FRI-UW-8615
December 1986

PUGET SOUND DREDGE DISPOSAL ANALYSIS (PSDDA) DISPOSAL SITE INVESTIGATIONS: PHASE 1 TRAWL STUDIES IN SARATOGA PASSAGE, PORT GARDNER, ELLIOTT BAY AND COMMENCEMENT BAY, WASHINGTON

Principal Investigators

Paul A. Dinnel, David A. Armstrong, Bruce S. Miller, Robert F. Donnelly
Fisheries Research Institute, School of Fisheries
University of Washington, Seattle

Part I

Crab and Shrimp Studies

by

Paul A. Dinnel, David A. Armstrong, and Anthony Whiley

Part II

Demersal Fish Studies

by

Robert F. Donnelly, Bruce S. Miller, Robert R. Lauth, and Shelley C. Clarke

FINAL REPORT

31 December 1986

for

Washington Sea Grant Program in Cooperation with
Seattle District, U.S. Army Corps of Engineers
Seattle, Washington

Submitted 31 December 1986

Approved:

for Roy E Nakatani
Robert C. Francis, Director

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ACKNOWLEDGMENTS

The work was supported by the Washington Sea Grant Program in cooperation with the Seattle District, U.S. Army Corps of Engineers. We appreciate the valuable assistance of Louie Echols, Washington Sea Grant Program; Frank Urabeck, Warren Baxter, Steve Martin and David Kendall of the U.S. Army Corps of Engineers; and members of the PSDDA Disposal Site Work Group (DSWG). All trawl work was conducted on board the R.V. *Kittiwake* skippered by Charles Eaton. Assistance in the field and laboratory was provided by Russ McMillan, Tom Wainwright, Greg Jensen, Dan Doty, Debbie Dole, Loann Hallum, and Sandy O'Neil. Carol Sisley, Carla Norwood and Kathy Boaz provided assistance with report preparation.

EXECUTIVE SUMMARY

The multi-agency Puget Sound Dredge Disposal Analysis (PSDDA) Program has been delegated the task of evaluating, selecting, monitoring and managing sites within the inland waters of Washington State for long-term, unconfined disposal of uncontaminated dredged materials. The Disposal Site Work Group (DSWG) of PSDDA was assigned the responsibility of selecting unconfined, open water disposal sites in central Puget Sound. DSWG selected seven preliminary disposal sites within five Zones of Siting Feasibility (ZSF's) in central Puget Sound (Saratoga Passage, Port Gardner, Elliott Bay and Commencement Bay) based on 19 selection factors covering physical parameters, human uses and historical biological resource data. Final site selection is now dependent, in part, on site-specific trawl investigations for biological resources in and around each of the five ZSF's.

This document is the final technical report detailing the results of trawl studies conducted in each of the five ZSF's during 1986. This report is divided into two parts: Part I summarizes the results of trawling conducted with a small 3-m research beam trawl especially useful for capturing Dungeness crab, shrimp and small bottomfish. Part II details the results of trawling conducted with a research (7.6 m) otter trawl primarily designed to capture bottomfish of all sizes.

Initial trawls in central Puget Sound identified three faunal groups of specific importance to Puget Sound commercial and sport fisheries: Dungeness crab, pandalid shrimp, and bottomfish (especially flatfish, Pacific hake, cod, and rockfish). Each of these resources has been analyzed in this report to provide the best possible biological data base for the final site selection process and to provide a "baseline" of information for future monitoring of these disposal sites. It should be noted that the Port Gardner data presented in this report are essentially abstracted from cruise reports from a closely related project (Navy Homeport Project). The final analyses of the Port Gardner data will be available at a later date.

Generally, Dungeness crab were found to be absent from Commencement Bay, of only minor concern in Elliott Bay and Saratoga Passage, and a major resource (especially females) in Port Gardner, where this species will be of primary concern in site selection and future monitoring.

Shrimp were ubiquitous throughout the areas sampled. Shrimp populations were highly variable depending on such factors as site, species, depth, season and habitat type. Shrimp populations were generally insignificant as commercial or sport resources in all of the five ZSF's with the possible exception of the inner Elliott Bay ZSF. Shrimp in this particular area may prove to be a siting concern, although this area is also heavily impacted by gillnet fishing for salmon, ship navigation and anchorage, and toxic contaminants in the nearby Duwamish Waterways.

Bottomfish were sampled by a research trawl and it is important to understand that the data generated are not comparable to that generated by commercial trawls, upon which the Washington Department of Fisheries bases its "flatfish index."

Bottomfish were low in abundance, biomass and species diversity at the Commencement Bay PSDDA sites. In contrast, bottomfish were highest in abundance, biomass and species diversity at the PSDDA sites in

Elliott Bay, when compared with the other locations sampled in Elliott Bay. Saratoga Passage PSDDA sites were not adequately sampled to make a concluding statement, but WDF studies have previously indicated they may be an important area to some commercial fishes. Preliminary analysis of Port Gardner bottomfish indicates that biomass and abundance decrease with depth and towards the mouth of Port Gardner, and are at maximum values during the winter.

PUGET SOUND DREDGE DISPOSAL ANALYSIS (PSDDA)
DISPOSAL SITE INVESTIGATIONS

PART I

Crab and Shrimp Studies

by

Paul A. Dinnel, David A. Armstrong, and Anthony Whiley

INTRODUCTION

In January 1986, the Disposal Site Work Group (DSWG) of the Puget Sound Dredge Disposal Analysis (PSDDA) team, selected preliminary preferred and alternative sites for the unconfined disposal of dredged materials in the main basin of Puget Sound (Phase I area). Initial site selections were based on information gathered from limited field studies conducted within the ZSF's (Zones of Siting Feasibility) and existing information from each ZSF. Selection of final preferred and alternative disposal sites required more detailed evaluations of important physical factors and biological resources in and around the identified sites. One of the key factors in choosing final sites will be an evaluation of important benthic and epibenthic fisheries resources including Dungeness crab (*Cancer magister*), commercial (Pandalid) shrimp and bottomfish.

The purpose of this report is to describe the findings of the trawling studies conducted in and around each of the preliminary PSDDA disposal sites during February, April, June and September of 1986. The trawls conducted during these seasons consisted of beam trawls known to be effective for capturing Dungeness crab but which also sampled shrimp and smaller bottomfish incidental to crabs. Demersal fauna were additionally sampled by a mediumsized otter trawl especially effective in capturing larger bottomfish and shrimp.

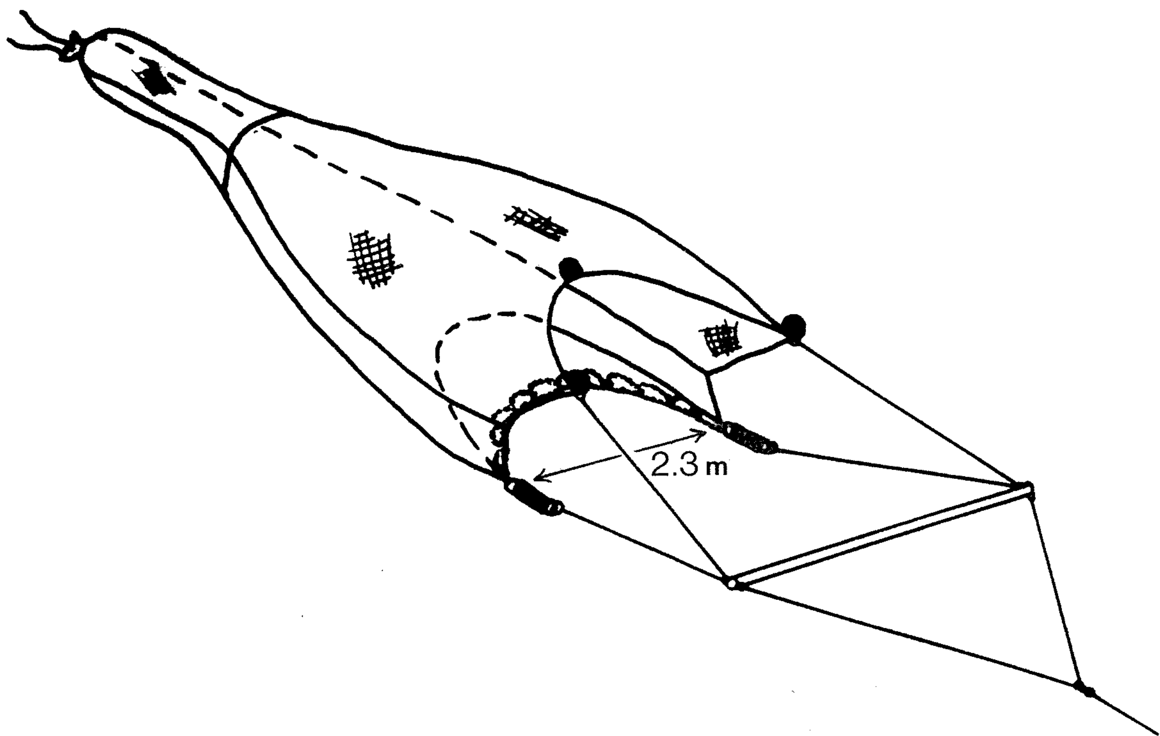
METHODS

Beam Trawl

All trawling was conducted aboard the 16 m research vessel *Kittiwake*. Dungeness crabs were sampled with a 3 m beam trawl (Figure 1, top; Gunderson and Ellis 1986) previously used elsewhere in Puget Sound (Dinnel et al. 1985a, 1985b, 1986; Weitkamp et al. 1986). The beam trawl was towed at each station approximately 232 meters (1/8 nautical mile) at a target ground speed and time of 2.5 km/hr (1.5 knots) for 5.5 minutes which yielded an area swept by the net (opening = 2.3 meters) of 534 m^2. All crabs caught in the trawl were measured, sexed, and assessed for molt condition (degree of shell softness) and reproductive condition (females with or without eggs) and returned to the water. Catches of shrimp and fish from the beam trawls were preserved for later processing in the laboratory.

Otter Trawl

Bottomfish and shrimp were sampled with a 7.6 m otter trawl (Figure 1, bottom) designed for the Southern California Coastal Water Research Project (Mearns and Allen 1978). The otter trawl was towed approximately 370 m (1/5 nautical mile) at a target ground speed and time of 4.2 km/hr (2.5 knots) for 5.3 minutes which yielded an area swept by the net (opening = 6 m) of 2,220 m^2. Incidentally caught crabs were processed on board as described above and returned to the water. Bottomfish and shrimp were identified and counted on board ship, and then at the end of the day, frozen for later processing in the laboratory. Laboratory processing for shrimp included identification to



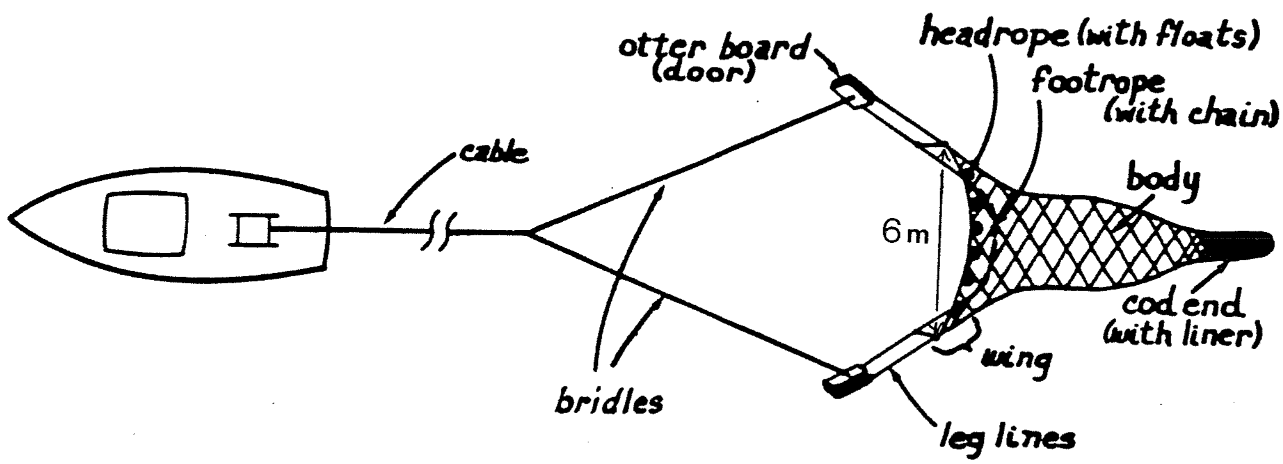


Figure 1. Diagrams of the beam trawl (top) and otter trawl (bottom) used in this study.

species (commercial species only), measurement of carapace lengths and assessments of reproductive condition (shrimp with or without eggs). Bottomfish processing included identification to species, measurements for length and weight, and a check for obvious external abnormalities or parasites (primarily flatfish). See Part II for further discussion of the bottomfish methods and results.

Sample Sites and Stations

Beam trawls. Beam trawl sampling was conducted in and around seven preliminary preferred or alternative disposal sites in four general areas of Puget Sound (Figure 2). The Saratoga Passage site was surveyed in February and June 1986, but not in September as the site was viewed as the second alternative to the Port Gardner preferred site. The trawl stations in Saratoga Passage consisted of three stations within the preliminary disposal site; eight stations stratified by depth (10, 20, 40 and 80 m below mean lower low water [MLLW]) along Transect 1 east and west of the disposal site; and three stations along Transect 2 north of the disposal site (Figure 3). Transect 2 was sampled only in June.

Beam trawl sampling in Port Gardner was conducted during four seasons (February, April, June and September 1986). Sampling was conducted at two preliminary disposal sites and along seven north-south transects crossing Port Gardner (sample depths from 10 to 165 m) (Figure 4). Three stations each were sampled within PSDDA Sites 1 and 2 during each season. The boundaries of PSDDA Site 1 were moved slightly eastward prior to sampling in September (dashed circle, Figure 4). Thus, this new site included PSDDA 1 Stations 1 and 2, Transect 3 Station 130M and Station H (which was added in September to provide better sampling coverage of the new site) (Figure 4). The Transect 1,

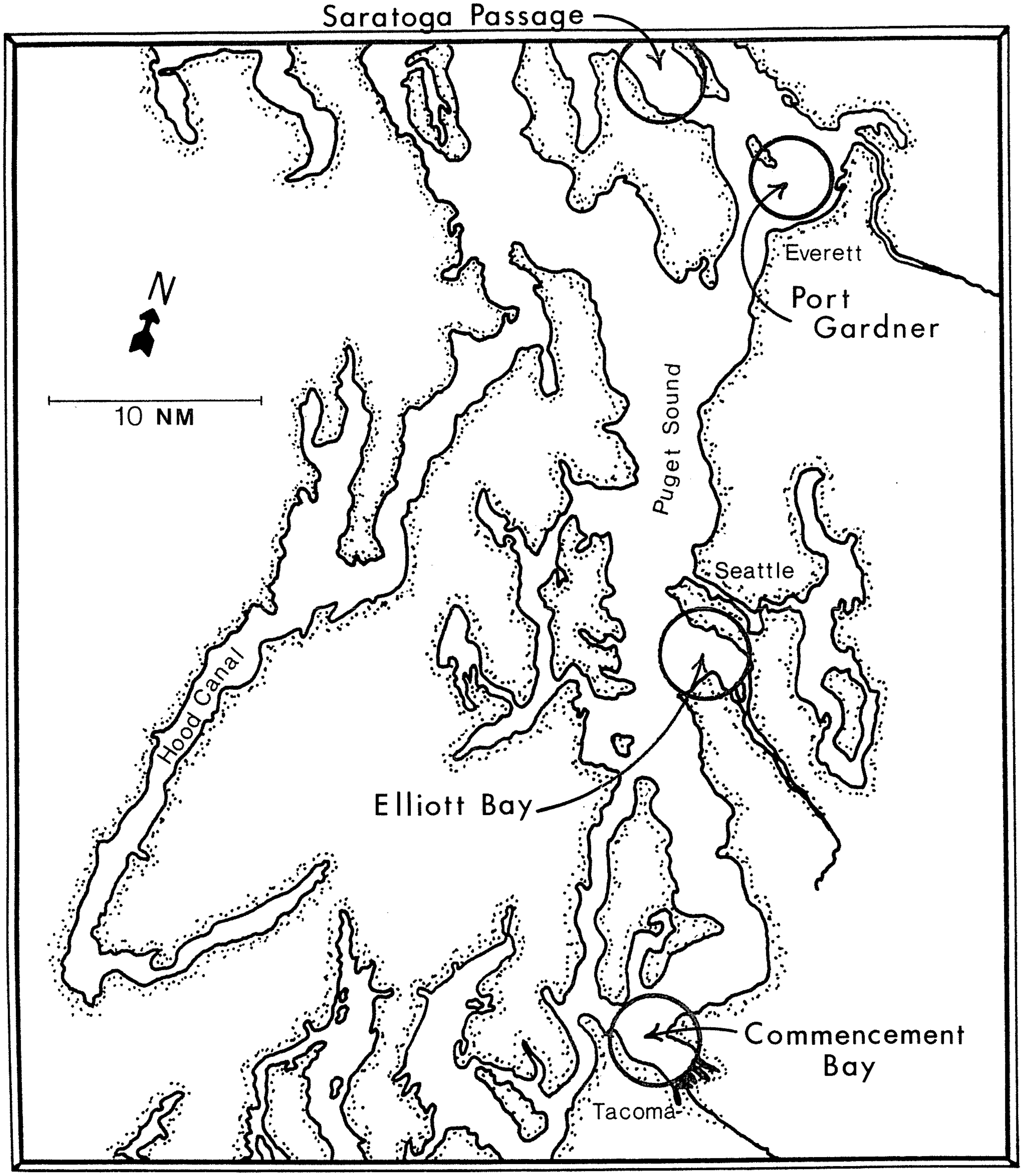


Figure 2. Map of Puget Sound showing the general locations of the preliminary PSDDA disposal sites in the Main Basin.

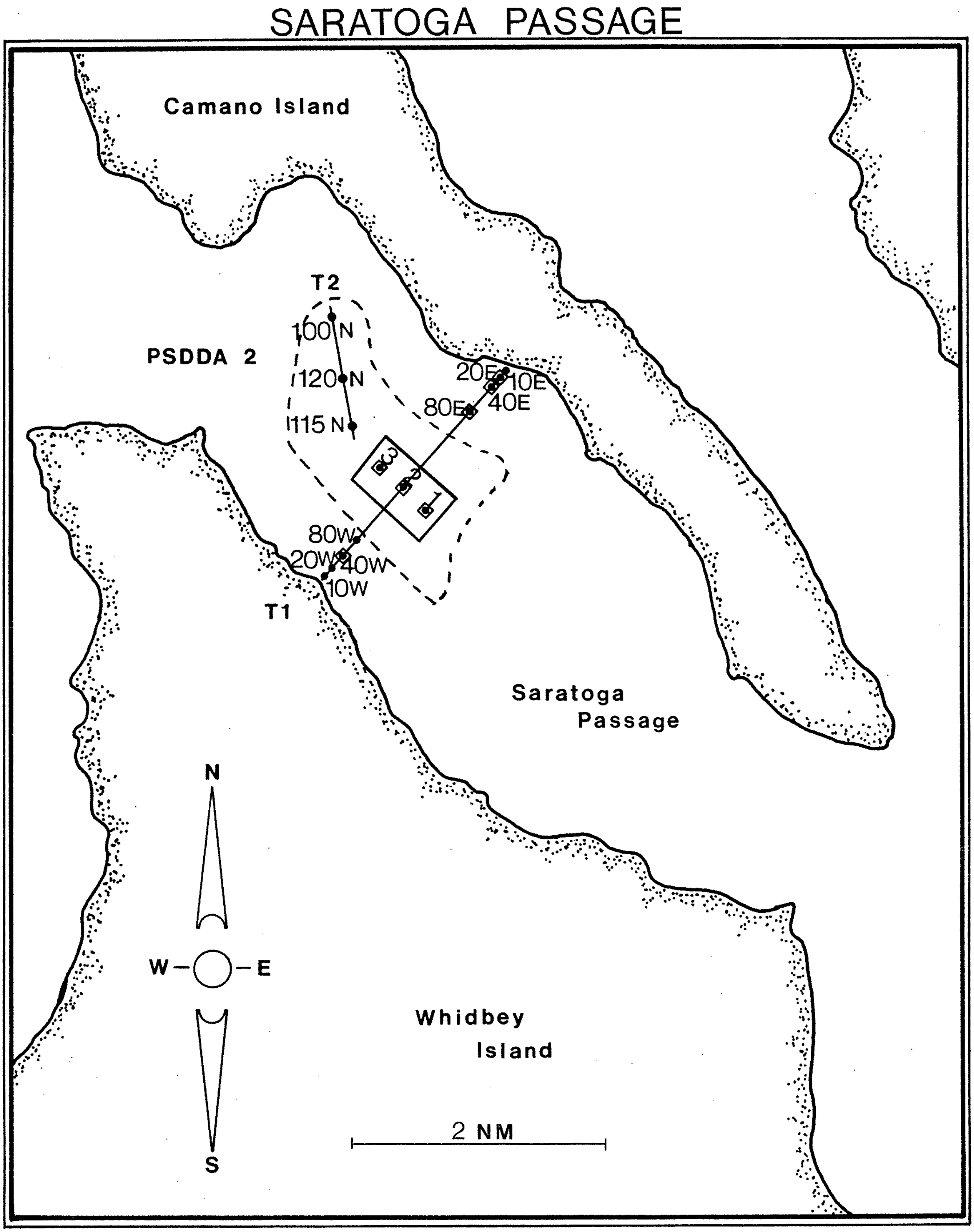


Figure 3. Map of Saratoga Passage showing the beam trawl (●) and otter trawl (□) sampling stations in and around the preliminary Saratoga Passage (PSDDA 2) disposal site. The dash line indicates the area of the Zone of Siting Feasibility (ZSF).

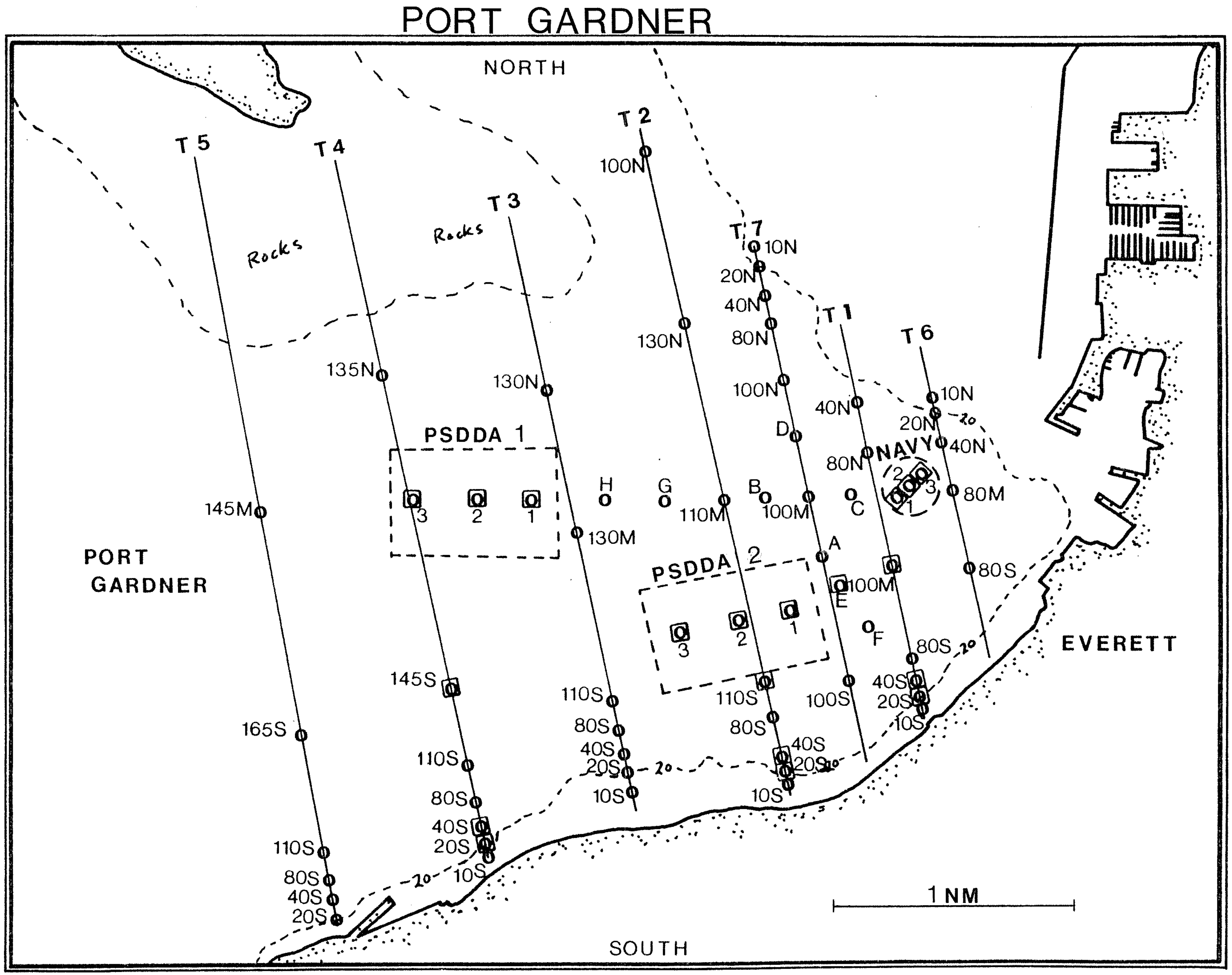


Figure 4. Beam trawl (O) and otter trawl (□) sample stations in Port Gardner. Depths in meters. N = North, M = Middle, S = South.

40N Station was dropped from the sampling array after February 1986 due to repeated gear damage at this location. Some additional beam trawl stations (A-H; Figure 4) were also added in June and September to provide better sampling coverage of the inner portion of the bay in relation to another proposed (NAVY) disposal site (Dinnel et al. 1987).

Beam trawl sampling in Elliott Bay was conducted during three seasons (February, June and September 1986) at two preliminary disposal sites and along two nearshore transects (10, 20, 40 and 80 m depths) (Figure 5). Three stations were sampled within PSDDA Site 1 in inner Elliott Bay during February and June. The location of PSDDA Site 1 was relocated slightly eastward prior to the September trawls; hence, two additional stations (Stations 4 and 5; Figure 5) were added to better characterize the resources within the new site. Three stations were trawled within PSDDA Site 2 (off Fourmile Rock) during all three seasons. The 40 m depth along Transect 2 off Fourmile Rock was deleted due to a rough bottom and repeated gear damage.

