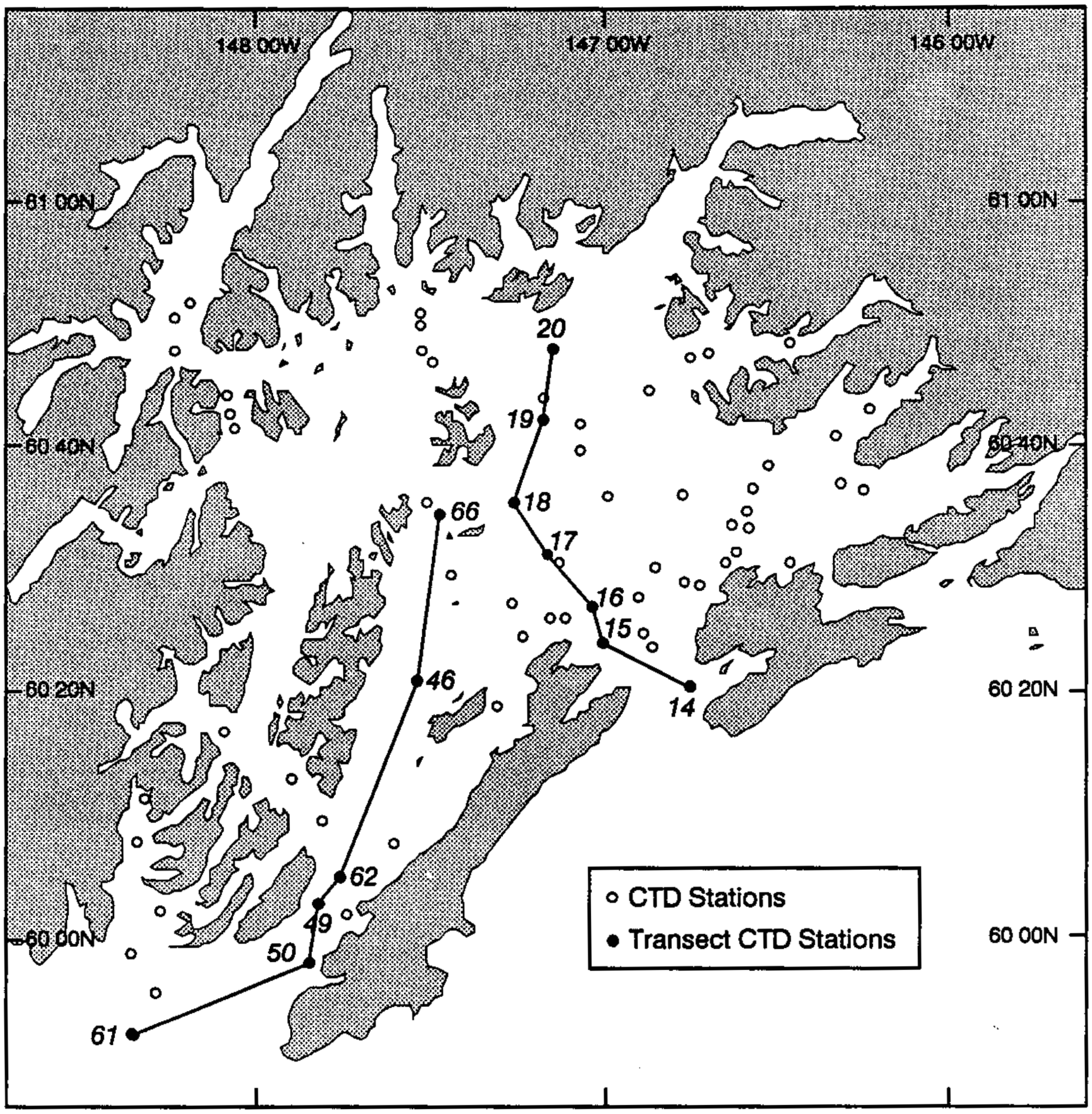


Figure 4. Ctd stations and transects, 1989 Survey 2, Fish/Shellfish Study #18.

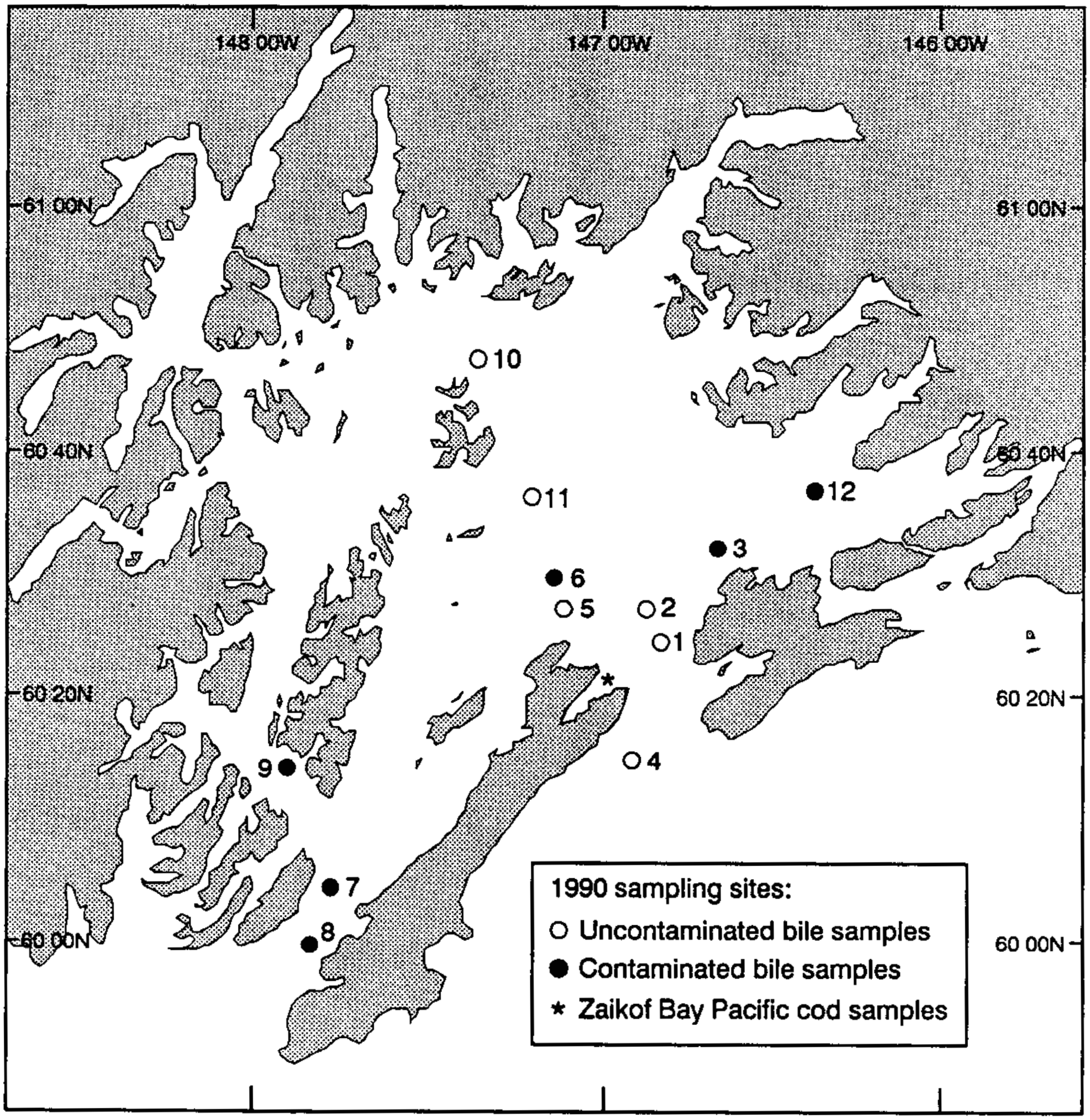


Figure 5. Map of sampling locations, 1990 Survey, Fish/Shellfish Study #18, showing distribution of contaminated bile samples. Numbers next to symbols identify sampling locations referred to in text. Zaikof Bay was sampled by jigging only, and fish from there were uncontaminated.

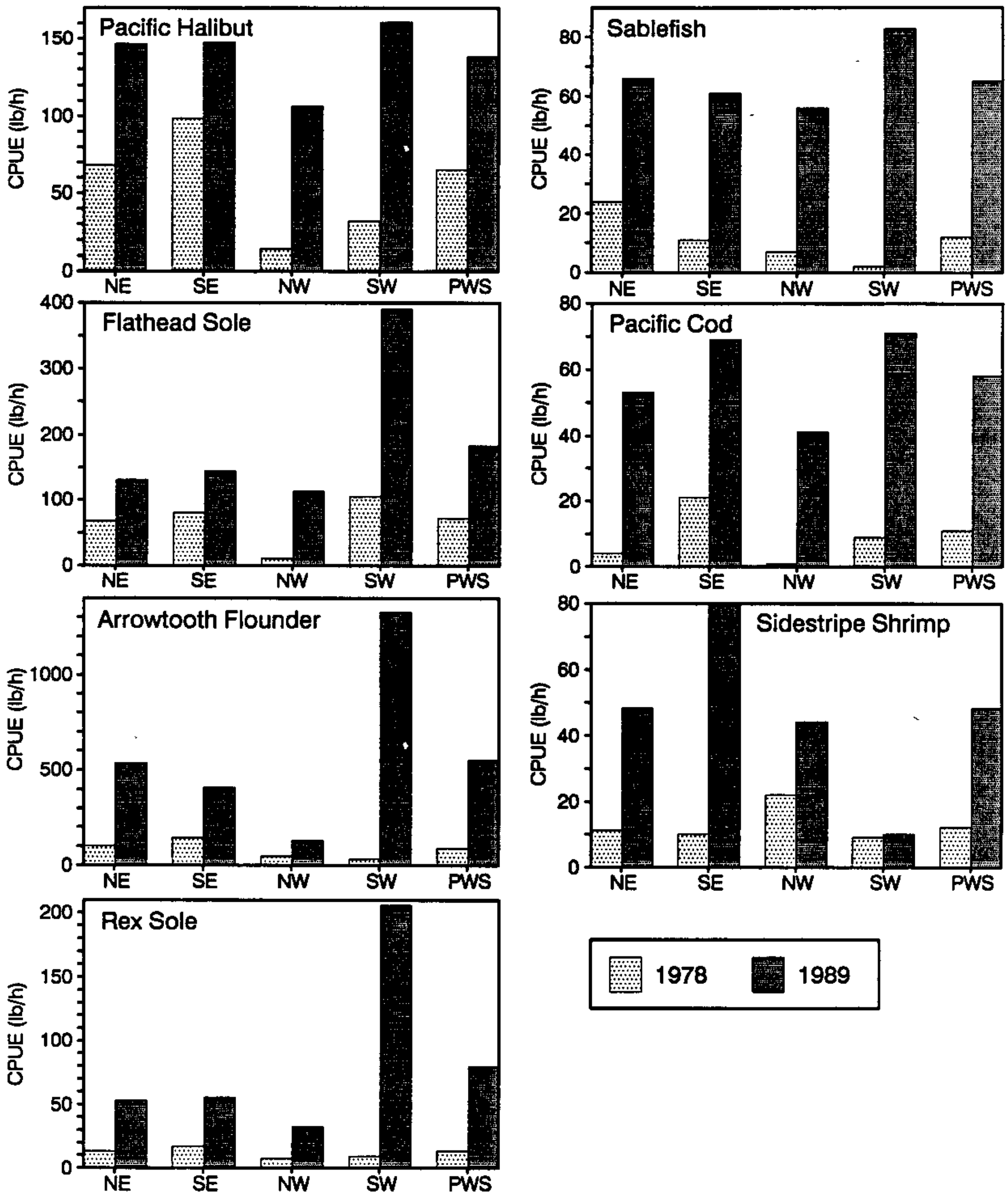
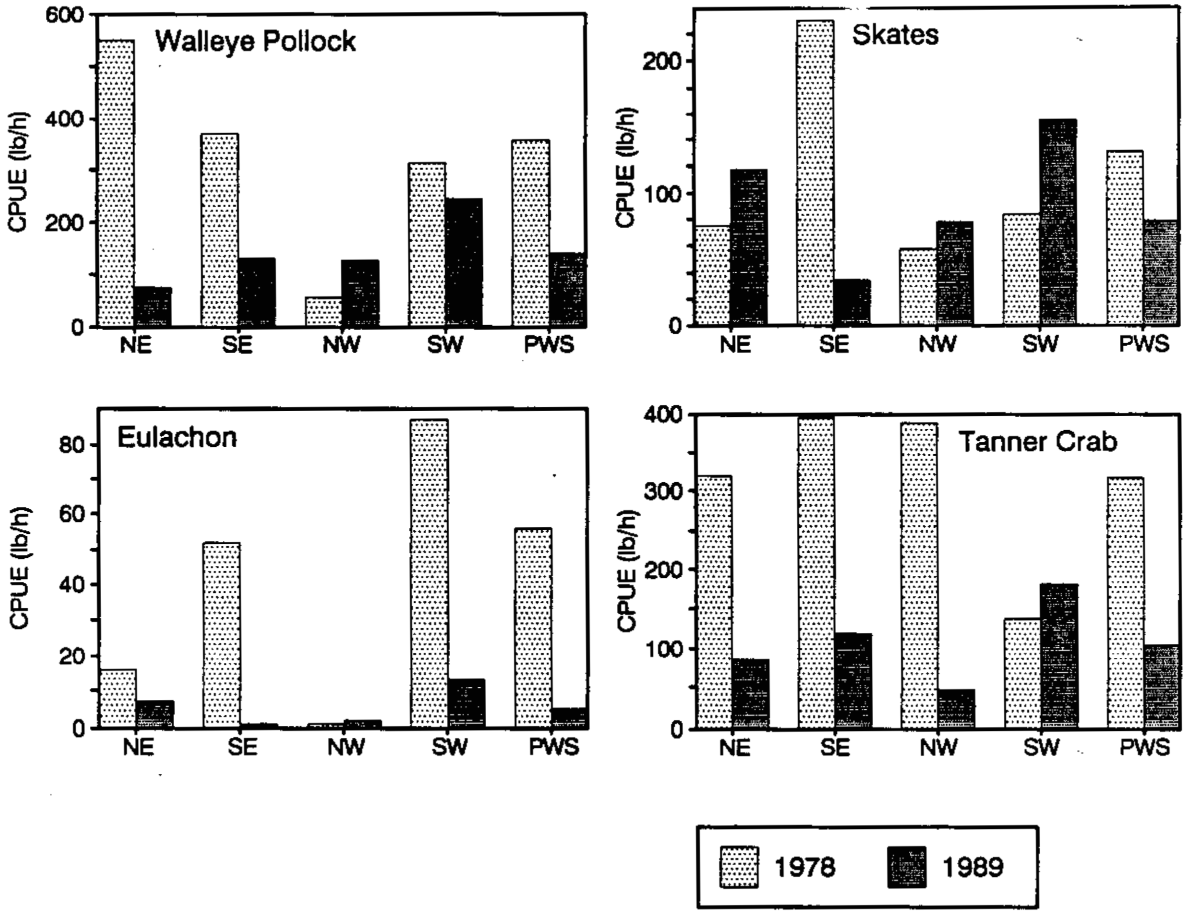


Figure 6. Mean CPUE by quadrant and combined quadrants of common species from 1978 <u>Oregon</u> cruise and 1989 Survey 1, Fish/Shellfish Study #18.



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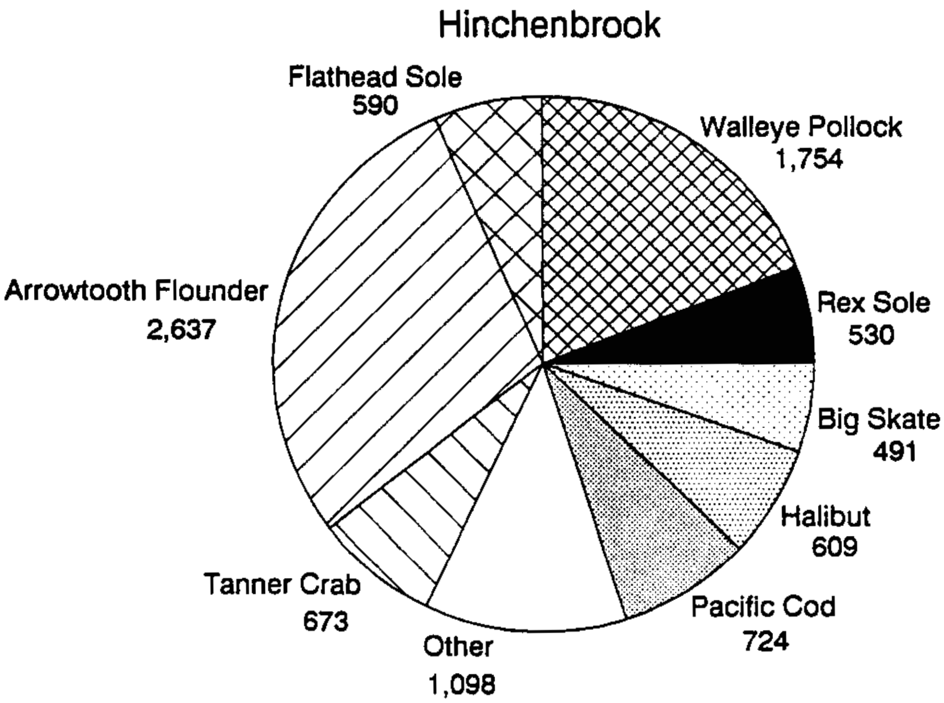


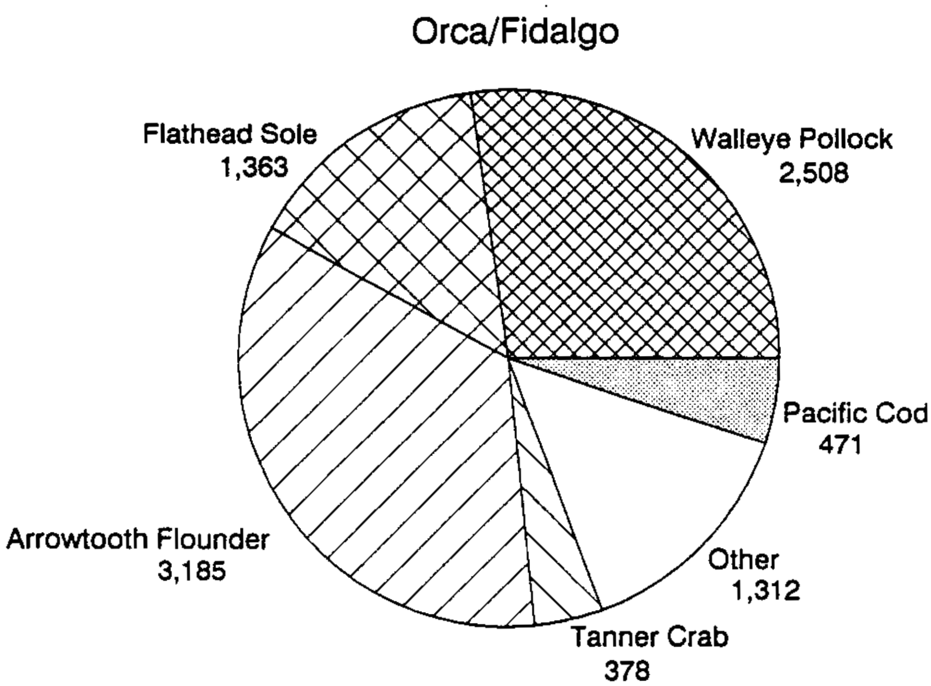
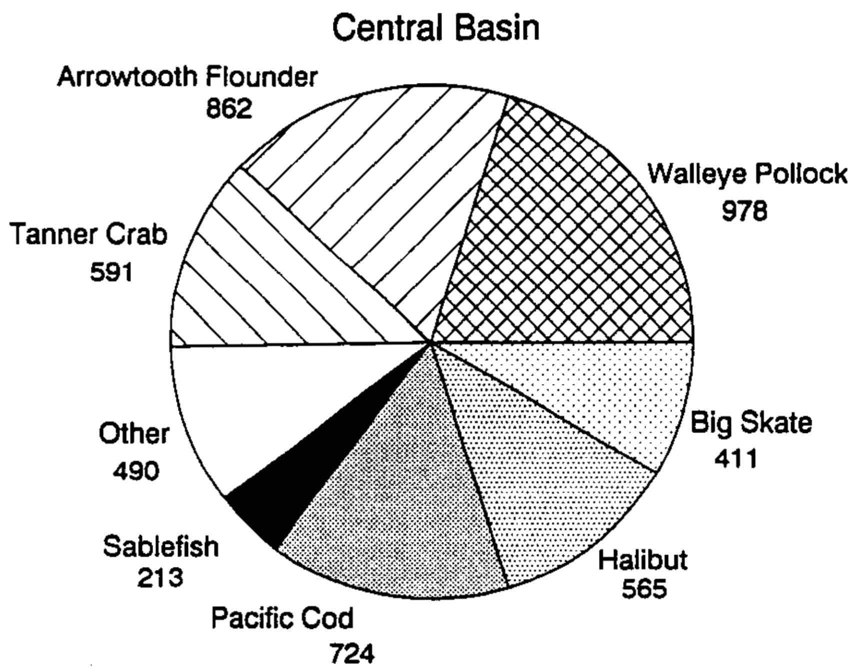
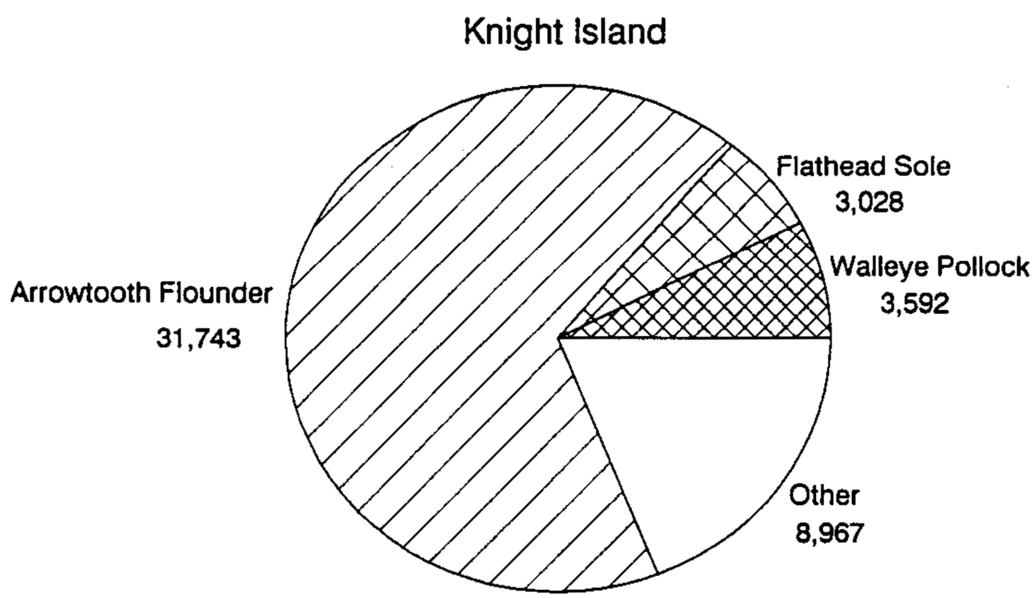


Figure 7. Percentage biomass by species in the six sampling areas of 1989 Survey 2, Fish/Shellfish Study #18. Species with less than 4% of total biomass are in the "other" category. Estimated total biomass (mt) is shown for each species.





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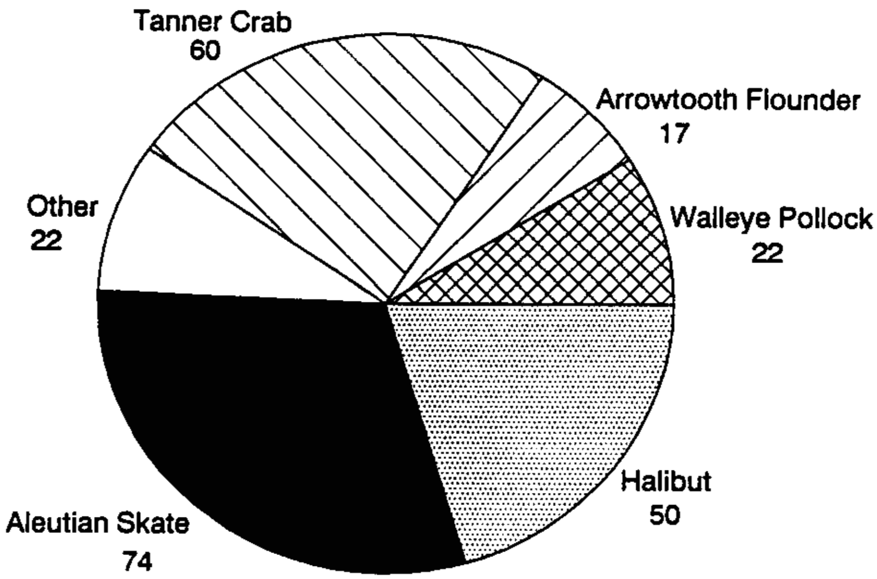
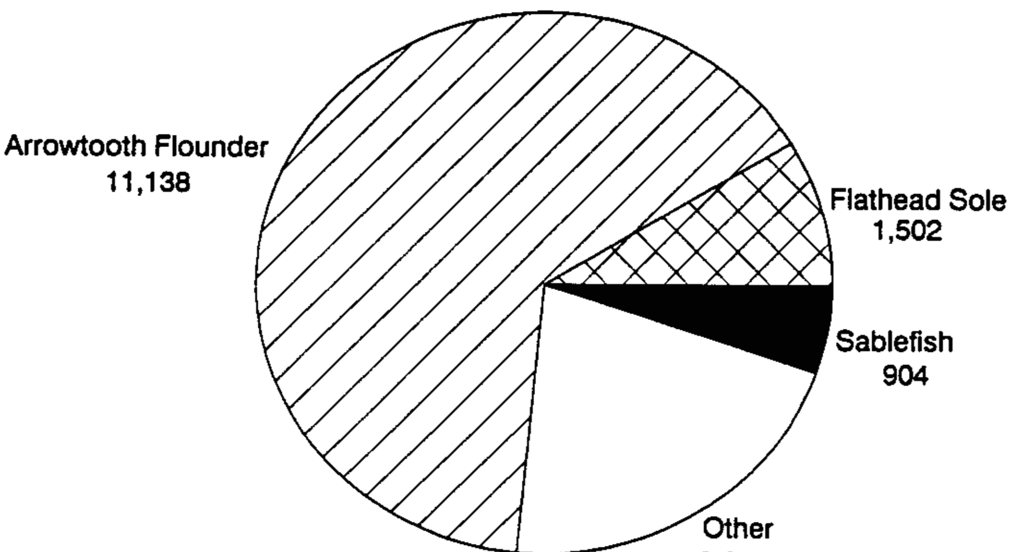
Port Wells



Outside PWS



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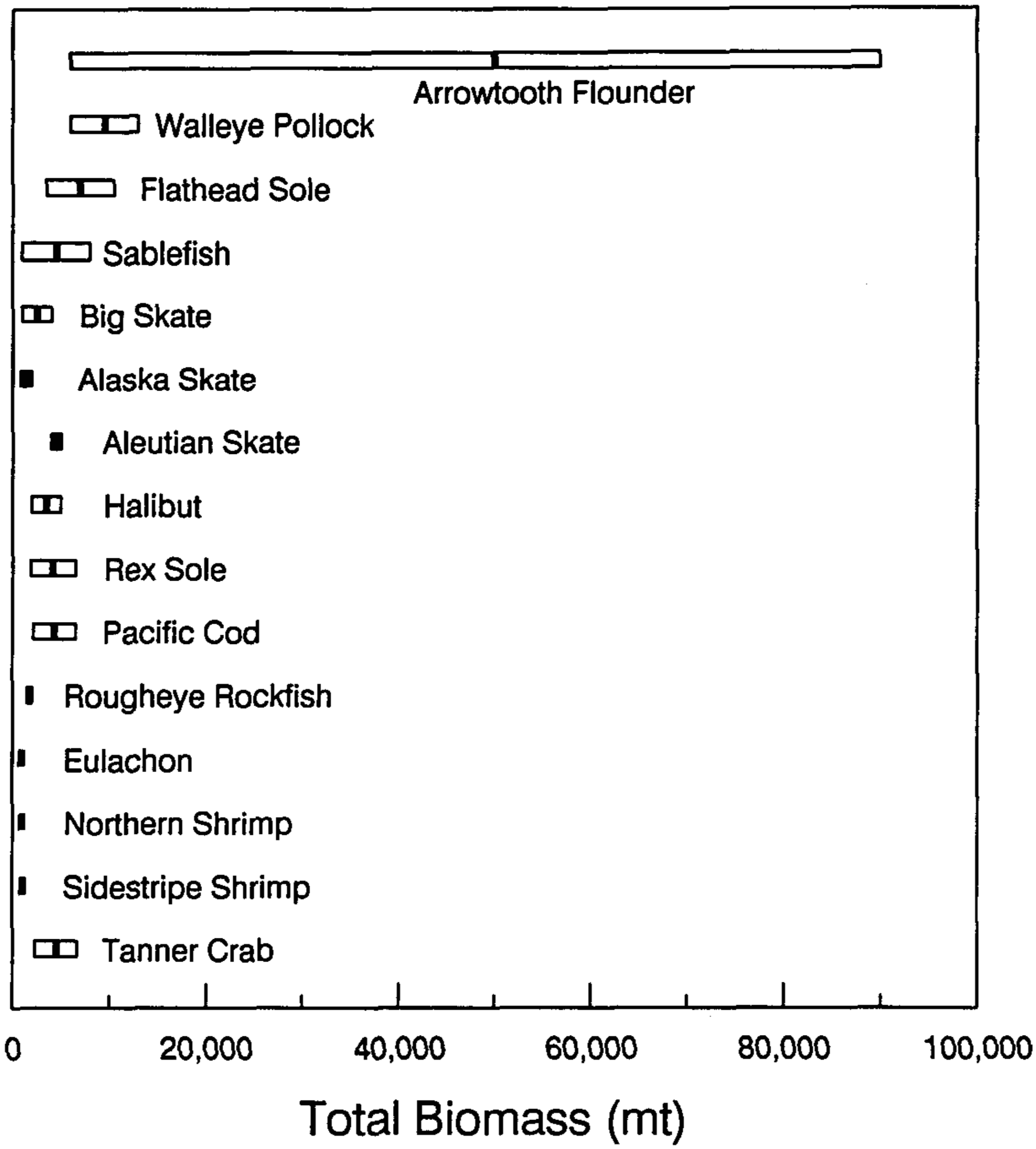


Figure 8. Estimated total biomass for species sampled in 1989 Survey 2, Fish/Shellfish Study #18. Central bar indicates point estimate; rectangle indicates 95% confidence interval.

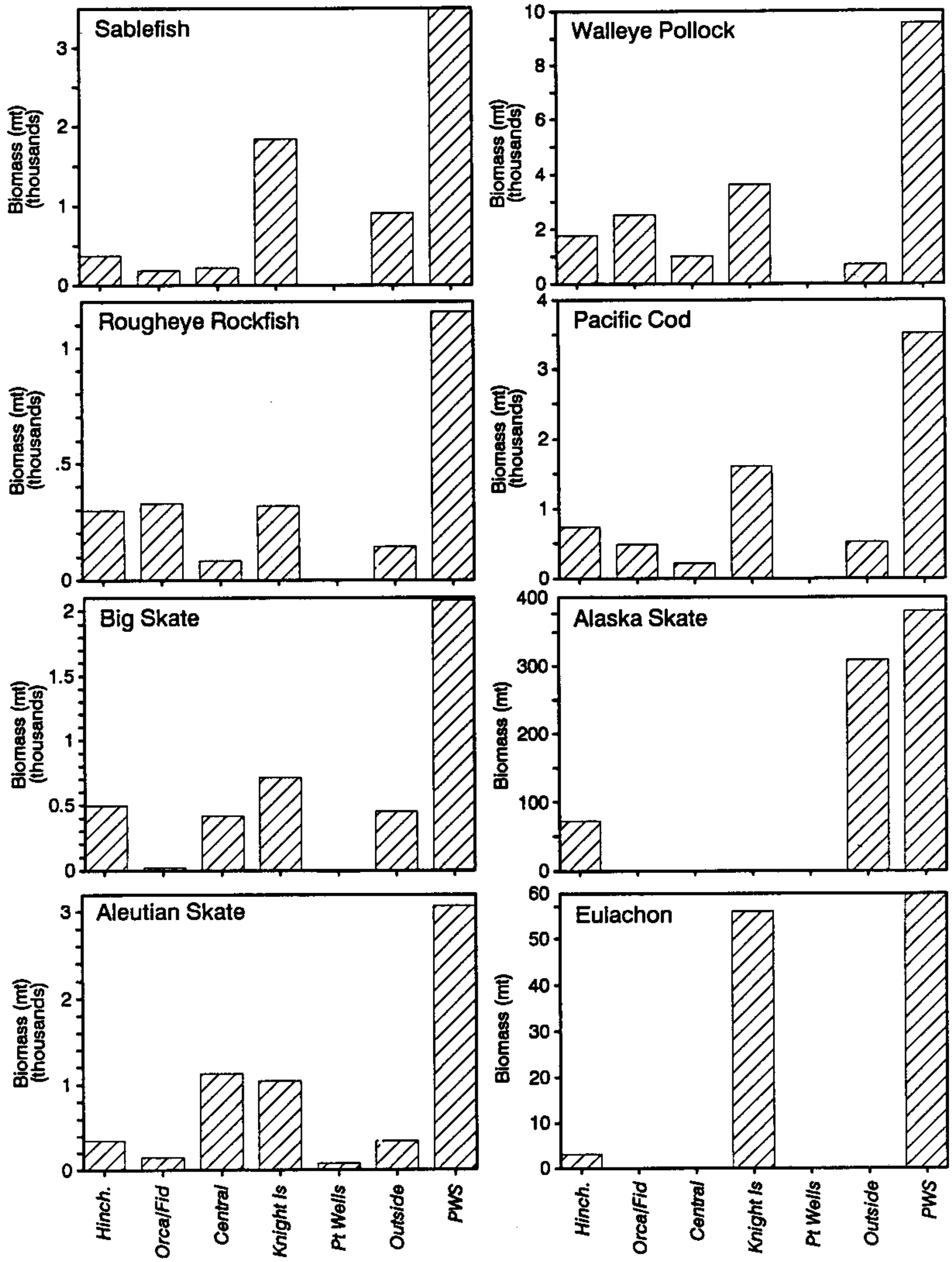
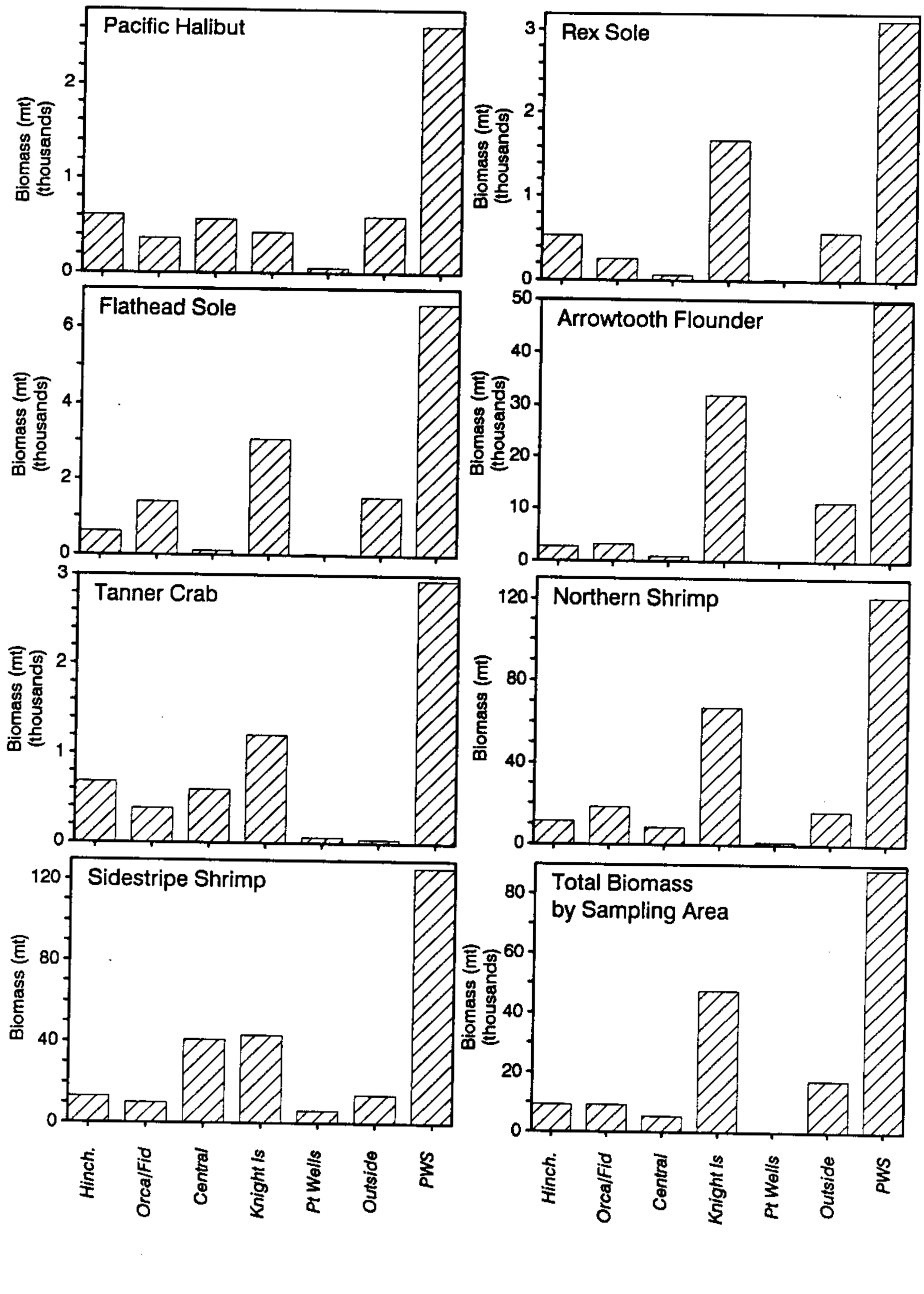


Figure 9. Estimated total biomass by species in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18.



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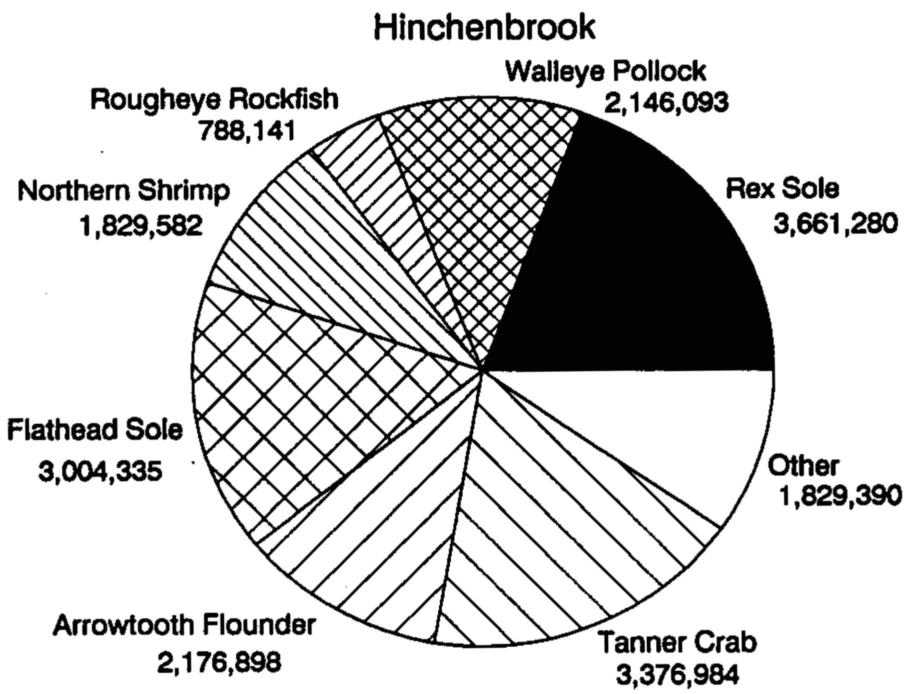


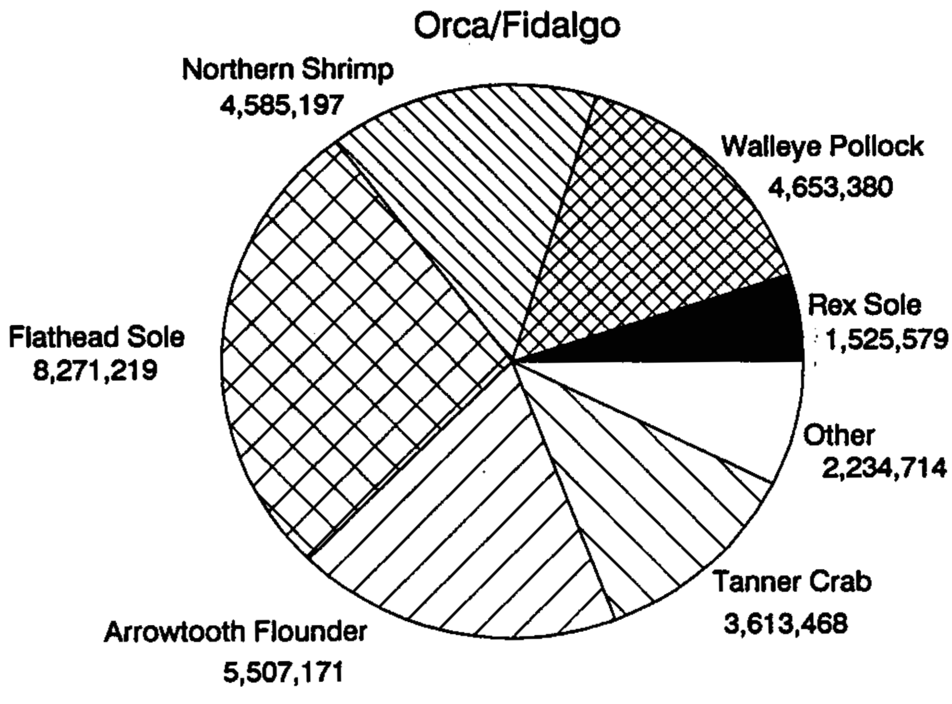
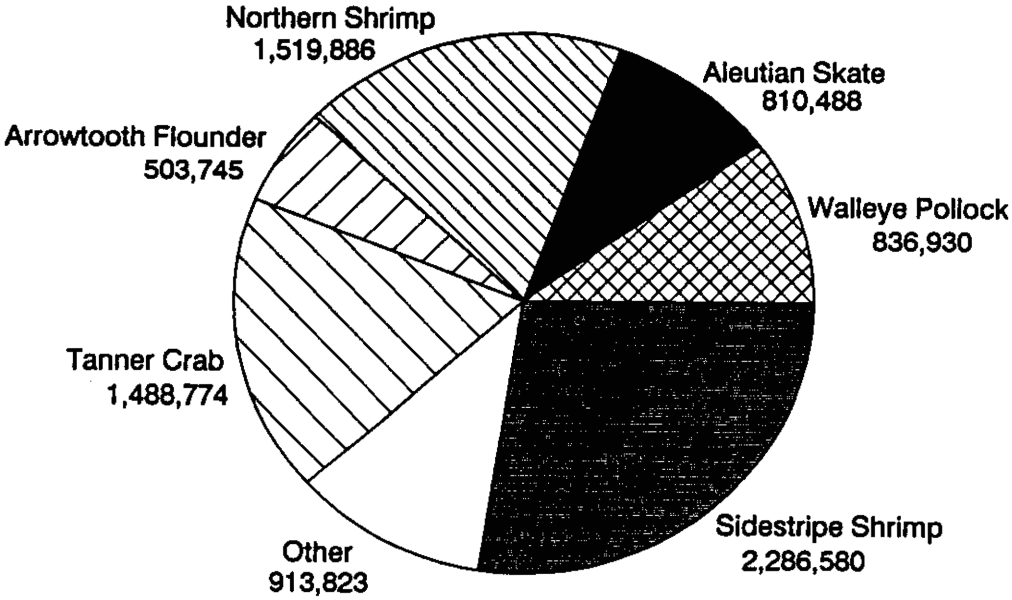
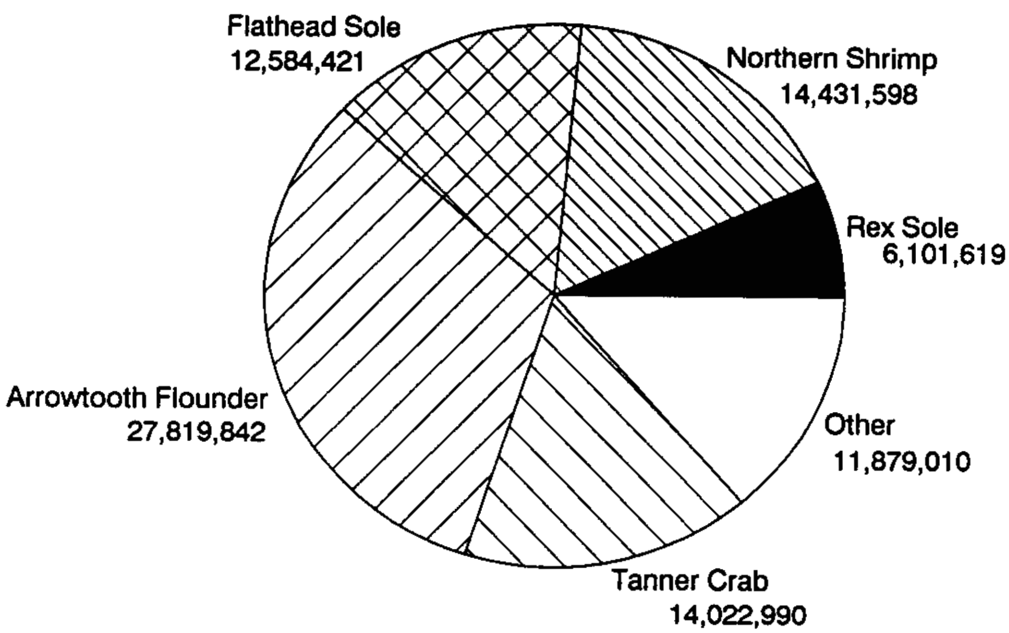


Figure 10. Percentage total population by species in the six sampling areas of 1989 Survey 2, Fish/Shellfish Study #18. Estimated total populations are shown for each species. Species making up less than 4% of the total are pooled in the "other" category.