Beam trawl sampling in Commencement Bay was conducted during three seasons (February, June and September 1986) at two preliminary PSDDA disposal sites and along two transects stratified by depth (10, 20, 40, 80 and 120 m below MLLW) (Figure 6). Three trawls each were made in PSDDA Sites 1 and 2 in February. By June, PSDDA Site 2 had been relocated to the north of PSDDA Site 1 based on information about relative deposition/erosion potential from the depositional analysis procedure. This new site (called PSDDA Site 2B in this report, Figure 5) was trawled together with PSDDA Site 1 in June. PSDDA Sites 1 and 2B were again sampled in September except that a slight shift of PSDDA Site 1 eastward resulted in the addition of one new station (PSDDA Site 1, Station 4; Figure 6) during this season. As was the case in Elliott Bay, rough bottom conditions resulted in the deletion of the 80 m station on the

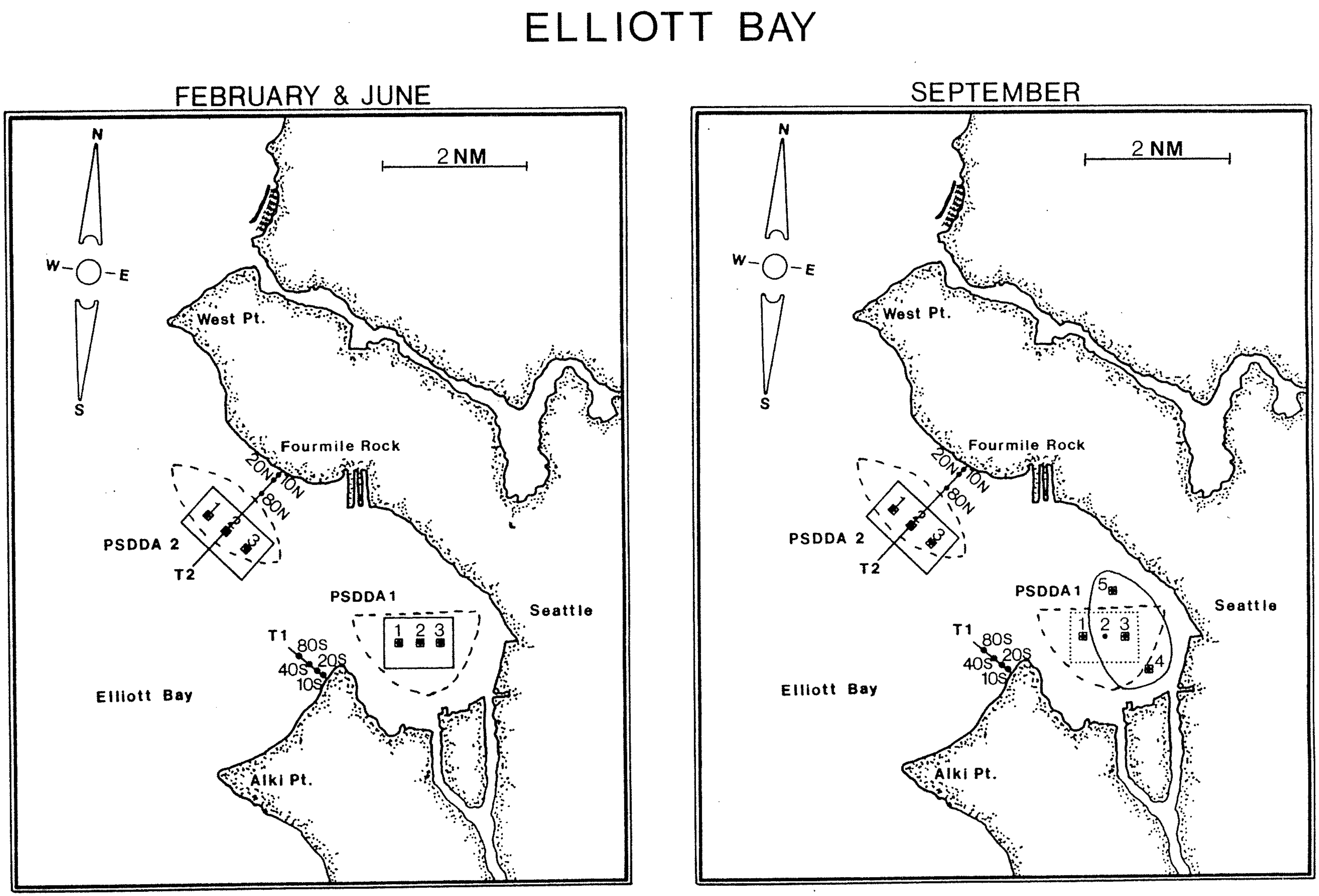
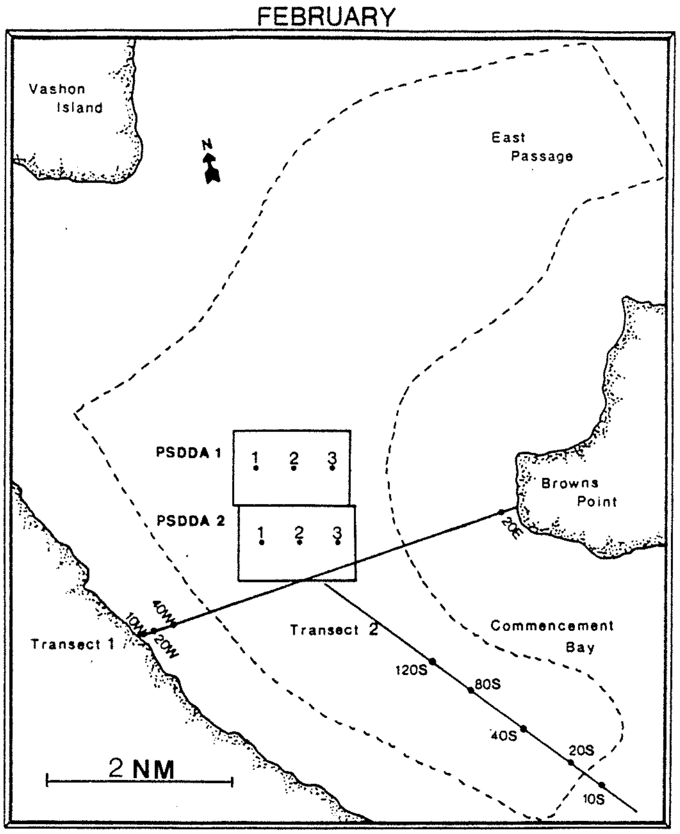
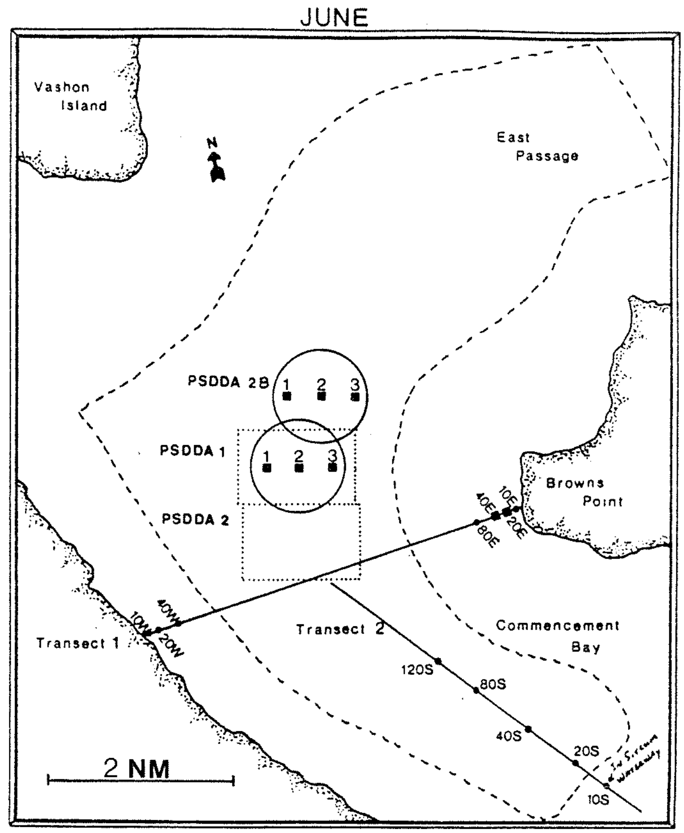


Figure 5. Maps of Elliott Bay showing the beam trawl (●) and otter trawl (□) sampling stations by season in and around the two proposed Disposal Sites in Elliott Bay. The dashed line areas indicate the Zones of Siting Feasibility (ZSF). The dotted line within PSDDA Site 1 (September) was the site originally selected within ZSF 1 and the solid line area shows the approximate location of the newly located site.

COMMENCEMENT BAY





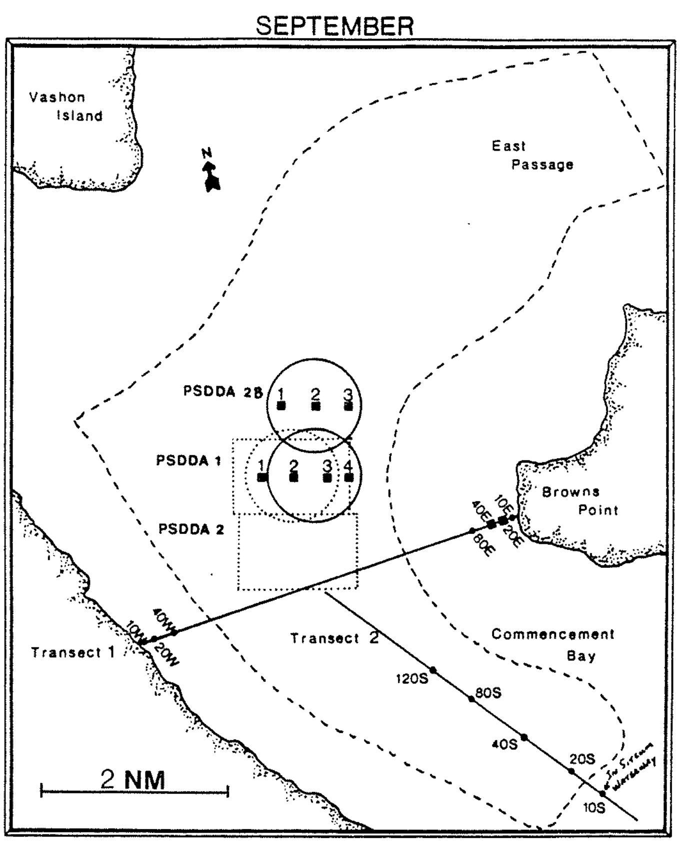


Figure 6. Maps of Commencement Bay showing the beam trawl (●) and otter trawl (□) sampling stations by season in and around the two preliminary disposal sites in Commencement Bay. The dashed line area shows the Zone of Siting Feasibility (ZSF). The dotted line areas show areas of prior locations for the preliminary disposal sites and the solid lines show the present disposal site locations.

west end of Transect 1.

The exact locations, depths and trawl directions for all trawl stations are recorded in Appendix Tables 1-4.

Otter trawls. Otter trawling was conducted at selected beam trawl stations in Saratoga Passage in June, in Port Gardner in February, April, June and September, and in Elliott and Commencement bays in June and September. See Part II of this report for further discussion of the otter trawl work and the results of the beam trawl fish catches.

RESULTS

Dungeness Crab

Saratoga Passage. The overall average beam trawl catches of Dungeness crab in Saratoga Passage were 1.2 and 42.8 crab/hectare (ha) for the February and June cruises, respectively. Dungeness crab were never caught within the preliminary PSDDA disposal site or at the deep Transect 2 stations north of the PSDDA site (Figure 7). All Dungeness crab were caught along Transect 1 on both east and west sides of Saratoga Passage. Station 10E (10 meters deep - east side) had the highest catches of Dungeness crab in both February and June. Only one Dungeness crab was caught by the otter trawl in June, this being at Station 20E on the Camano Island side of Saratoga Passage. Dungeness crab catches for both trawl types and for both seasons are summarized in Appendix Table 5.

Histograms of Dungeness crab carapace width-frequencies show that about 95% of the crabs caught were mature animals ranging in size from 100 to 165 mm carapace width (CW) (Figure 8). Only two juvenile (20-30 mm) crabs were caught, this being in February. These two individuals undoubtedly belonged to

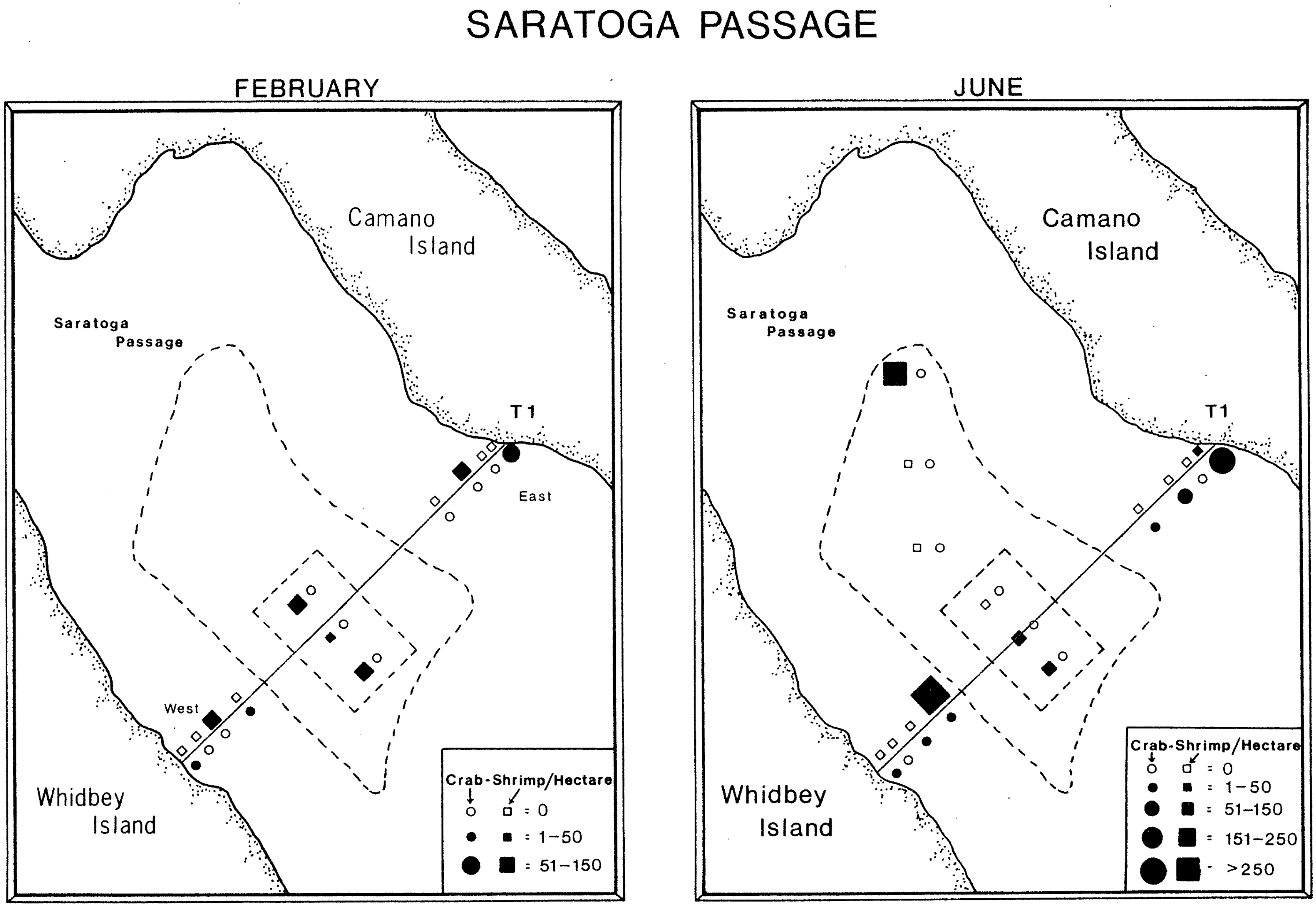


Figure 7. Maps of Saratoga Passage showing the approximate beam trawl Dungeness crab and shrimp catches at each sample station by season.

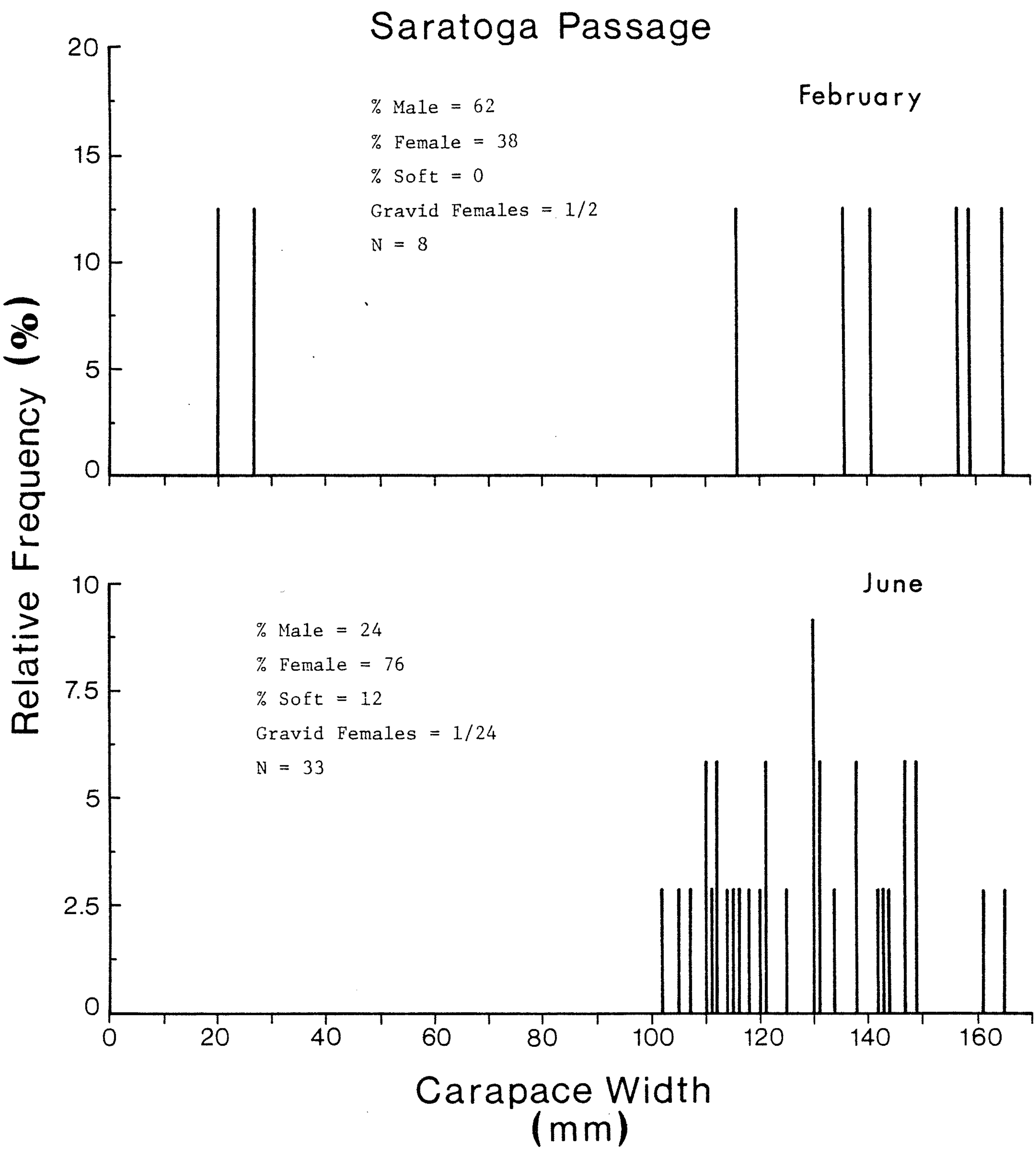


Figure 8. Dungeness crab size-frequency histograms by season for crabs caught in Saratoga Passage.

the 1985 year group. Soft crabs (indicative of recent molting) were only found in June (12%) and only one gravid female was caught during each season.

Occasional rock crabs (Cancer productus and C. gracilis) were also caught by beam trawl in Saratoga Passage. Once again, these crabs were all caught at the inshore stations of Transect 1.

Port Gardner. Up to 63 stations in Port Gardner were sampled by beam trawl in February (n = 56), April (n = 55), June (n = 55) and September (n = 63) 1986. The overall average numbers of Dungeness crab caught/ha (± 1 standard deviation) in Port Gardner and within each of the preliminary disposal sites (n = 3 in each case) for each season were (Figure 9):

Average # Crab/ha ± 1 Standard Deviation

Season	Port Gardner	NAVY	PSDDA 2	PSDDA 1
February	126 ± 150	225 ± 98	6 ± 11	0 ± 0
April	85 ± 127	388 ± 141	19 ± 19	0 ± 0
June	114 ± 178	502 ± 103	19 ± 32	0 ± 0
September	100 ± 119	76 ± 51	11 ± 0	25 ± 29
Average	106.2 ± 145.3	297.8 ± 103.3	13.8 ± 19.4	6.2 ± 14.5

Dungeness crab were also sampled by otter trawl (incidental to fish catches) at selected stations in Port Gardner and at each disposal site (n = 3) during each season. Crab catches by otter trawl were usually less than the beam trawl (based on equivalent area trawled) and substantially less at the NAVY disposal site (Figure 9). The average numbers (± 1 standard deviation)

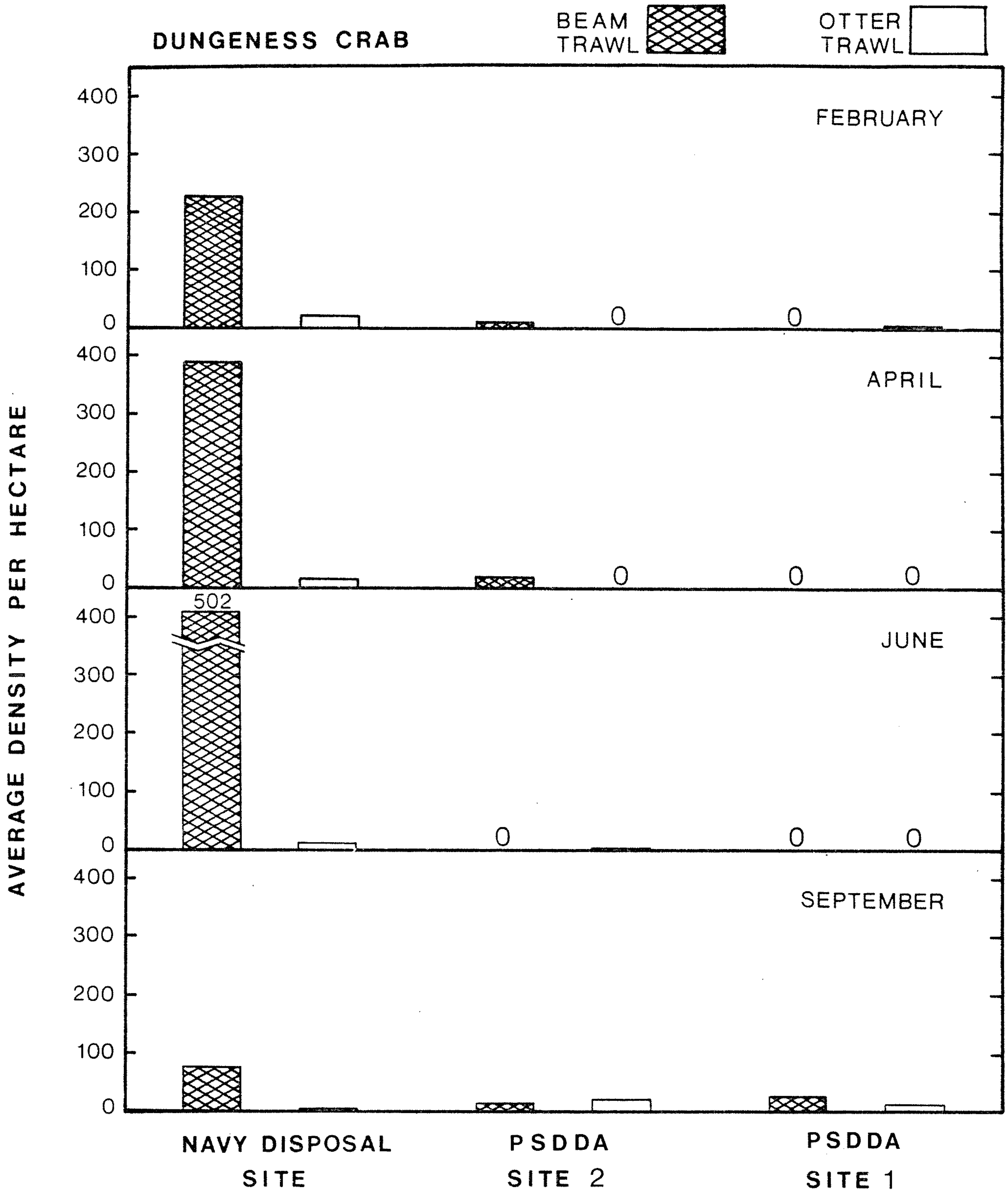


Figure 9. Comparative average densities of Dungeness crab at the Navy Disposal Site and the two control sites in Port Gardner by season and by trawl type.

of Dungeness crab caught/ha at the three disposal sites for each season were:

Average # Crab/ha ± 1 Standard Deviation

Season	NAVY	PSDDA 2	PSDDA 1
February	21 ± 10	0 ± 0	2 ± 3
April	15 ± 6	0 ± 0	0 ± 0
June	9 ± 9	1 ± 2	0 ± 0
September	2 ± 3	20 ± 7	12 ± 4
Average	11.8 ± 7.5	5.2 ± 3.6	3.5 ± 2.5

Dungeness crab catches for the beam trawl in Port Gardner are summarized in Appendix Tables 8-12. The otter trawl crab catches are summarized in Appendix Tables 14, 15 and 17.

Based on the beam trawl sampling efforts, the average annual abundance of Dungeness crabs in Port Gardner was estimated to be 106 crab/ha within our sampling grid. The estimated relative abundances at PSDDA Sites 1 (= Control 1) and 3 (= Control 2) were only 13% and 6%, respectively, of this average annual abundance for Port Gardner.

The distributions of male and female crabs illustrated in Figures 10 and 11 show that males were relatively scarce. Typically the males accounted for only 10% of the total crab catch and were generally found at the shallower stations (averge depth of capture for males = 29 m). Female crabs were much more plentiful, were found in abundance at deeper depths (down to ~100 m; average capture depth = 63 m), and especially preferred the "nearshore slope" area of Port Gardner instead of the deep, flat areas in the middle of the bay.

MALE CRAB — PORT GARDNER

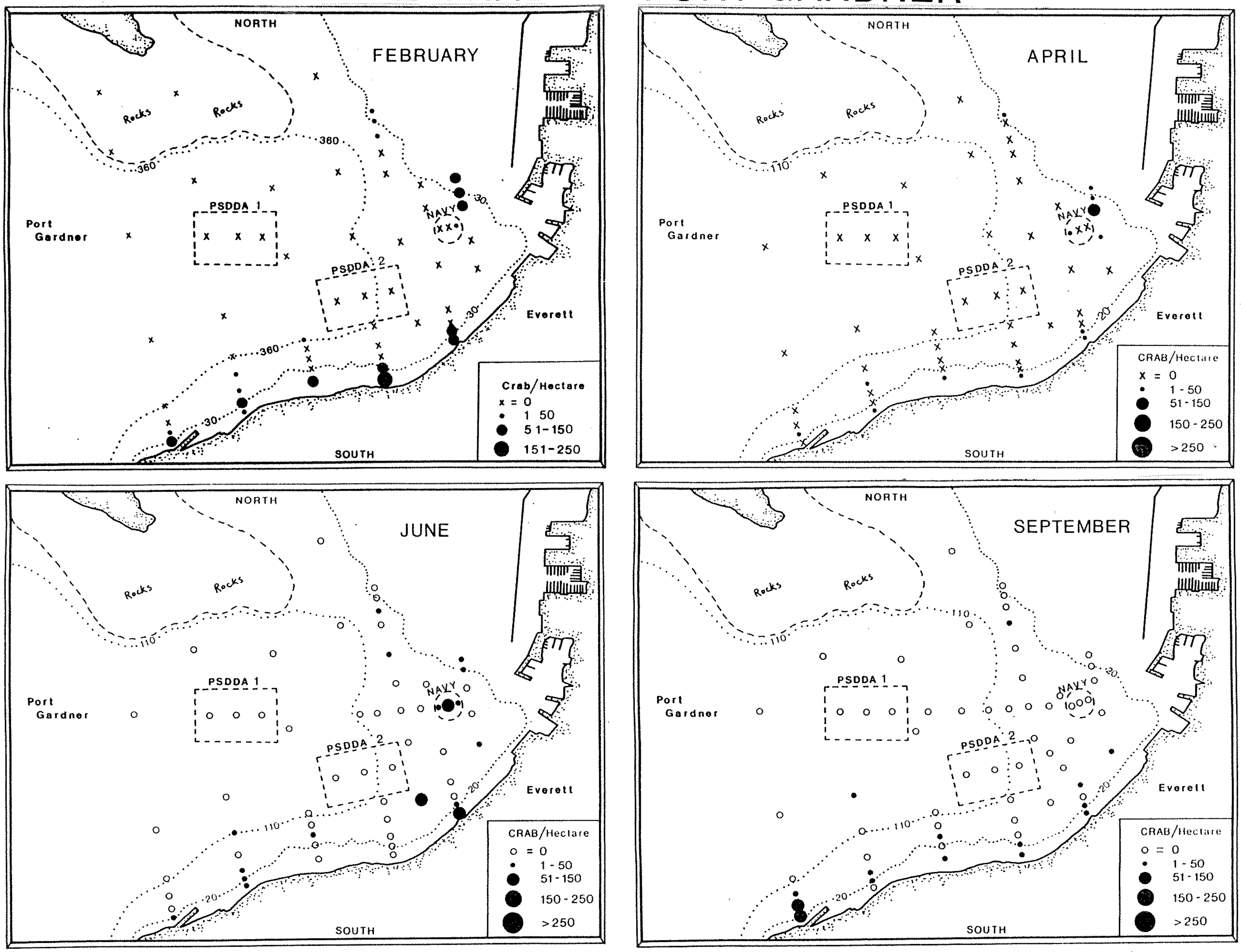


Figure 10. Distribution of male Dungeness crabs caught by beam trawl in Port Gardner during the seasonal sampling in 1986.

FEMALE CRAB – PORT GARDNER

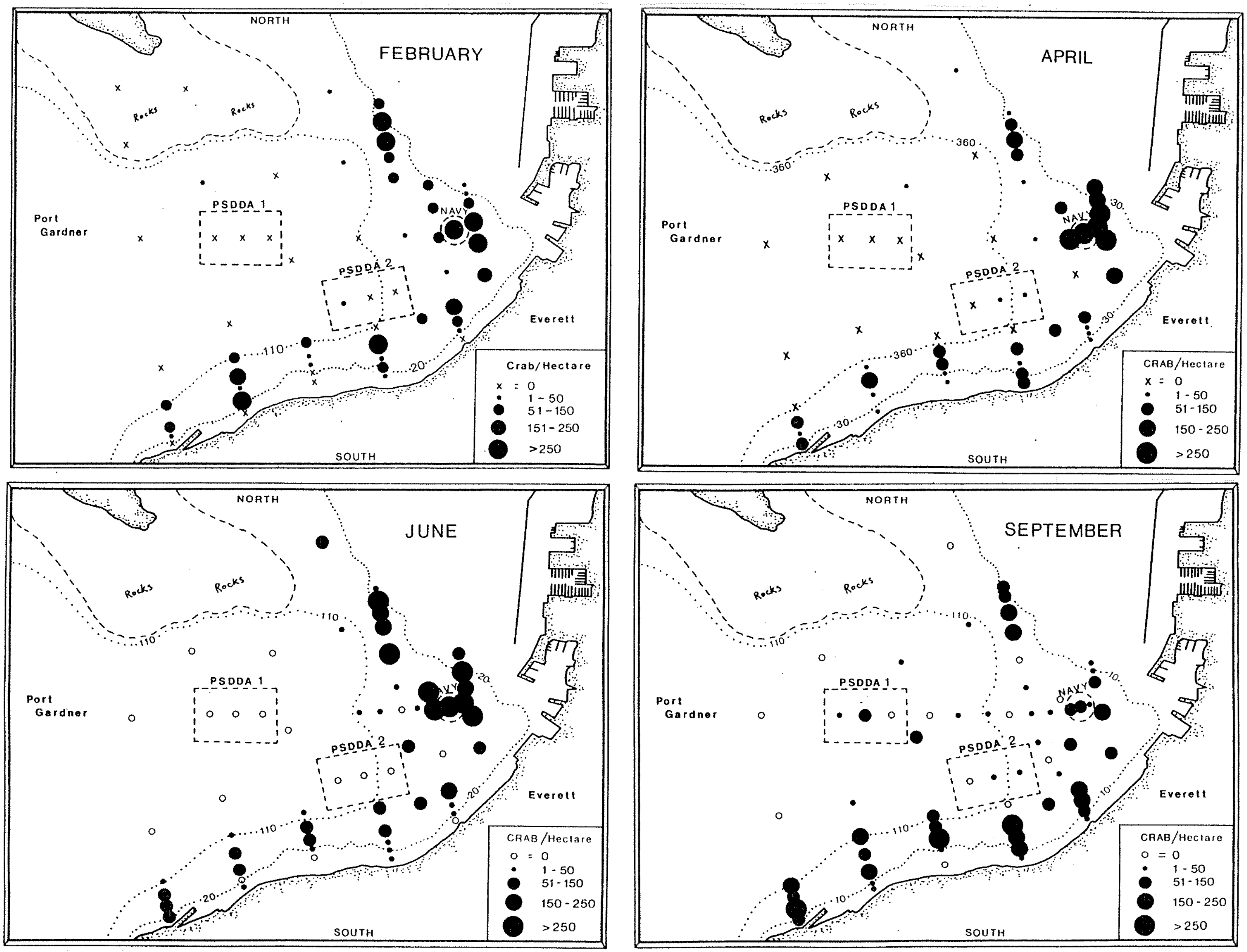


Figure 11. Distribution of female Dungeness crabs caught by beam trawl in Port Gardner during the seasonal sampling in 1986.

This pattern is illustrated in greater detail in Figure 12 which shows that the highest abundances of Dungeness crab occur above 100 m depth. Rarely were crabs found at stations in the middle of the bay except during September when crabs may have "spread out" to deeper areas while foraging for food.