Central Basin



Knight Island



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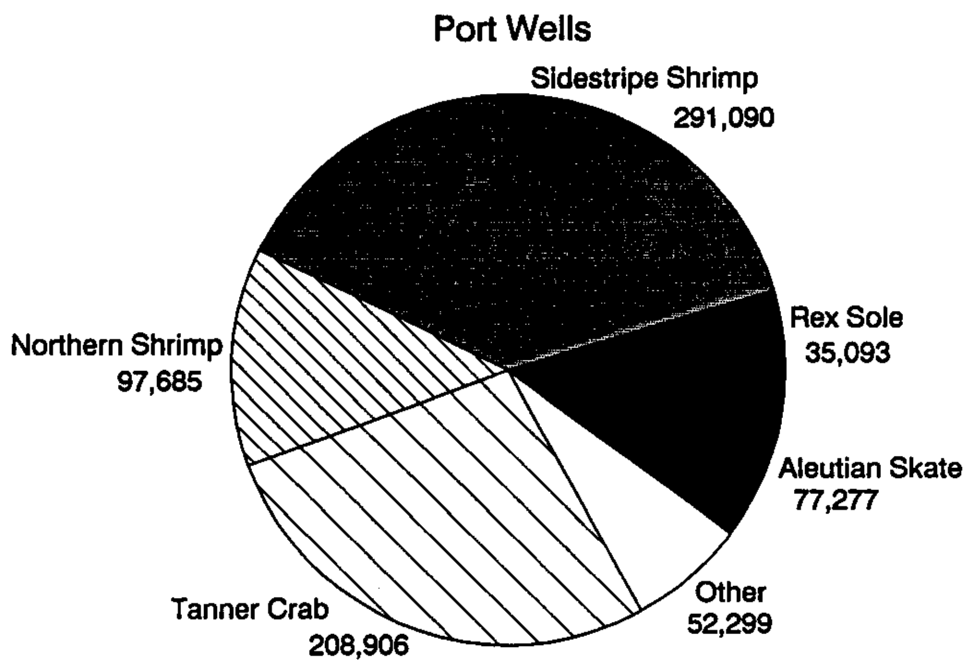

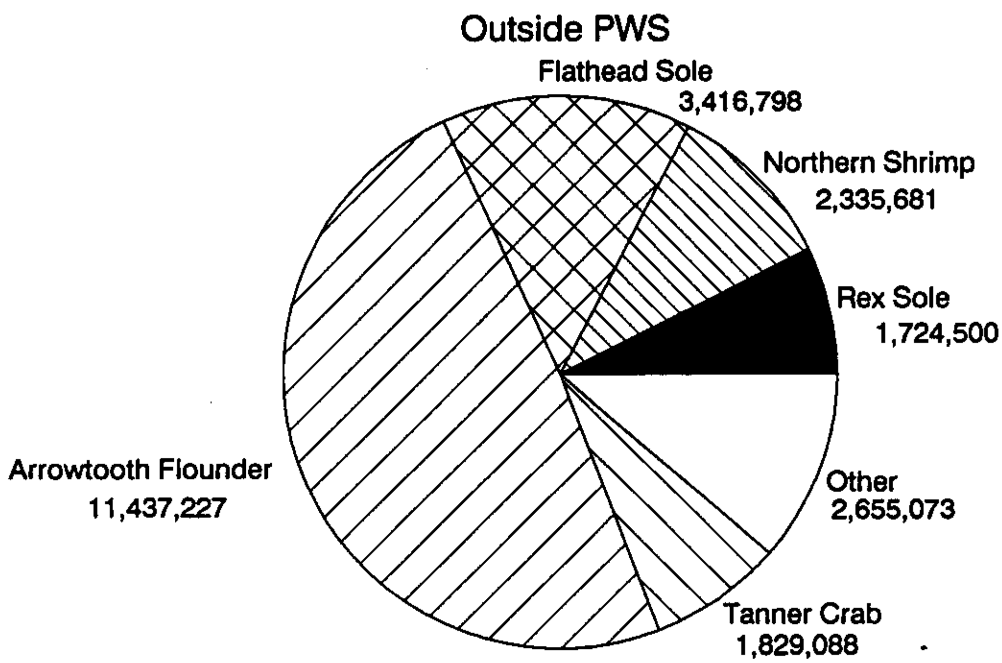

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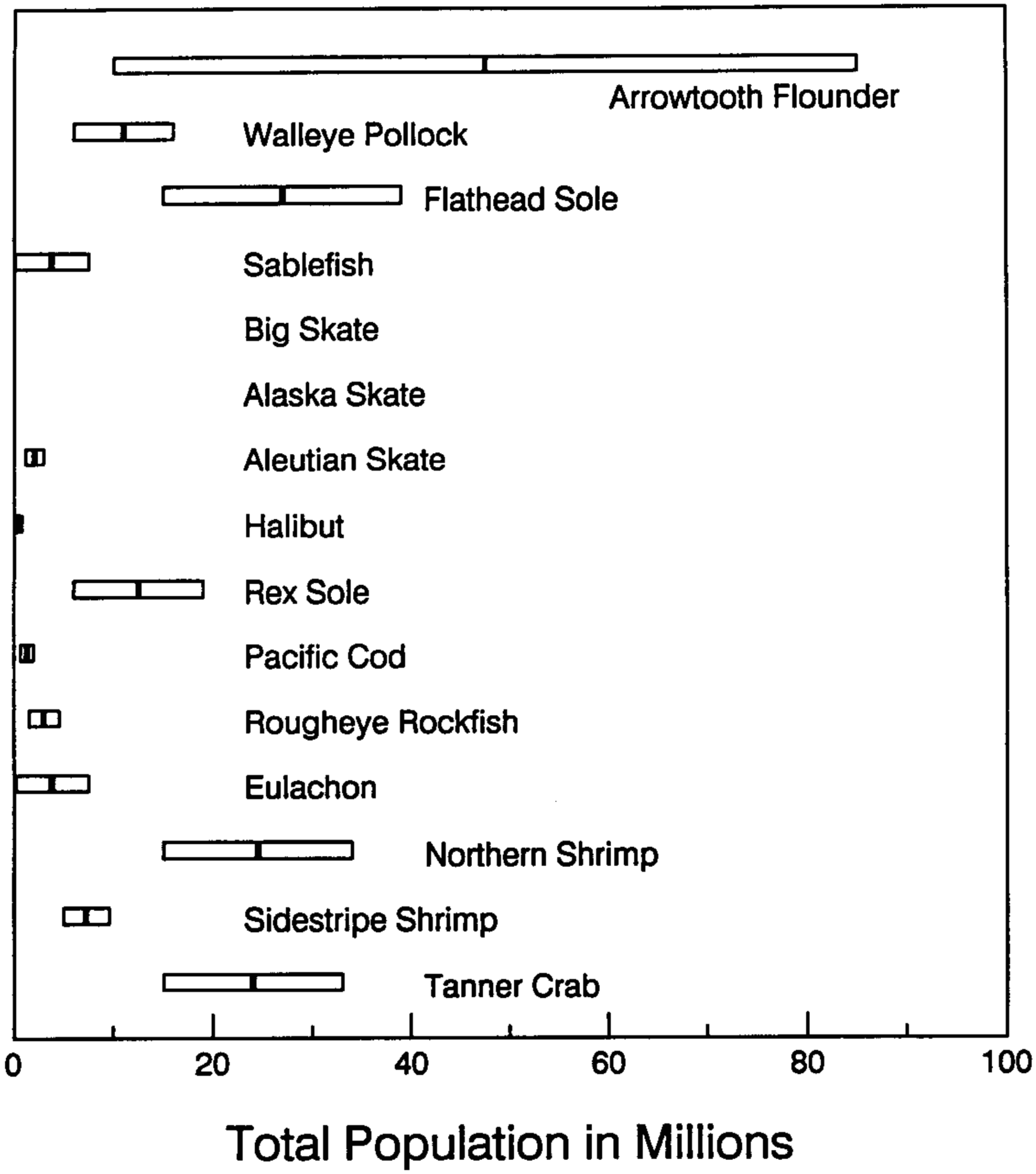


Figure 11. Estimated total populations of species in 1989 Survey 2, Fish/Shellfish Study #18. Central bar indicates the point estimate; rectangle indicates 95% confidence interval.

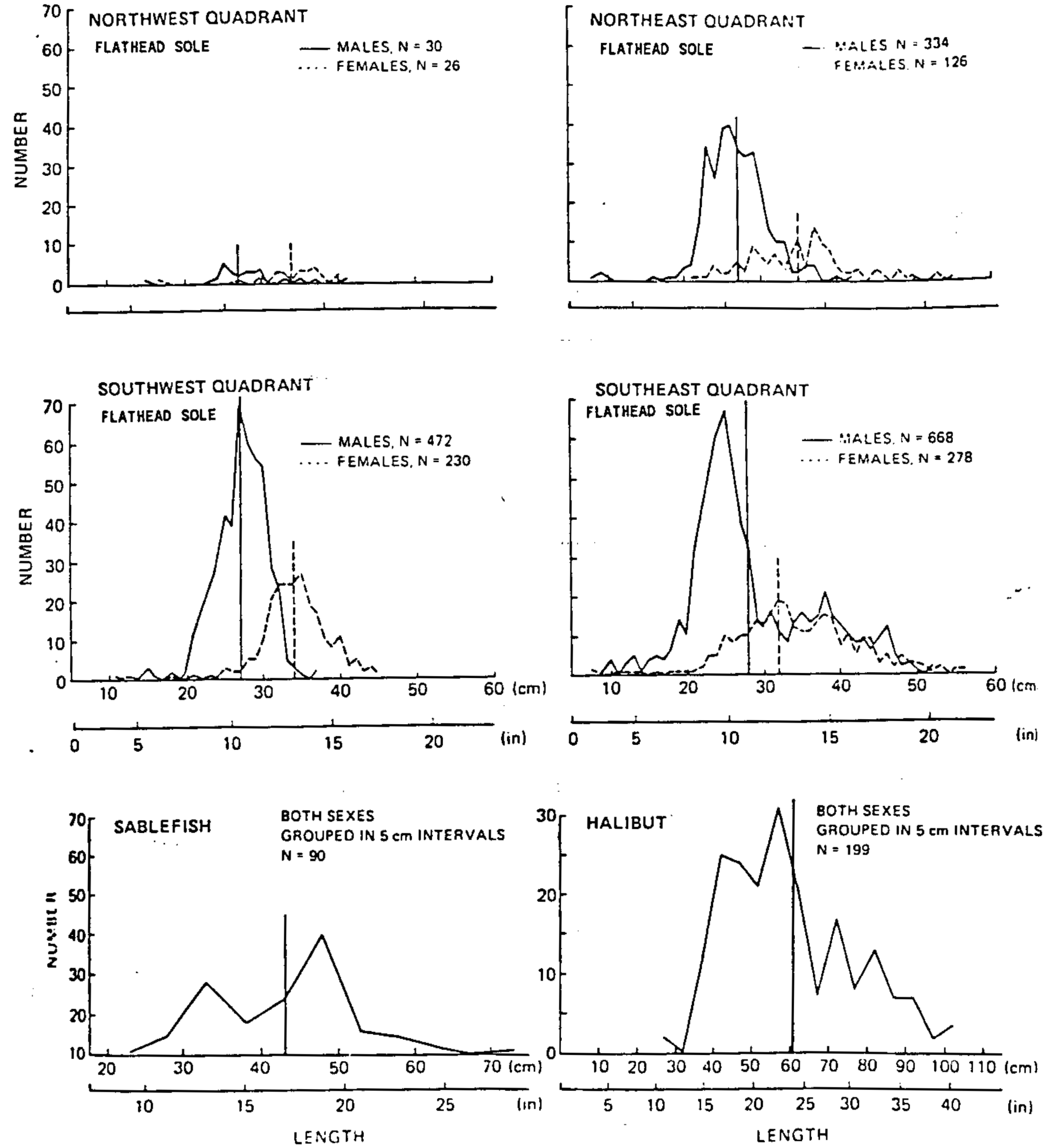


Figure 12. Length frequencies of flathead sole, sablefish, and halibut from 1978 *Oregon* cruise, copied from the 1978 *Oregon* report.

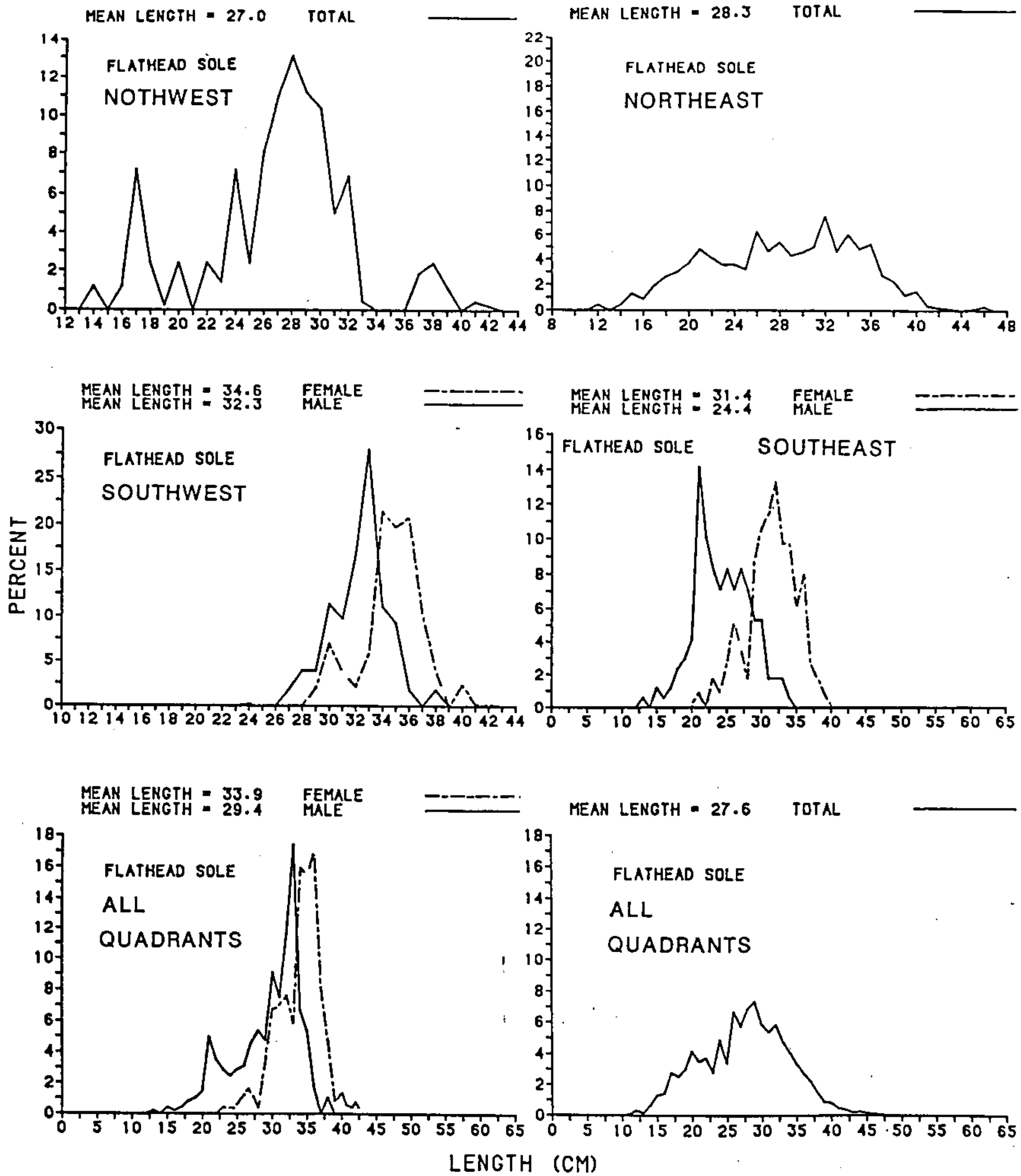


Figure 13. Length frequencies of bottomfish from 1989 Survey 1, Fish/Shellfish Study #18.

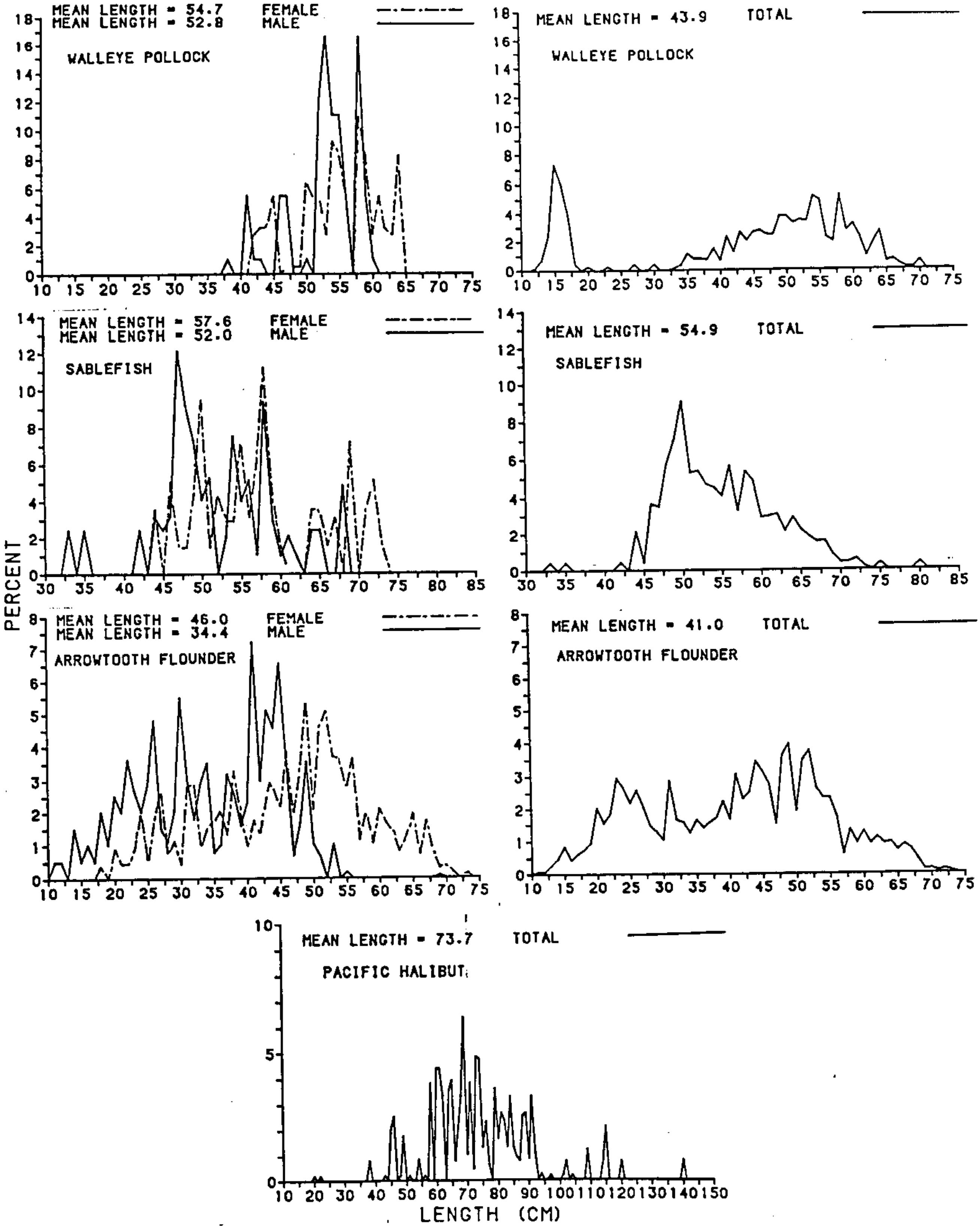


Figure 13, continued.

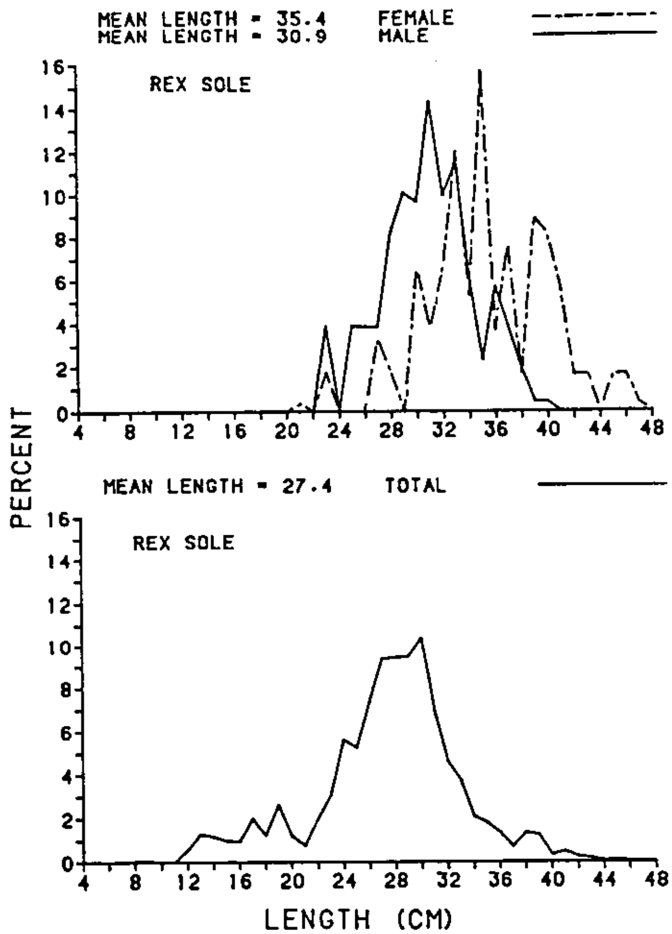


Figure 13, continued.

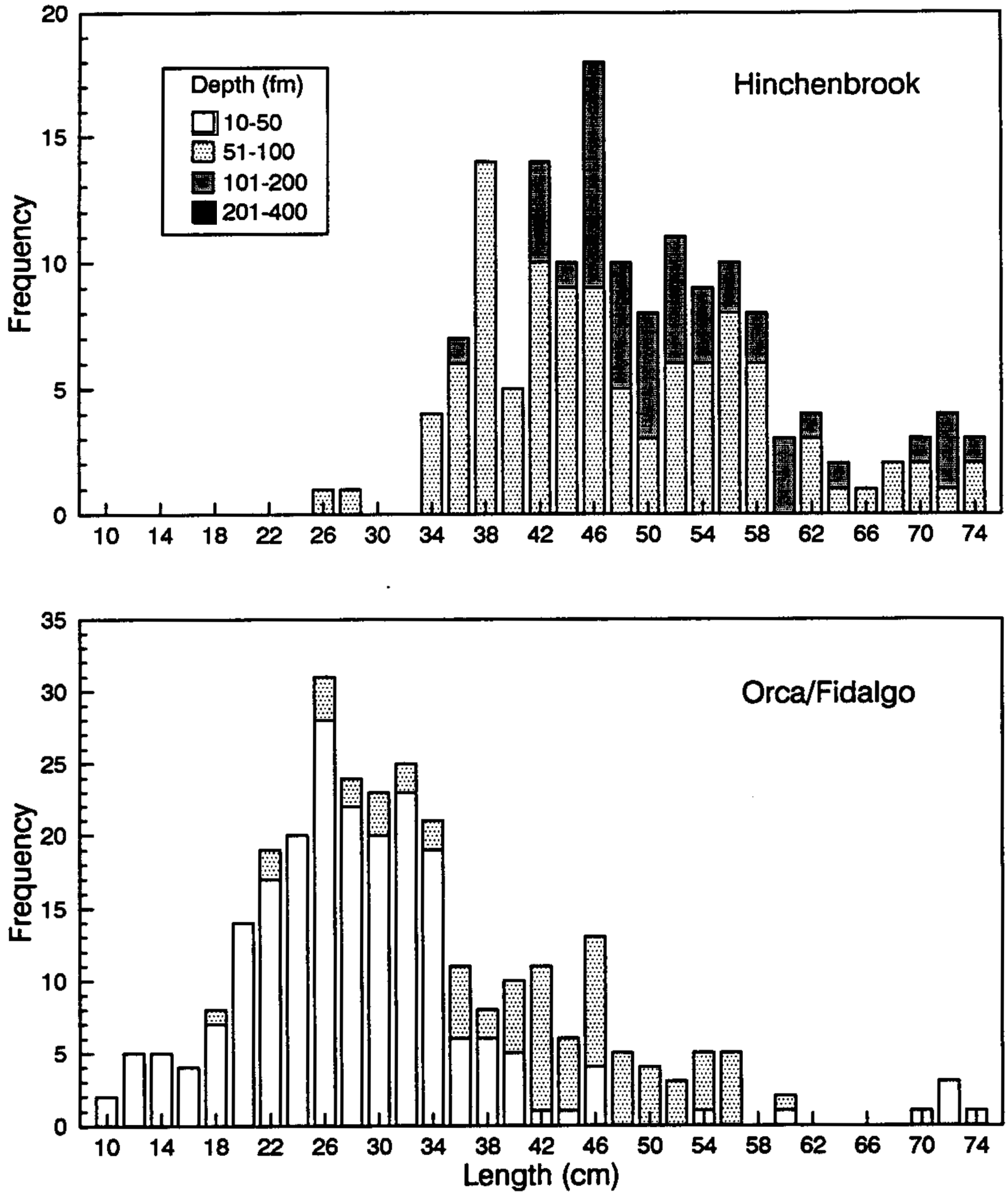


Figure 14. Length frequencies of arrowtooth flounder by depth strata in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18. Arrowtooth flounder were not measured in the Port Wells area.

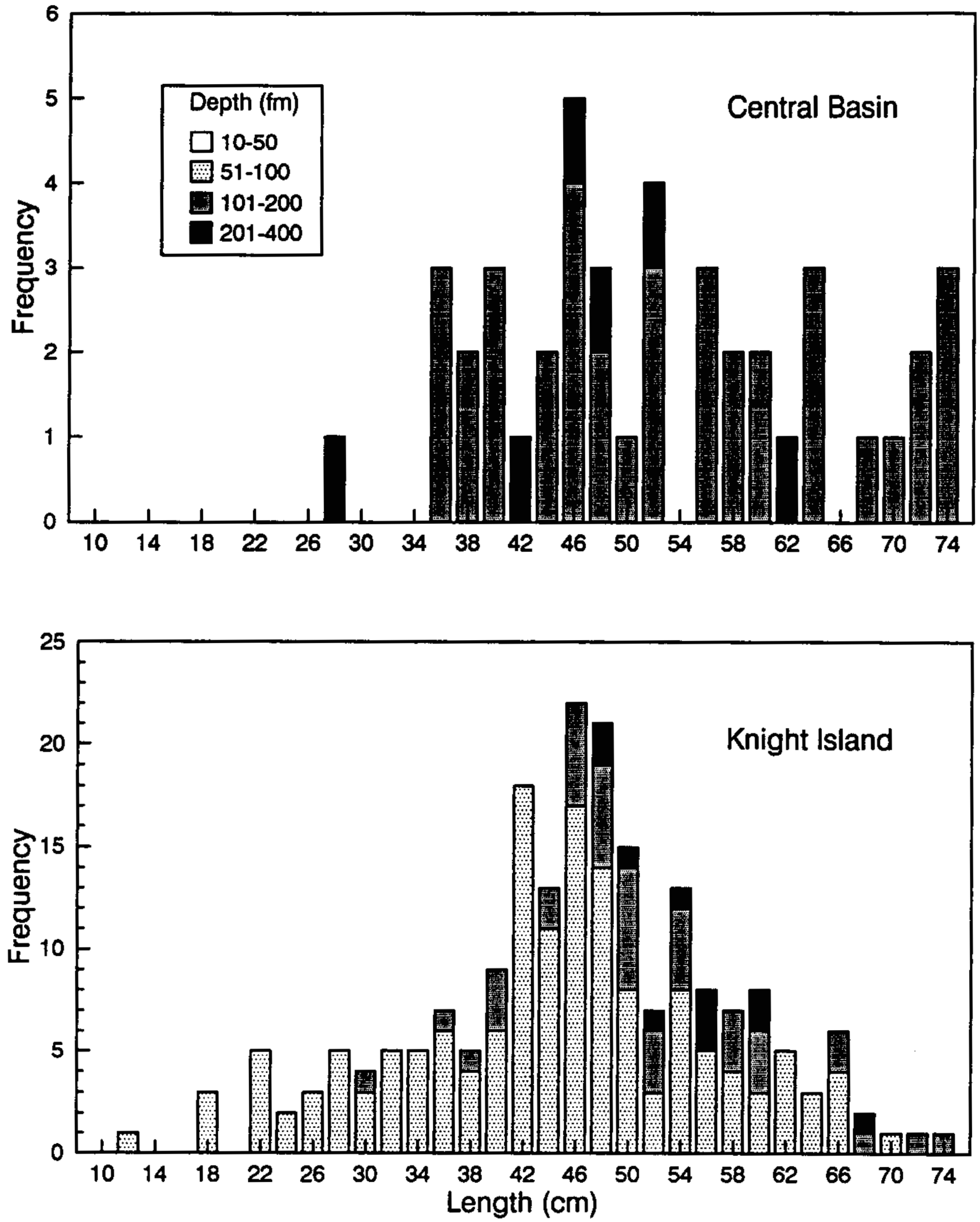


Figure 14, continued.

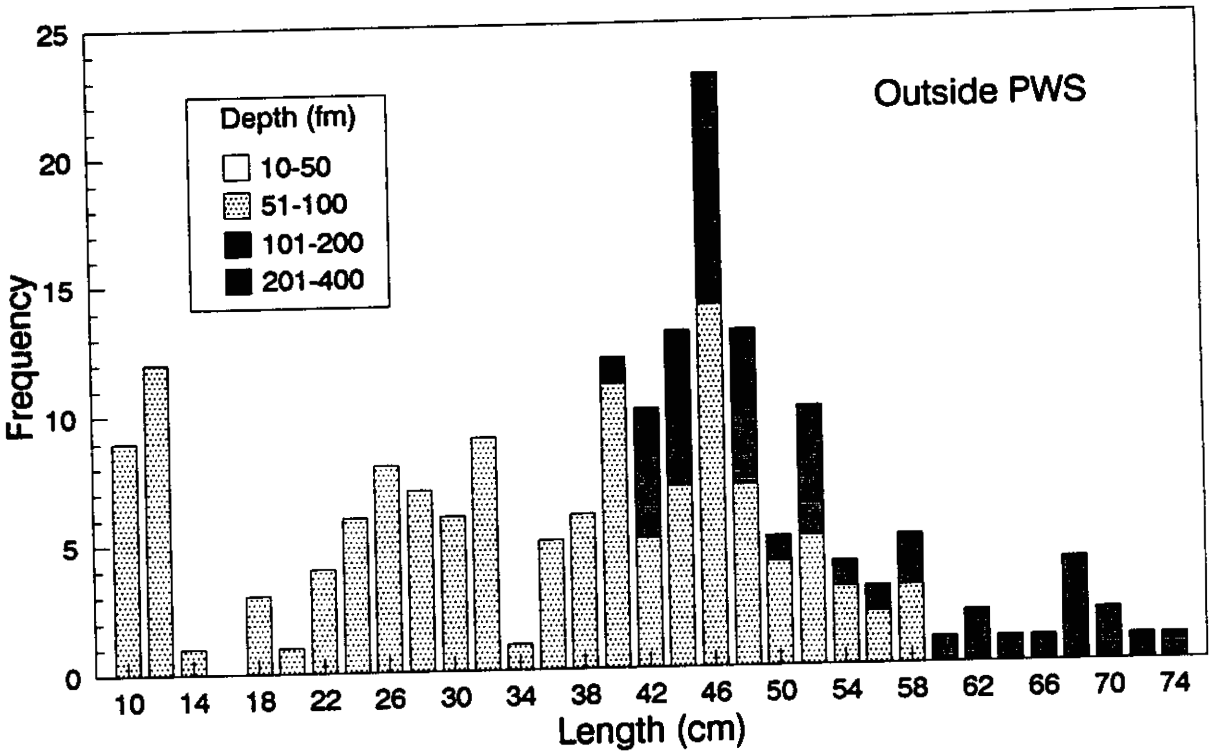
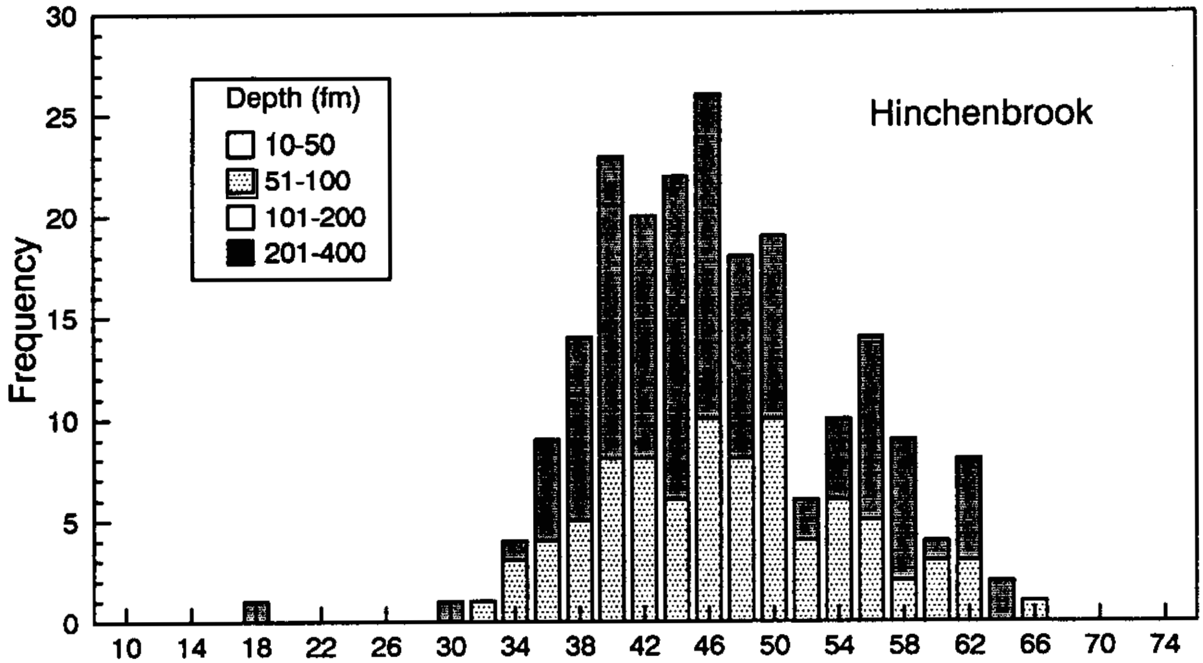


Figure 14, continued.



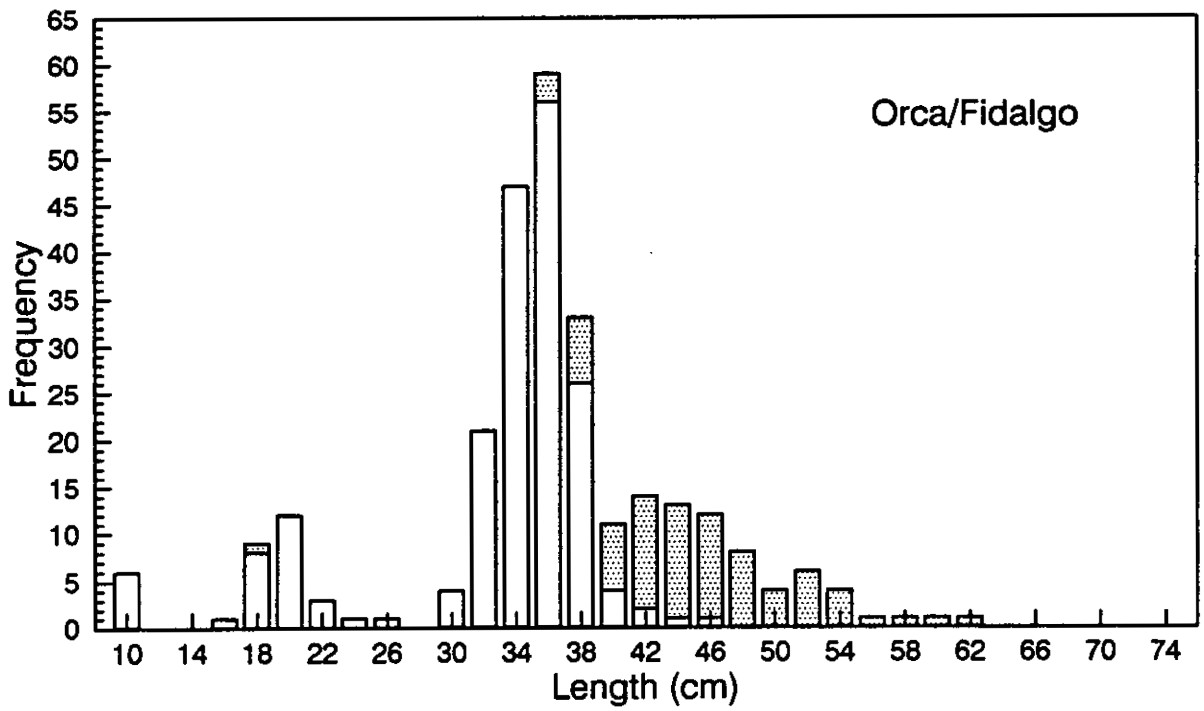


Figure 15. Length frequencies of walleye pollock by depth strata in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18. Walleye pollock were not measured in the Port Wells area.

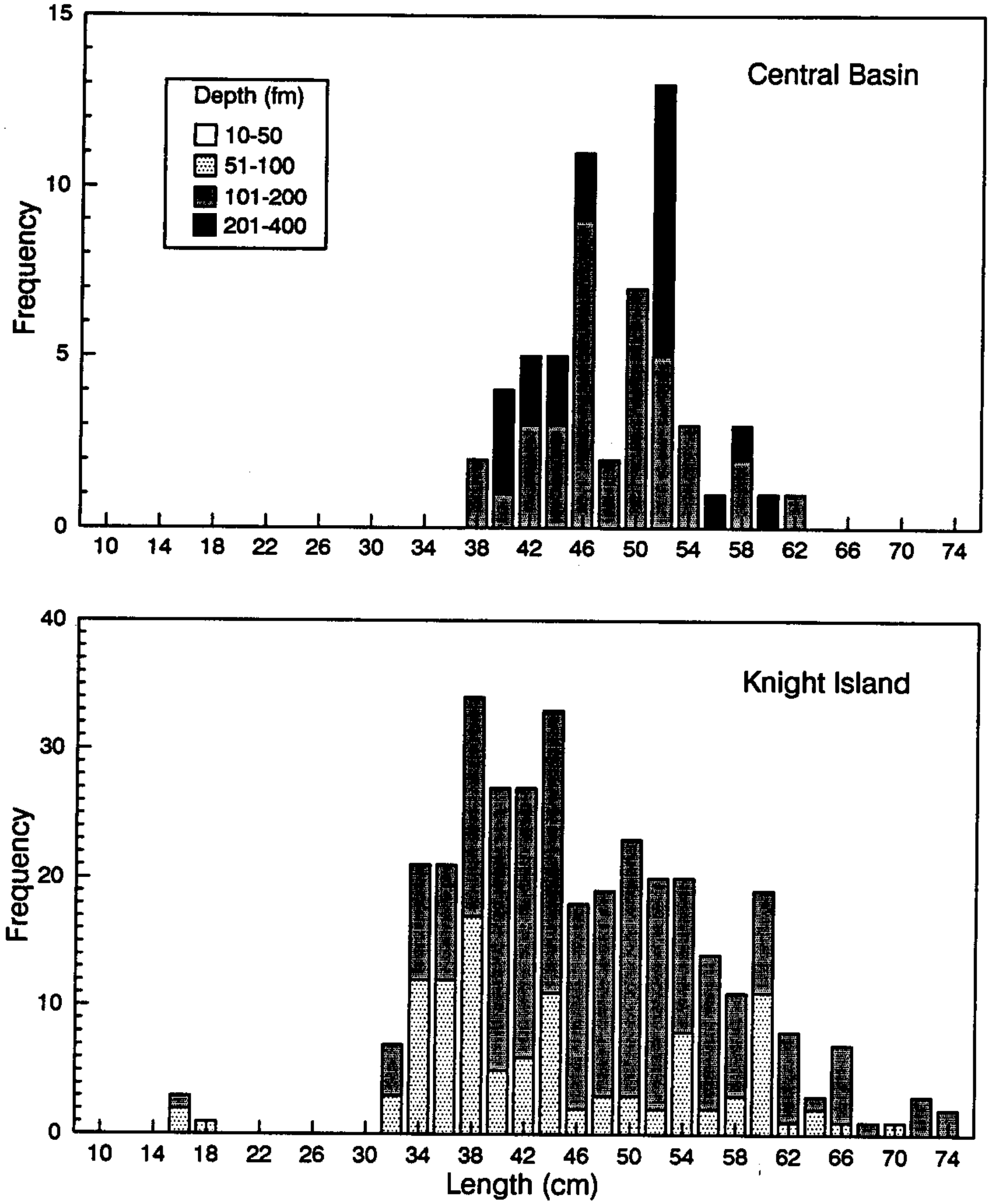


Figure 15, continued.

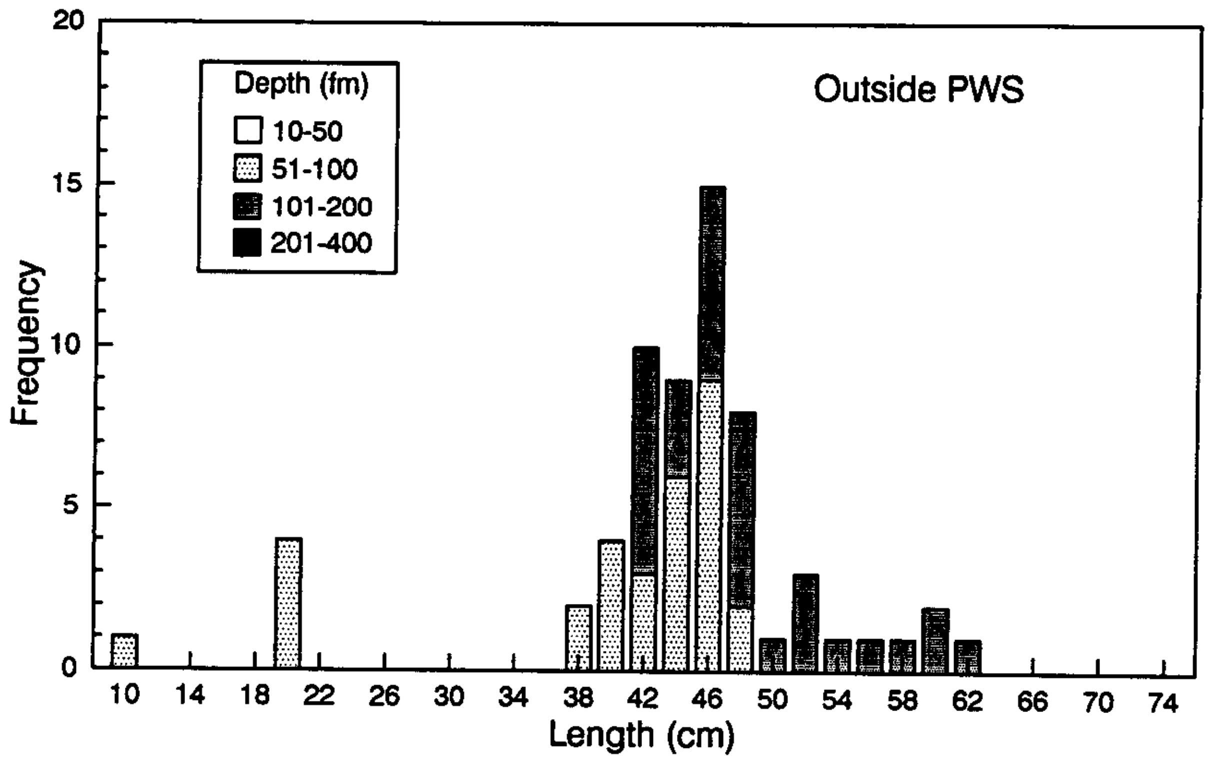


Figure 15, continued.