The average carapace width of all Dungeness crabs caught in Port Gardner was 125 ± 13 mm with little difference between males (132 ± 21 mm) and females (124 ± 11 mm). Histograms of carapace width-frequencies (Figure 13) show, however, that the size range for male crabs was greater (80-180 mm) than that for the females (100-150 mm) and that crabs less than about 2 years of age were not caught in the trawls.

Size-frequency histograms (Figure 14) for male crabs by season show a gradual increase in average size from 131 mm in February to 139 mm in September with no recruitment of young crabs (i.e., < 100 m CW) after April. These histograms also suggest that larger legal-sized (≥ 160 mm) crabs disappear from the population, probably due to removal by the commercial/sport fishery.

Female size-frequency histograms (Figure 15) show a pattern different than the males. Essentially no growth is evident based on the seasonal average sizes (123-126 mm CW), but close inspection of the histograms indicates that growth of the smaller females (CW 100-130 mm) is occuring but that this growth is counteracted by a decline in the proportion of females > 130 mm CW, possibly due to natural mortality or emigration to areas outside our sampling grid.

Elliott Bay. Only four Dungeness crab were caught by beam trawl in Elliott Bay during all three sample seasons. None were caught by the otter trawl. Two Dungeness crabs (both mature, non-gravid females) were caught in

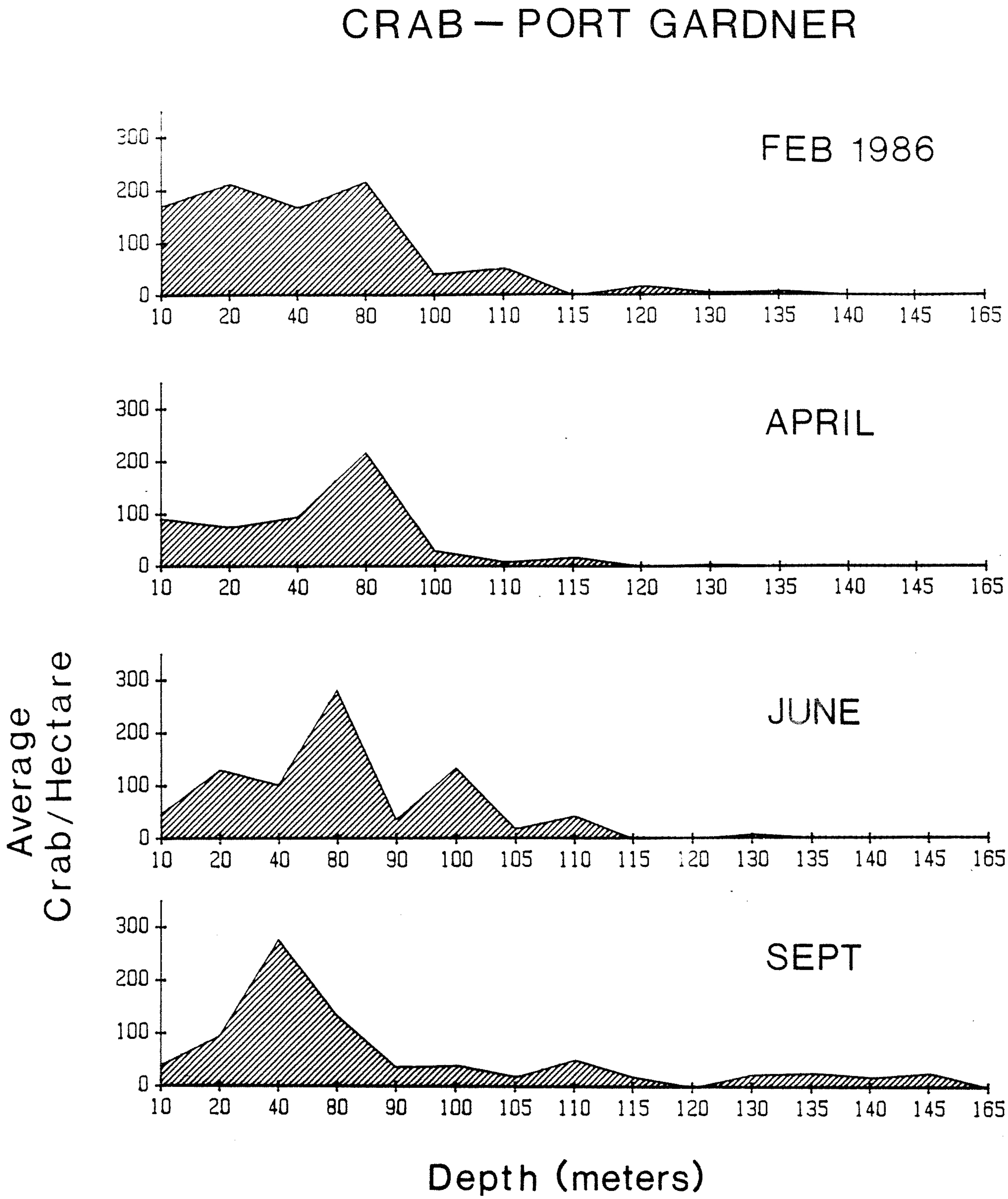


Figure 12. Distribution by depth of all Dungeness crabs caught by beam trawl in Port Gardner during seasonal sampling in 1986.

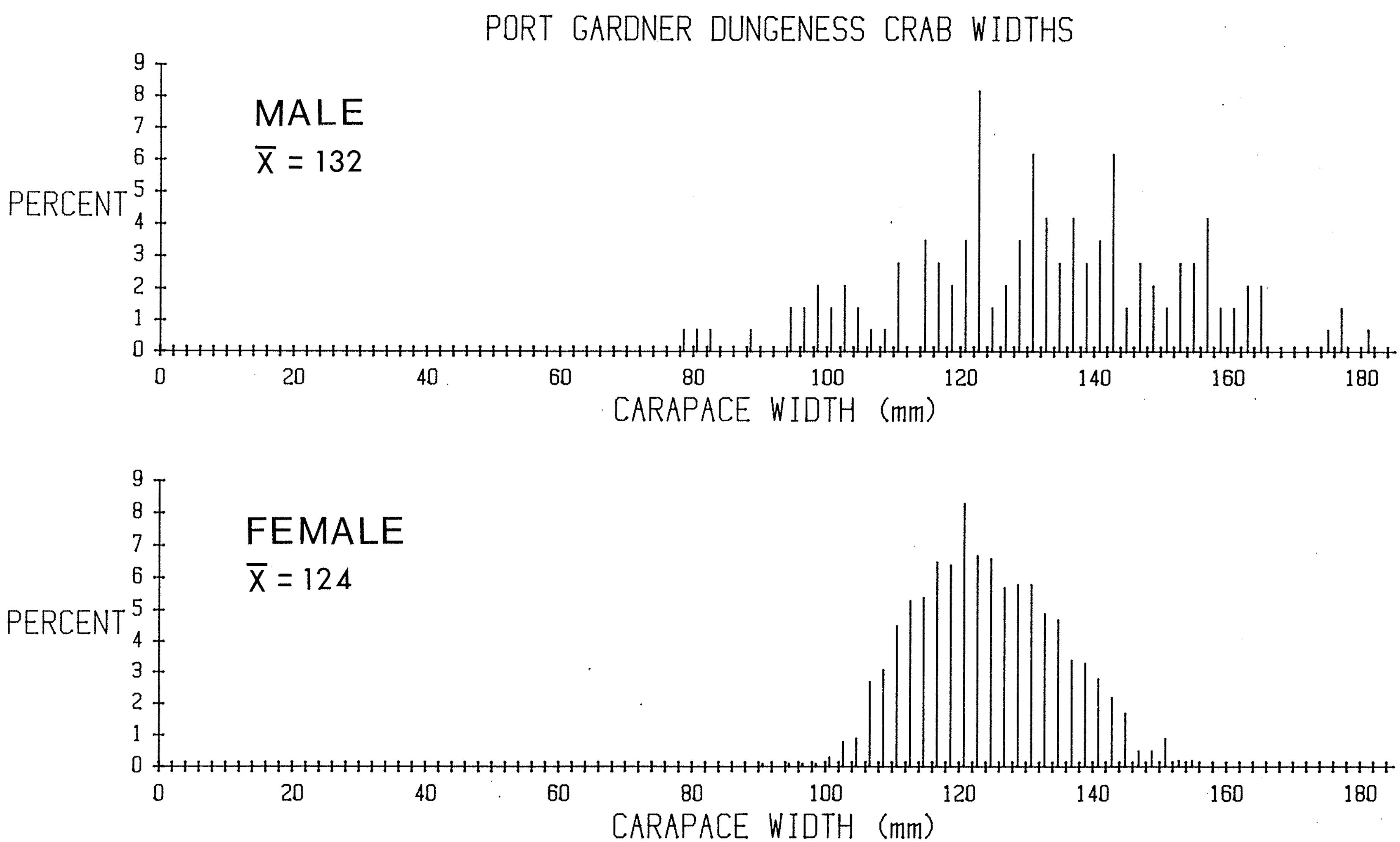


Figure 13. Carapace width-frequency histograms of all male and female Dungeness crabs caught by beam trawl in Port Gardner during seasonal sampling in 1986.

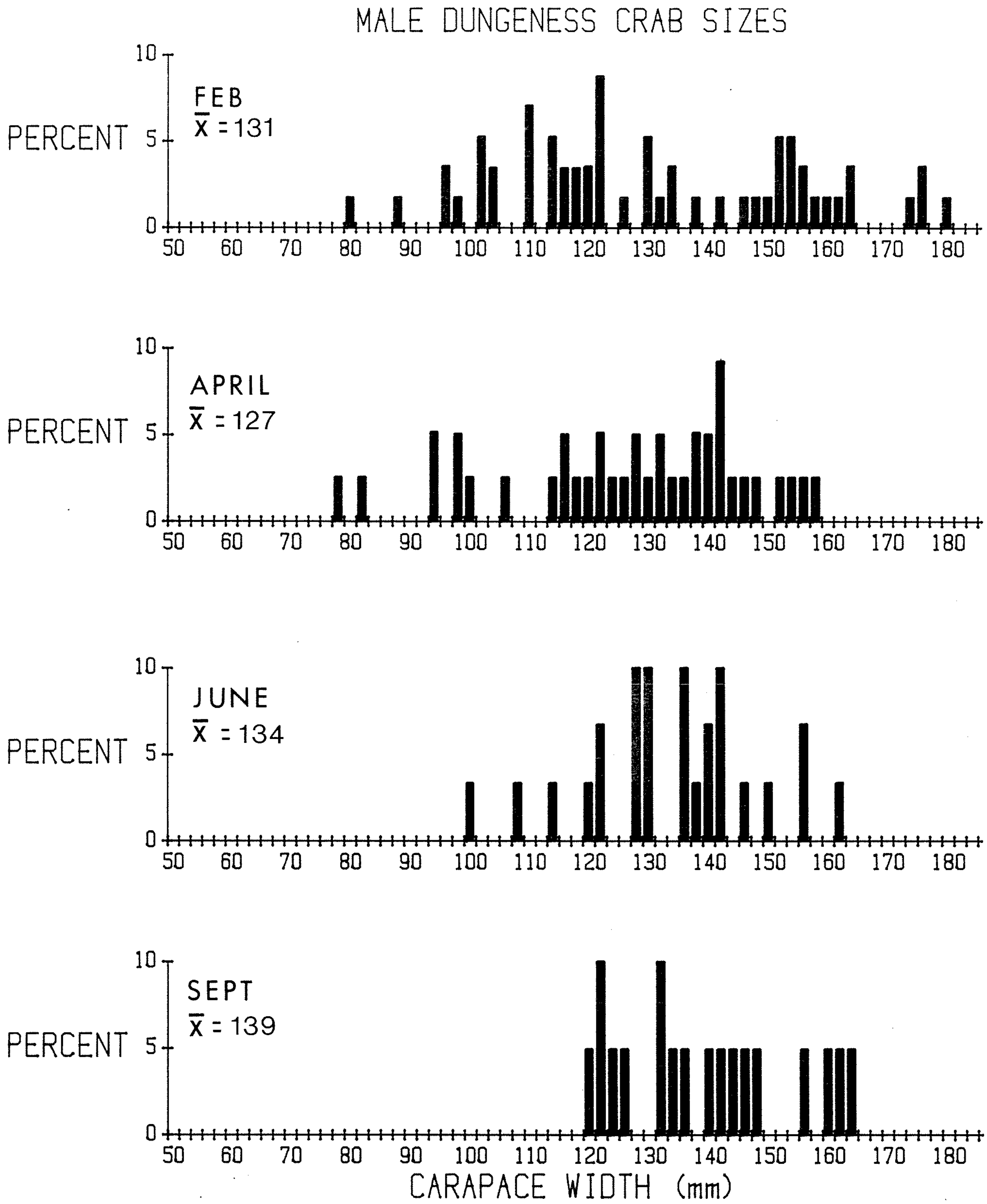


Figure 14. Carapace width-frequency histograms for all male Dungeness crab caught by beam trawl in Port Gardner during seasonal sampling in 1986.

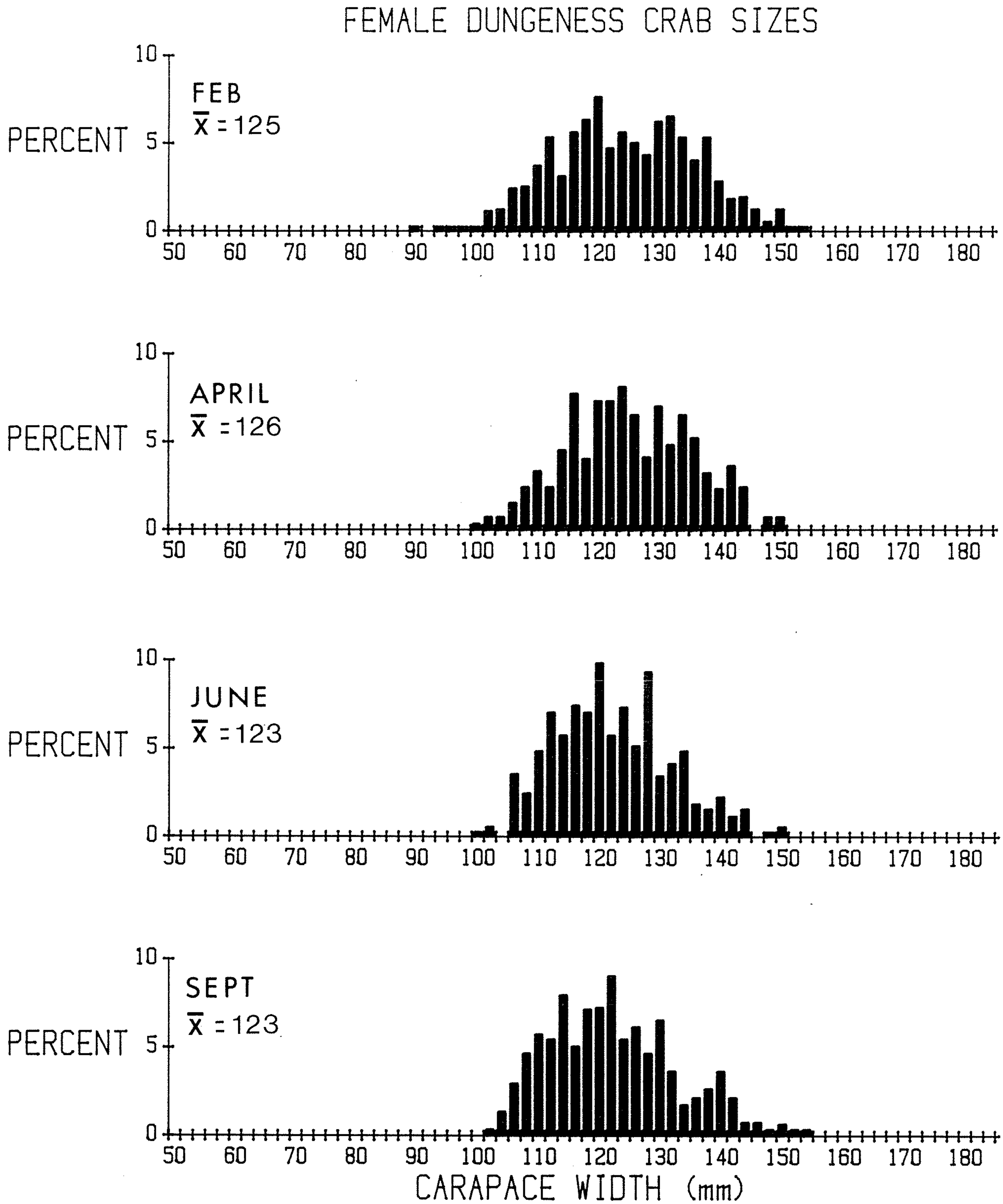


Figure 15. Carapace width-frequency histograms for all female Dungeness crabs caught by beam trawl in Port Gardner during seasonal sampling in 1986.

June at the 10 and 20 m stations of Transect 1 off Duwamish Head (Figure 16). Two mature males were caught in September, also at the 10 m station of Transect 1. Occasional rock crabs were also caught at the shallower stations of Transects 1 and 2.

Commencement Bay. No Dungeness crab were caught in Commencement Bay by either trawl gear. Occasional rock crabs were again caught at the shallower stations (10-40 m) in all three seasons.

Shrimp

Catch data were collected on six species of Pandalid shrimp of commercial or sport value. These six species were: Spot prawn, *Pandalus platyceros*; Coonstripe shrimp, *P. danae*; Humpback shrimp, *P. hypsinotus*; Flexed shrimp, *P. goniurus*; Pink shrimp, *P. borealis*; Smooth pink shrimp, *P. jordani*; and sidestripe shrimp, *Pandalopsis dispar* (Butler 1980).

Saratoga Passage. The overall average number of shrimp caught by the beam trawl in Saratoga Passage in February and June was essentially the same at 51.9 and 56.2 shrimp/ha, respectively. The largest shrimp catch (300 shrimp/ha) was at the 80 m station on the Whidbey Island side of Transect 1 in June, followed by the 100 m station (243 shrimp/ha) on Transect 2, also in June (Figure 7). The two most abundant shrimp species were the pink and smooth pink shrimps (Appendix Table 6).

The average shrimp catch within the preliminary PSDDA disposal site was 46.8 and 68.7 shrimp/ha for February and June, respectively. Sidestripe shrimp were the most abundant shrimp species caught by the beam trawl in the disposal site in February, while pink shrimp were the most common species in

ELLIOTT BAY

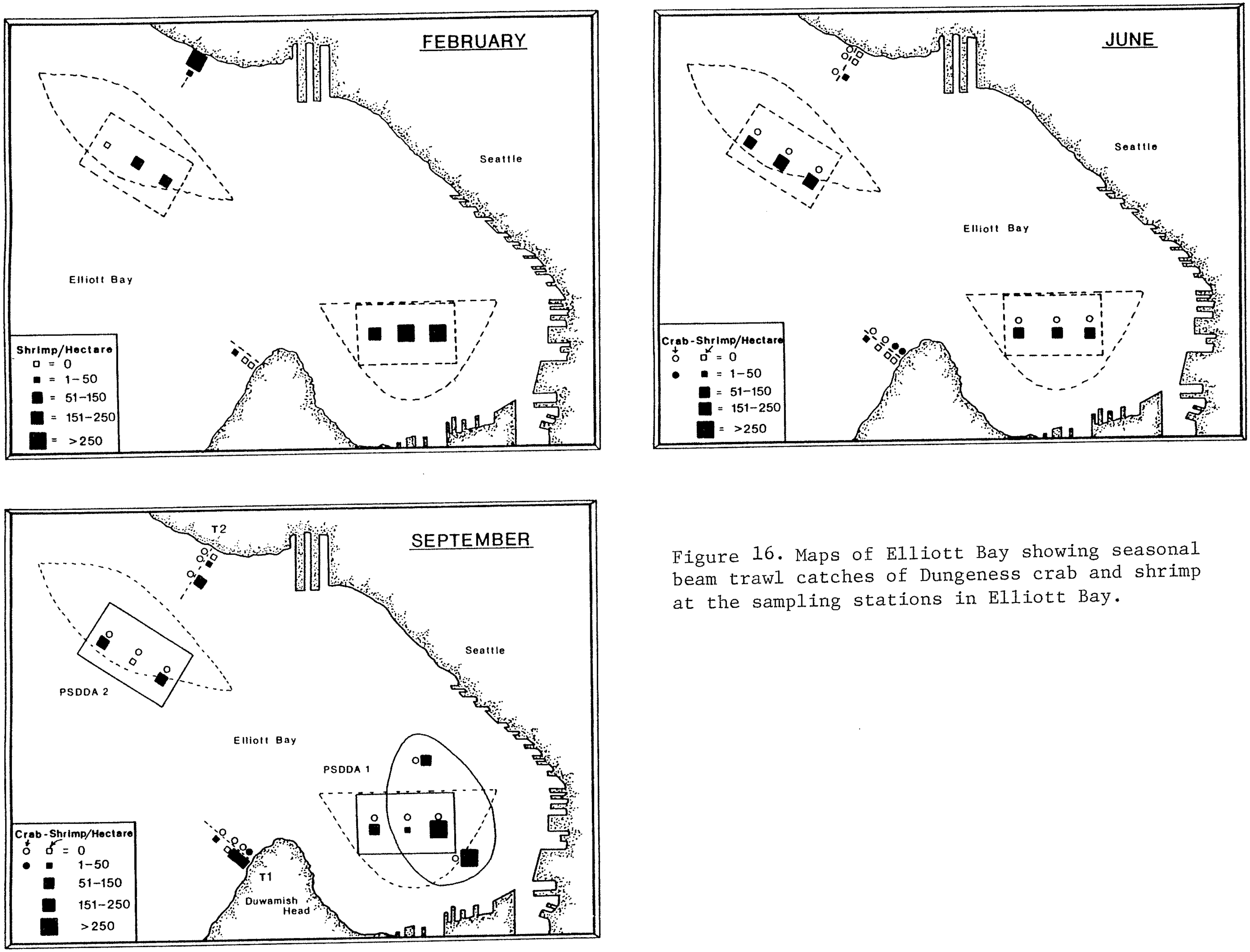


Figure 16. Maps of Elliott Bay showing seasonal beam trawl catches of Dungeness crab and shrimp at the sampling stations in Elliott Bay.

June (Figure 9; Appendix Table 6). However, the otter trawl in June caught more sidestripe shrimp than pink shrimp and caught a total of 126.2 shrimp/ha for all species combined (Figure 17; Appendix Table 7).

Port Gardner. The overall average number of shrimp/ha (± 1 standard deviation; all species combined) caught by the beam and otter trawls in the 3 preliminary Port Gardner disposal sites during each season of 1986 were (n = 3 in each case):

Average # Shrimp/ha ± 1 Standard Deviation

Season	NAVY	PSDDA 2	PSDDA 1
Beam Trawl:			
February	687 ± 518	81 ± 11	0 ± 0
April	0 ± 0	12 ± 11	56 ± 19
June	8 ± 13	0 ± 0	6 ± 11
September	293 ± 249	6 ± 11	31 ± 11
Average	446.9 ± 381.6	25.0 ± 35.1	23.4 ± 25.4
Otter Trawl:			
February	188 ± 170	354 ± 184	135 ± 43
April	113 ± 21	32 ± 21	30 ± 5
June	5 ± 5	117 ± 149	80 ± 44
September	443 ± 81	86 ± 20	101 ± 18
Average	186.9 ± 175.0	147.1 ± 164.2	86.3 ± 48.4

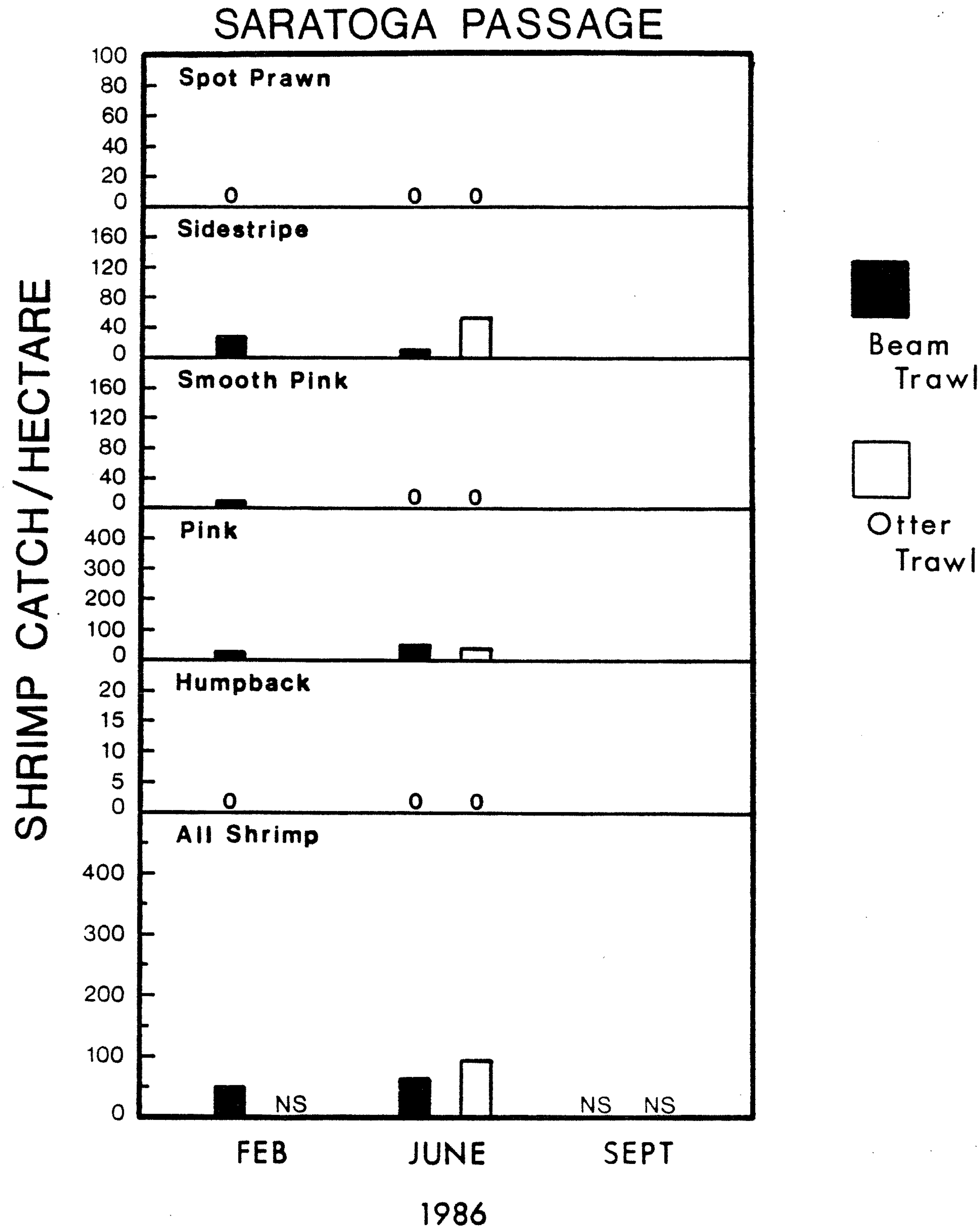


Figure 17. Beam and otter trawl shrimp catches by species and by season for PSDDA Site 2 in Saratoga Passage. The bars are the average catches for the three stations within the Disposal Site. N.S. = not sampled.

For each gear type, the pattern of relative shrimp densities between the three disposal sites (based on annual averages) was NAVY > PSDDA 2 > PSDDA 1.

Plots of overall shrimp abundances in Port Gardner by season (Figure 18) show that the nearshore slope area (including the NAVY site) was the most important area for shrimp with relatively few shrimp occurring at the deeper stations in the middle of the bay. Figure 18 also shows that there was a distinct seasonality in general shrimp abundances with the highest densities being present during the fall-winter period. The fate of these shrimp during spring and summer is presently unknown.

Plots of shrimp distributions by depth (Figure 19) reinforce the finding that the nearshore slope area provides the most important habitat. The great majority of all shrimp caught by beam trawl in 1986 were found at stations between about 20 and 100 m depth with the exception of April when very few shrimp were caught (Figure 19).

The shrimp species most commonly caught within the three disposal sites in Port Gardner varied with site, season and trawl gear (Figure 20). Generally, sidestripe and pink shrimp were the most abundant at the disposal sites with the smooth pink shrimp being fairly abundant at the NAVY site. Coonstripe shrimp were never caught at these relatively deep stations and humpback and flexed shrimp were scarce. The reasons for the sometimes extreme differences in shrimp density estimates between the two trawl gears are presently unknown and may be, in part, species-dependent. The Port Gardner shrimp catch data for both trawls are summarized in Appendix Tables 13, 14 and 16-18.

Elliott Bay. The overall average beam trawl catches of shrimp in Elliott

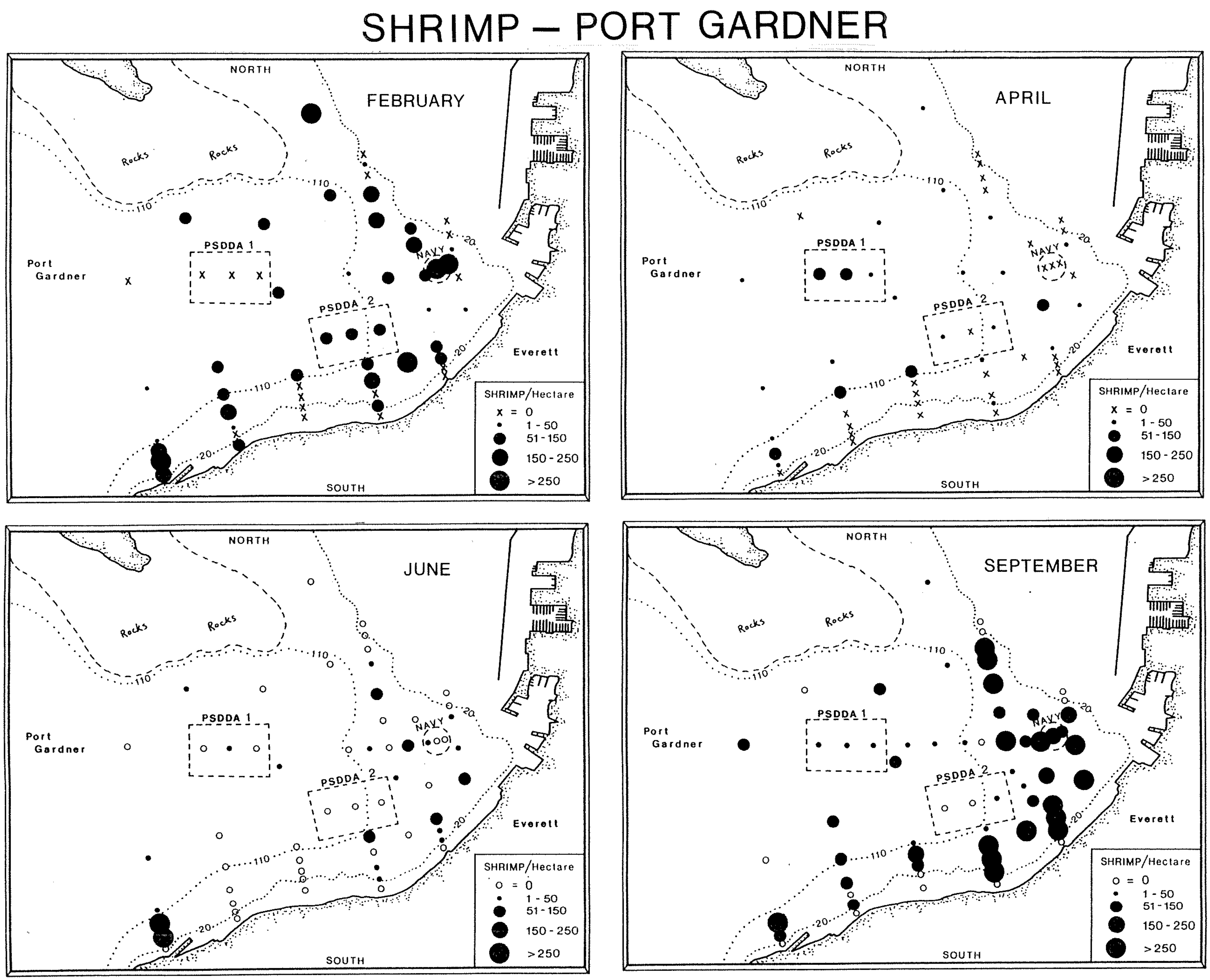


Figure 18. Distribution of shrimp (all species combined) caught by beam trawl in Port Gardner during seasonal sampling in 1986.