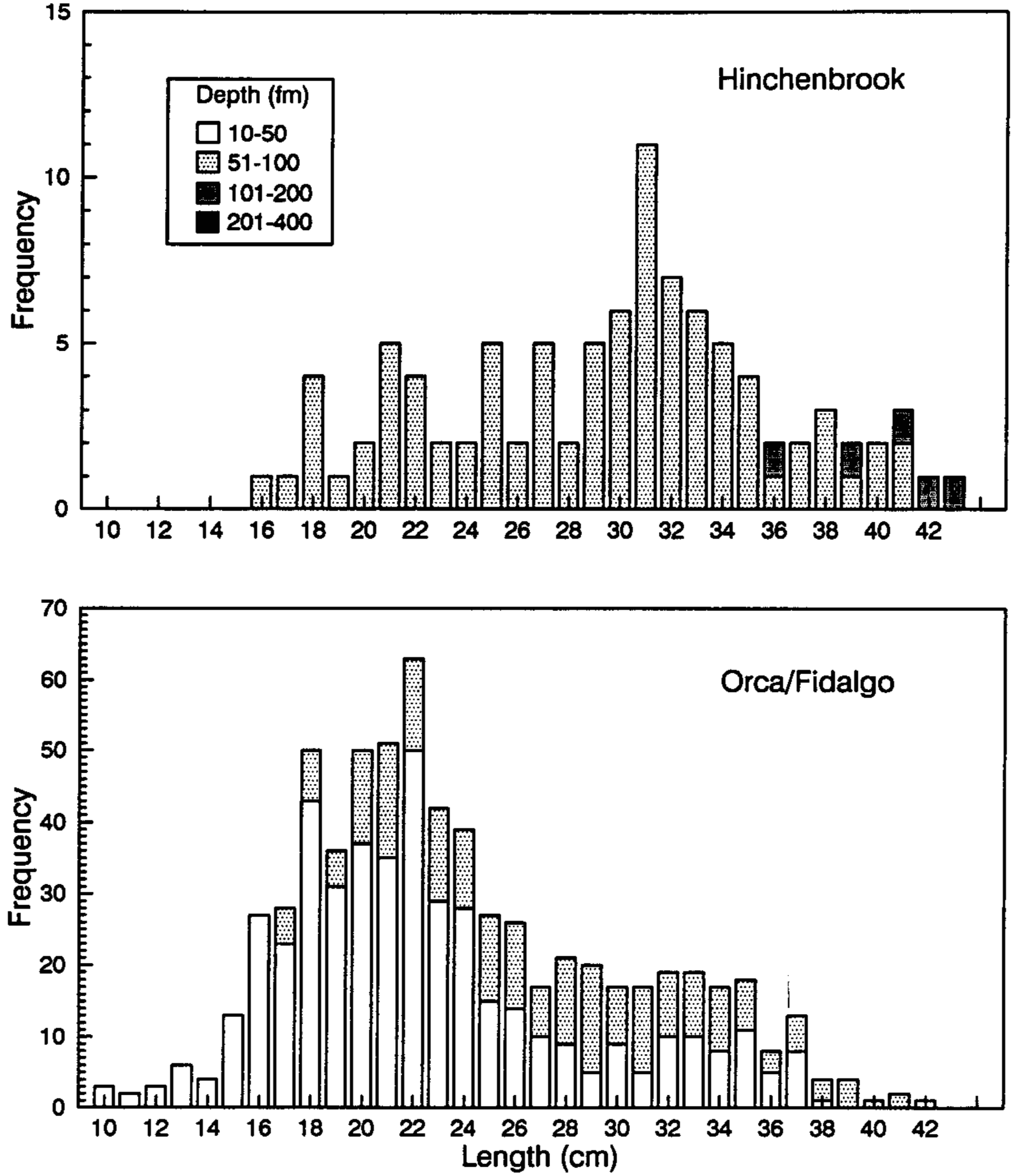


Figure 16. Length frequencies of flathead sole by depth in areas sampled by 1989 Survey 2, Fish/Shellfish Study #18. Flathead sole were not measured in the Port Wells area.

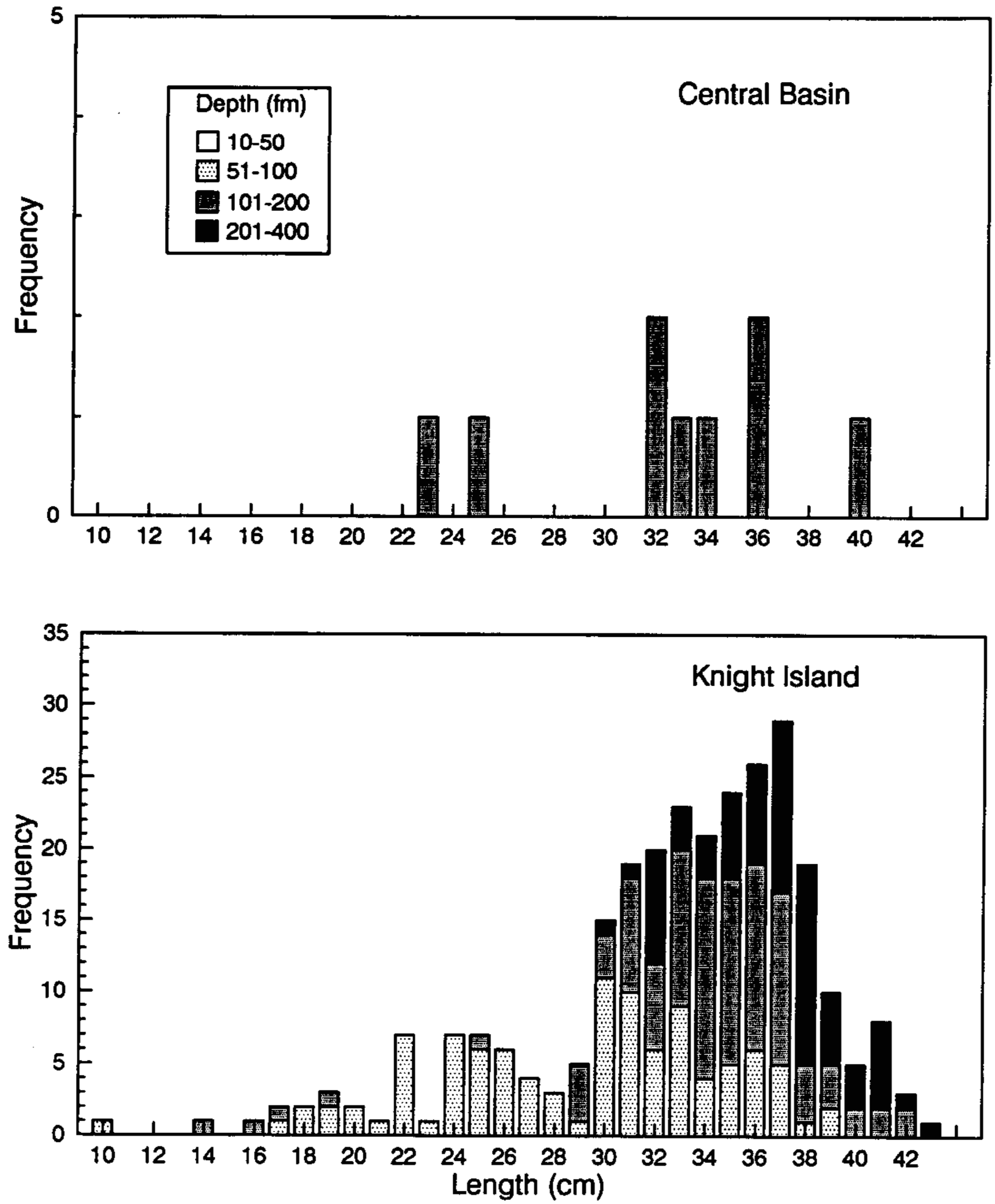


Figure 16, continued.

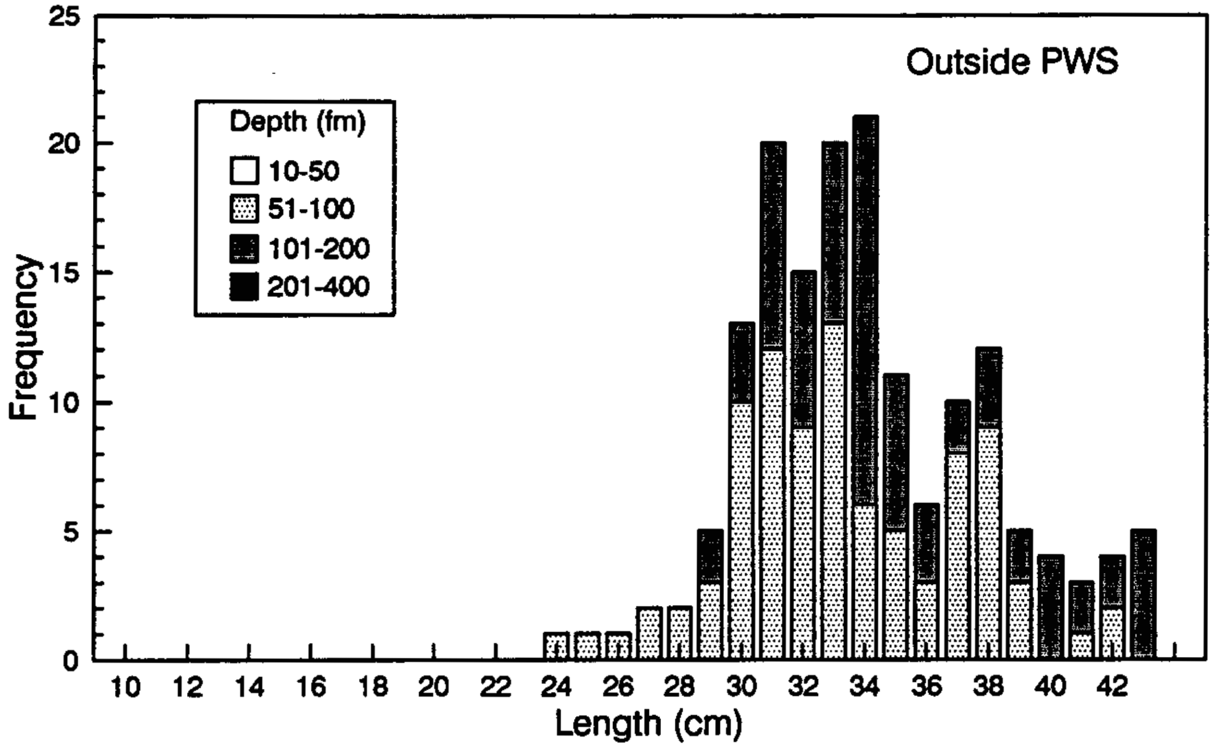


Figure 16, continued.

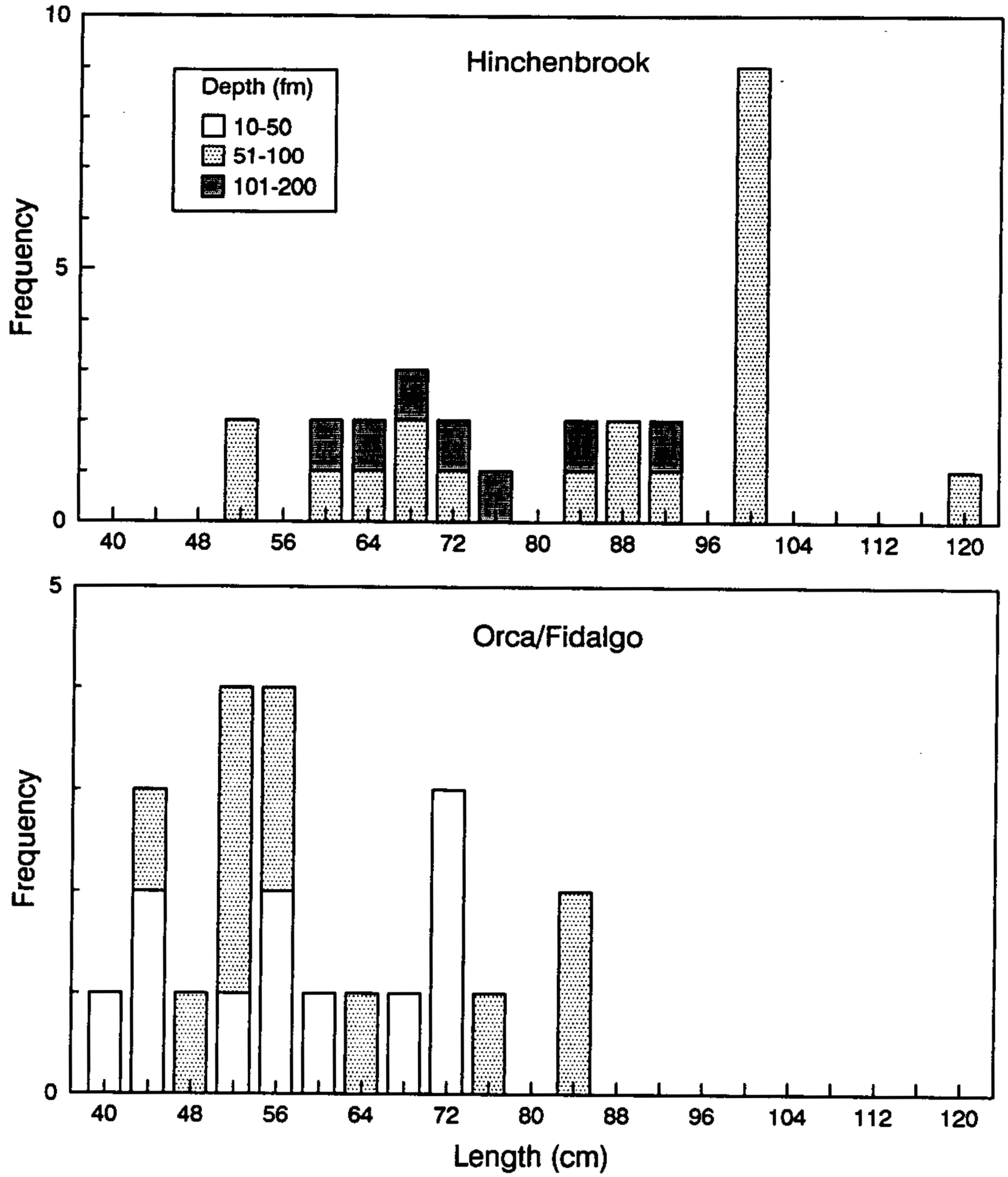


Figure 17. Length frequencies of halibut by depth strata in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18.

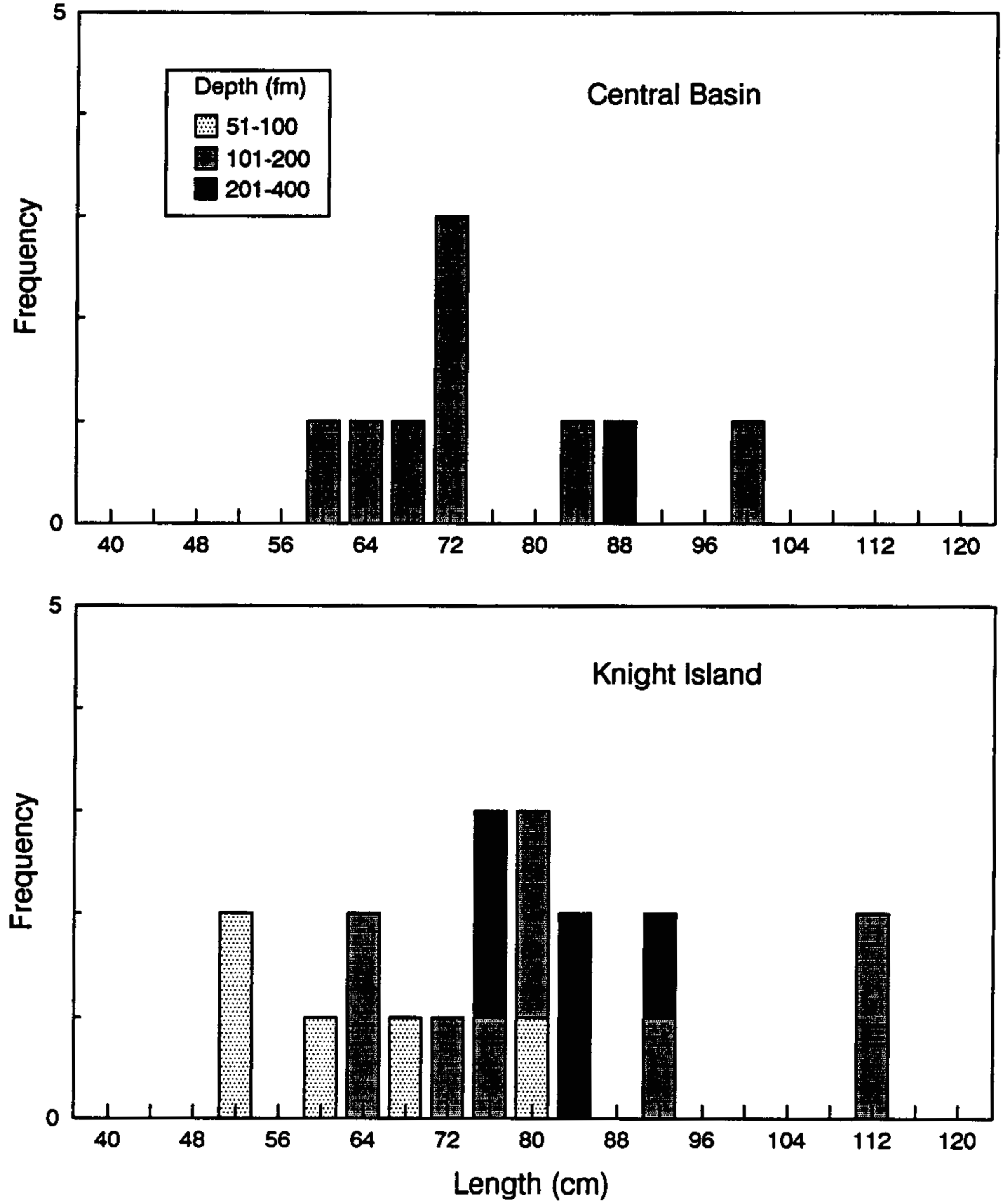


Figure 17, continued.

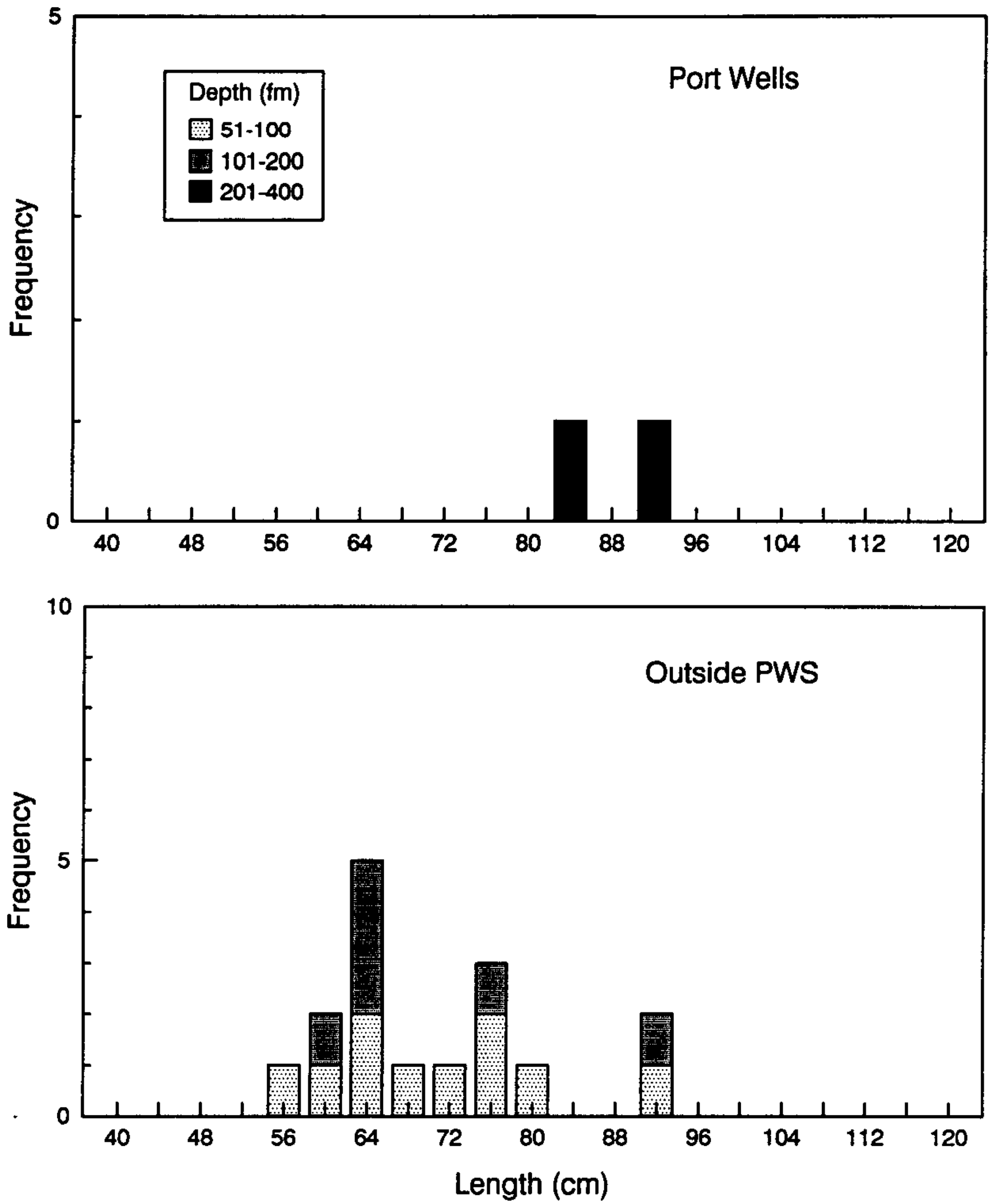


Figure 17, continued.

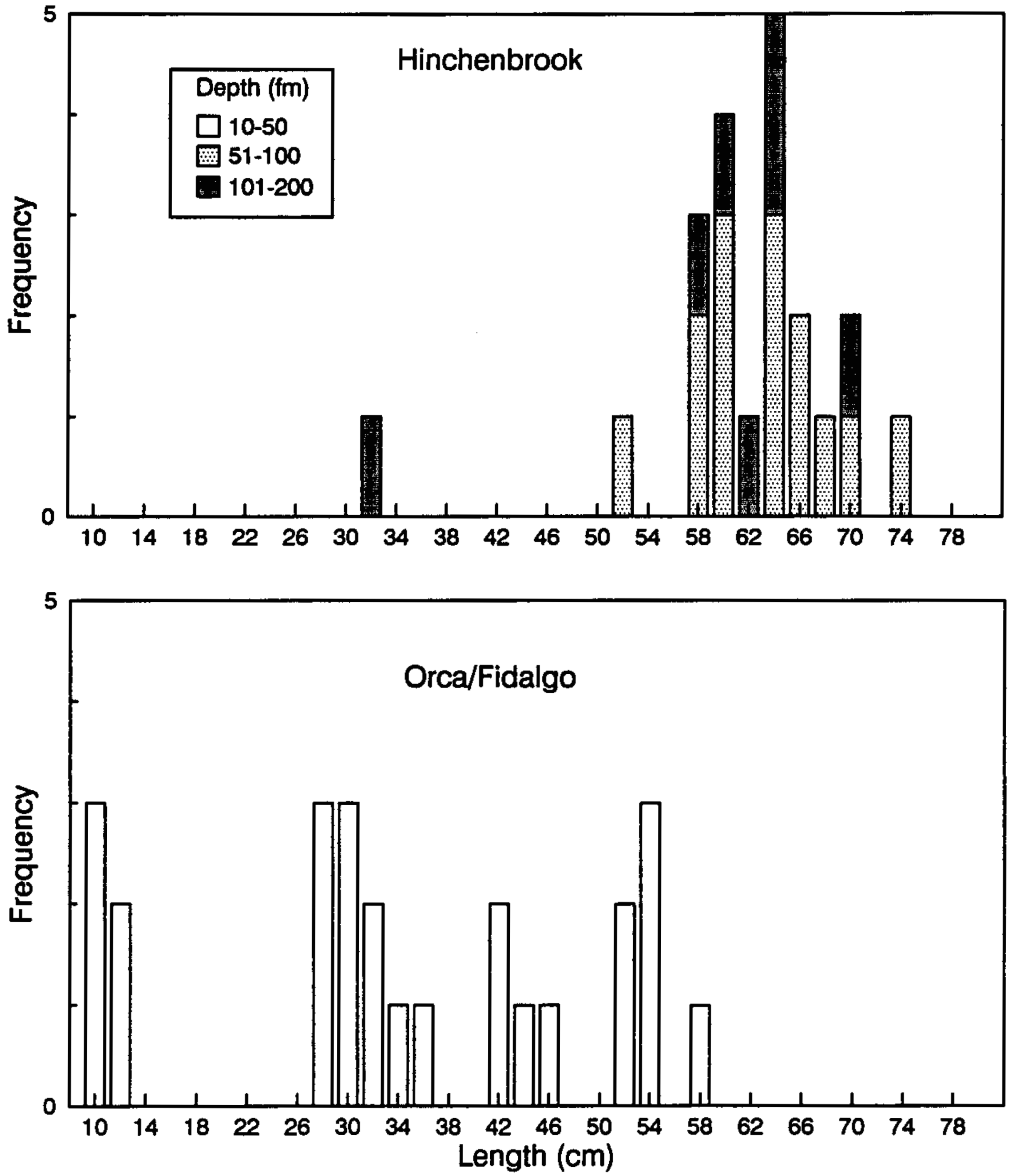


Figure 18. Length frequencies of Pacific cod by depth strata in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18. No Pacific cod were measured in Central Basin and Port Wells areas.

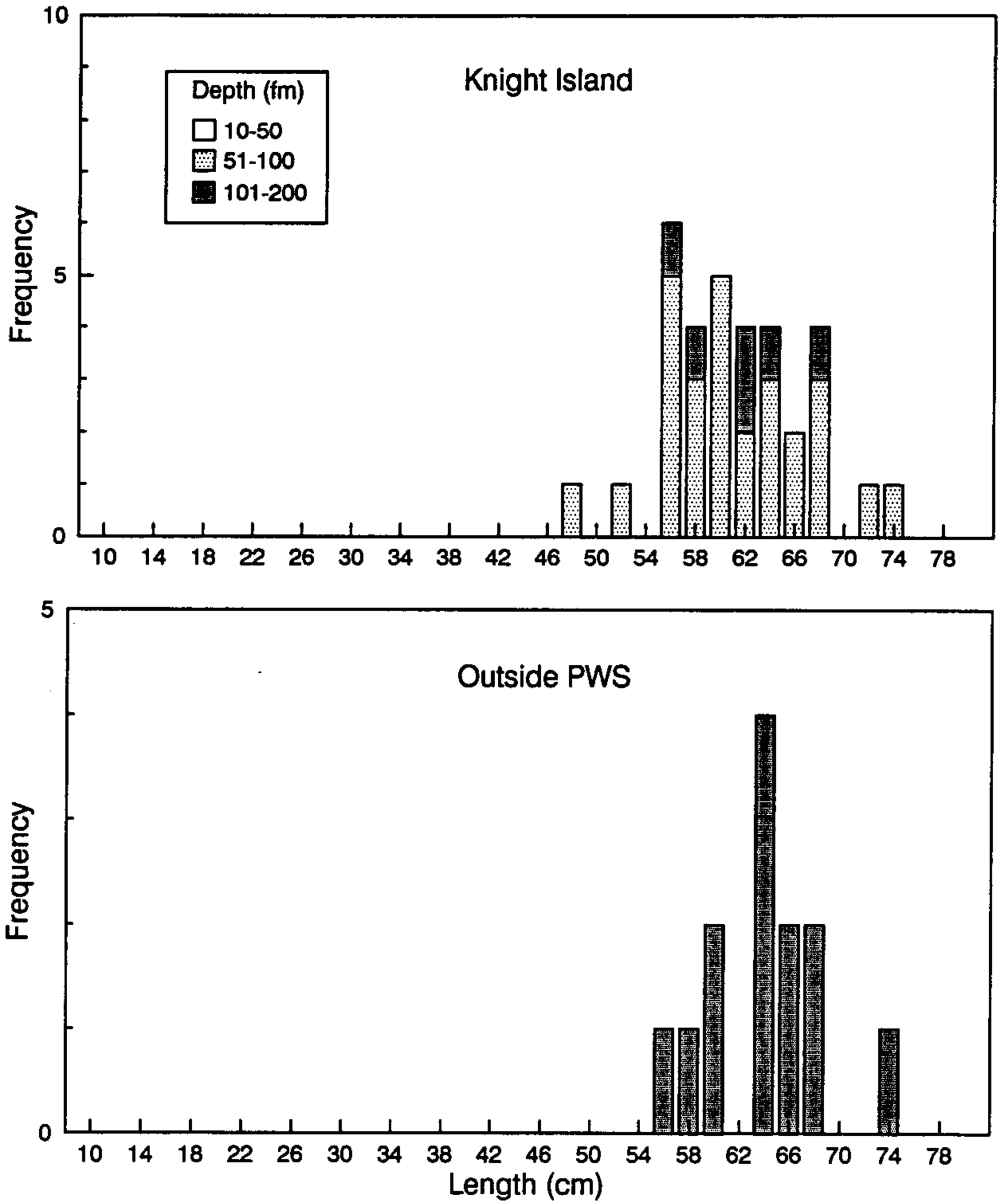


Figure 18, continued.

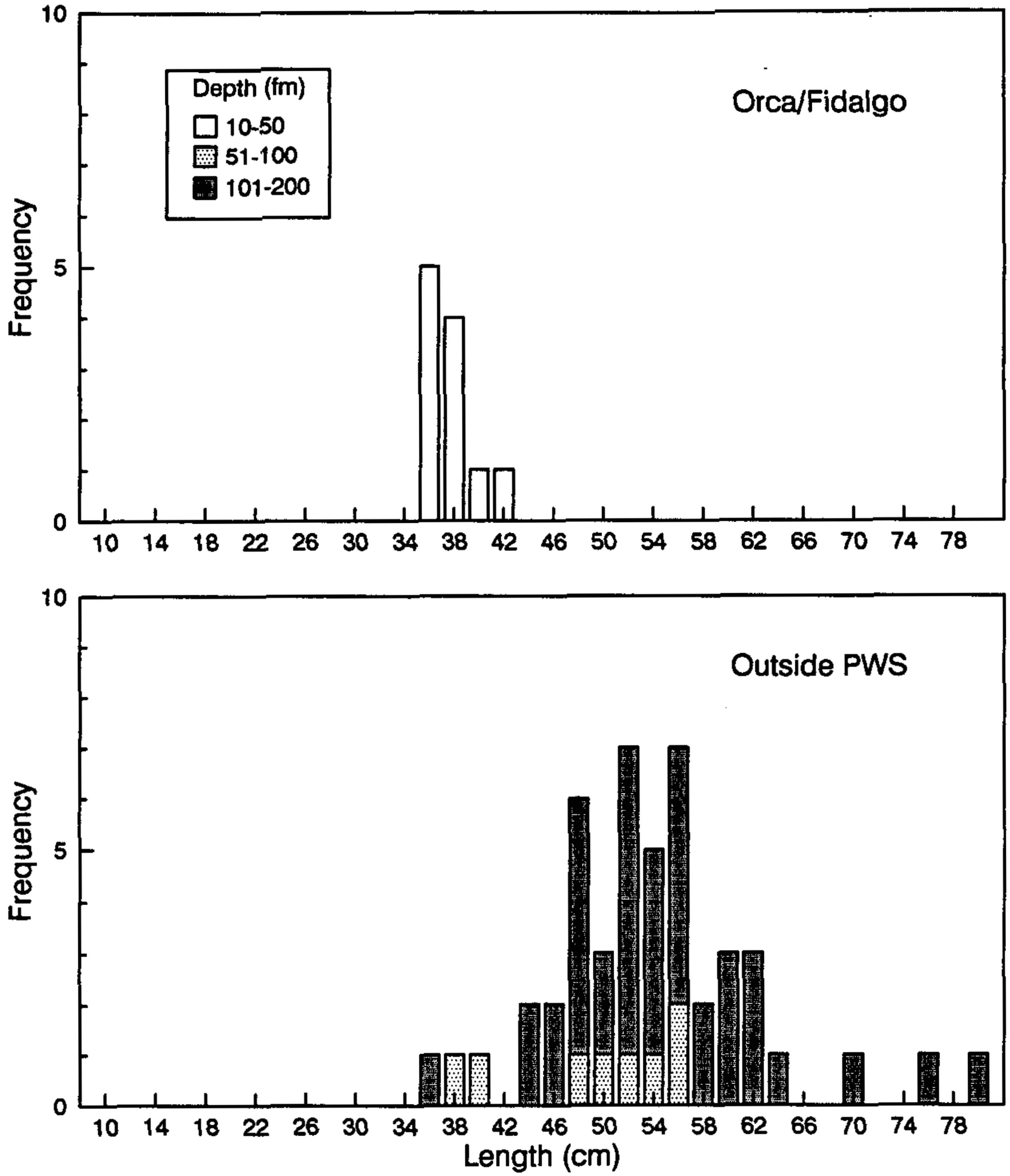


Figure 19. Length frequencies of sablefish by depth strata in areas sampled in 1989 Survey 2, Fish/Shellfish Study #18. Sablefish were measured only in Orca/Fidalgo and Outside PWS.

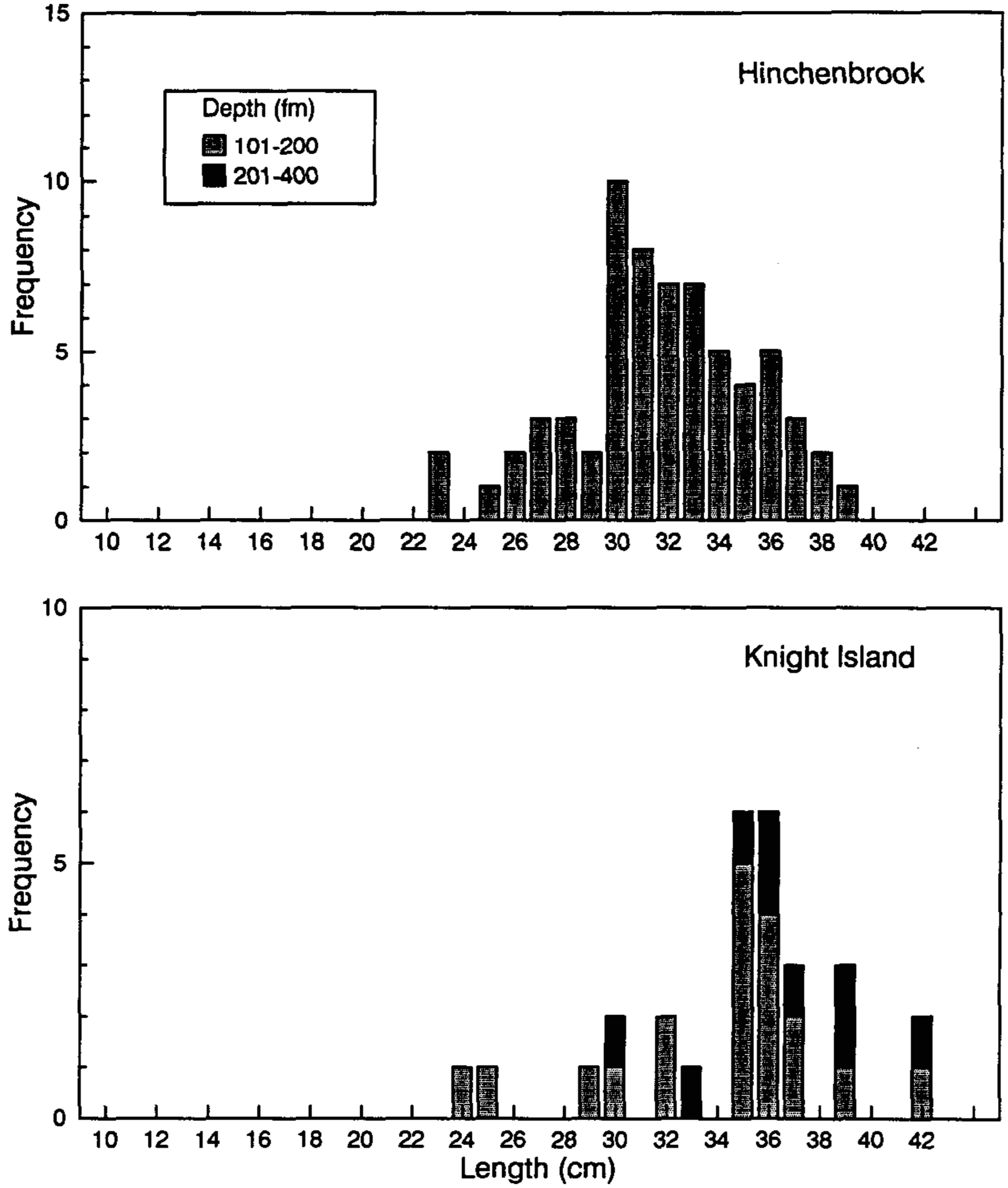


Figure 20. Length frequencies of rex sole by depth strata in areas sampled during 1989 Survey 2, Fish/Shellfish Study #18. Rex sole were measured only in the Hinchenbrook and Knight Island areas.

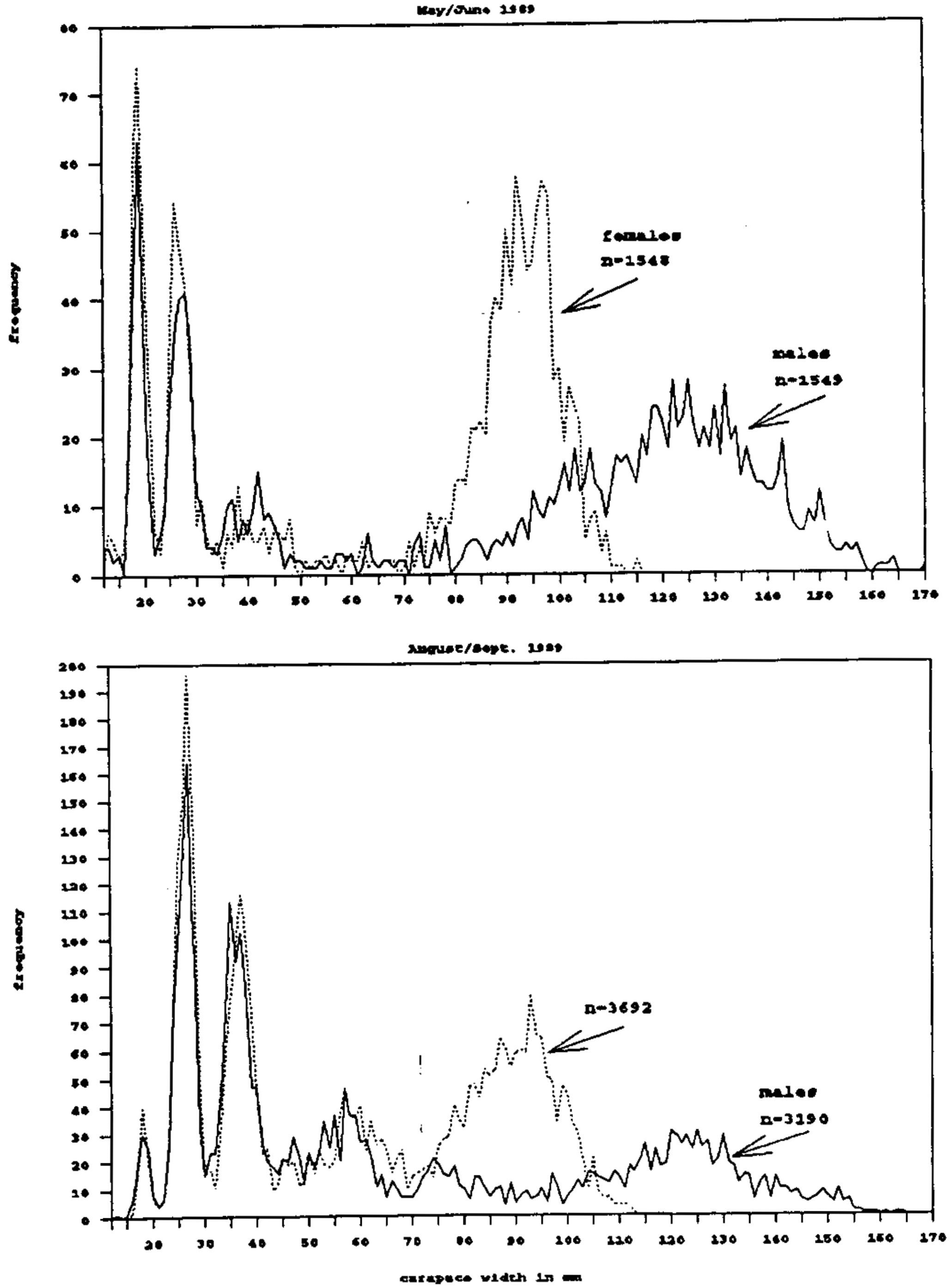


Figure 21. Width frequencies of Tanner crab, 1989 Surveys 1 and 2, Fish/Shellfish Study #18.

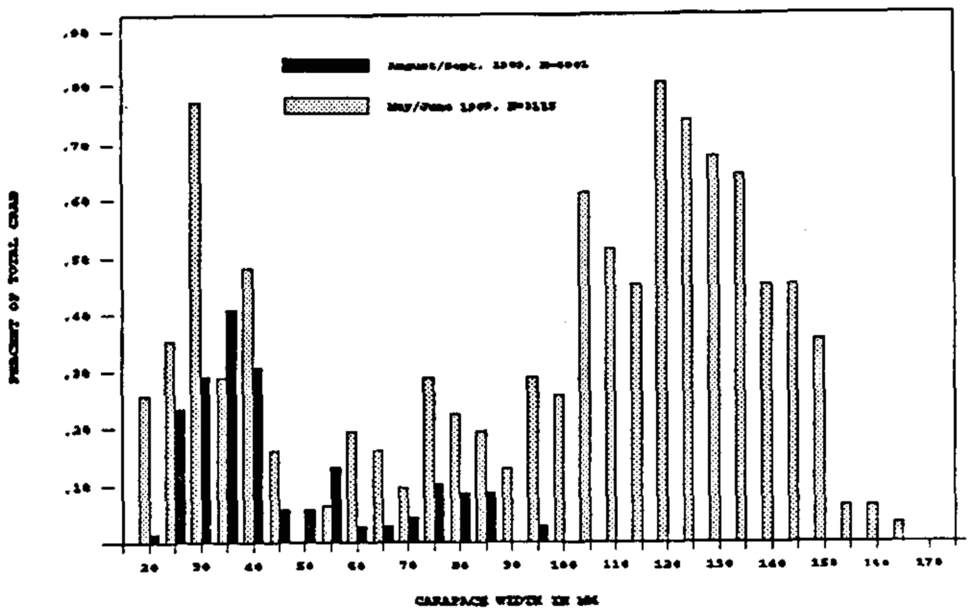


Figure 22. Width frequencies of soft-shell and recently molted Tanner crab, 1989 Surveys, Fish/Shellfish Study #18.

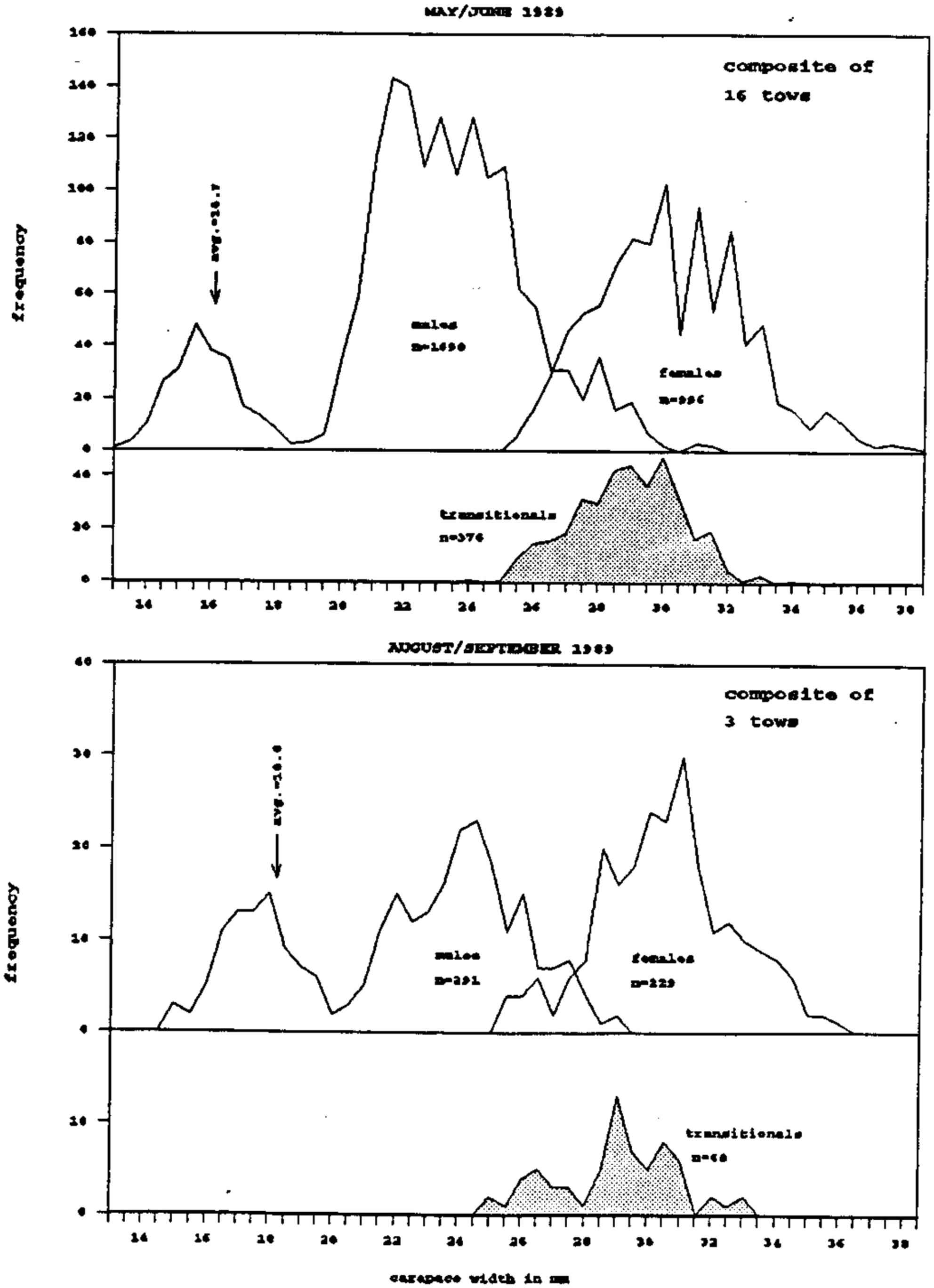


Figure 23. Carapace-length frequencies by sex of sidestripe shrimp, 1989 Surveys 1 and 2, Fish/Shellfish Study #18.