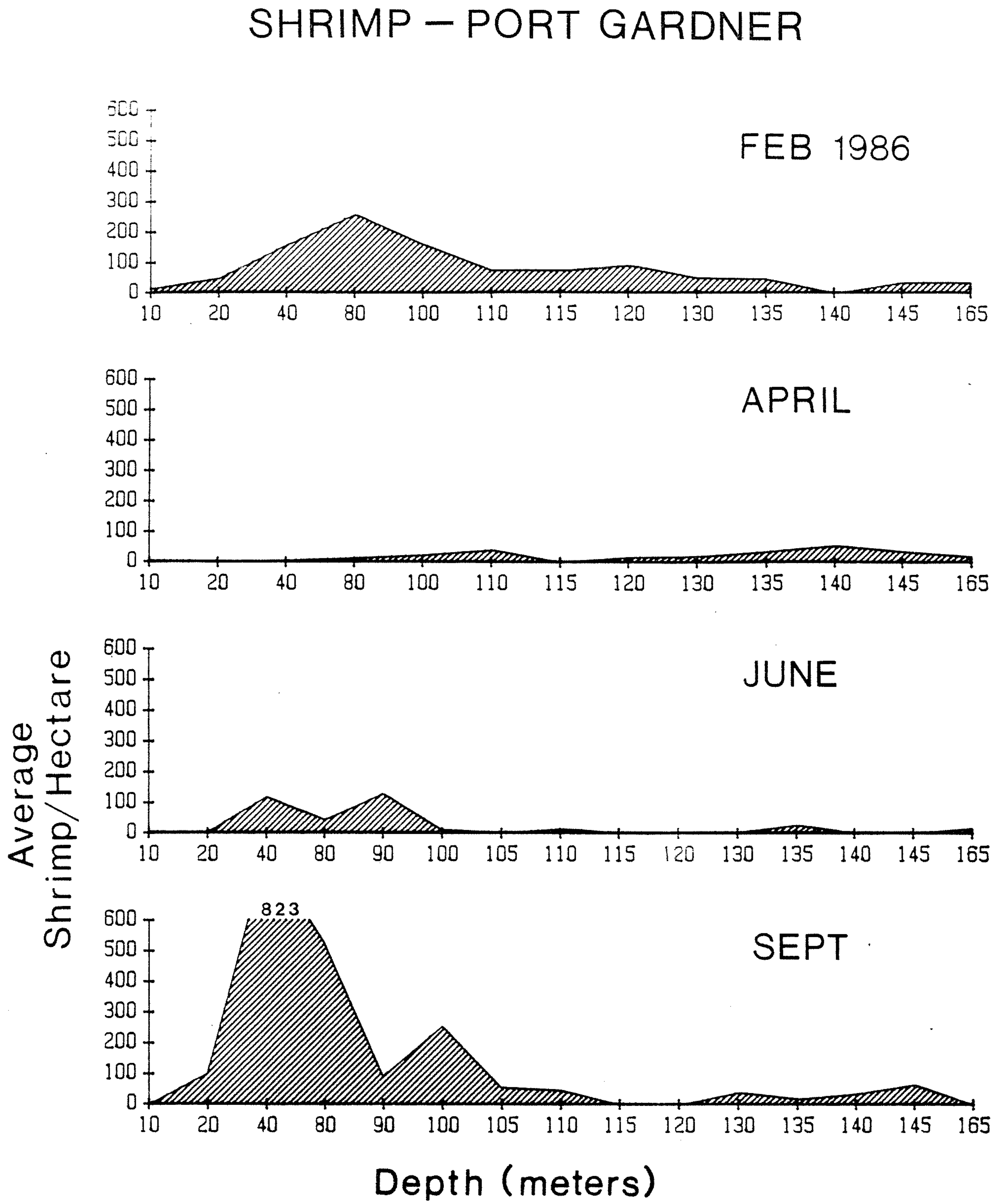


Figure 19. Distribution by depth of shrimp (all species combined) caught by beam trawl in Port Gardner during seasonal sampling in 1986.

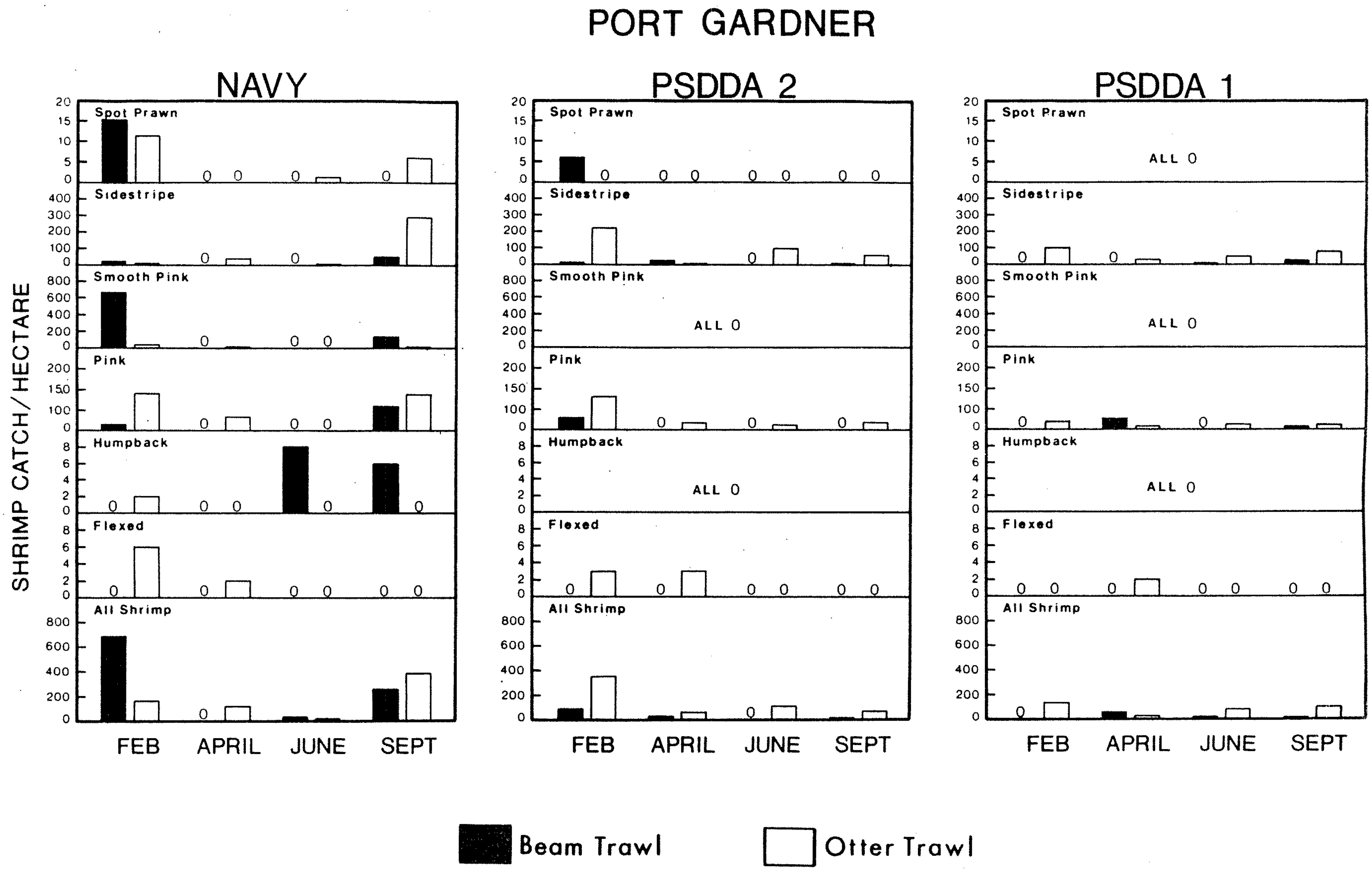


Figure 20. Number of shrimp caught per hectare by both beam and otter trawls in the three preliminary disposal sites in Port Gardner during seasonal sampling in 1986.

Bay during February, June and September were 131, 66 and 135 shrimp/ha, respectively. Generally, shrimp were most abundant in the beam trawls at PSDDA Site 1 (inner Elliott Bay) in February; most abundant at PSDDA Site 2 (Fourmile Rock) in June; and substantially more abundant at PSDDA Site 1 in September (Figures 8 and 10; Appendix Table 6) Sidestripe and pink shrimp were the most abundant shrimp in the beam trawls at the Fourmile Rock site while pink and smooth pink shrimp were most common at the inner bay disposal site (Figure 21). The otter trawl catches generally showed the same pattern of shrimp distribution except that spot prawn catches were higher than for the beam trawl at the inner bay site in September and a few humpback shrimp were caught in June and September (Figure 21; Appendix Table 7).

A "t"-test was conducted to compare the mean catches of shrimp between the two Elliott Bay disposal sites (data from all seasons combined; Log_{10} transformation of catches). The results showed that shrimp were caught in significantly higher numbers ($p = 0.0009$) when data from both types of trawl gear were combined, but that the level of significance was marginal for each gear type alone ($p = 0.054$ for the beam trawl shrimp catches and $p = 0.050$ for the otter trawl catches).

Commencement Bay. The overall average beam trawl shrimp catches in Commencement Bay in February, June and September 1986 were 49, 29 and 128 shrimp/ha, respectively. The two largest shrimp catches in Commencement Bay were off Browns Point in September where coonstripe shrimp were plentiful (1,067/ha) at the 10 m station and pink shrimp were relatively abundant (502/ha) at the 80 m station (Figure 22; Appendix Table 6).

Shrimp catches were very low at the PSDDA 2 site which was only sampled in February (Figure 23). Beam trawl and otter trawl shrimp catches at PSDDA Sites 1 and 2B were almost identical in both June and September with pink and

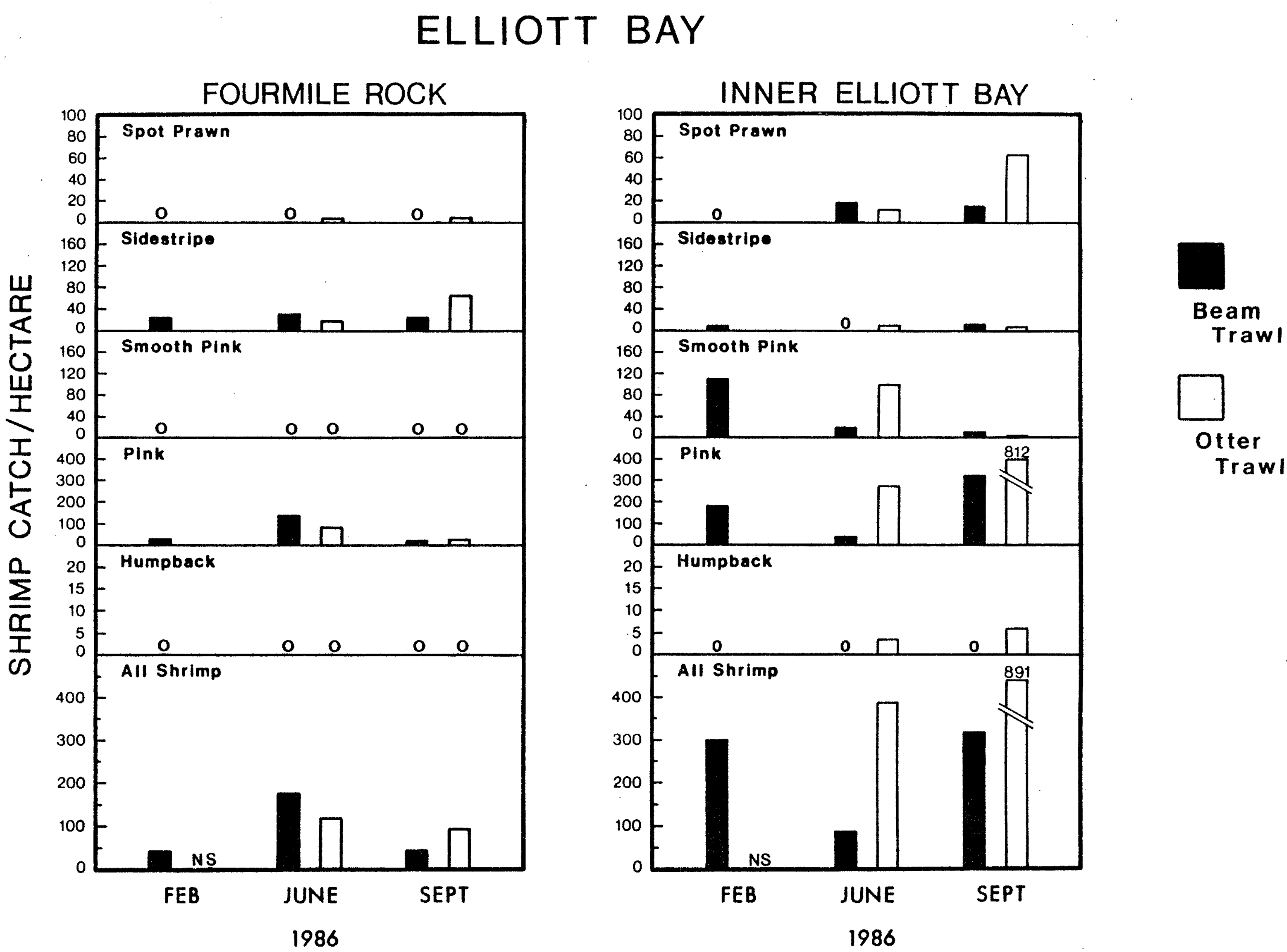


Figure 21. Beam and otter trawl shrimp catches by site, by species and by season for the two Elliott Bay proposed disposal sites. The bars are average catches for the three to five stations within each disposal site. N.S. = not sampled.

COMMENCEMENT BAY

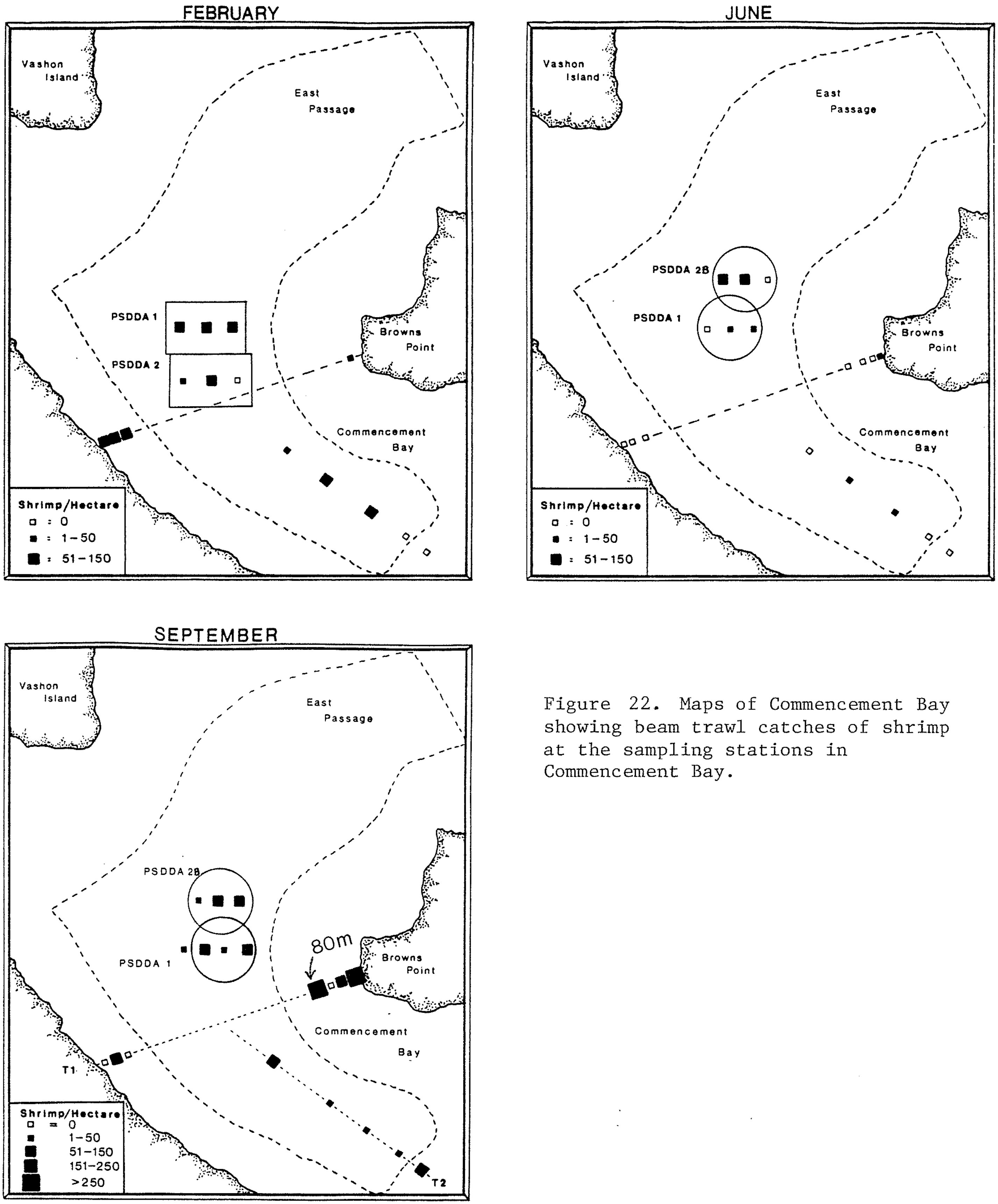


Figure 22. Maps of Commencement Bay showing beam trawl catches of shrimp at the sampling stations in Commencement Bay.

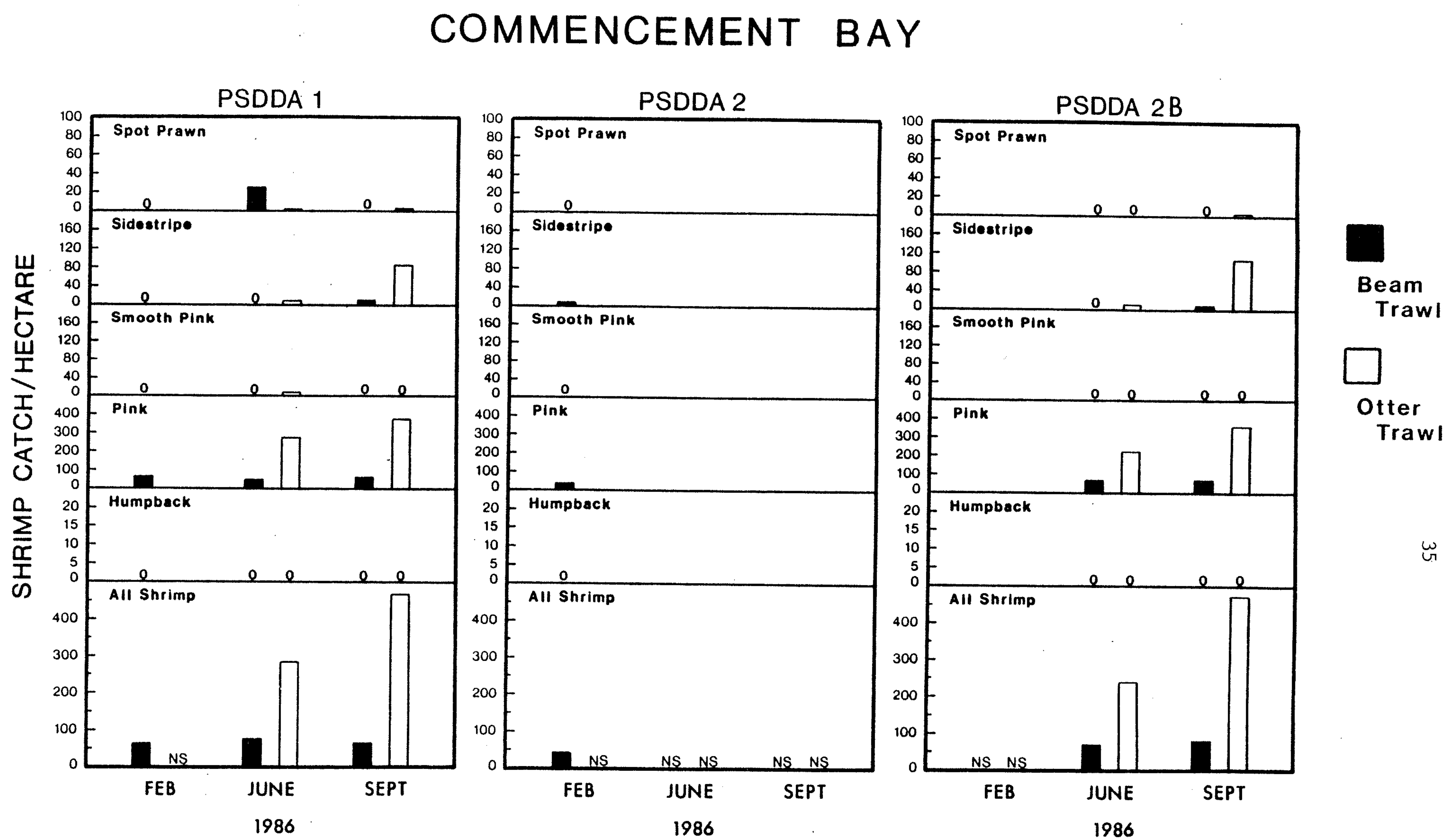


Figure 23. Beam and otter trawl shrimp catches by site, by species and by season for the proposed disposal sites in Commencement Bay. The bars are the average catches for the three to four stations within each disposal site. N.S. = not sampled.

sidestripe shrimp being the dominant species (Figure 23; Appendix Table 5 and 6). "T"-tests conducted to compare the mean shrimp catches (data from all seasons combined; Log_{10} transformation of catches) between PSDDA Sites 1 and 2B showed that there were no significant differences ($p = 0.05$) in mean catches regardless of trawl type.

Shrimp distributions by depth. The combination of all shrimp data from all seasons and areas (except Port Gardner) shows that the different species have specific depth preferences. Coonstripe shrimp preferred the shallowest depths (<30 m), often being associated with eelgrass (*Zostera marina*) and various algas (Figure 24). The mid-depths (50-100 m) were generally preferred by spot prawns and pink, smooth pink and humpback shrimp. Sidestripe and some pink shrimp were found at the deepest (100-150 m) depths.

Shrimp size distributions. Coonstripe shrimp was the smallest species caught with carapaces lengths (CL) between about 9 to 12 mm and were generally larger with increasing depth (Figure 25). Both species of pink shrimp were small to moderate in size, averaging 13 to 18 mm CL with no trend in size with depth. Sidestripe and humpback shrimp were moderately large in size (18 - 24 mm average CL), trending to smaller sizes with increasing depth. The largest shrimp, the spot prawn, averaged 26 to 34 mm CL and also trended to smaller sizes at depth.

Shrimp length-frequencies. Spot prawn were not caught in any of the PSDDA sites in February but showed indications of a slightly bimodal length-frequency during June and September with one size group from about 25 to 38 mm and a second size group from about 40 to 45 mm (Figure 26). Sidestripe shrimp

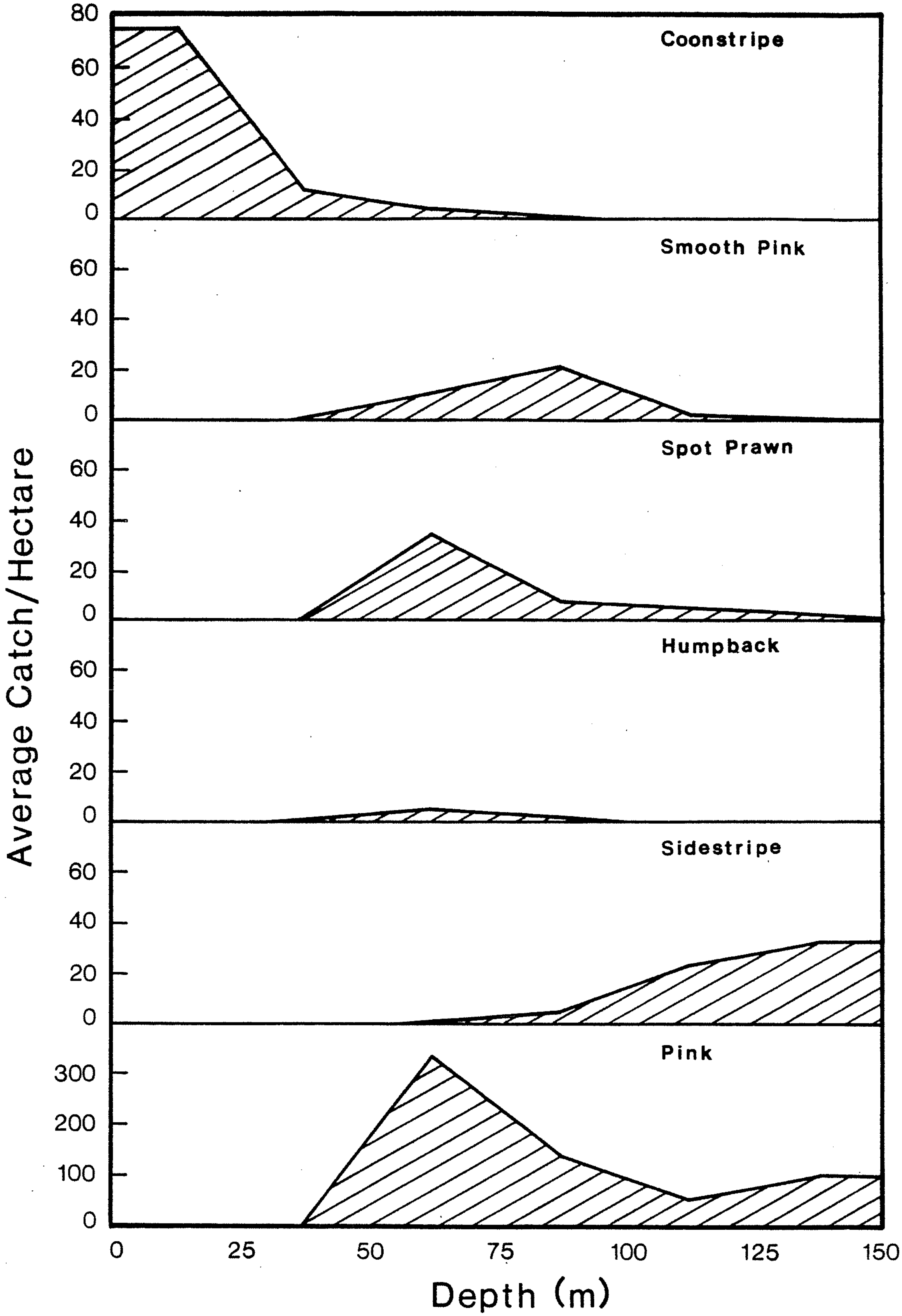


Figure 24. Distribution by depth and by species for all beam trawl-caught shrimp, all areas (except Port Gardner) and seasons combined.

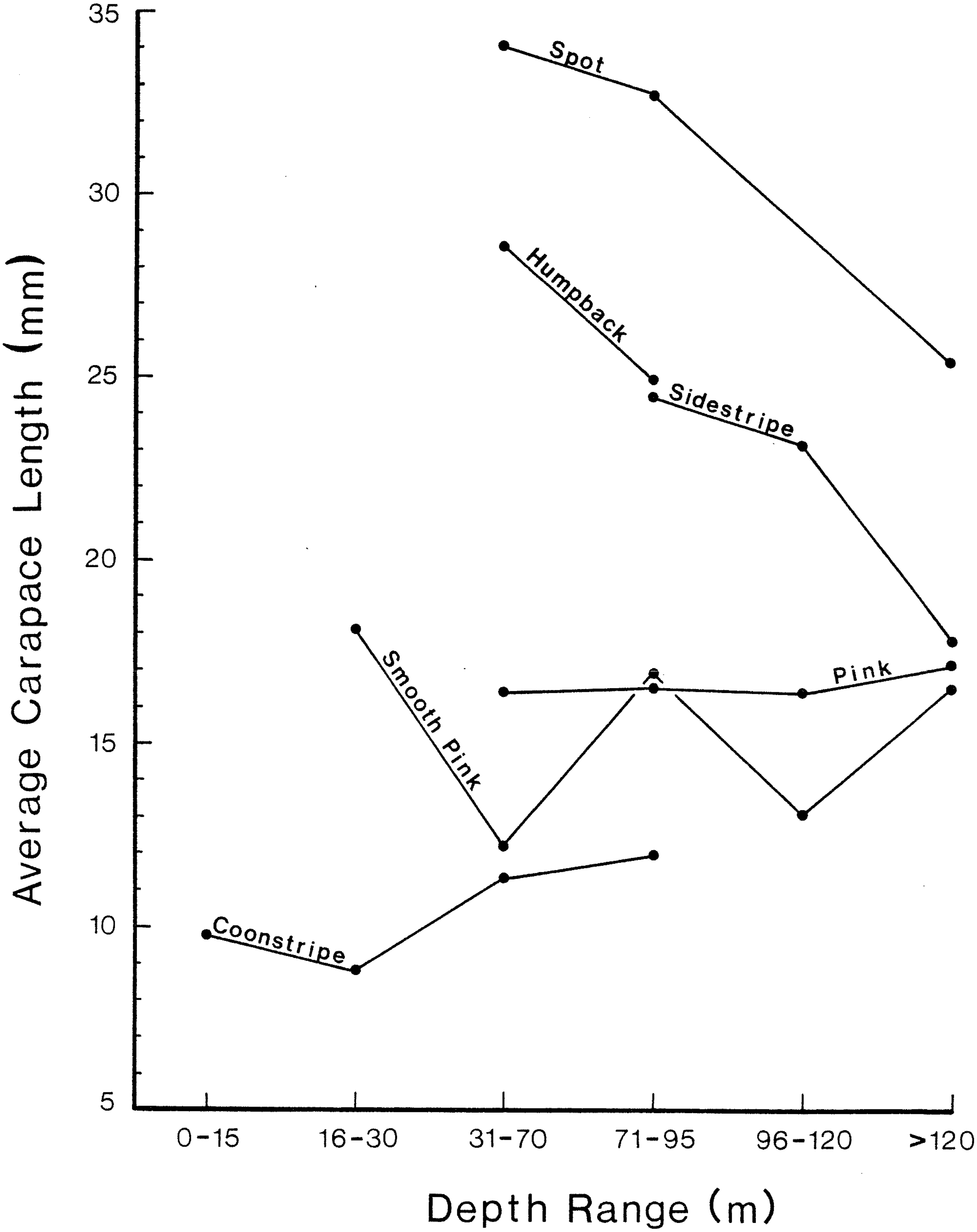


Figure 25. Average carapace lengths by species and by depth ranges for all shrimp caught, all seasons and areas (except Port Gardner) combined.

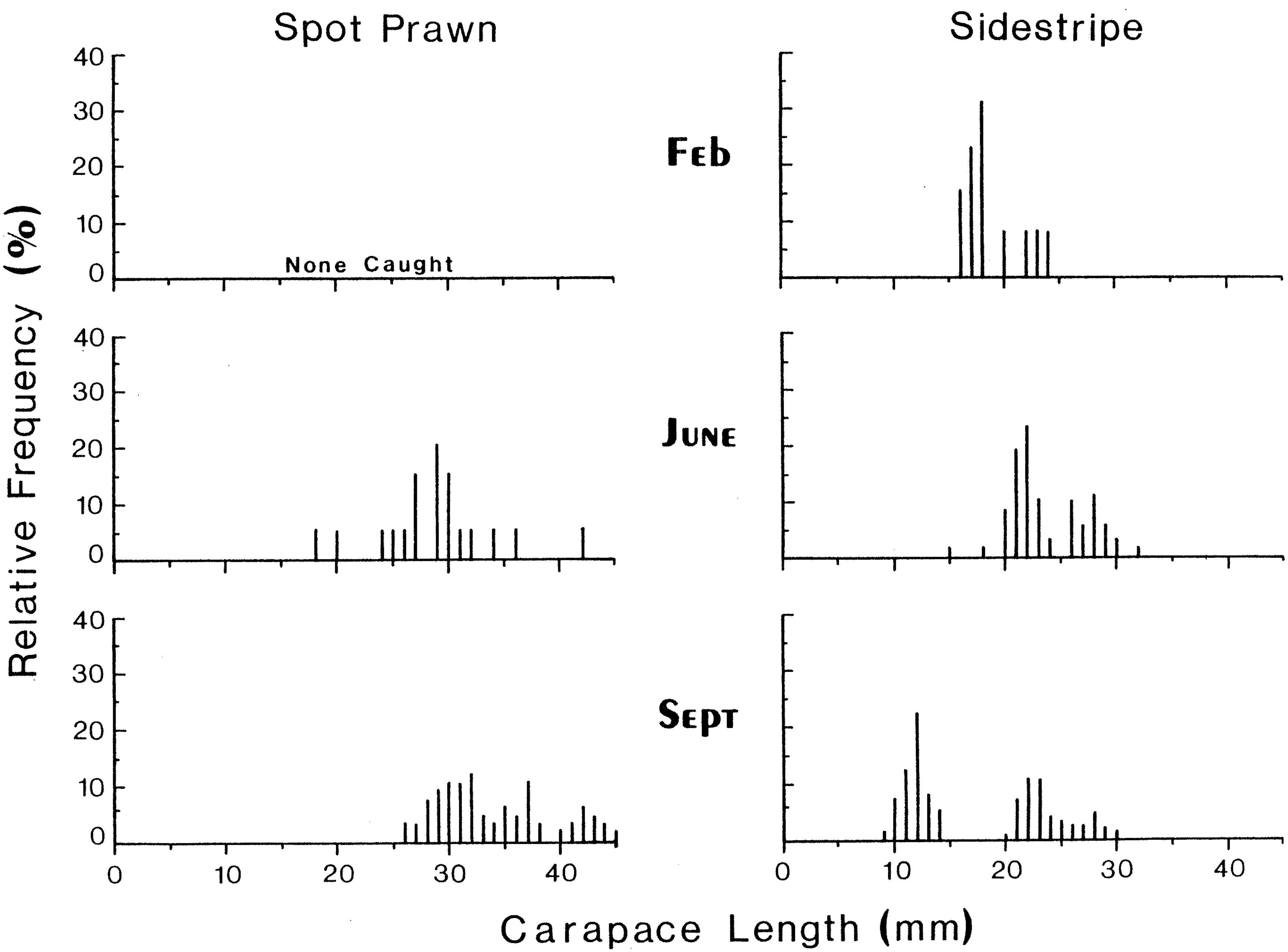


Figure 26. Length-frequency histograms for all spot prawn and sidestripe shrimp caught during the three sampling seasons, all areas (except Port Gardner) combined.

length-frequency patterns suggested a single size group in both February (16-24 mm) and June (20-30 mm) and a bimodal pattern in September (10-15 mm and 20-30 mm) (Figure 26). Coonstripe shrimp length-frequencies suggested a single size group in February and June (8-18 mm) and recruitment of young shrimp in September (6-10 mm) (Figure 27). Relatively few humpback shrimp were caught, but those that were suggested a single size group with sizes between 22-30 mm (Figure 27). Smooth pink shrimp length-frequencies gave a suggestion of a slight bimodal size distribution with size groups from 10-14 mm and 17-20 mm in February with both groups growing progressively larger in June and September (Figure 28). Pink shrimp also showed a bimodal size distribution with size groups from 9-13 mm and 15-20 mm in February. The distinction of the two apparent size groups was less clear in June and September but there was a hint of new recruitment in September with shrimp between 9-12 mm (Figure 28).

DISCUSSION AND CONCLUSIONS

Dungeness Crab

Dungeness crab were completely absent from all trawls conducted in Commencement Bay in 1986. Although an occasional Dungeness crab has been caught in other trawling operations in the shallow waterways (C. Eaton, pers. comm.), it is clear that this species will not be a factor in siting a disposal site in Commencement Bay.

Only four Dungeness crab were caught in Elliott Bay, all by beam trawl at the shallow stations on the Duwamish Head Transect (Figure 16). Commercial crabbing operations were also observed in shallow water areas between Fourmile Rock and West Point. However, the scarcity of Dungeness crabs in the trawls and the total lack of crabs in the trawls from the preliminary disposal sites

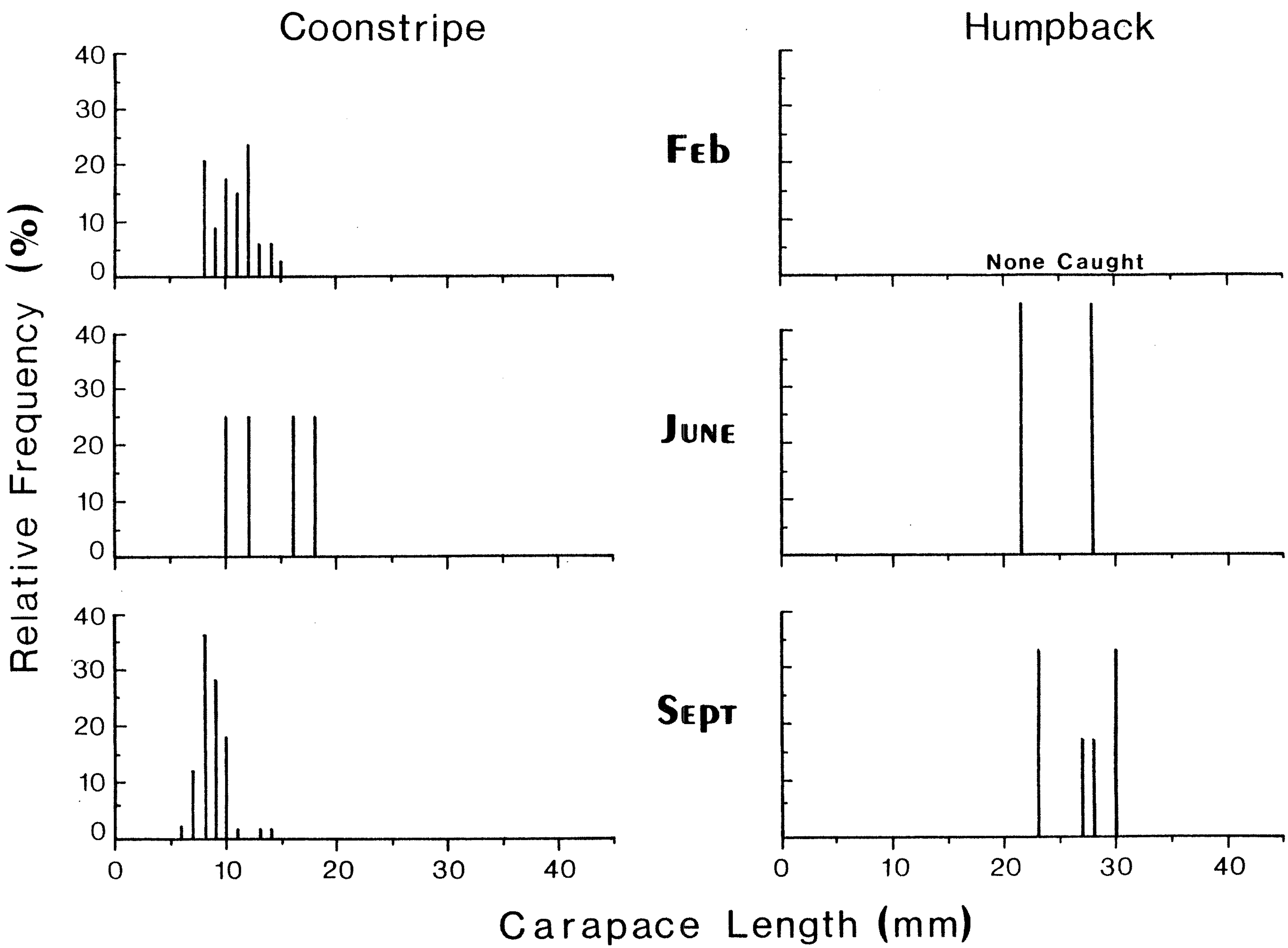


Figure 27. Length-frequency histograms for all coonstripe and humpback shrimp caught during the three sampling seasons, all areas (except Port Gardner) combined.

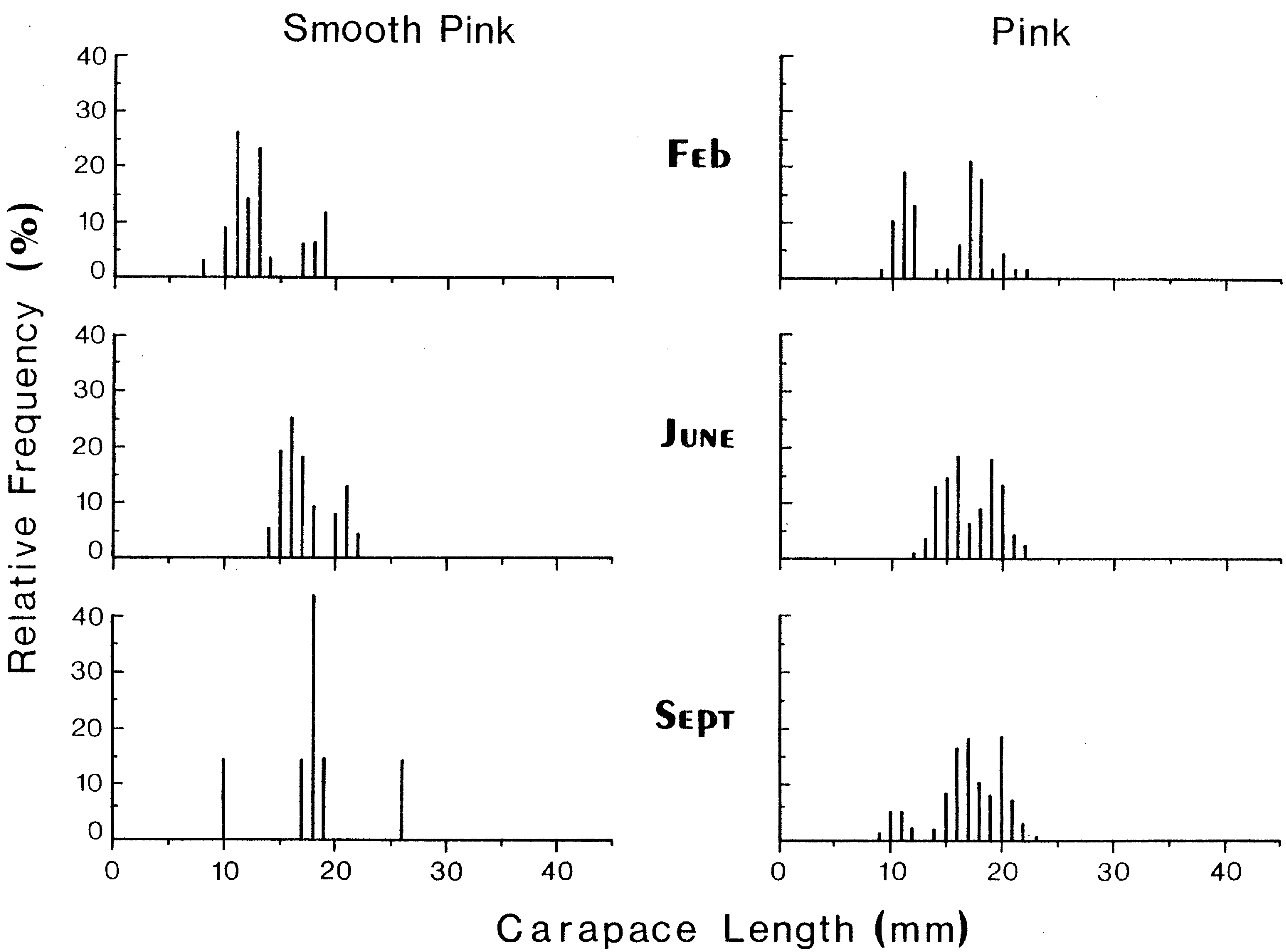


Figure 28. Length-frequency histograms for all smooth pink and pink shrimp caught during the three sampling seasons, all areas (except Port Gardner) combined.

indicates that this species is also not a factor in selecting a final Elliott Bay disposal site location.

Dungeness crab were moderately abundant in the beam trawl catches from Saratoga Passage (Figure 7); however, all crabs were caught along the shoreward slope areas at depths <80 m. No crabs were caught in the preliminary disposal area nor in the deeper water areas north of the disposal site. Hence, the present location of the proposed disposal site is probably in the best location for avoiding impacts to crab. However, evidence from the trawls in Port Gardner suggests that some Dungeness crab move into deep water (i.e., 100-150 m) during the late summer to early fall period. Trawls were not made in Saratoga Pass during this period. Thus, care should be exercised about any assumptions that crab are absent year-round.

Dungeness crab were found to be a very important resource in Port Gardner, consistently averging about 100 crab/ha for all seasons sampled. Of the crabs caught in the trawls, almost 90% were mature females, 78% of which were gravid during the February sampling. Thus, Port Gardner appears to be an important habitat area for the mature females.

The most important area of Port Gardner for the females is the nearshore slope area with few crabs being found in the deeper mid-portion of the Bay (Figures 9-12). Figure 9 shows that, unlike the NAVY disposal site, the two preliminary PSDDA sites contain relatively few crabs. Of these two sites, the PSDDA 1 site in the middle of the bay is farthest from the nearshore crab aggregations. A possible exception to this rule may be during summer-early fall when crabs appear to "spread out" into the deeper areas, but still at densities far less than the "slope" area.

Shrimp

Commercially important species of shrimp were caught in all of the preliminary PSDDA disposal sites. Summaries of the shrimp catches within the disposal sites of each area (Table 1) show that the average shrimp catches by weight for the combined otter trawl catches were 0.56, 0.06, 1.69 and 1.22 kg/ha for Saratoga Passage, Port Gardner, Elliott Bay and Commencement Bay, respectively.

Historically, shrimp have been the basis of a viable trawl fishery in Puget Sound and Hood Canal. Annual landings of shrimp exceeded 400,000 pounds during several years between 1904 and 1915 and averaged about 50,000 pounds during the 1920's and 1930's (Smith 1937). The averge landings between 1935 and 1982 have been highly variable (8 to 144 thousand pounds) and averaged 58,000 pounds (Figure 29).

The historical shrimping grounds fished from the late 1800's through the 1930's included each of the areas in which a PSDDA disposal site is proposed (Figure 30). Saratoga Passage and Elliott Bay are shown as historical spot prawn shrimping areas while Commencement Bay was trawled for smooth pink shrimp. Our present trawls caught spot prawn in Elliott and Commencement Bays but no spot prawn in Saratoga Passage. Relatively few smooth pink shrimp were caught but the closely related pink shrimp was caught in small numbers in Saratoga Passage and in moderate numbers in Elliott and Commencement Bays (Table 1).

Some perspective on the relative importance of shrimp resources in the preliminary disposal sites can be attained by comparing the average otter trawl catches in these sites with otter trawl catches of shrimp in other areas of Puget Sound and Hood Canal. Chew (unpublished data) conducted shrimp surveys during the winter of each year from 1967 to 1979 at about ten sites in

Table 1. Average shrimp catches, lengths and weights (wet biomass) for all shrimp caught by otter trawl in the proposed PSDDA disposal sites in Saratoga Passage, Port Gardner, Elliott Bay and Commencement Bay during all sample months (combined), 1986.

Species	Saratoga Passage	Port Gardner	Elliott Bay	Commencement Bay
Spot Prawn				
Ave. #/Ha	0	0.8	23.2	1.5
Ave. carapace length (mm)	-	19.0	33.6	26.8
Ave. weight/shrimp (g)	0	5.0	23.0	12.0
Total weight/Ha (kg)	0	0.00	0.53	0.02
Sidestripe				
Ave. #/Ha	54.1	6.2	23.2	53.3
Ave. carapace length (mm)	23.2	18.0	23.0	15.3
Ave. weight/shrimp (g)	6.2	5.0	6.0	1.9
Total weight/Ha (kg)	0.33	0.02	0.14	0.10
Smooth Pink				
Ave. #/Ha	0	0	23.9	0.8
Ave. carapace length (mm)	-	-	16.9	16.5
Ave. weight/shrimp (g)	0	0	3.4	3.1
Total weight/Ha (kg)	0	0	0.08	0.00
Pink				
Ave. #/Ha	72.1	17.2	260.6	306.4
Ave. carapace length (mm)	16.5	14.4	16.8	17.2
Ave. weight/shrimp (g)	3.2	2.5	3.5	3.6
Total weight/Ha (kg)	0.23	0.04	0.91	1.10
Humpback				
Ave. #/Ha	0	0	2.4	0
Ave. carapace length (mm)	-	-	26.4	-
Ave. weight/shrimp (g)	0	0	12.0	0
Total weight/Ha (kg)	0	0	0.03	0
All Species Combined				
Ave. #Ha	126.2	24.2	333.3	362.0
Total weight/Ha (kg)	0.56	0.06	1.69	1.22

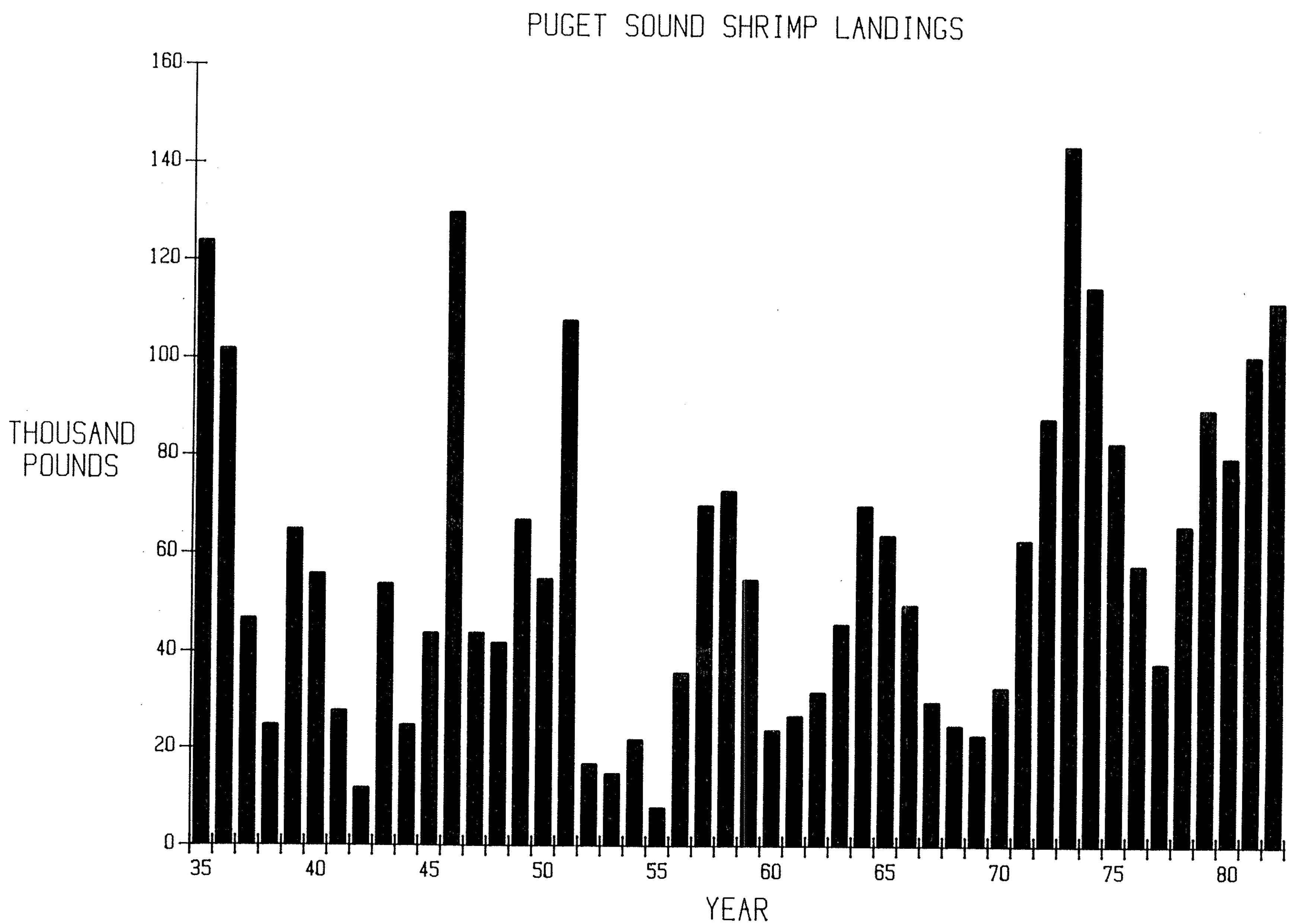


Figure 29. Annual commercial shrimp landing from Puget Sound (including Hood Canal) from 1935 to 1982. Data from WDF (1974 and 1982).

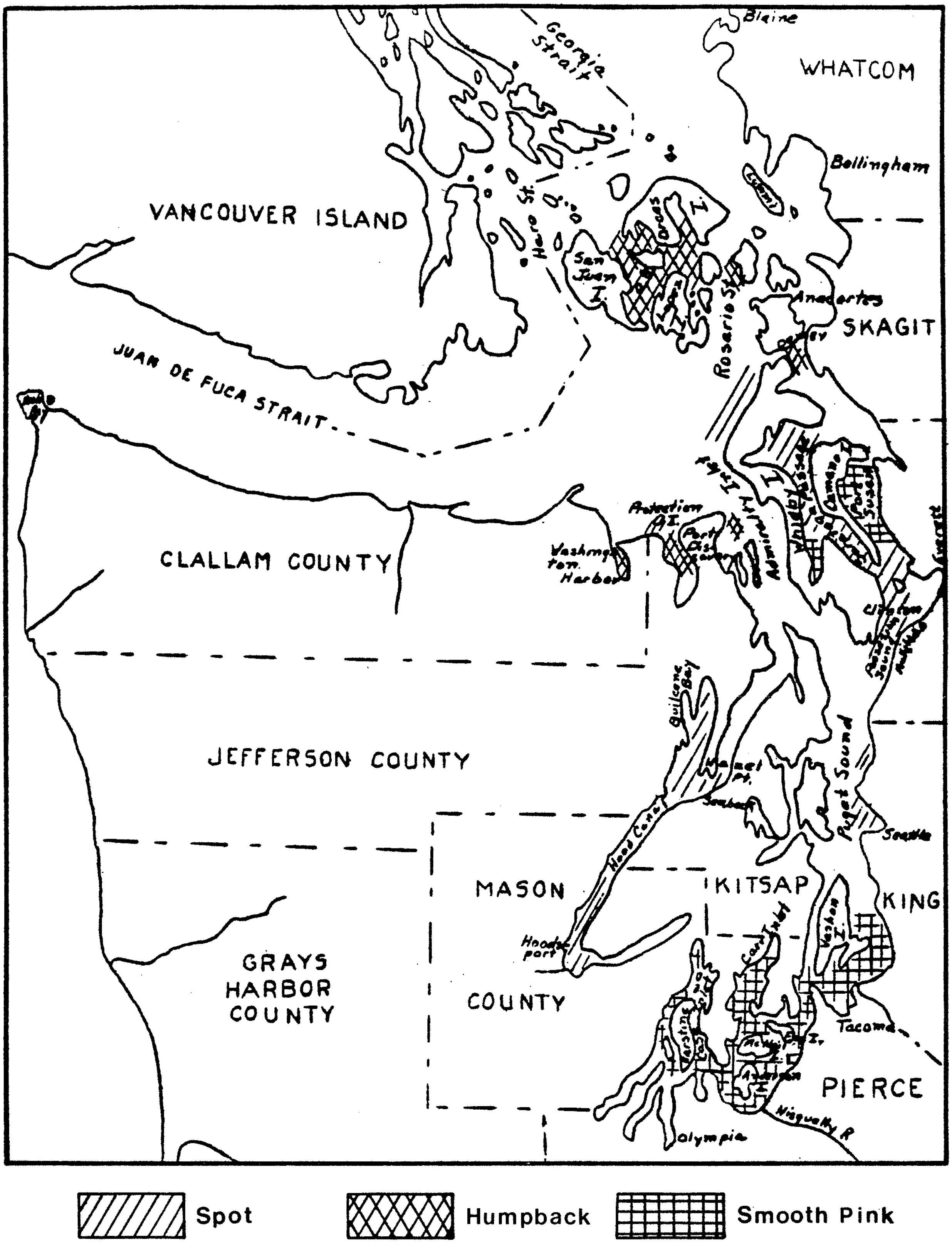


Figure 30. Map of Western Washington showing areas of commercial shrimp production from late 1800's to mid-1930's. The Humpback shrimp is <u>Pandalus hypsinotus</u>. From Smith (1937).

Hood Canal and Puget Sound. Summaries of Chew's data show that the average shrimp catches/ha in four areas of Hood Canal and three areas of Puget Sound all (except Seabeck, Hood Canal) exceeded the average catches in any of the preliminary PSDDA disposal sites (Tables 1 and 2). The one disposal site that appeared to have a potential for commercial shrimp harvesting was the inner Elliott Bay site where spot prawn, sidestripe, pink and smooth pink shrimp were caught in reasonable numbers (Figure 10, Appendix Table 7). Table 3 provides a breakdown of relative shrimp densities within the two preliminary PSDDA sites in Elliott Bay and shows that the inner Elliott Bay site contained about 3 to 7 times the density of shrimp that were caught at the Four-mile Rock site (data from June and September otter trawls). However, this area is also severely impacted by Indian salmon fishing, ship navigation lanes and anchorage areas as well as toxic contaminants in the sediments of the nearby Duwamish Waterways; hence, the value of these shrimp to a fishery is suspect. The potential value of the reproductive capacity of these stocks for supplying new recruits to other productive areas of Puget Sound is not presently known but cannot be ruled out in the decision making process. The Commencement Bay disposal sites also contained some sidestripe and pink shrimp, but both sites contained essentially equal populations, hence, not affording a choice between these two sites based on this factor.

Table 2. Estimated average shrimp catches/Ha from otter trawls conducted in selected areas of Hood Canal and Puget Sound from 1967 to 1979. These estimates are derived from unpublished data collected and summarized by Dr. Kenneth Chew, School of Fisheries, University of Washington.

Location/Depth (m)	Number of trawls	Catch/Ha (kg)
Dabob Bay		
20 - 45	33	2.9
45 - 70	26	2.7
70 - 125	24	3.5
Pleasant Harbor		
35 - 65	5	2.9
65 - 90	8	10.0
Seabeck		
45 - 80	3	0.8
Potlatch		
70 - 90	4	6.8
Port Susan		
25 - 70	9	12.8
80 - 120	7	5.7
Tulalip		
50 - 80	3	13.5
80 - 120	4	11.8
Carr Inlet		
45 - 80	4	15.1
80 - 135	3	2.4

Table 3. Shrimp weights/ha from the Elliott Bay preliminary disposal sites as estimated from the otter trawl catches in June and September 1986. Shrimp weights for each species were calculated from length-weight regressions developed from data collected by K. Chew (unpublished).