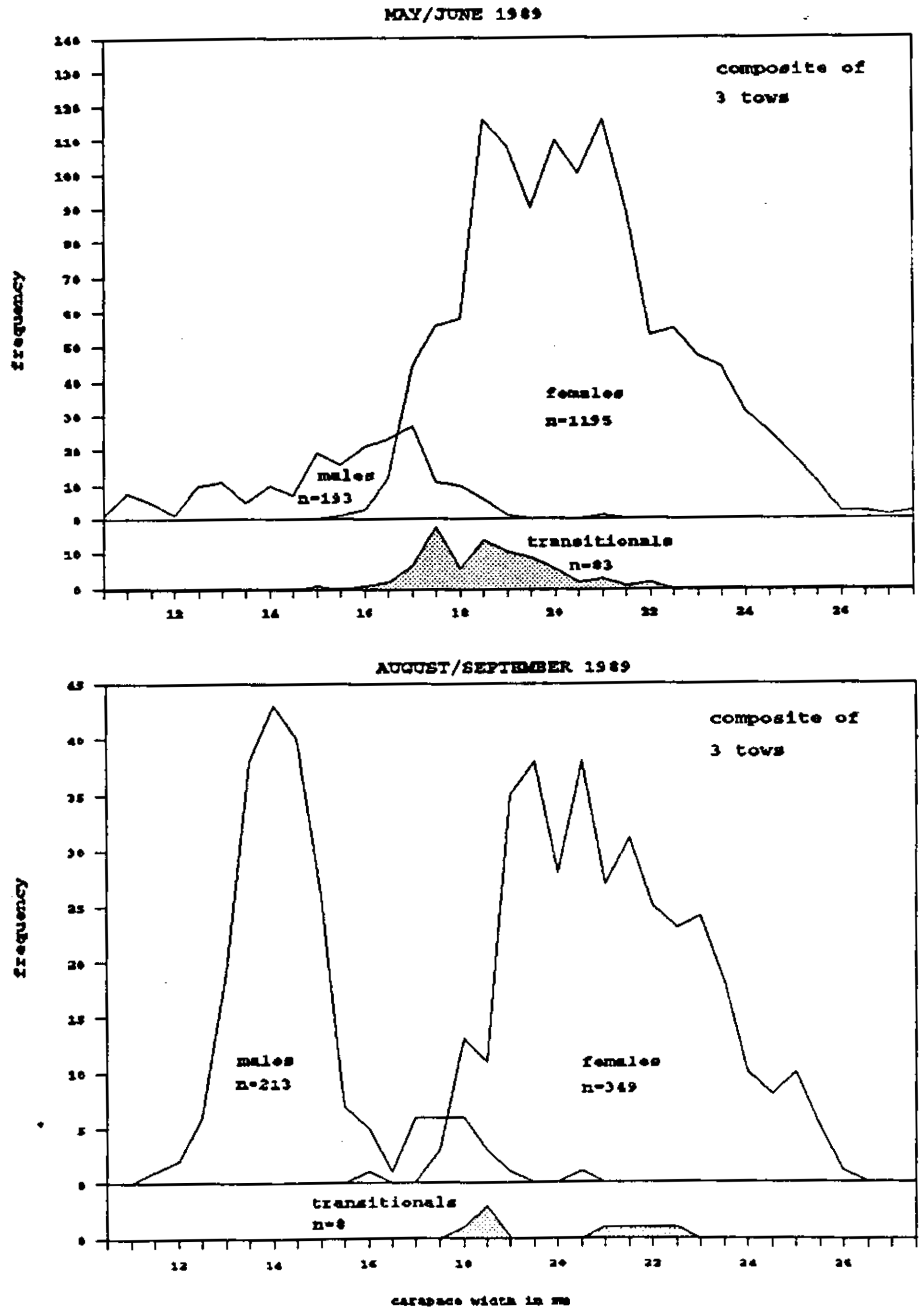


Figure 24. Carapace-length frequencies by sex of northern shrimp, 1989 Surveys 1 and 2, Fish/Shellfish Study #18.

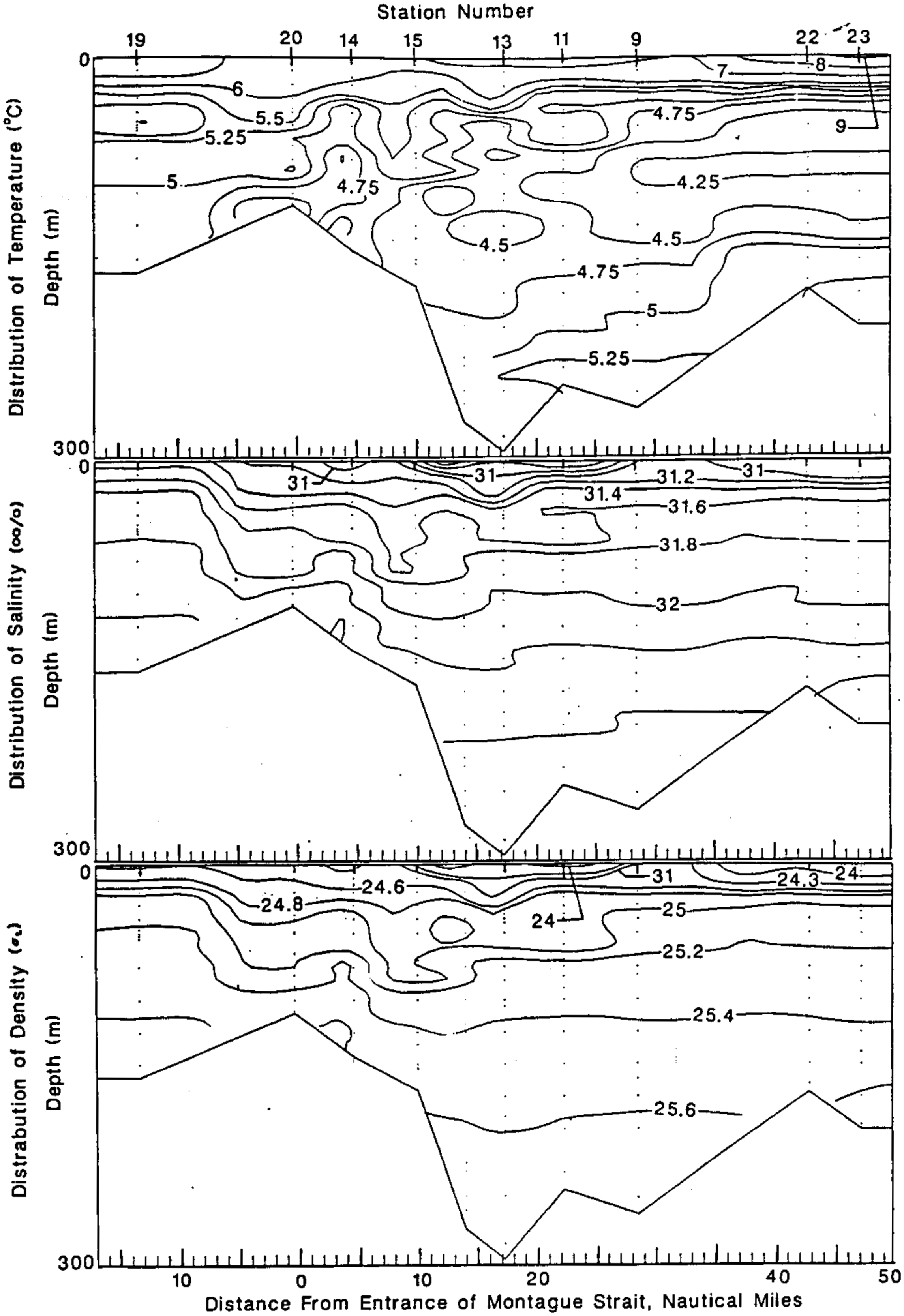


Figure 25. Contours of temperature (°C), salinity (‰), and density (σt) of Montague Strait transect, 1989 Survey 1, Fish/Shellfish Study #18.

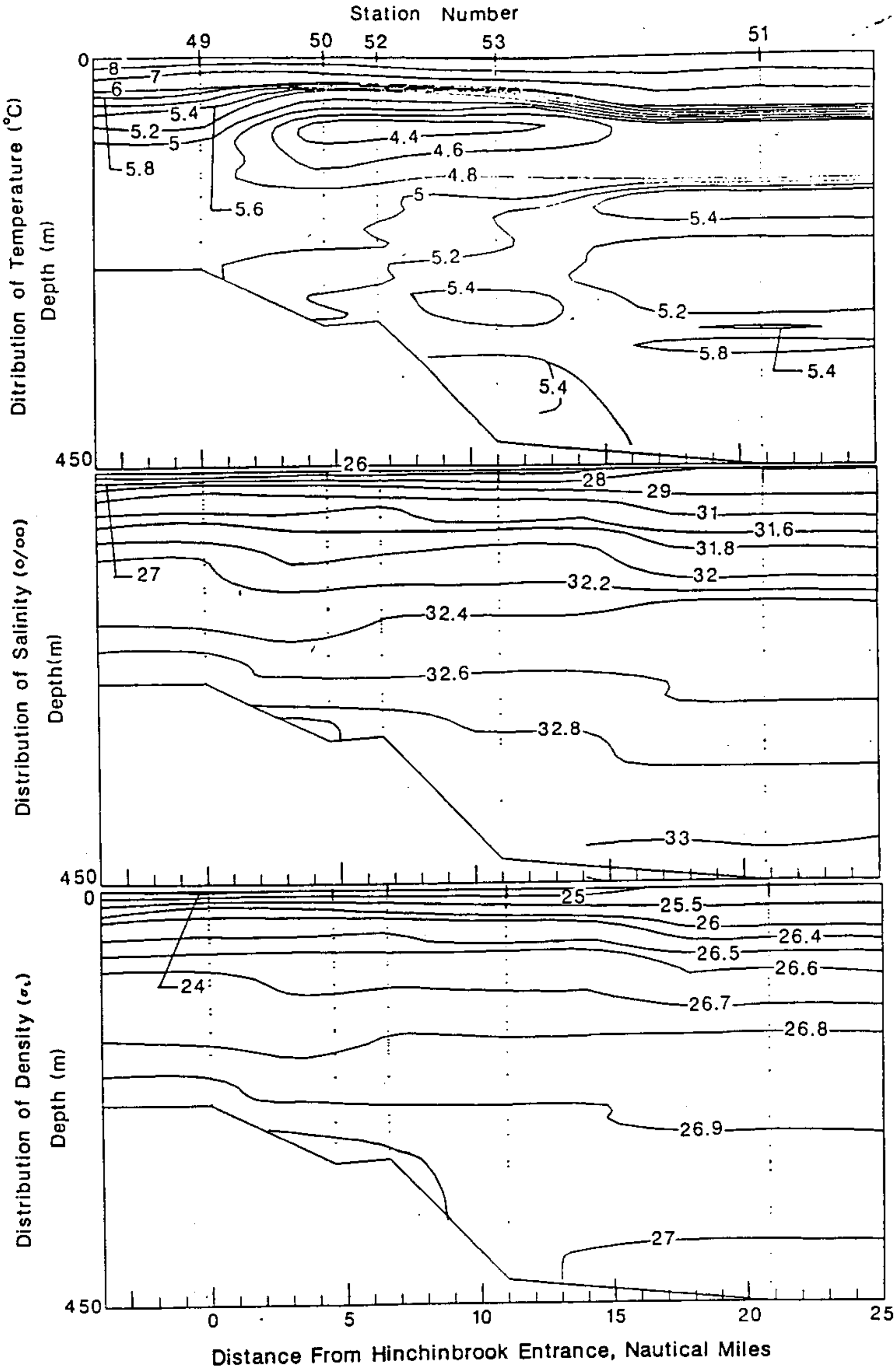


Figure 26. Contours of temperature (°C), salinity (‰), and density (σt) of Hinchinbrook Entrance transect, 1989 Survey 1, Fish/Shellfish Study #18.

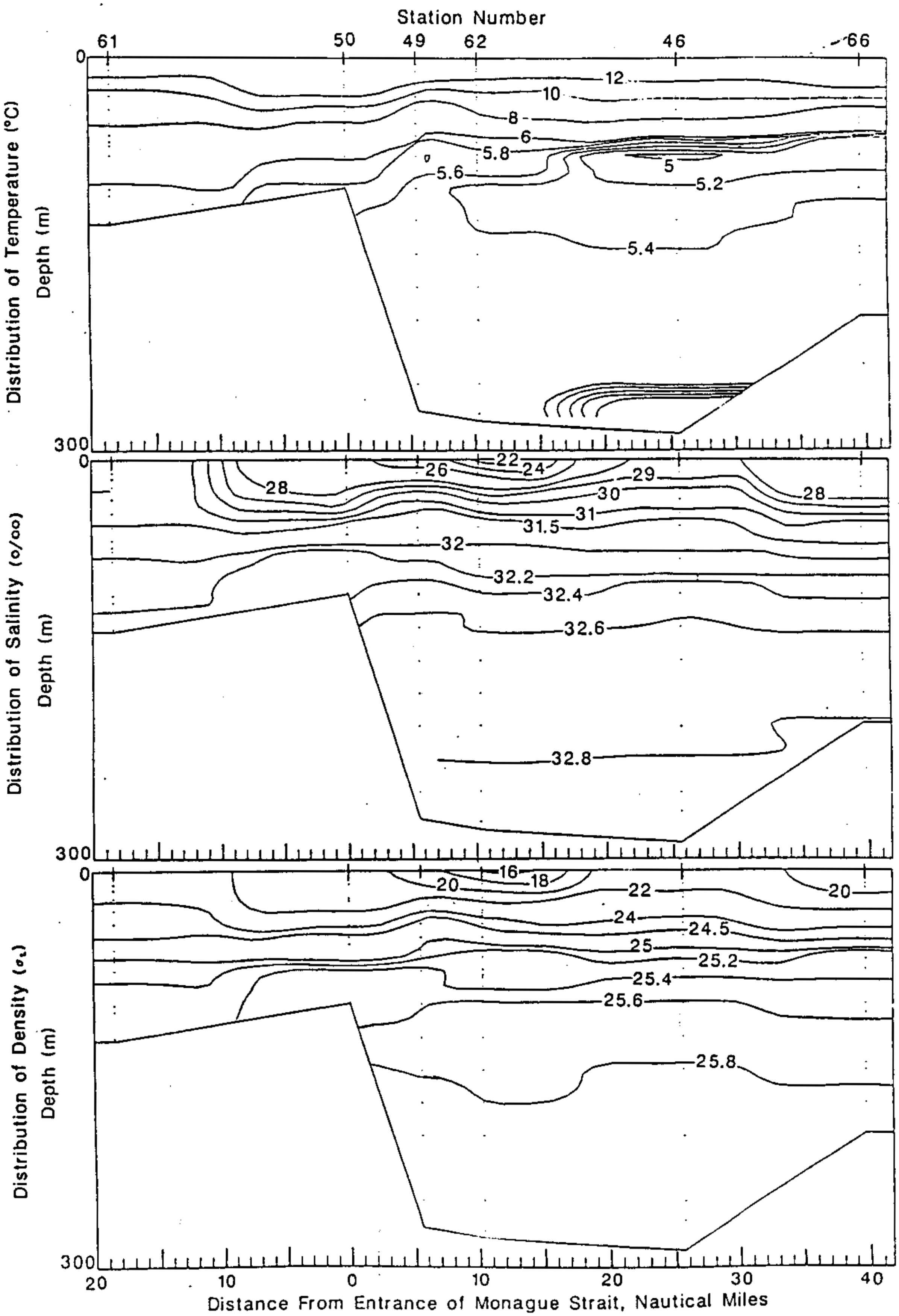


Figure 27. Contours of temperature (°C), salinity (‰), and density (σt) of Montague Strait transect, 1989 Survey 2, Fish/Shellfish Study #18.

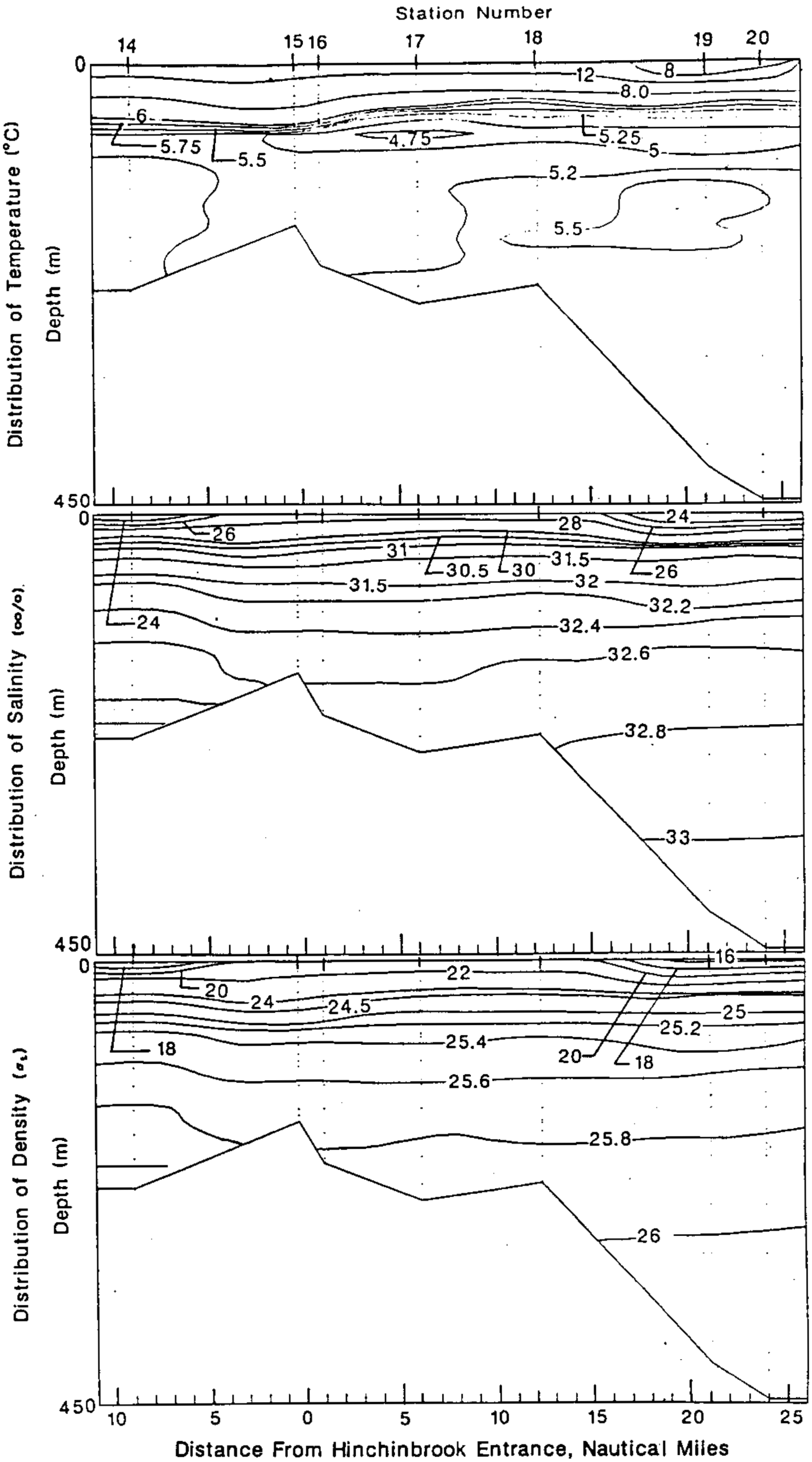


Figure 28. Contours of temperature (°C), salinity (‰), and density (σt) of Hinchinbrook Entrance transect, 1989 Survey 2, Fish/Shellfish Study #18.

Appendix 1.--Concentration (ng/g) of naphthalene (NPH) and phenanthrene (PHN) in bile from species of bottomfish trawled from sites in Prince William Sound in 1989 and 1990. ID is number for tracking samples in the Damage Assessment database. Dashes indicate missing data because of degraded samples.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143008	1	29000	4500
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143001	1	29000	4000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143002	1	120000	27000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143003	1	140000	23000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143004	1	96000	17000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143005	1	94000	14000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143006	1	160000	29000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143007	1	73000	13000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143012	1	100000	18000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143009	1	89000	17000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143010	1	97000	17000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143011	1	82000	14000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143014	1	82000	14000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143013	1	88000	14000
Walleye pollock	FPTAR	58.1750	134.2417	19-Jun-90	143015	1	250000	45000
Flathead sole	GREEI	60.1906	147.9061	21-May-89	2827	1	--	--
Flathead sole	GREEI	60.1906	147.9061	21-May-89	2830	1	28000	6500
Flathead sole	GREEI	60.1906	147.9061	21-May-89	2827	2	--	--
Flathead sole	GREEI	60.1906	147.9061	21-May-89	2824	1	32000	8600
Flathead sole	GREEI	60.1906	147.9061	21-May-89	2824	2	31000	8500
Flathead sole	GREEI	60.2400	147.7300	18-Jun-89	4380	1	26000	4800
Flathead sole	GREEI	60.2600	147.7500	18-Jun-89	4384	1	46000	11000
Pacific halibut	GREEI	60.2175	147.6664	22-May-89	2837	1	26000	4300
Pacific halibut	GREEI	60.2175	147.6664	22-May-89	2834	1	72000	15000
Pacific halibut	GREEI	60.2175	147.6664	22-May-89	2840	1	41000	11000
Pacific halibut	GREEI	60.2600	147.7500	18-Jun-89	4403	1	12000	1100
Pacific herring	GREEI	60.2600	147.7500	18-Jun-89	4390	1	120000	25000
Pacific herring	GREEI	60.2600	147.7500	18-Jun-89	4394	1	160000	31000
Walleye pollock	GREEI	60.2175	147.6664	22-May-89	2852	2	120000	32000
Walleye pollock	GREEI	60.2175	147.6664	22-May-89	2852	1	120000	31000
Walleye pollock	GREEI	60.2600	147.7500	18-Jun-89	4409	1	--	--
Walleye pollock	GREEI	60.2600	147.7500	18-Jun-89	4412	1	--	--
Walleye pollock	GREEI	60.2600	147.7500	18-Jun-89	4406	1	96000	23000
Sablefish	GREEI	60.1906	147.9061	21-May-89	2818	1	15000	2300
Sablefish	GREEI	60.1906	147.9061	21-May-89	2815	1	13000	2600
Sablefish	GREEI	60.1906	147.9061	21-May-89	2821	1	13000	1600
Sablefish	GREEI	60.2175	147.6664	22-May-89	2849	1	11000	1000
Sablefish	GREEI	60.2175	147.6664	22-May-89	2843	1	16000	3700

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Sablefish	GREEI	60.2175	147.6664	22-May-89	2846	1	29000	2300
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119806	1	85000	14000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119744	1	75000	11000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119809	1	83000	14000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119812	1	130000	21000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119815	1	120000	14000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119818	1	100000	18000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119747	1	63000	11000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119750	1	130000	18000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119803	1	130000	28000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119738	1	110000	15000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119735	1	150000	20000
Dover sole	KNIGI	60.1950	147.9125	21-Jun-90	119741	1	49000	7100
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119714	1	9700	1600
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119640	1	41000	7400
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119723	2	40000	5500
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119726	1	26000	4200
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119729	1	75000	9400
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119732	1	26000	3500
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119714	2	9500	1600
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119717	1	11000	1900
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119720	1	29000	4100
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119702	1	20000	4200
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119705	1	130000	24000
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119708	1	30000	6700
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119711	1	71000	12000
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119723	1	38000	5400
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119643	1	37000	5700
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119646	1	30000	4700
Flathead sole	KNIGI	60.1950	147.9125	21-Jun-90	119649	1	19000	3300
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119628	2	16000	2200
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119821	1	77000	10000
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119824	1	72000	8600
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119637	1	26000	3500
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119634	1	60000	8300
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119631	1	33000	4500
Pacific halibut	KNIGI	60.1950	147.9125	21-Jun-90	119628	1	15000	2100
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119517	2	42000	7900
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119446	1	28000	5100
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119520	1	38000	7800
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119523	1	34000	5900