	Estimated Total Weight (Kg)/ha			
	June		September	
Species	Four-Mile Rock	Inner Elliott	Four-Mile Rock	Inner Elliott
Spot Prawn	0.016	0.210	0.107	1.641
Sidestripe Shrimp	0.108	0.060	0.388	0.064
Smooth Pink Shrimp	0	0.362	0	0.010
Pink Shrimp	0.265	0.470	0.141	3.004
Humpback Shrimp	0	0.034	0	0.064
Total Weight	0.389	1.136	0.636	4.783

Part II

Demersal Fish Studies

by

Robert F. Donnelly, Bruce S. Miller, Robert R. Lauth, and Shelley C. Clarke

INTRODUCTION

This study investigated fish assemblages at preliminary Puget Sound Dredge Disposal Analysis (PSDDA) disposal sites in the main basin of Puget Sound and evaluates these assemblages prior to actual disposal of dredged materials. Information obtained will be used in the final site selection process and can be used as baseline data to monitor changes in fish assemblages following disposal activities.

Disposal of dredged materials can affect fish habitats in many ways. Sediment type has been shown to be particularly important for spawning (Morton 1977). Alteration of substrate particle composition by dredged materials and consequent alteration of spawning grounds could be detrimental to the abundance of certain fish species.

Dredged materials can alter the species composition of fish at disposal sites by causing changes in the benthic community upon which the fish feed (Lunz and Kendall 1982). A Rhode Island dredged materials disposal study (Saila et al. 1972) suggests that covering the bottom with a uniform sediment type would decrease the diversity of prey organisms and possibly decrease the diversity of fish species. Desbruyeres et al. [1980, in Thistle (1981)] found five times greater benthic faunal density six months after a disturbance at 2160 m; however, the fauna in the disturbed area was taxonomically different from the surrounding fauna. At a deepwater disposal site in Puget Sound, Bingham (1978) showed a similar effect. Nine months after disposal, diversity of prey organisms was greater at the disposal site than at reference areas. A disturbance caused by an oil spill in shallow water actually resulted in a biomass increase six months to one year after the spill (Orensanz and Gallucci 1982). The work of Grassle (1977), however, cautions that the recovery after disturbance may be depth dependent. Grassle's study found that a deepsea site (1760 m deep) had a colonization rate two orders of magnitude lower than a comparable intertidal site.

Although it is important to be aware of the potential changes, it is difficult to accurately predict what impact the disposal of dredged materials will have on fish assemblages due to the individual nature of each disposal site. Therefore, it is important to identify areas where fish resource conservation is essential from a commercial or ecological perspective before a decision is made regarding disposal. This report documents the benthic fish assemblages of the preliminary main basin PSSDA disposal sites and adjacent reference areas, and can aid in selection of sites where disposal of dredged materials will have a minimal impact.

MATERIALS AND METHODS

Bottomfish (benthic and demersal fishes) were sampled in Commencement Bay, Elliott Bay, Saratoga Passage and Port Gardner during 1986. Commencement Bay was sampled on June 13 and September 8; Elliott Bay was sampled on July 3 and September 9; and Saratoga Passage was sampled once on July 1. Port Gardner was sampled during four seasons on February 12 and 13, April 18 and 21, June 30 and July 2, and September 11 and 15. Marine environmental data (salinity, dissolved oxygen, water temperature and water clarity) were also collected.

A 7.6-m, single wire otter trawl (Mearns and Allen 1978) was the primary sampling gear for bottomfish. The body of the net was made of 3.5 mm stretch mesh and the cod end of 0.5 cm stretch mesh covered with 2.5 mm stretch mesh to prevent chafing. The net was deployed from the 16-m research vessel Kittiwake. The effective fishing width of the otter trawl was 6 m. Each sample consisted of one otter trawl haul towed for a distance of 370 m at a target ground speed of 4.2 km per hour. The total area swept (sampled) was 2,220 m^2. Fish were also collected incidentally by the beam trawl used to sample crabs (see Appendix A). The beam trawl is described elsewhere in the crab and shrimp section (Part I) of this report.

Sampling was conducted both inside and outside of each preliminary PSDDA site (Figures 1-4). Three replicate samples were collected inside each PSDDA site and NAVY site (Port Gardner only) during each sampling cruise. One sample was taken from each station outside of the PSDDA sites and at each of the U.S. Army Corps of Engineers' established reference stations (Clarke 1986) during each cruise. Reference stations were not sampled in Commencement Bay. PSDDA sites and reference stations were the only locations sampled in Elliott Bay (Fig. 2). In Commencement Bay, Saratoga Passage and Port Gardner the PSDDA site(s), the reference station(s) and several additional stations stratified by depth were sampled.

Each trawl catch was brought onboard and fish were sorted by species and life history stage (adult or juvenile), counted and recorded; miscellaneous observations (e.g., spawning condition) were also recorded. The catch was then placed into plastic bags, labeled, put into ice chests and covered with ice. The samples were transported to the University of Washington and placed into a 0°C freezer until processed.

Surface water temperature, salinity and dissolved oxygen samples were taken from a bucket of water collected from the surface waters. Bottom water

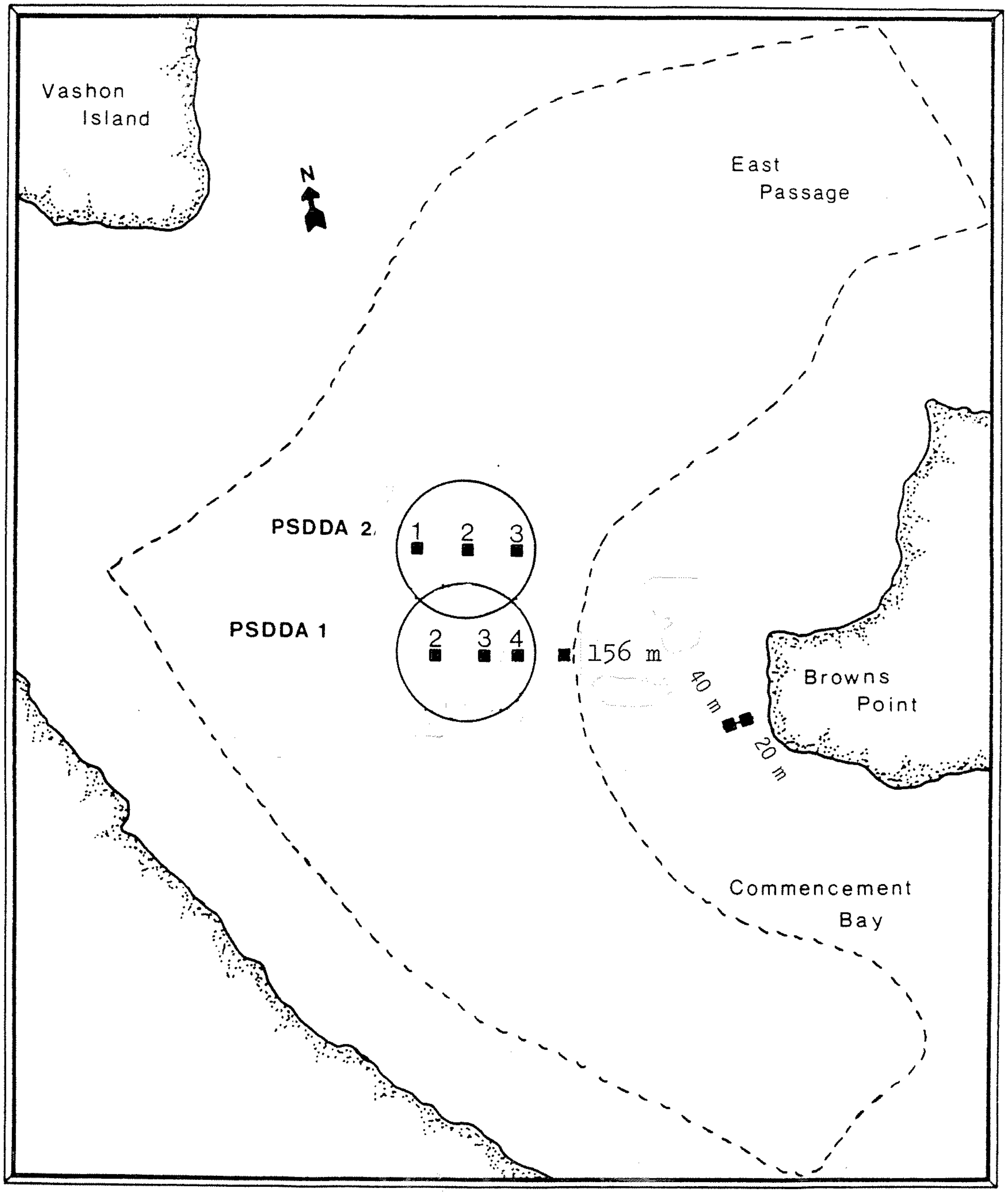


Figure 1. Map of Commencement Bay showing locations sampled for bottomfish (■) on June 13 (summer) and September 8 (autumn). The large area enclosed by the dashed line is the zone of siting feasibility (ZSF). Circular areas enclosed by solid lines are the preliminary PSDDA sites.

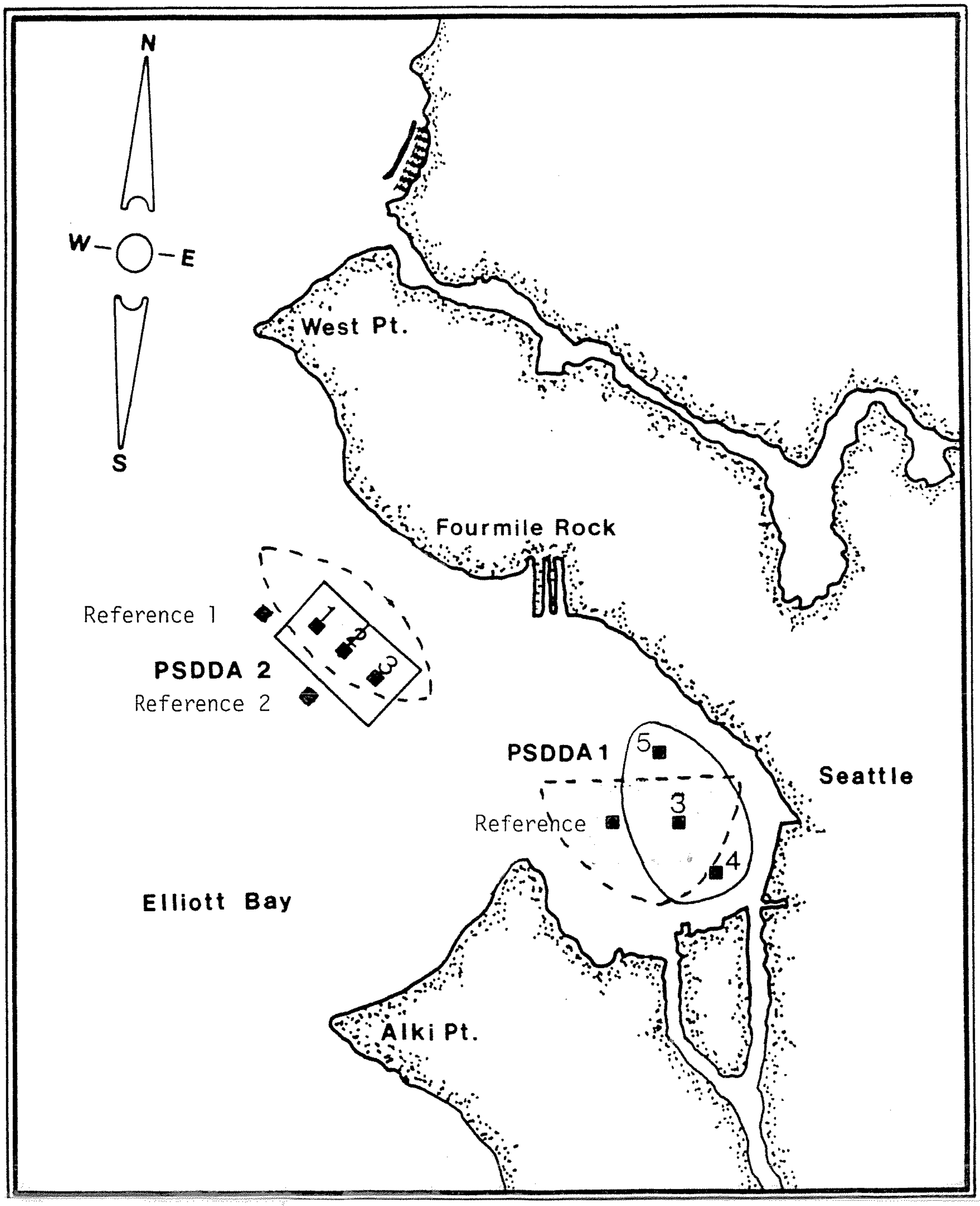


Figure 2. Map of Elliott Bay showing locations sampled for bottomfish (■) on July 3 (summer) and September 9 (autumn). The areas enclosed by the dashed lines are the ZSFs. The solid lines enclose the preliminary PSDDA sites.

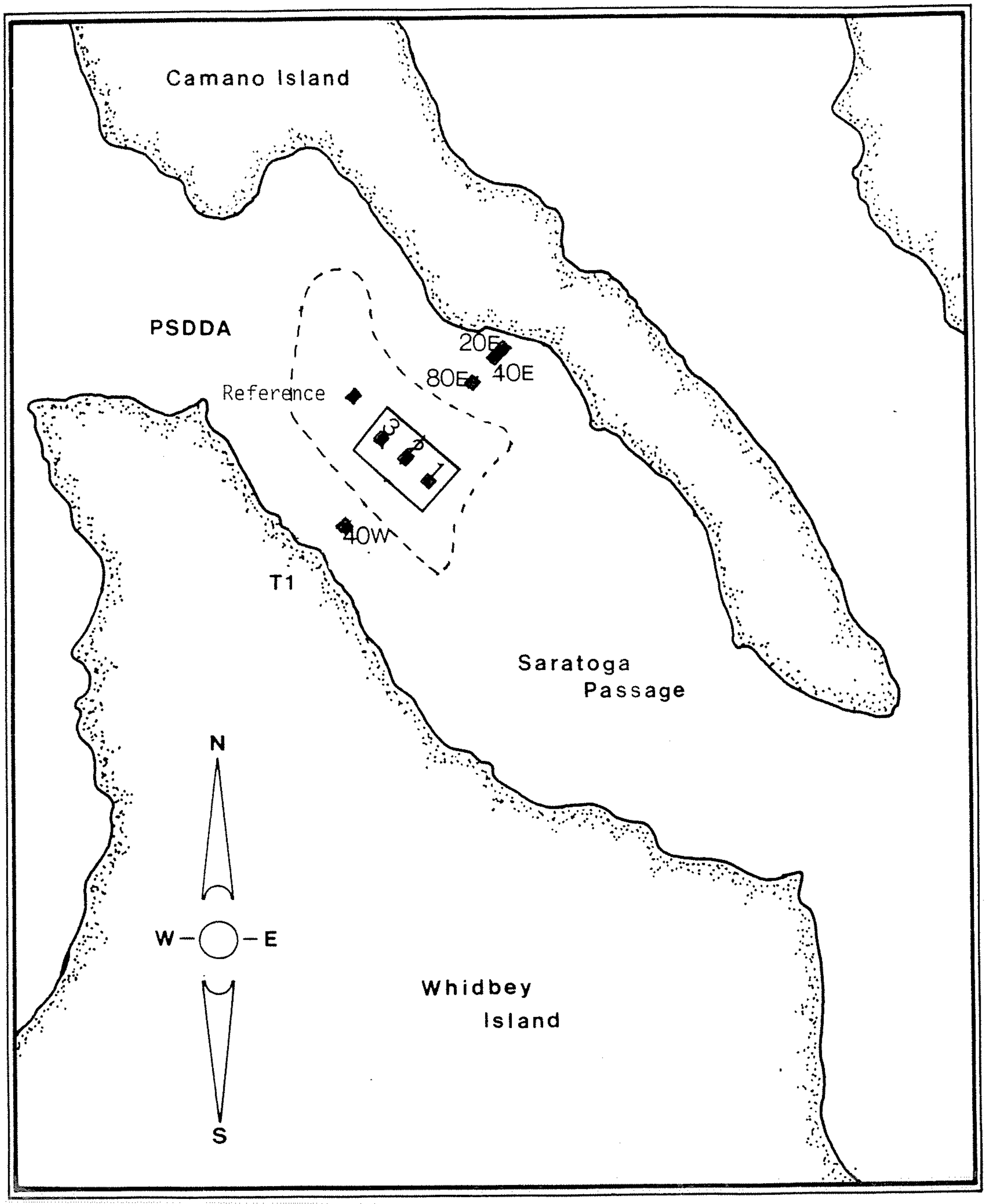


Figure 3. Map of Saratoga Passage showing locations sampled for bottom-fish (■) on July 1 (summer). The area enclosed by the dashed line is the ZSF. The rectangular area enclosed by the solid line is the PSDDA site.

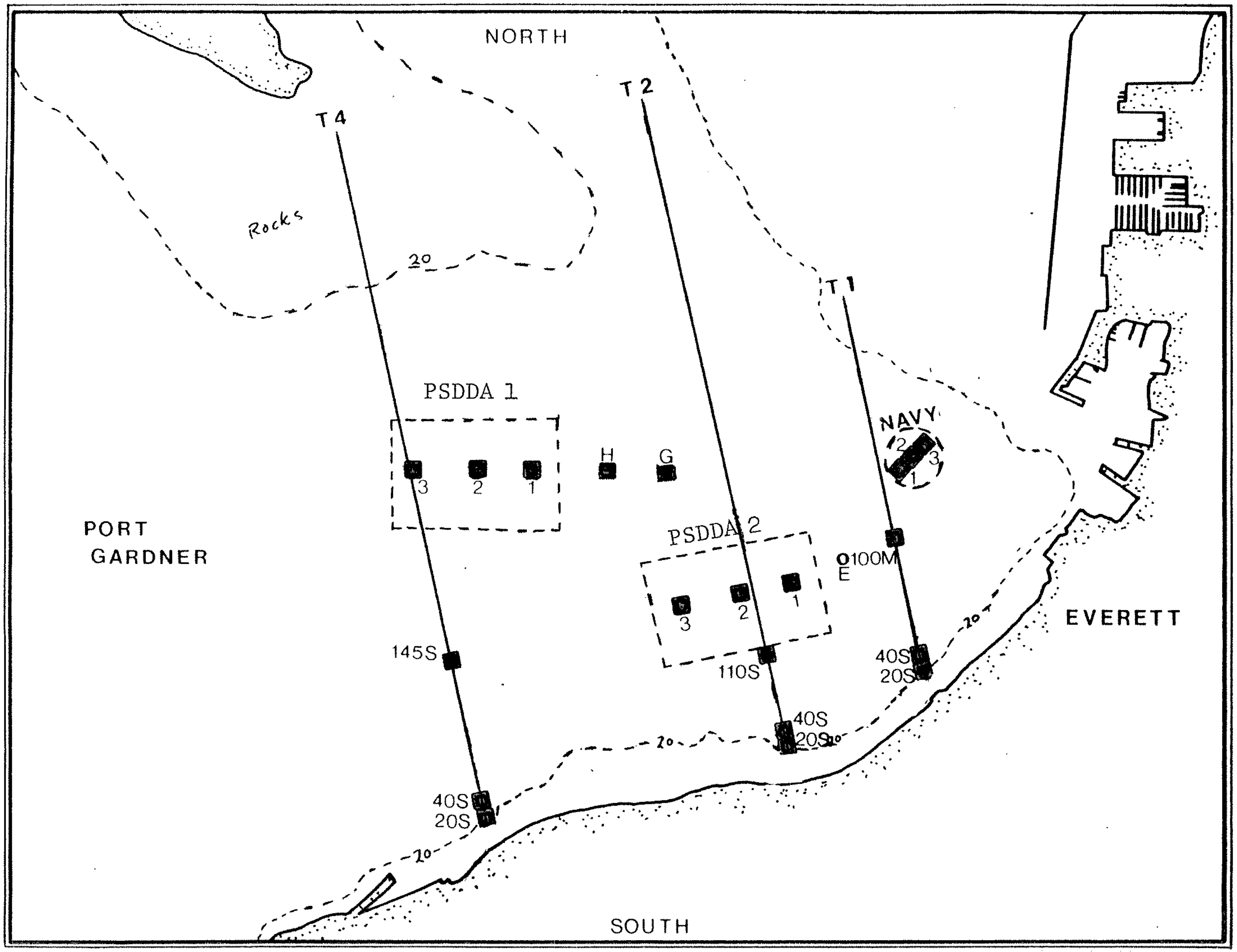


Figure 4. Map of Port Gardner showing the station sampled for bottomfish (■). The irregular dashed line represents the 20 m contour. The rectangular areas enclosed by dashed lines are PSDDA sites and the circular area enclosed by a dashed line is the NAVY site. Stations G and H are reference stations 1 and 2, respectively. T1, T2, and T4 are transects 1, 2, and 4, respectively.

temperature, salinity and dissolved oxygen samples were taken from water collected approximately 1 m above the bottom with a Scott-Richards water bottle. Water temperatures were measured with a hand-held thermometer and recorded in the field. Water samples for salinity determination were placed into bottles for later measurement in the laboratory. Water samples for dissolved oxygen determination were placed into acid washed glass bottles, fixative added, the bottles glass stoppered, and the contents later processed in the laboratory. Water clarity measurements were taken with a Secchi disc from the lee side of the vessel and recorded in the field.

Laboratory Processing of Fish

Fish samples were removed from the freezer and thawed. The contents were separated by species and life history stage. Total length (mm) of each fish and total weight (grams) of each life history stage were recorded on data forms and then entered into electronic storage. Since the tips of ratfish tails were often missing, a length from the snout to the posterior end of the second dorsal fin, as well as total length (when possible), was recorded for this species. Adult flatfish and ratfish were sexed.

Flatfish Diseases

Marine flatfishes in Puget Sound are known to be infected by blood worms (the nematode, *Philometra*), skin tumors, liver tumors and fin erosion (Amish 1976; Angell et al. 1975; Miller and Wellings 1971; Wellings et al. 1976; Malins et al. 1982).

Blood worms are clearly visible and typically located in the subcutaneous areas near or at the base of the dorsal and anal fins (Amish 1976). Skin tumors (Angell et al. 1975; McArn et al. 1968; Miller and Wellings 1971) are found as two main stages: angioepithelial nodules and epidermal papillomas. All flatfish were externally inspected for blood worms and skin tumors.

Liver tumors are thought to be indicators of pollution (Malins et al. 1982). In the advanced stage, liver tumors are characterized by small nodules visible on the external surface of the liver. English sole caught in polluted areas have often been shown to have liver tumors (Malins et al. 1982; Tetra Tech 1985). Gross examination (non-microscopic) of the external surface of the livers from about 20% of all flatfish caught was done in the laboratory.

Another disease associated with flatfish in polluted areas is fin erosion. Fin erosion typically affects the dorsal and anal fins and is characterized by partial destruction of the fin(s) in question. The severity ranges from minor defects to extensive destruction of the fin(s) (Wellings et al. 1976). All flatfish were examined in the field for fin erosion.

Environmental Measurements

Salinity samples were processed by the University of Washington, School of Oceanography Technical Services group, by conductivity bridge (Paquette 1958). Dissolved oxygen samples were processed by the University of Washington, School of Fisheries Environmental Laboratory, using titration techniques described in Standard Methods (1980).

Data Analysis

Species richness, defined as the total number of species present at each sample site or station, was determined for all stations in Commencement Bay, Elliott Bay and Saratoga Passage.

Species diversity was calculated using the Shannon-Wiener species diversity index H' (Pielou 1978) as follows:

$$H' = -\sum_{i=1}^{n} P_i \ln P_i$$

where P_i was the proportion of the total sample that belonged to the i^{th} species and n = the number of species. As a consequence of the formula, H' increases with an increase in the number of species and/or as the individuals caught become more evenly distributed across all species present.

Abundance and biomass averages were calculated for the combined PSDDA site samples. "Replicate" samples were taken only at the proposed PSDDA sites and the NAVY site in Port Gardner; all other stations were sampled once per season. Length-frequency histograms were constructed for the most abundant species from the Elliott Bay, Commencement Bay and Saratoga Passage otter trawl data.

The number of flatfish caught per hectare was calculated for each site by multiplying the abundance estimates for each flatfish species by the constant 4.5 [which is equal to 10,000 m^2 (one hectare) divided by 2,220 m^2 (the total area swept by the otter trawl during each sample)]. Similarly, the reader can also convert to biomass caught per hectare, or number caught per hectare, for the remaining fish species by multiplying the given biomass or abundance values by the constant 4.5.

RESULTS

A total of 55 species of fish were collected by otter trawl during this study (Table 1). Common names are used throughout this report, although Table 1 lists both the common and scientific names of all fish caught. The following results are from the otter trawl data only, since beam trawl results (Appendix A) did not add significant additional information for the purpose of

Table 1. List of bottomfish species caught by otter trawl during this study. Species are listed in alphabetical order according to their common name.

Fish Species	
Common Name	**Scientific Name**
American shad	*Alosa sapidissima*
arrowtooth flounder	*Atheresthes stomias*
black eelpout	*Lycodes diapterus*
blackbelly eelpout	*Lycodopsis pacifica*
blackfin starsnout poacher	*Bathyagonus nigripinnis*
blacktip poacher	*Xeneretmus latifrons*
bluebarred prickleback	*Plectobranchus evides*
bluespotted poacher	*Xeneretmus triacanthus*
canary rockfish	*Sebastes pinniger*
C-O sole	*Pleuronichthys coenosus*
copper rockfish	*Sebastes caurinus*
Dover sole	*Microstomus pacificus*
English sole	*Parophyrs vetlus*
flathead sole	*Hippoglossoides elassodon*
lingcod	*Ophiodon elongatus*
longfin smelt	*Spirinchus thaleichthys*
longnose skate	*Raja rhina*
northern ronquil	*Ronquilus jordani*
northern spearnose poacher	*Agonopsis vulsa*
Pacific cod	*Gadus macrocephalus*
Pacific hake	*Merluccius productus*
Pacific herring	*Clupea harengus pallasi*
Pacific lamprey	*Lampetra tridentata*
Pacific sanddab	*Citharichthys sordidus*
Pacific staghorn sculpin	*Leptocottus armatus*
Pacific tomcod	*Microgadus proximus*
pallid eelpout	*Lycodapus mandibularis*
pile perch	*Rhacochilus vacca*
plainfin midshipman	*Porichthys notatus*
quillback rockfish	*Sebastes maliger*
ratfish	*Hydrolagus colliei*
red brotula	*Brosmophycis marginata*
rex sole	*Glyptocephalus zachirus*
rock sole	*Lepidopsetta bilineata*
rockfish UID	*Sebastes sp.*
roughback sculpin	*Chitonotus pugetensis*
sablefish	*Anoplopoma fimbria*
sailfin sculpin	*Nautichthys oculofasciatus*
sand sole	*Psettichthys melanostictus*
sculpin UID	*Artedius sp.*
shiner perch	*Cymatogaster aggregata*
shortfin eelpout	*Lycodes brevipes*
slender sole	*Lyopsetta exilis*
slim sculpin	*Radulinus asprellus*
snailfish UID	Cyclopteridae
snake prickleback	*Lumpenus sagitta*
soft sculpin	*Gilbertidia sigalutes*
speckled sanddab	*Citharichthys stigmaeus*
spiny dogfish	*Squalus acanthias*
spinyhead sculpin	*Dasycottus setiger*
splitnose rockfish	*Sebastes diploproa*
starry flounder	*Platichthys stellatus*
sturgeon poacher	*Agonus acipenserinus*
tadpole sculpin	*Psychrolutes paradoxus*
walleye pollock	*Theragra chalcogramma*

final site selections. Abundance, biomass, species richness and species diversity were used to characterize the fish assemblage at each PSDDA location.

Flatfish caught per hectare was calculated (Appendix E) at the request of the U.S. Army Corps of Engineers because 6 flatfish/hectare was recommended as a preliminary criterion by Washington Department of Fisheries (WDF) as a minimum number of flatfish needed to support a commercial fishery (WDF 1987). However, it must be understood that the 7.6 m research otter trawl used in this study, and by other research groups (e.g., Southern California Coastal Water Research Project), is selective (as is all sampling gear) and it is unknown how the 7.6 m trawl catches compare to the actual abundance of flatfish present, or how the catches compare to the catches used by WDF to compute the 6 flatfish/hectare criterion. For example, the 7.6 m research trawl probably catches relatively more juveniles than adults compared to a commercial trawl.

Commencement Bay

Abundance and biomass. Total abundance and biomass values showed seasonal and depth differences between many of the catches (Figures 5 and 6). The summer values were lower than the autumn values. The deeper stations, which included the PSDDA sites, had the lowest values regardless of season. Total abundance and biomass values were highest at 40 m then declined at 20 m (Figures 5 and 6). English sole, Dover sole and ratfish were found in most samples and generally the PSDDA sites contained the lowest abundance and biomass of these three species when compared to the samples collected outside the PSDDA sites. English sole abundance and biomass values were greatest at 40 m in both early summer and autumn, while at the deeper stations, including the PSDDA sites, the English sole abundance and biomass values were lower than

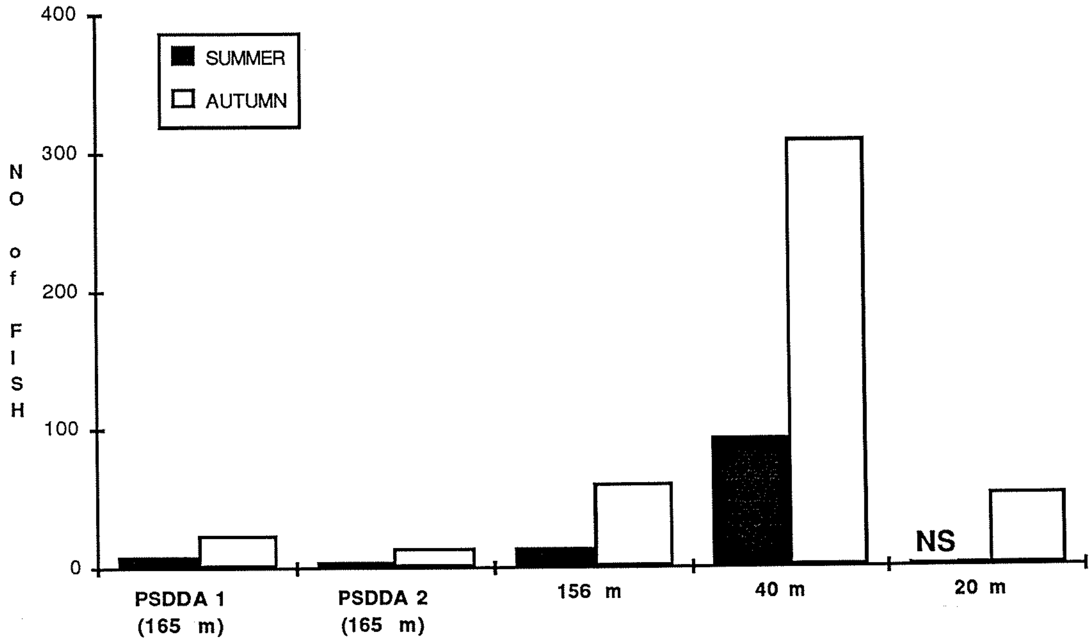


Figure 5. Number (abundance) of fish caught in Commencement Bay, shown by station and season. The values are based on a single sample, except for the PSDDA sites, which are the average of three samples. NS = not sampled.

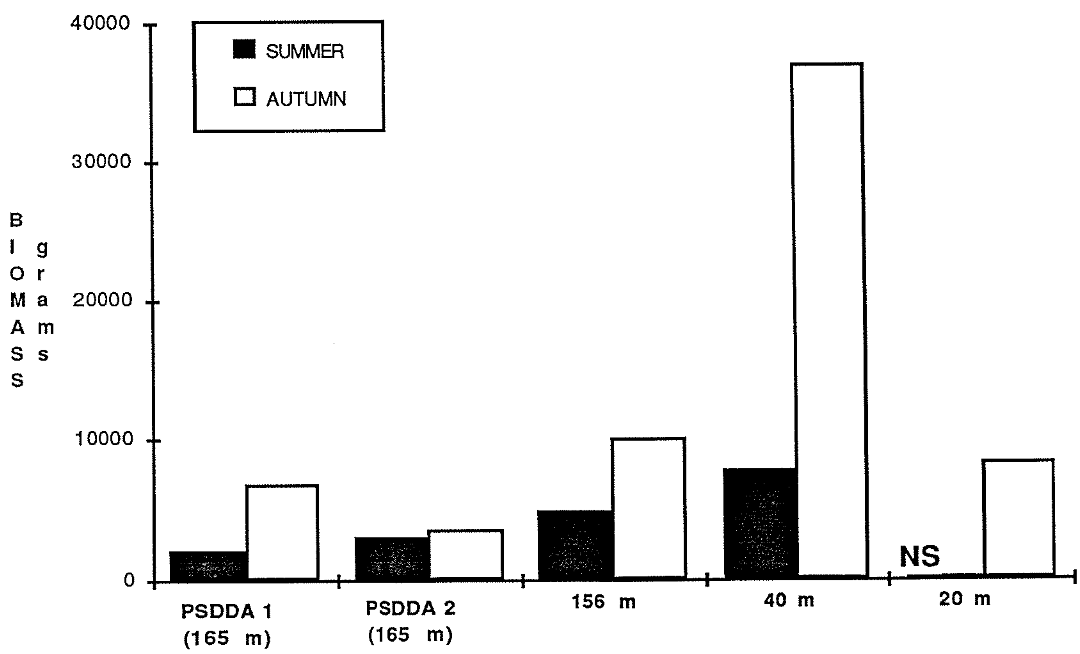


Figure 6. Biomass (in grams) of fish caught in Commencement Bay, shown by station and season. The values are based on a single sample, except for the PSDDA sites, which are the average of three samples. NS = not sampled.

those of the Dover sole and ratfish (Figures 7, A and B and 8, A and B). The abundance and biomass of ratfish was greater at the deeper stations than at either 20 m or 40 m.

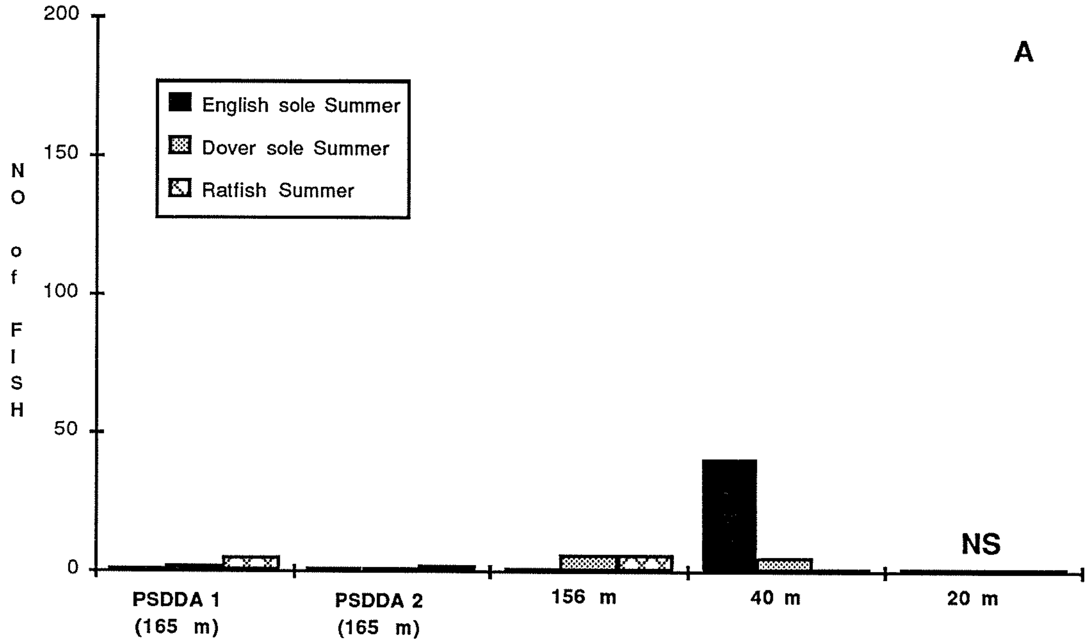
Species richness. The values for species richness varied by season and depth (Figure 9). Summer samples had lower values than the autumn period. The deeper locations, which included the PSDDA sites, had the lowest values for species richness.

Species diversity. Values for species diversity, H', were similar throughout Commencement Bay, except for the 156 m station (Figure 10). The 156 m station had a much lower value during the summer than the autumn.

Length-frequency. A significant proportion of English sole caught during the summer at 40 m were less than 205 mm (Figure 11, A and B). These fish were entirely missing from the autumn samples at the same station (Figure 11, A and B). English sole caught at 20 m during autumn sampling were larger than the fish caught at 40 m (Figure 12 and 11B).

Fish health. English sole, Dover sole, rex sole and rock sole all showed indications of blood worm infections. Incidences ranged from 0% to 100% (Table 2). English sole had consistently high infection rates, often as high as 100%, although the sample sizes associated with the highest incidence rates were less than 5 fish each. Incidence of skin tumors and fin erosion were all 0%. Gross examination of flatfish livers did not reveal any evidence of liver tumors.

Environmental measurements. Water temperature showed an inverse relation to depth (Table 3). Water temperatures were higher at the surface than at depth, while salinities were lower at the surface and higher at depth. The Secchi disc measurements were similar at all recording sites.



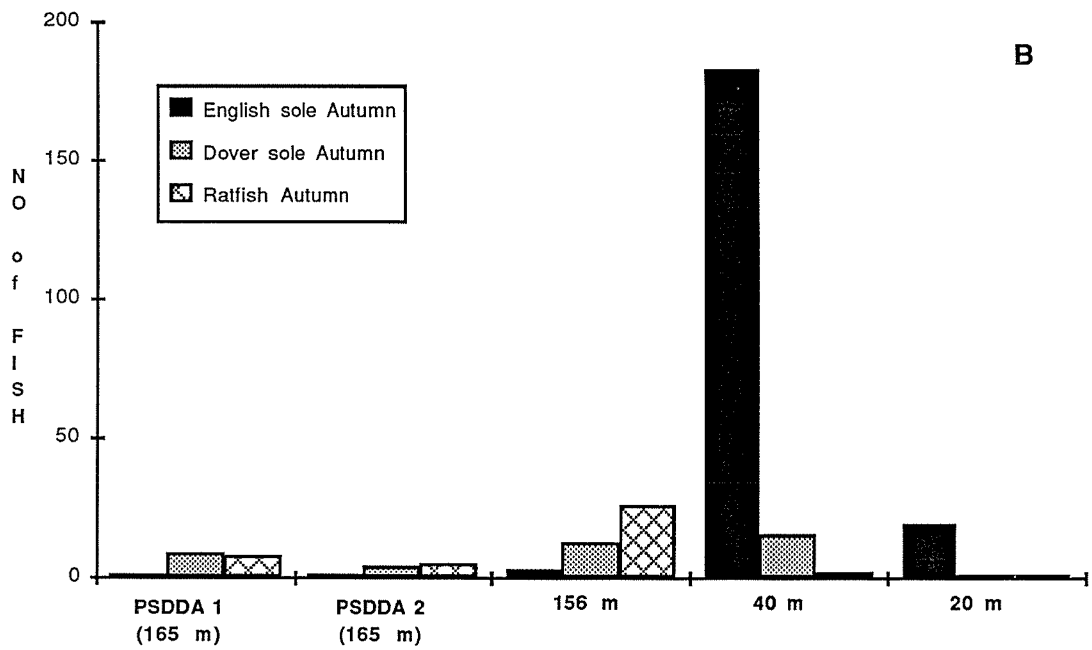


Figure 7. Number (abundance) of English sole, Dover sole and ratfish caught in Commencement Bay during summer (A) and autumn (B), shown by station. The values are based on a single sample, except for the PSDDA sites, which are the average of three samples. NS = not sampled.

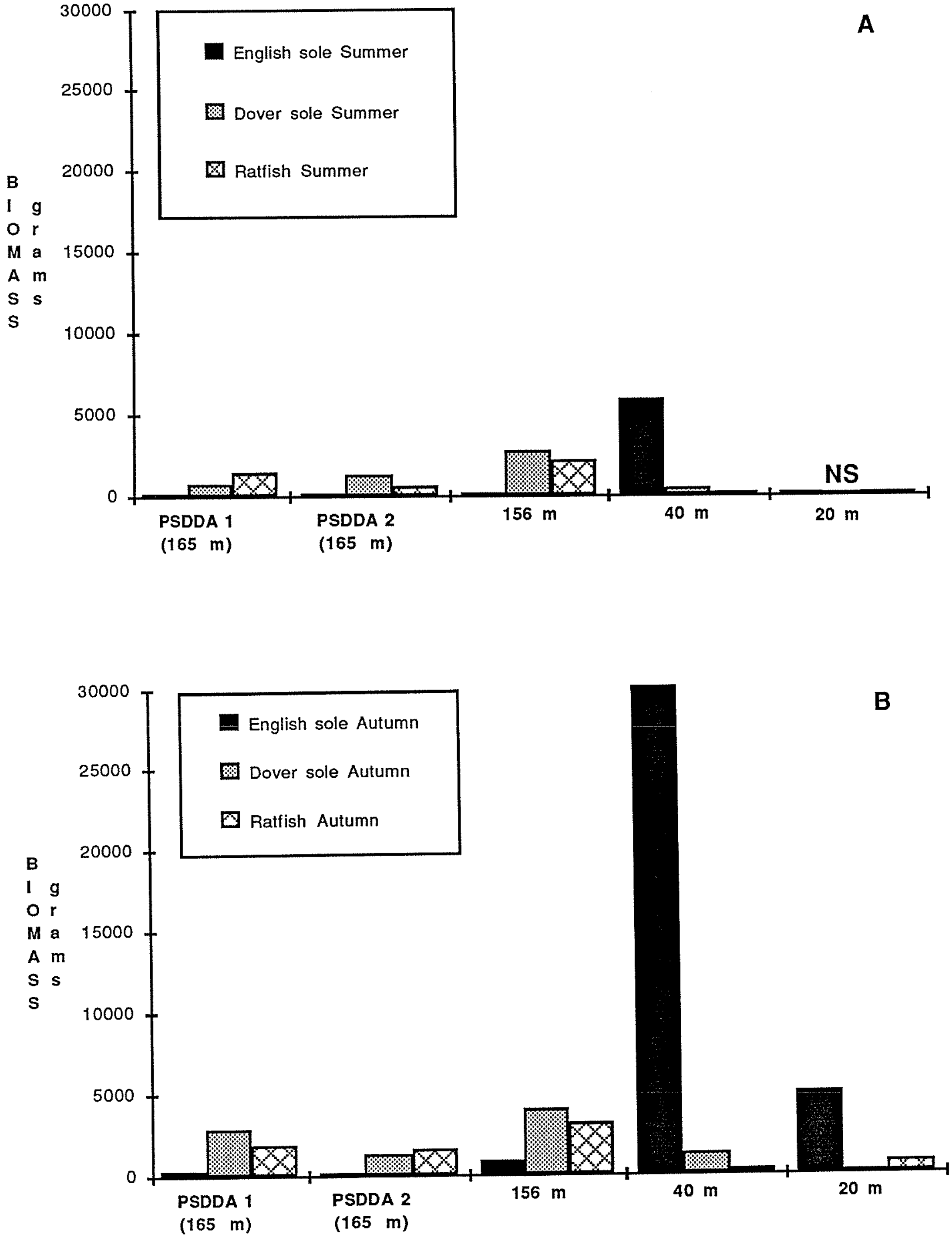


Figure 8. Biomass (in grams) of English sole, Dover sole and ratfish caught in Commencement Bay during summer (A) and autumn (B). Values are based on a single sample, except for the PSDDA sites, which are the average of three samples. NS = not sampled.

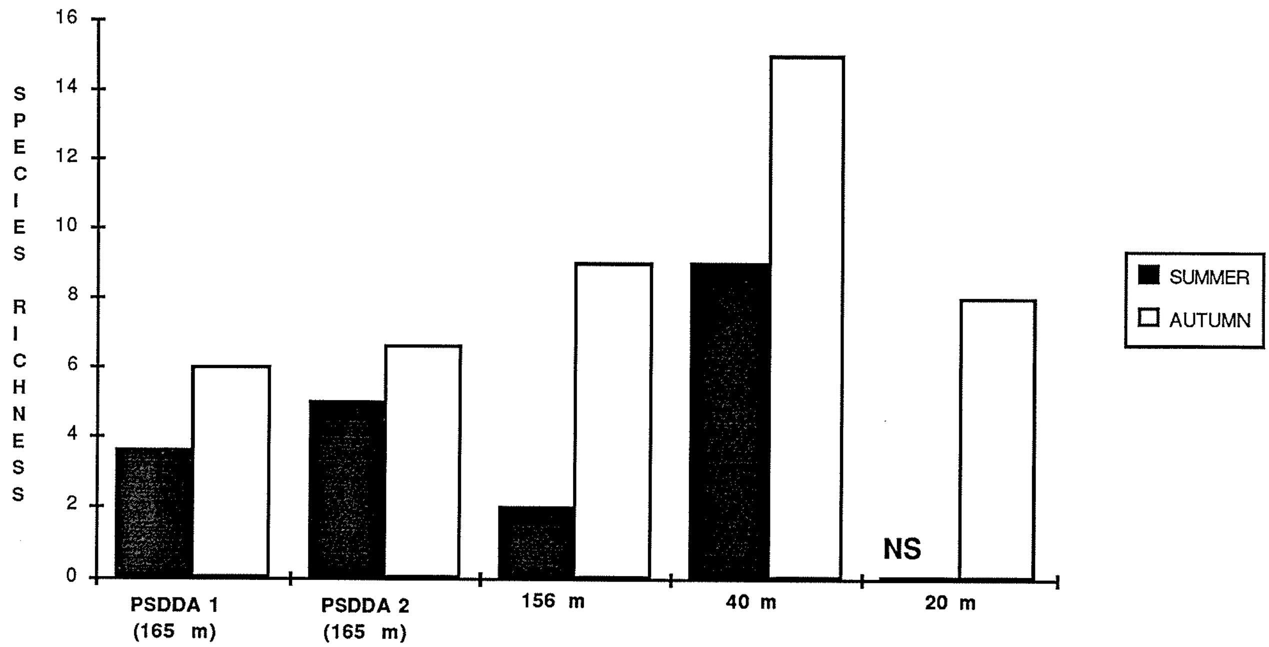


Figure 9. Species richness (total number of species) of fish caught in Commencement Bay, shown by station and season. NS = not sampled.

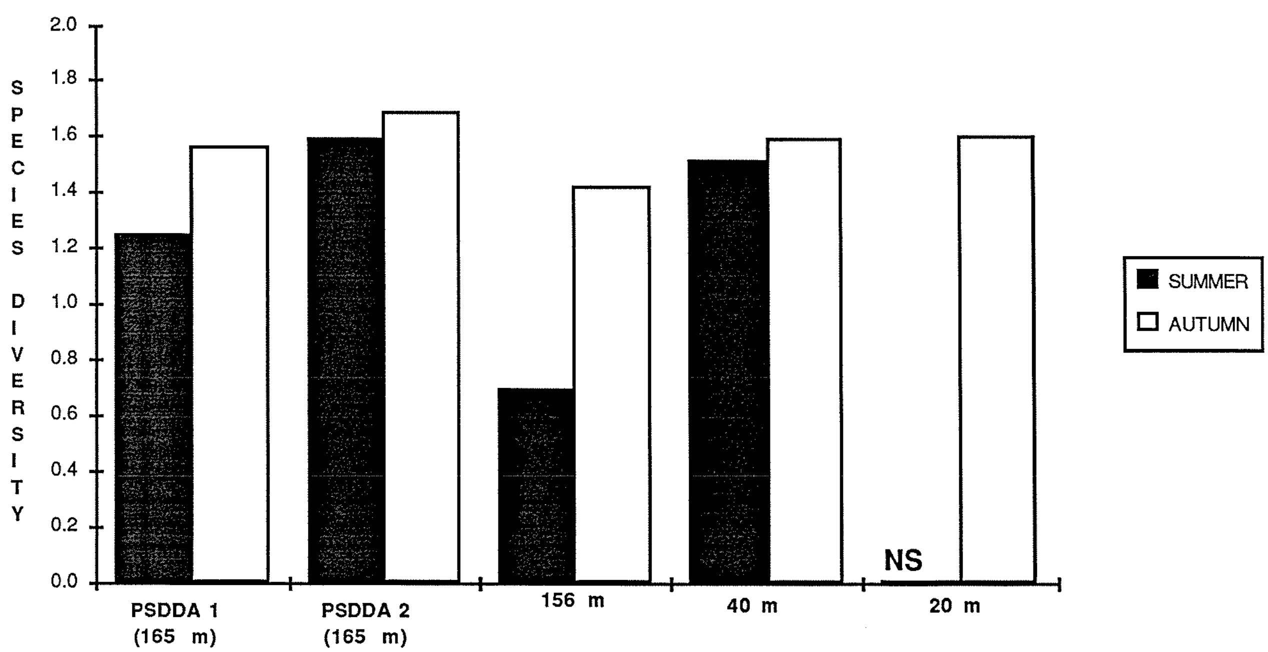
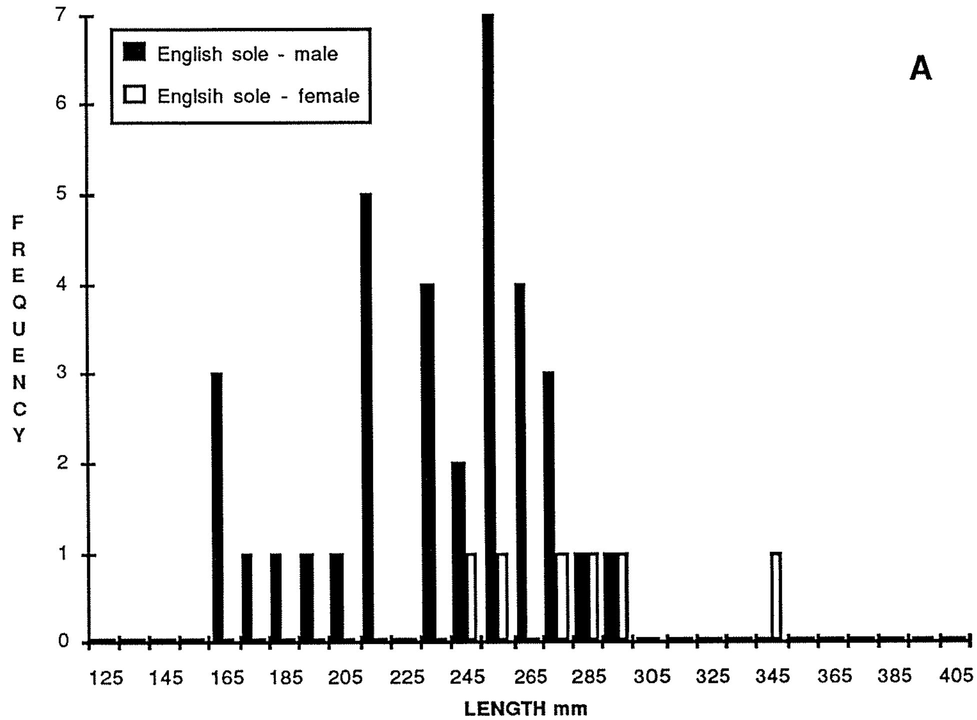


Figure 10. Species diversity (H') of fish caught in Commencement Bay, shown by station and season. NS = not sampled.



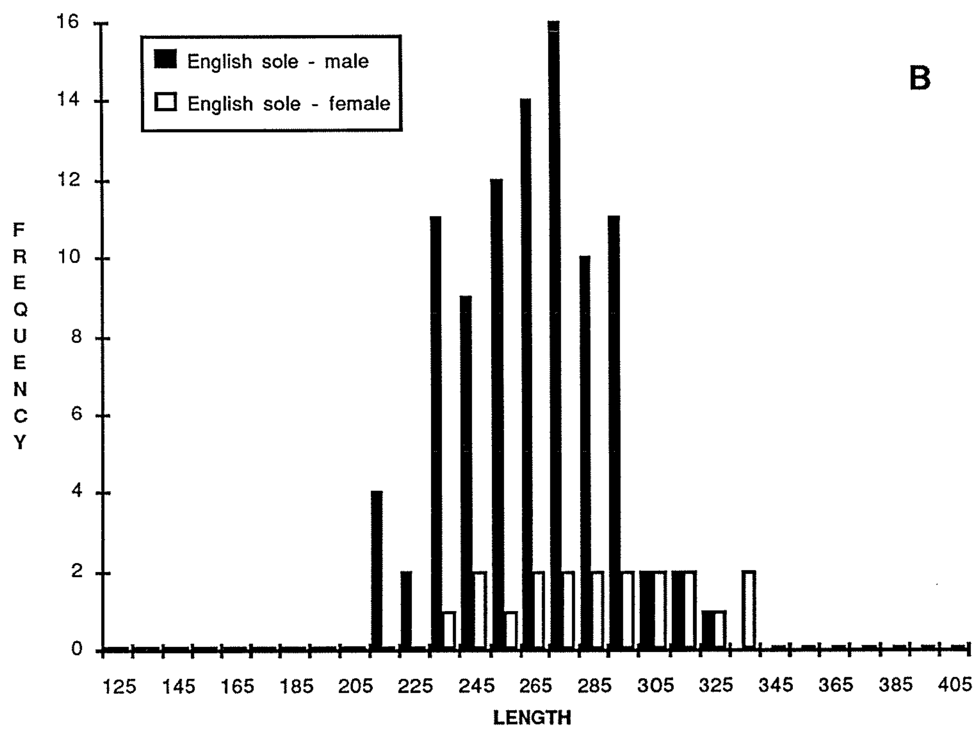


Figure 11. Length frequency of English sole, shown by sex, caught in Commencement Bay during summer (A) and autumn (B) at 40 m.

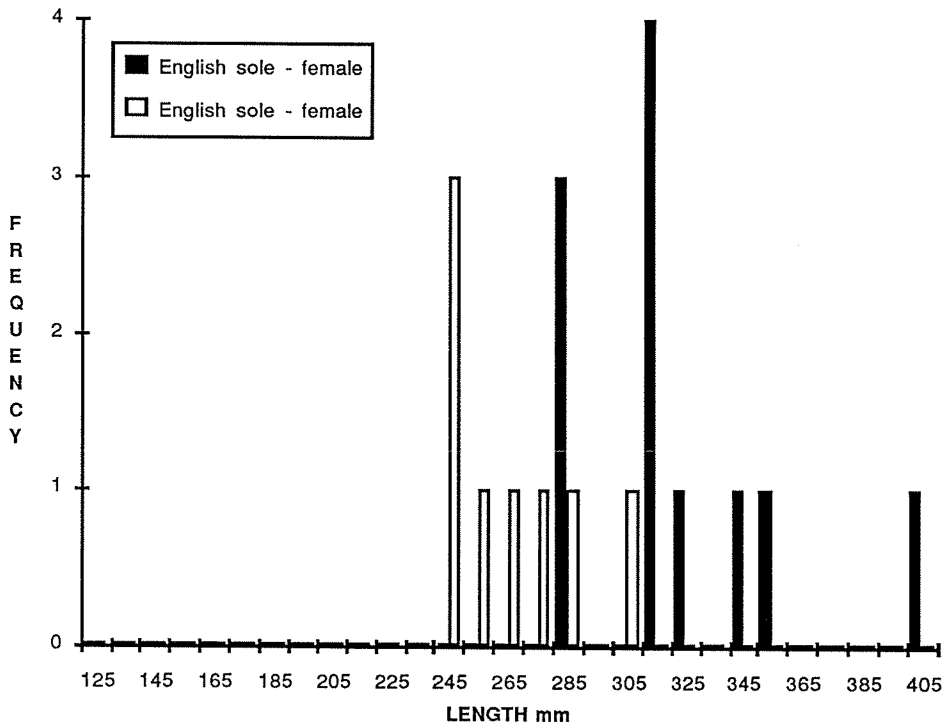


Figure 12. Length frequency of English sole, shown by sex, caught in Commencement Bay during autumn at 20 m.

Table 2. Percent incidence and sample size (in parentheses) of blood worm (*Philometra* sp.) infection in flatfish caught in Commencement Bay, shown by species, station and season. S = summer, A = autumn.

	PSDDA 1 (165 m)		PSDDA 2 (165 m)		156 m		40 m		20 m	
	S	A	S	A	S	A	S	A	S	A
English sole		0(2)	100(1)	100(4)		33(3)	43(40)	48(115)		58(19)
Dover sole	0(4)	0(3)	0(5)	0(10)	0(6)	9(11)	0(5)	35(5)		
Slender sole	0(3)	0(13)	0(2)	0(4)		0(3)		0(12)		
Rock sole							0(2)	20(10)		31(16)
Rex sole		100(1)		0(1)		0(3)	0(5)	0(7)		
Arrowtooth flounder								0(1)		
C-O sole								0(1)		0(1)
Speckled sanddab										0(3)

Table 3. Environmental measurements of temperature, salinity and water clarity in Commencement Bay during autumn by station.

	Surface	Depth
	Temperature, °C	
PSDDA 1 (165 m)	15.1	11.3
PSDDA 2 (165 m)	14.3	11.2
40 m	13.5	12.0
	Salinity, °/oo	
PSDDA 1 (165 m)	26.8	30.9
PSDDA 2 (165 m)	28.6	30.9
40 m	28.7	30.3
	Secchi, m	
PSDDA 1 (165 m)	5.0	
PSDDA 2 (165 m)	6.0	
40 m	6.0	

Elliott Bay

Abundance and biomass. The abundance and biomass values varied by station and by season (Figures 13 and 14). Abundance and biomass values were higher for autumn than for summer at all stations except PSDDA 1 Reference station.

Six species of fish dominated the catches in Elliott Bay: English sole, Dover sole, Pacific hake, slender sole, ratfish and blackbelly eelpout, although not every species was found at each site (Figures 15, A and B and 16, A and B). The PSDDA 1 site (inner Elliott Bay) was the shallowest and had the largest abundance and biomass of Pacific hake, slender sole and blackbelly eelpout. The PSDDA 2 site Fourmile Rock) had a greater abundance and biomass of English sole, Dover sole and ratfish than the PSDDA 1 site. The PSDDA 2 site had lower abundance and biomass values compared with the values found at the adjacent reference stations. Generally, abundance and biomass values increased from the summer to the autumn sampling; specifically, English sole, Dover sole, and ratfish. The shallower PSDDA 1 area had greater numbers of the smaller fishes such as blackbelly eelpouts and slender sole in contrast to the deeper PSDDA 2 area where the larger species dominated.

Species richness. The values for species richness varied by season and depth (Figure 17). Species richness was generally lower during the summer than the autumn, except for the PSDDA 1 reference station, where values were the same. The PSDDA 1 site and the PSDDA 1 reference station generally had larger values than the PSDDA 2 site and the PSDDA 2 reference stations, except for the PSDDA 2 site during the autumn.

Species diversity. The values for species diversity, H', generally diminished from the inner bay PSDDA 1 site and reference station to the Fourmile Rock PSDDA 2 site and reference station (Figure 18) irrespective of

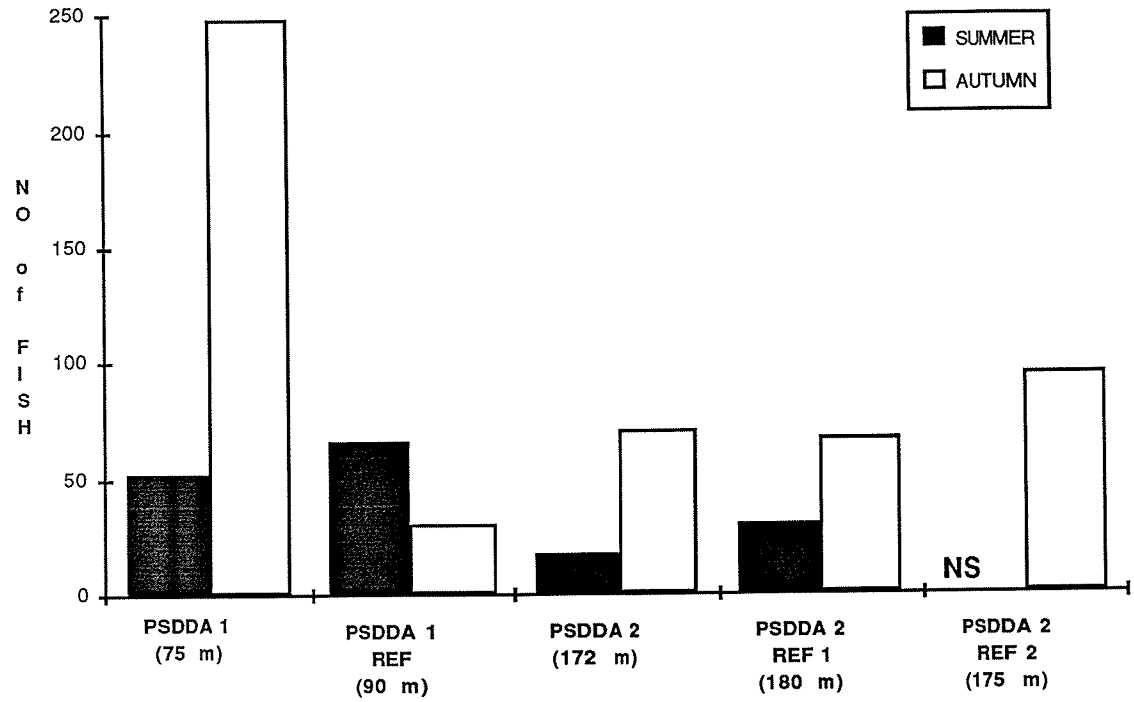


Figure 13. Number (abundance) of fish caught in Elliott Bay shown by station and season. The values at the PSDDA ref. sites are based on a single sample, while the values at the PSDDA sites are averages of three samples. NS = not sampled.