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119517	1	40000	7900
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119508	1	31000	5800
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119449	1	21000	4300
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119502	1	61000	12000
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119526	1	34000	6100
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119529	1	26000	5100
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119511	1	43000	7800
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119514	1	37000	7000
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119443	1	63000	9300
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119440	1	17000	2300
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119437	1	13000	3000
Dover sole	MONTI	59.9219	147.8853	20-Jun-90	119505	1	30000	5000
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119609	1	42000	7100
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119538	1	43000	6100
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119612	1	54000	10000
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119615	1	36000	6000
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119606	1	17000	3100
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119547	2	16000	2300
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119541	1	23000	3800
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119544	1	30000	5200
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119547	1	17000	2500
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119603	1	20000	2700
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119550	1	18000	3000
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119535	1	28000	3900
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119535	2	27000	3700
Flathead sole	MONTI	59.9219	147.8853	20-Jun-90	119532	1	25000	4200
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119234	1	34000	4700
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119222	1	40000	5100
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119219	1	28000	3900
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119216	1	54000	9200
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119237	1	83000	11000
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119228	1	19000	2200
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119231	1	45000	4700
Pacific halibut	MONTI	60.0417	147.7600	19-Jun-90	119225	1	50000	7600
Walleye pollock	MONTI	60.4383	147.0217	19-Jun-90	119209	1	47000	9100
Walleye pollock	MONTI	60.4383	147.0217	19-Jun-90	119201	1	72000	14000
Walleye pollock	MONTI	60.4383	147.0217	19-Jun-90	119205	1	120000	28000
Walleye pollock	MONTI	60.4383	147.0217	19-Jun-90	119209	2	46000	8900
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119417	1	75000	15000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119405	1	190000	36000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119429	1	150000	25000

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119433	1	280000	54000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119421	1	94000	19000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119425	1	130000	21000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119401	1	84000	16000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119409	2	120000	22000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119409	1	120000	22000
Walleye pollock	MONTI	59.9219	147.8853	20-Jun-90	119413	1	53000	9300
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119308	1	32000	4100
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119326	1	56000	6800
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119311	1	50000	6300
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119240	1	68000	6800
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119314	1	40000	6000
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119246	1	63000	6500
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119249	1	62000	6500
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119311	2	50000	6400
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119323	2	57000	7200
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119317	1	45000	5900
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119329	1	54000	7200
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119332	1	54000	6900
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119243	1	94000	14000
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119302	1	67000	7100
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119320	1	68000	8700
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119323	1	57000	7300
Sablefish	MONTI	60.0417	147.7600	19-Jun-90	119305	1	56000	6800
Flathead sole	MONTL	60.1461	147.7094	22-May-89	2870	1	16000	4800
Flathead sole	MONTL	60.1461	147.7094	22-May-89	2867	1	29000	4900
Flathead sole	MONTL	60.1461	147.7094	22-May-89	2873	1	14000	3400
Flathead sole	MONTL	60.0042	147.8314	23-May-89	2903	1	10000	1700
Flathead sole	MONTL	60.0042	147.8314	23-May-89	2909	1	30000	6200
Flathead sole	MONTL	60.0042	147.8314	23-May-89	2906	1	20000	6600
Pacific halibut	MONTL	59.9447	147.8120	23-May-89	2936	1	14000	900
Pacific halibut	MONTL	59.9447	147.8120	23-May-89	2933	1	15000	2000
Pacific halibut	MONTL	59.9447	147.8120	23-May-89	2930	1	9300	2300
Pacific cod	MONTL	60.1086	147.5714	22-May-89	2879	1	--	--
Pacific cod	MONTL	60.1086	147.5714	22-May-89	2876	1	--	--
Pacific cod	MONTL	60.1086	147.5714	22-May-89	2882	1	--	--
Pacific cod	MONTL	60.1086	147.5714	22-May-89	2879	2	--	--
Pacific cod	MONTL	60.0042	147.8314	23-May-89	2915	1	--	--
Pacific cod	MONTL	60.0042	147.8314	23-May-89	2912	2	--	--
Pacific cod	MONTL	60.0042	147.8314	23-May-89	2912	1	--	--
Pacific cod	MONTL	60.0042	147.8314	23-May-89	2918	1	--	--

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Pacific cod	MONTL	60.0042	147.8314	23-May-89	2915	2	--	--
Walleye pollock	MONTL	60.2175	147.6664	22-May-89	2855	1	150000	48000
Walleye pollock	MONTL	60.2175	147.6664	22-May-89	2858	1	110000	32000
Walleye pollock	MONTL	59.8872	147.9347	23-May-89	2927	1	--	--
Walleye pollock	MONTL	59.8872	147.9347	23-May-89	2921	1	--	--
Walleye pollock	MONTL	59.8872	147.9347	23-May-89	2924	1	--	--
Sablefish	MONTL	60.0042	147.8314	23-May-89	2897	1	19000	3100
Sablefish	MONTL	60.0042	147.8314	23-May-89	2894	1	13000	2200
Sablefish	MONTL	60.0042	147.8314	23-May-89	2900	1	5800	560
Sablefish	MONTL	60.0042	147.8314	23-May-89	2897	2	18000	2800
Flathead sole	MONTT	59.9283	147.4275	19-Jun-89	4439	2	8500	890
Flathead sole	MONTT	59.9283	147.4275	19-Jun-89	4439	1	8600	1200
Flathead sole	MONTT	59.9283	147.4275	19-Jun-89	4436	1	8200	820
Flathead sole	MONTT	59.9283	147.4275	19-Jun-89	4442	1	6400	470
Pacific halibut	MONTT	59.7006	147.6364	19-Jun-89	4420	1	22000	2200
Pacific halibut	MONTT	59.7006	147.6364	19-Jun-89	4417	1	25000	3100
Pacific halibut	MONTT	59.7006	147.6364	19-Jun-89	4423	1	11000	700
Pacific halibut	MONTT	59.7006	147.6364	19-Jun-89	4420	2	20000	2000
Pacific cod	MONTT	59.9283	147.4275	19-Jun-89	4449	1	64000	18000
Pacific cod	MONTT	59.9283	147.4275	19-Jun-89	4446	1	--	--
Pacific cod	MONTT	59.9283	147.4275	19-Jun-89	4443	1	--	--
Walleye pollock	MONTT	59.7006	147.6364	19-Jun-89	4431	1	--	--
Walleye pollock	MONTT	59.7006	147.6364	19-Jun-89	4428	1	--	--
Walleye pollock	MONTT	59.7006	147.6364	19-Jun-89	4425	1	--	--
Sablefish	MONTT	59.9283	147.4275	19-Jun-89	4456	2	5100	200
Sablefish	MONTT	59.9283	147.4275	19-Jun-89	4456	1	5200	160
Flathead sole	MONTU	60.4511	147.4814	26-May-89	2951	1	22000	4100
Flathead sole	MONTU	60.4511	147.4814	26-May-89	2957	1	50000	14000
Flathead sole	MONTU	60.4511	147.4814	26-May-89	2954	1	38000	10000
Flathead sole	MONTU	60.4511	147.4814	26-May-89	2951	2	23000	3800
Pacific halibut	MONTU	60.4172	147.0892	17-Jun-89	4365	1	13000	1900
Pacific halibut	MONTU	60.4172	147.0892	17-Jun-89	4362	1	30000	4800
Pacific halibut	MONTU	60.4172	147.0892	17-Jun-89	4359	1	11000	540
Pacific cod	MONTU	60.6131	147.1686	07-Jun-89	4174	1	--	--
Pacific cod	MONTU	60.6131	147.1686	07-Jun-89	4171	1	22000	2000
Pacific cod	MONTU	60.6156	147.1136	07-Jun-89	4168	1	--	--
Pacific cod	MONTU	60.6131	147.1686	07-Jun-89	4174	2	--	--
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4374	1	--	--
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4371	2	--	--
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4371	1	--	--
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4374	2	--	--

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4368	1	--	--
Pacific cod	MONTU	60.4172	147.0892	17-Jun-89	4368	2	--	--
Walleye pollock	MONTU	60.4511	147.4814	26-May-89	2963	1	300000	120000
Walleye pollock	MONTU	60.4511	147.4814	26-May-89	2960	1	97000	28000
Walleye pollock	MONTU	60.4511	147.4814	26-May-89	2966	1	130000	38000
Walleye pollock	MONTU	60.4317	147.0183	18-Jun-90	118942	1	110000	26000
Walleye pollock	MONTU	60.4317	147.0183	18-Jun-90	119008	1	110000	18000
Walleye pollock	MONTU	60.4317	147.0183	18-Jun-90	118946	1	91000	17000
Walleye pollock	MONTU	60.4317	147.0183	18-Jun-90	118950	1	79000	16000
Walleye pollock	MONTU	60.4317	147.0183	18-Jun-90	119004	1	73000	12000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119127	1	94000	18000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119131	1	70000	13000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119135	1	80000	15000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119147	1	71000	14000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119143	1	170000	30000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119123	1	87000	18000
Walleye pollock	MONTU	60.4383	147.0217	19-Jun-90	119139	1	330000	66000
Sablefish	MONTU	60.4292	147.0114	17-Jun-89	4356	1	3000	260
Sablefish	MONTU	60.4292	147.0114	17-Jun-89	4350	1	17000	680
Sablefish	MONTU	60.4292	147.0114	17-Jun-89	4353	1	12000	1100
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119028	1	19000	2700
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119025	1	14000	2600
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119105	2	54000	6100
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119108	1	26000	3200
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119111	1	52000	6400
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119031	1	23000	3200
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119034	1	13000	2000
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119117	1	36000	4400
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119120	1	40000	4800
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119105	1	56000	6200
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119046	1	69000	9100
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119037	1	17000	2600
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119040	1	28000	3200
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119043	1	30000	3700
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119114	1	47000	6000
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119049	1	55000	6700
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119102	1	43000	5100
Sablefish	MONTU	60.4383	147.0217	18-Jun-90	119111	2	55000	6400
Pacific halibut	NAKEI	60.7947	147.2539	02-Jun-89	4134	1	70000	14000
Pacific halibut	NAKEI	60.7903	147.4211	05-Jun-89	4162	1	55000	7400
Pacific halibut	NAKEI	60.7903	147.4211	05-Jun-89	4165	1	27000	3000

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120016	1	45000	6200
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120010	1	56000	5700
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120013	1	74000	12000
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120028	1	47000	6200
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120025	1	47000	9500
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120022	1	59000	8400
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120007	1	34000	4500
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120004	1	46000	5900
Pacific halibut	NAKEI	60.6050	147.1350	22-Jun-90	120019	1	56000	6900
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119904	1	140000	25000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119833	1	95000	17000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119836	1	240000	38000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119845	1	170000	33000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119830	1	96000	18000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119907	1	73000	14000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119910	1	160000	32000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119827	1	290000	61000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119842	1	170000	28000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119919	1	37000	6700
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119848	1	140000	24000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119901	1	73000	13000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119916	1	440000	87000
Pacific cod	NAKEI	60.6050	147.1350	22-Jun-90	119839	1	420000	81000
COD	NAKEI	60.6050	147.1350	22-Jun-90	119913	1	54000	9000
Walleye pollock	NAKEI	60.7947	147.2539	02-Jun-89	4132	1	--	--
Walleye pollock	NAKEI	60.7947	147.2539	02-Jun-89	4131	1	--	--
Walleye pollock	NAKEI	60.7947	147.2539	02-Jun-89	4133	1	--	--
Sablefish	NAKEI	60.7947	147.2539	02-Jun-89	4130	2	23000	2100
Sablefish	NAKEI	60.7947	147.2539	02-Jun-89	4129	1	47000	6600
Sablefish	NAKEI	60.7947	147.2539	02-Jun-89	4128	1	--	--
Sablefish	NAKEI	60.7947	147.2539	02-Jun-89	4130	1	26000	2600
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119936	1	81000	8400
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119942	1	86000	9900
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119948	1	64000	7000
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119939	1	61000	7100
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119930	1	33000	4100
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	120001	1	48000	6600
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119933	1	66000	7200
Sablefish	NAKEI	60.6050	147.1350	22-Jun-90	119945	1	69000	9900
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110537	1	29000	7000
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110543	1	57000	13000

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110611	1	86000	22000
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110540	1	71000	15000
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110632	1	34000	6700
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110629	1	40000	11000
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110549	1	130000	27000
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110617	1	18000	4200
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110620	1	49000	9300
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110608	1	21000	4400
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110626	1	28000	8200
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110602	1	35000	9900
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110605	1	20000	4900
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110546	1	47000	9700
Dover sole	NHINC	60.5583	146.5669	14-Jun-90	110623	1	24000	6100
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110638	1	17000	2700
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110644	1	29000	4400
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110641	1	12000	2000
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110712	1	15000	2700
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110727	1	31000	5200
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110706	1	22000	4100
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110635	1	19000	3000
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110649	1	18000	3600
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110715	1	17000	3000
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110718	1	21000	2500
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110709	1	18000	3100
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110724	1	24000	3200
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110703	1	30000	6100
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110647	1	26000	4800
Flathead sole	NHINC	60.5583	146.5669	14-Jun-90	110721	1	22000	2600
Pacific halibut	NHINC	60.5583	146.5669	14-Jun-90	110517	1	25000	3700
Pacific halibut	NHINC	60.5583	146.5669	14-Jun-90	110514	1	20000	3300
Pacific halibut	NHINC	60.5583	146.5669	14-Jun-90	110534	1	32000	4300
Walleye pollock	NHINC	60.5583	146.5669	14-Jun-90	110523	1	37000	7300
Walleye pollock	NHINC	60.5583	146.5669	14-Jun-90	110530	1	60000	13000
Walleye pollock	NHINC	60.5583	146.5669	14-Jun-90	110526	1	51000	10000
Walleye pollock	NHINC	60.5583	146.5669	14-Jun-90	110520	1	81000	16000
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110736	1	35000	5800
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110730	1	35000	5200
Sablefish	NHINC	60.4689	146.6880	14-Jun-90	110508	1	16000	2100
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110742	1	39000	6600
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110739	1	48000	8100
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110745	1	37000	5200

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110733	1	40000	6400
Sablefish	NHINC	60.4689	146.6880	14-Jun-90	110502	1	21000	2700
Sablefish	NHINC	60.4689	146.6880	14-Jun-90	110505	1	15000	2200
Sablefish	NHINC	60.5583	146.5669	14-Jun-90	110742	2	39000	6500
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110927	1	52000	11000
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110933	1	36000	7100
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110847	1	26000	4600
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110903	2	32000	5200
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110930	1	40000	6400
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110921	1	22000	4400
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110918	1	30000	7900
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110939	1	140000	26000
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110906	1	36000	5300
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110909	1	21000	4000
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110924	1	28000	5300
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110915	1	26000	4800
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110903	1	33000	5300
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110850	1	100000	23000
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110936	1	48000	7000
Dover sole	NMONT	60.2483	146.9033	16-Jun-90	110912	1	21000	3800
Walleye pollock	NMONT	60.2483	146.9033	15-Jun-90	110804	1	100000	16000
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110832	2	33000	3700
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110838	1	29000	4000
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110814	1	20000	2500
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110835	1	40000	4300
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110829	1	55000	7700
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110826	1	24000	3500
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110844	1	26000	3200
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110817	1	31000	4300
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110820	1	31000	4200
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110832	1	36000	3800
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110823	1	37000	4900
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110811	1	50000	7300
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110808	1	27000	3000
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110841	1	27000	3200
Sablefish	NMONT	60.2483	146.9033	15-Jun-90	110820	2	32000	4200
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120126	1	39000	6800
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120135	1	67000	13000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120117	1	62000	12000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120102	1	23000	4200
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120129	1	47000	10000

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120120	1	160000	35000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120105	1	78000	12000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120141	1	65000	15000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120123	1	32000	5000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120108	1	170000	32000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120049	1	73000	11000
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120114	1	63000	9500
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120138	1	51000	6500
Dover sole	ORCAB	60.5919	146.4083	23-Jun-90	120111	1	62000	10000
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139201	1	37000	4100
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139231	1	27000	3800
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139148	1	51000	6300
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139139	1	25000	3400
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139222	1	21000	2900
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139207	1	26000	3300
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139211	1	38000	5000
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139225	1	27000	3200
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139228	1	42000	5800
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139145	1	38000	5100
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139204	1	53000	5700
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139213	1	35000	4500
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139142	1	30000	3000
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139219	1	27000	3200
Flathead sole	ORCAB	60.5919	146.4083	23-Jun-90	139216	1	47000	6500
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	120147	1	140000	24000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	120144	1	330000	71000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139130	1	150000	25000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139136	1	89000	17000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139112	1	160000	26000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139121	1	180000	34000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139106	1	170000	32000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139109	1	190000	32000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139124	1	96000	15000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139127	1	140000	25000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139118	1	34000	5800
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139103	1	130000	21000
Pacific cod	ORCAB	60.5919	146.4083	23-Jun-90	139115	1	180000	31000
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110422	1	49000	10000
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110416	1	14000	2500
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110431	1	460000	92000
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110410	1	9200	1700

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110419	1	48000	7000
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110428	1	100000	21000
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110404	1	19000	2500
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110401	1	11000	1800
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110413	1	25000	3700
Sablefish	PETCH	60.3717	146.7958	14-Jun-90	110425	1	41000	5600
Flathead sole	PFIDA	60.7881	146.6395	31-May-89	4074	1	15000	2400
Flathead sole	PFIDA	60.7881	146.6395	31-May-89	4068	1	22000	2200
Flathead sole	PFIDA	60.7881	146.6395	31-May-89	4071	1	12000	880
Pacific halibut	PFIDA	60.7881	146.6395	31-May-89	4098	1	24000	2800
Pacific halibut	PFIDA	60.7881	146.6395	31-May-89	4100	1	23000	1800
Pacific halibut	PFIDA	60.7881	146.6395	31-May-89	4099	1	8000	1200
Pacific halibut	PFIDA	60.7881	146.6395	31-May-89	4098	2	23000	2700
Pacific cod	PFIDA	60.7881	146.6395	31-May-89	4095	1	--	--
Pacific cod	PFIDA	60.7881	146.6395	31-May-89	4092	1	--	--
Pacific cod	PFIDA	60.7881	146.6395	31-May-89	4101	1	--	--
Walleye pollock	PFIDA	60.7881	146.6395	31-May-89	4097	1	--	--
Walleye pollock	PFIDA	60.7881	146.6395	31-May-89	4096	1	--	--
Walleye pollock	PFIDA	60.7881	146.6395	31-May-89	4077	1	--	--
Walleye pollock	PFIDA	60.7881	146.6395	31-May-89	4077	2	--	--
Flathead sole	PGRAV	60.6381	146.3767	29-May-89	4035	1	10000	1100
Flathead sole	PGRAV	60.6381	146.3767	29-May-89	4038	1	14000	1500
Flathead sole	PGRAV	60.6381	146.3767	29-May-89	4041	1	11000	950
Pacific halibut	PGRAV	60.6381	146.3767	29-May-89	4029	1	23000	2500
Pacific halibut	PGRAV	60.6381	146.3767	29-May-89	4027	1	16000	1500
Pacific cod	PGRAV	60.6381	146.3767	29-May-89	4043	1	--	--
Pacific cod	PGRAV	60.6381	146.3767	29-May-89	4042	2	--	--
Pacific cod	PGRAV	60.6381	146.3767	29-May-89	4042	1	--	--
Pacific cod	PGRAV	60.6381	146.3767	29-May-89	4044	1	57000	7500
Walleye pollock	PGRAV	60.6286	146.5025	29-May-89	4011	1	--	--
Walleye pollock	PGRAV	60.6286	146.5025	29-May-89	4008	1	--	--
Walleye pollock	PGRAV	60.6281	146.5017	29-May-89	4003	1	--	--
Flathead sole	PWELL	60.7103	148.0606	04-Jun-89	4147	1	17000	2100
Flathead sole	PWELL	60.7103	148.0606	04-Jun-89	4148	1	23000	2600
Flathead sole	PWELL	60.7103	148.0606	04-Jun-89	4148	2	21000	2800
Flathead sole	PWELL	60.7103	148.0606	04-Jun-89	4149	1	19000	2300
Pacific halibut	PWELL	60.8308	148.1911	19-May-89	2803	1	4300	380
Pacific halibut	PWELL	60.8308	148.1911	19-May-89	2806	1	5100	560
Pacific halibut	PWELL	60.8308	148.1911	19-May-89	2800	1	4200	440
Walleye pollock	PWELL	60.7103	148.0606	04-Jun-89	4156	1	--	--
Walleye pollock	PWELL	60.7103	148.0606	04-Jun-89	4158	1	--	--

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Walleye pollock	PWELL	60.7103	148.0606	04-Jun-89	4157	1	--	--
Sablefish	PWELL	60.7103	148.0606	04-Jun-89	4160	1	40000	3300
Sablefish	PWELL	60.7103	148.0606	04-Jun-89	4160	2	40000	3200
Sablefish	PWELL	60.7103	148.0606	04-Jun-89	4161	1	28000	3000
Sablefish	PWELL	60.7103	148.0606	04-Jun-89	4159	1	34000	2700
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	118909	1	33000	4900
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	118912	1	30000	4800
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	118915	1	18000	3400
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	118906	1	27000	3700
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	111147	1	12000	2200
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	111150	1	29000	3600
Pacific halibut	ZAIKB	60.3000	147.0667	17-Jun-90	118903	1	17000	2800
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118918	1	19000	3100
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118933	1	15000	2500
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118936	1	23000	3600
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118939	1	14000	2400
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118930	1	9100	1500
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118921	1	15000	2200
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118924	1	25000	4400
Pacific halibut	ZAIKB	60.3000	147.0667	18-Jun-90	118927	1	17000	2800
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111144	1	17000	3100
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111105	1	78000	17000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111108	1	130000	22000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111111	1	56000	9200
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111114	1	55000	9800
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111117	1	120000	25000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111120	1	66000	12000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111123	1	120000	22000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111126	1	100000	18000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111132	1	130000	23000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111135	1	180000	32000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111138	1	92000	19000
Pacific cod	ZAIKB	60.3000	147.0667	17-Jun-90	111102	1	130000	24000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111036	1	71000	13000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111040	1	54000	10000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111044	1	37000	6300
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111032	1	220000	39000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	110942	1	56000	8500
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	110945	1	59000	12000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	110950	1	96000	16000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111004	1	43000	7400

Appendix 1.--continued.

Species	Collection Site[a]	N Lat.	W Long.	Date	ID	Rep[b]	NPH	PHN
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111008	1	100000	17000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111008	2	99000	17000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111012	1	77000	13000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111016	1	73000	13000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111020	1	200000	33000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111024	1	95000	16000
Walleye pollock	ZAIKB	60.3000	147.0667	17-Jun-90	111028	1	87000	15000

[a]Site (LOCATABV in Damage Assessment database): FPTAR = F. Pt. Arden; GREEI = Green Island; KNIGI = Knight Island; MONTI = Montague Is.; MONTL = Lower Montague; MONTT = Montague Trench; MONTU = Upper Montague; NAKEI = Naked Island; NHINC = North Hinchinbrook; NMONT = N Montague; ORCAB = Orca Bay; PETCH = Port Etches; PFIDA = Port Fidalgo; PGRAV = Port Gravina; PWELL = Port Wells; ZAIKB = Zaikof Bay.

[b]Replicate analysis of same bile sample.