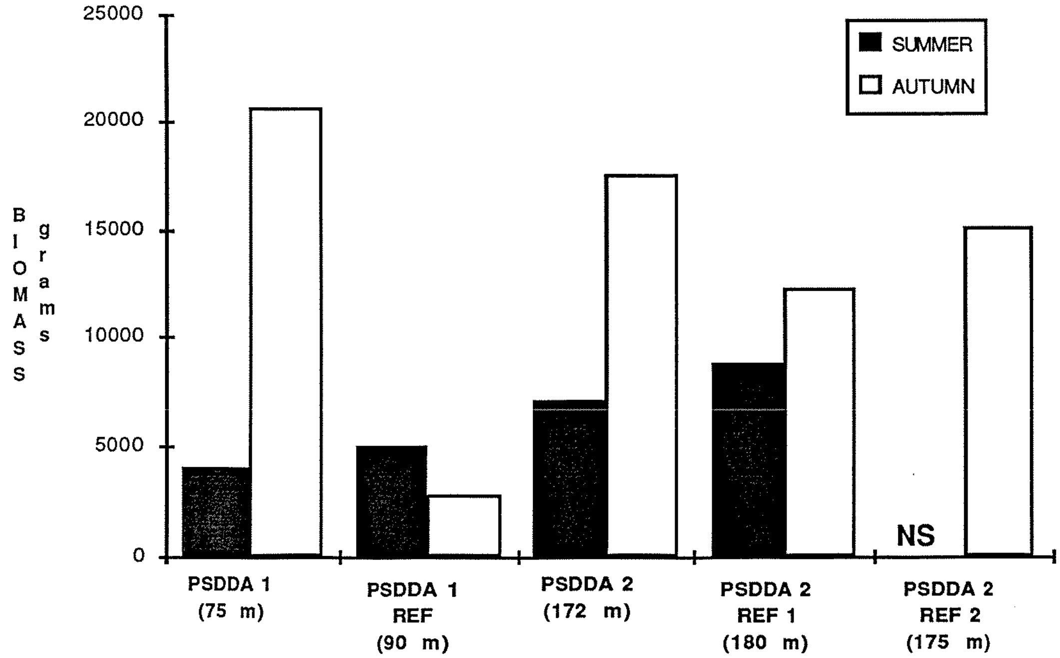
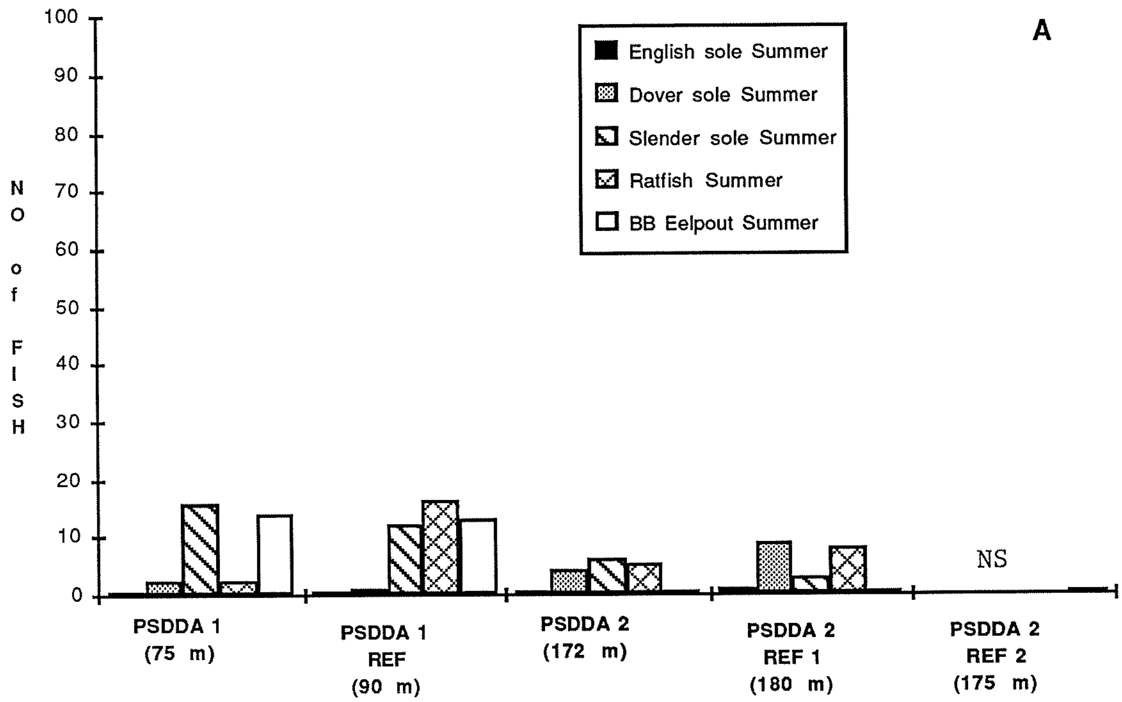


Figure 14. Biomass (in grams) of fish caught in Elliott Bay, shown by station and season. The values at the PSDDA ref. sites are based on a single sample, while the values at the PSDDA sites are averages of three samples. NS = not sampled.



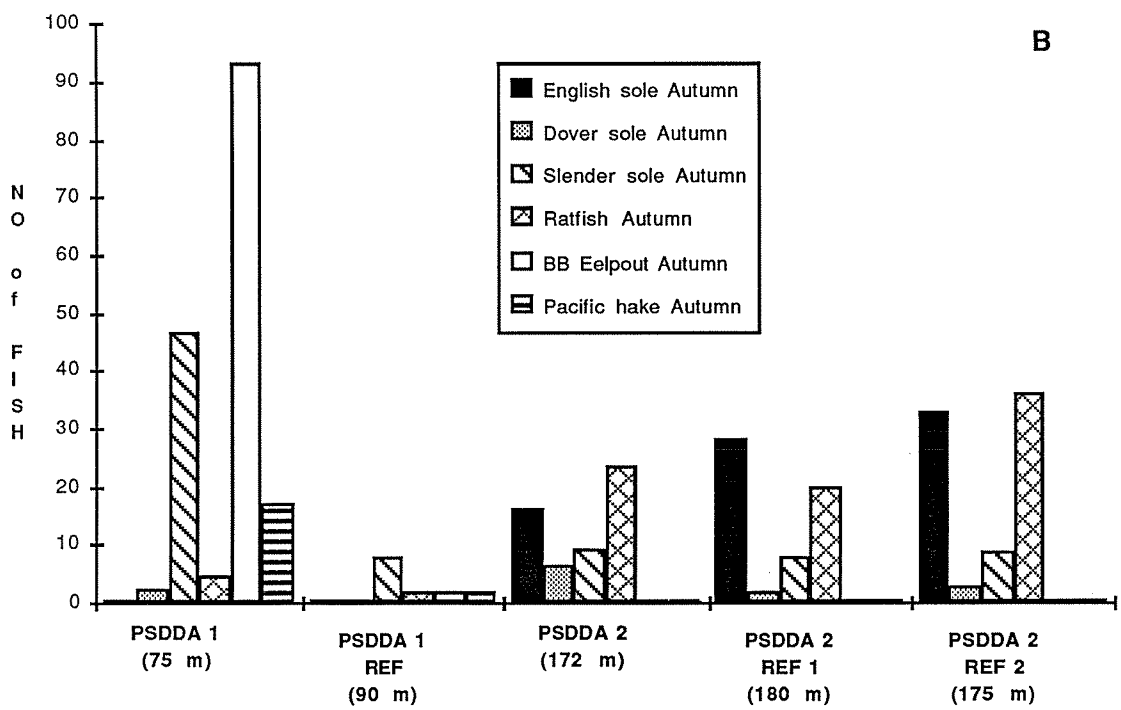
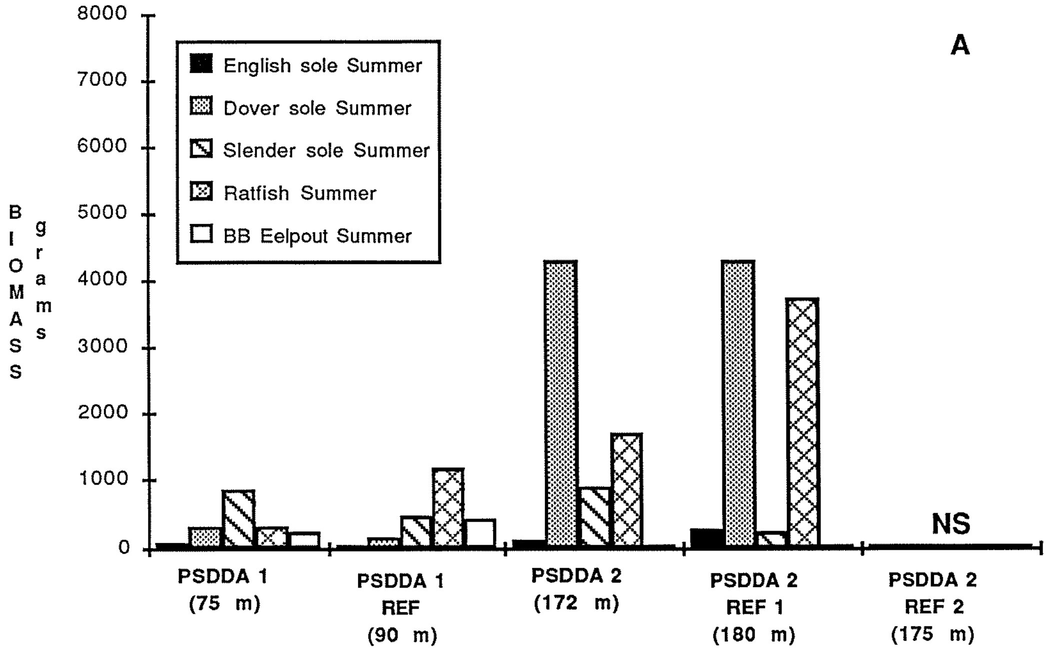


Figure 15. Number (abundance) of English sole, Dover sole, slender sole, ratfish and blackbelly eelpout (BB) caught in Elliott Bay during summer (A) and autumn (B), shown by station. The values at the PSDDA ref. sites are based on a single sample, while the values at the PSDDA sites are averages of three samples. NS = not sampled.



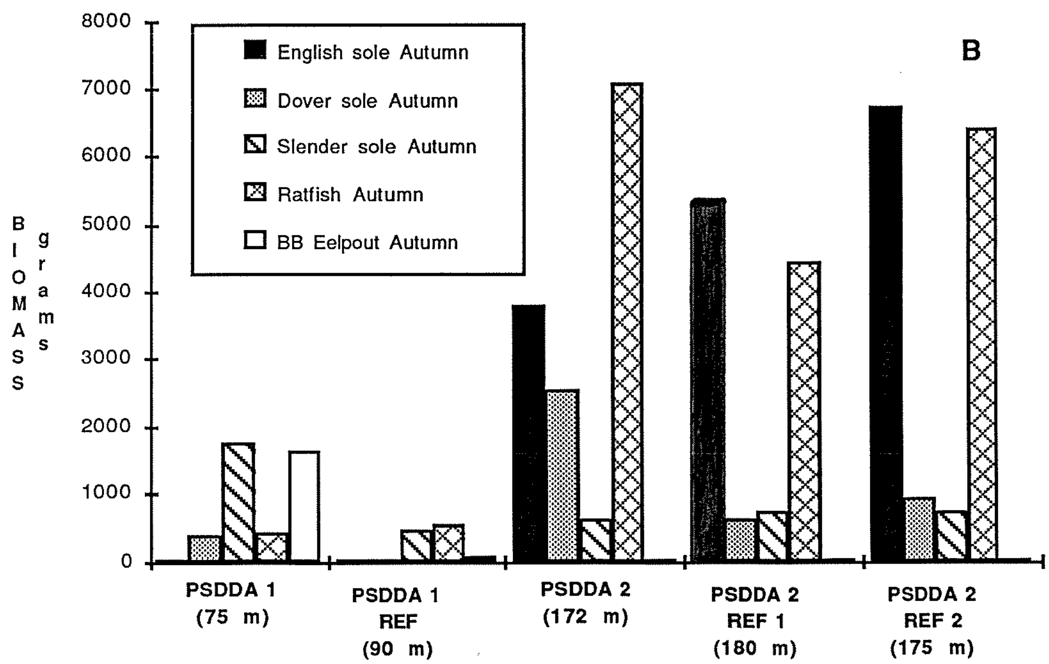


Figure 16. Biomass (in grams) of English sole, Dover sole, slender sole, ratfish and blackbelly eelpout (BB) caught in Elliott Bay during summer (A) and autumn (B), shown by station. The values at the PSDDA ref. sites are based on a single sample, while the values at the PSDDA sites are averages of three samples. NS = not sampled.

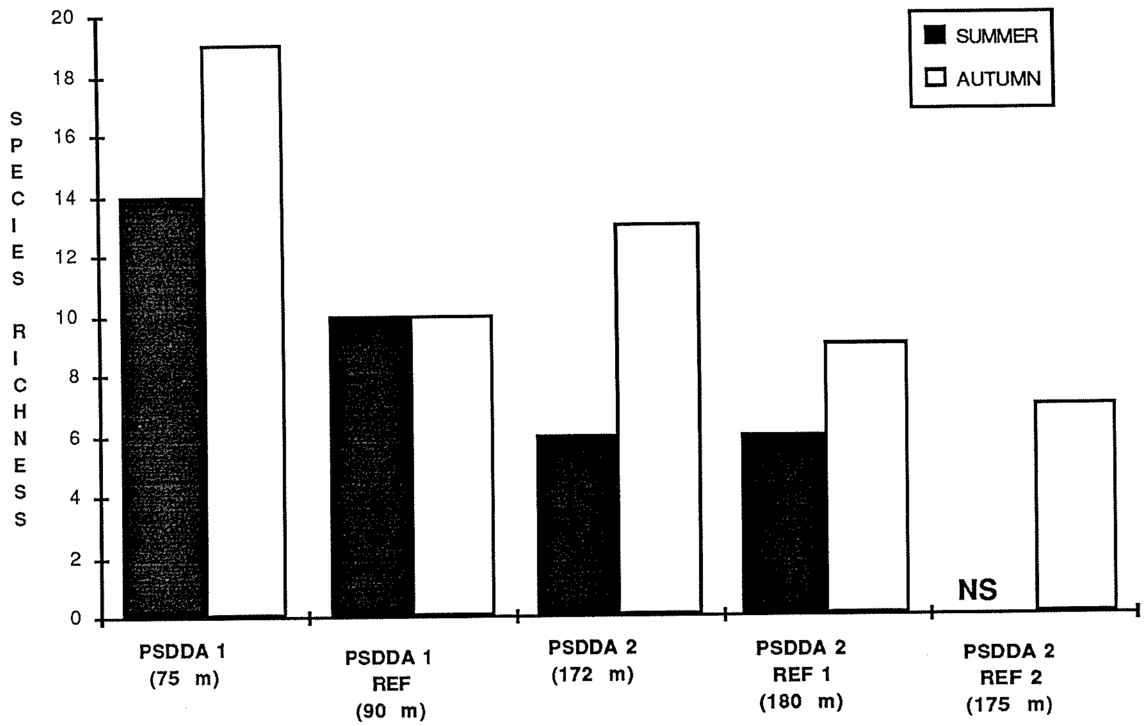


Figure 17. Species richness (total number of species) of fish caught in Elliott Bay, shown by station and season. NS = not sampled.

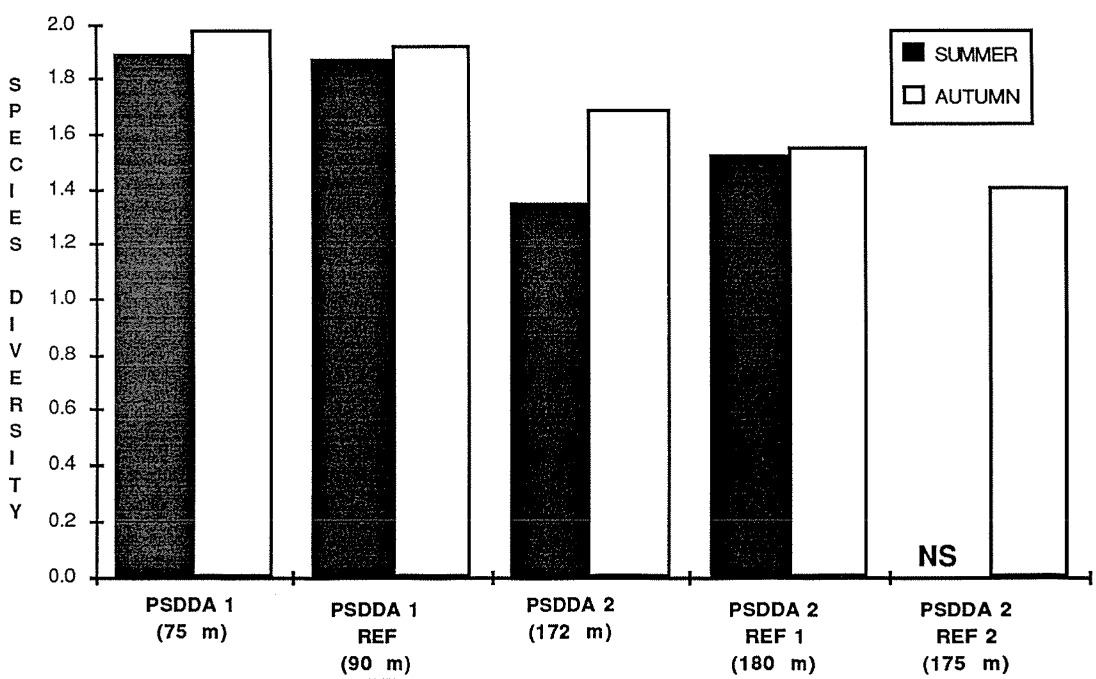


Figure 18. Species diversity (H') of fish caught in Elliott Bay, shown by station and season. NS = not sampled.

season.

Length-frequency. English sole data from the PSDDA 2 Reference Station 1 during autumn suggested a bimodal distribution of adults with no juveniles present (Figure 19).

Fish health. English sole, Dover sole and flathead sole showed evidence of blood worm infections (Table 4). Incidence in these three species ranged from 0% to 42%. The PSDDA 2 area had the highest incidence of blood worm infection in English sole and Dover sole with flathead sole showing only a minor incidence. There were no indications of skin tumors or fin erosion. Gross examination of flatfish livers did not show any indication of liver tumors.

Environmental measurements. Temperature and dissolved oxygen values were higher at the surface than at depth (Table 5), while salinity was lower at the surface than at depth. Dissolved oxygen and Secchi disc measurements showed a seasonal pattern: dissolved oxygen was slightly lower in autumn than in summer and Secchi disc values were slightly higher in autumn than in summer.

Saratoga Passage

Abundance and biomass. Only one sample cruise on July 1 was conducted in Saratoga Passage. Abundance and biomass showed variation by depth and by station (Figures 20 and 21). Abundance relative to biomass was greater for all stations except for the PSDDA site. The PSDDA site had an intermediate abundance value and had the highest biomass value. The dominant species included ratfish, English sole, Dover sole, slender sole and adult Pacific hake. Pacific hake were found in the PSDDA site and the reference station, while English sole were only found at the shallower locations. Dover sole were confined to the 40 m west station. Ratfish and slender sole occurred at

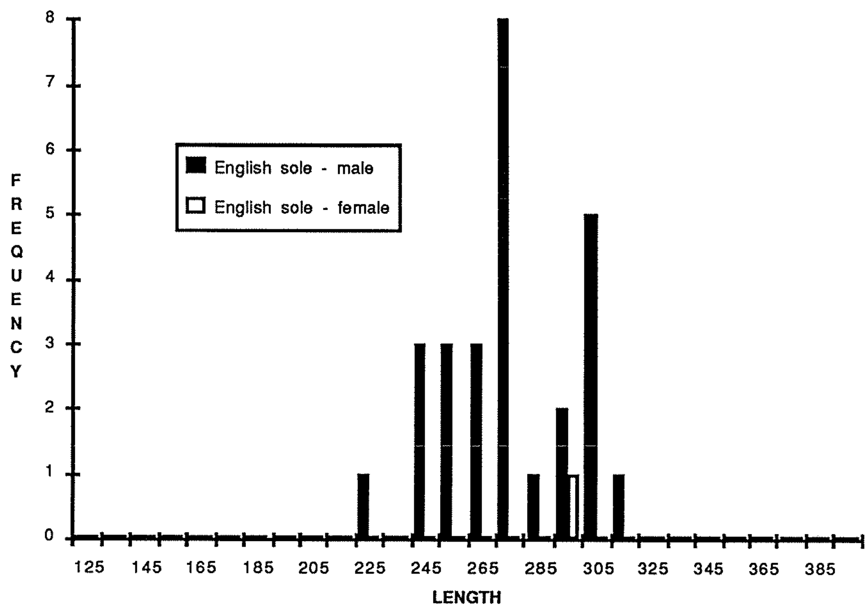


Figure 19. Length frequency of English sole, shown by sex, caught at PSDDA 2, reference 1, during autumn in Elliott Bay.

Table 4. Percent incidence and sample size (in parentheses) of blood worm (Philometra sp.) infection in flatfish caught in Elliott Bay, shown by species, station and season. S = summer, A = autumn.

	PSDDA 1 (75 m)		PSDDA 1 Ref (90 m)		PSDDA 2 (172 m)		PSDDA 2 Ref 1 (180 m)		PSDDA 2 Ref 2 (175 m)	
	S	A	S	A	S	A	S	A	S	A
English sole	0(1)				0(2)	35(55)	0(1)	14(28)		42(33)
Dover sole	0(13)	0(7)	0(1)		0(26)	5(20)	0(9)	0(2)		0(3)
Slender sole	0(80)	0(148)	0(13)	0(62)	0(35)	0(28)	0(3)	0(8)		0(9)
Flathead sole	6(54)	3(73)	0(15)	0(17)	0(5)					
Rock sole	0(5)	0(1)	0(1)							
Rex sole	0(9)	0(9)				0(1)				

Table 5. Environmental measurements of water temperature, dissolved oxygen, salinity and water clarity in Elliott Bay, by station and season.

	Summer		Autumn	
	Surface	Bottom	Surface	Bottom
		Temperature, °C		
PSDDA 1 (75 m)	13.5	10.3	18.5	11.9
PSDDA 2 (172 m)	13.9	11.0	12.9	-
		Dissolved Oxygen, mg/l (% saturation)		
PSDDA 1 (75 m)	9.72 (110%)	7.79 (84%)	8.36 (105%)	7.67 (92%)
PSDDA 2 (172 m)	9.77 (113%)	7.65 (84%)	6.34 (73%)	--
		Salinity, °/oo		
PSDDA 1 (75 m)	28.1	29.9	28.9	30.7
PSDDA 2 (172 m)	28.8	30.2	30.1	

Secchi, m

	Summer	Autumn
PSDDA 1 (75 m)	4.0	7.0
PSDDA 2 (172 m)	4.5	-

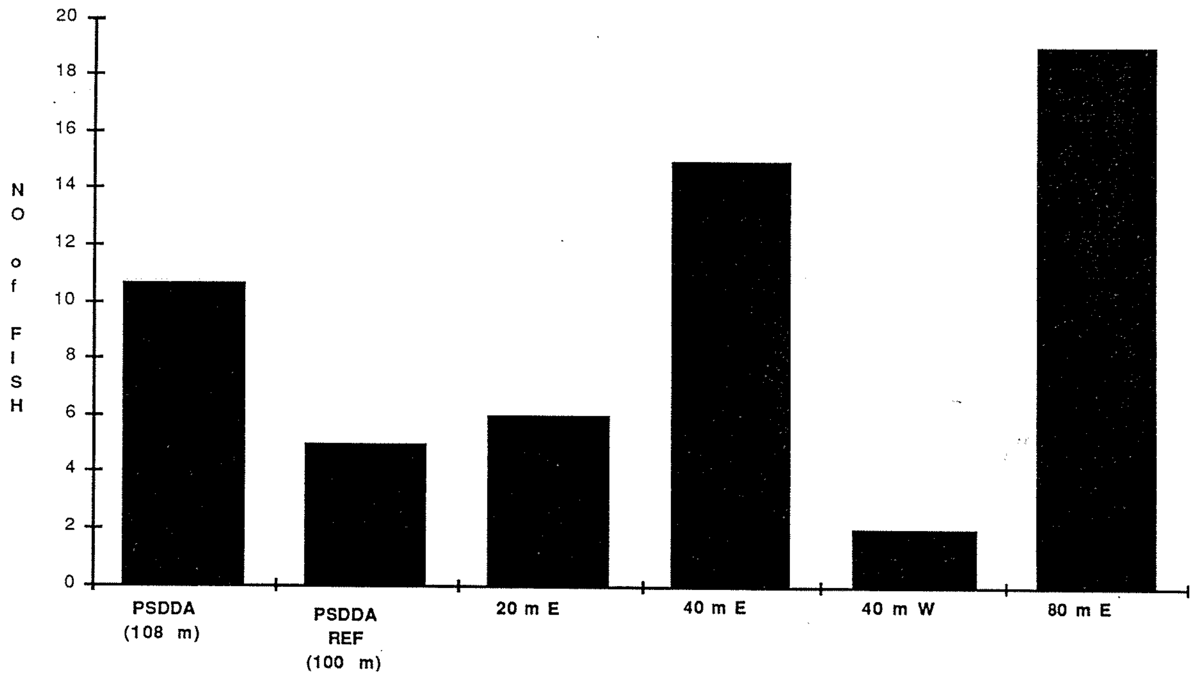


Figure 20. Number (abundance) of fish caught in Saratoga Passage during summer, shown by station. The values are based on a single sample, except for the PSDDA site, which is the average of three samples.

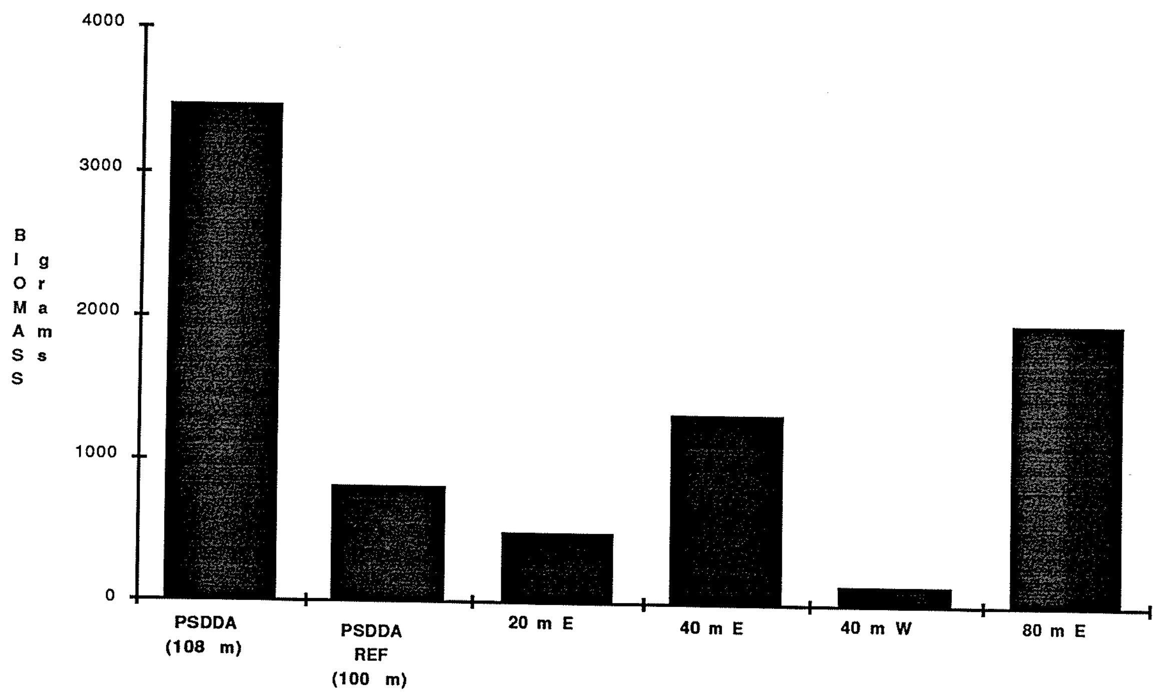


Figure 21. Biomass (in grams) of fish caught in Saratoga Passage during summer, shown by station. The values are based on a single sample, except for the PSDDA site, which is the average of three samples.

the deeper (PSDDA) stations and intermediate depths (Figures 22 and 23).

Species richness. Values for species richness fluctuated by depth; the highest values occurred at the PSDDA site reference station (Figure 24). All other species richness values were lower and showed no discernible pattern.

Species diversity. Values for species diversity, H', varied by depth, the deeper stations, including PSDDA, had the highest values (Figure 25). No pattern was apparent among the shallower stations.

Fish health. Incidence of blood worms, skin tumors and fin erosion were all 0% (Table 6). No evidence of liver tumors was found based on gross examination of flatfish livers.

Environmental measurements. No environmental measurements were collected in Saratoga Passage because of weather conditions that forced an early curtailment of sampling.

Port Gardner

Abundance and biomass. Abundance and biomass fluctuated by time of year, depth, and station. The NAVY site generally had the largest number and biomass of fish throughout the year. During the winter the 40 m depth had numbers of fish comparable to the NAVY site; however, the biomass values were lower. (Figures 26 and 27). PSDDA 1 and PSDDA 2 sites had low values for abundance and biomass for all seasons except winter when abundance was at its highest (compared with other seasons) and biomass values were second only to the NAVY site (Figures 26 and 27). Five of the locations that were sampled throughout the year were situated at depths of 100 m or more; these included: PSDDA 1, PSDDA 2, 100m M, 110m S and 145m S. The 110m S and 145m S stations had the lowest abundance and biomass values of the 5 deep locations.

Species diversity. Species diversity, H', values showed seasonal and depth differences between many stations, but showed no discernable pattern

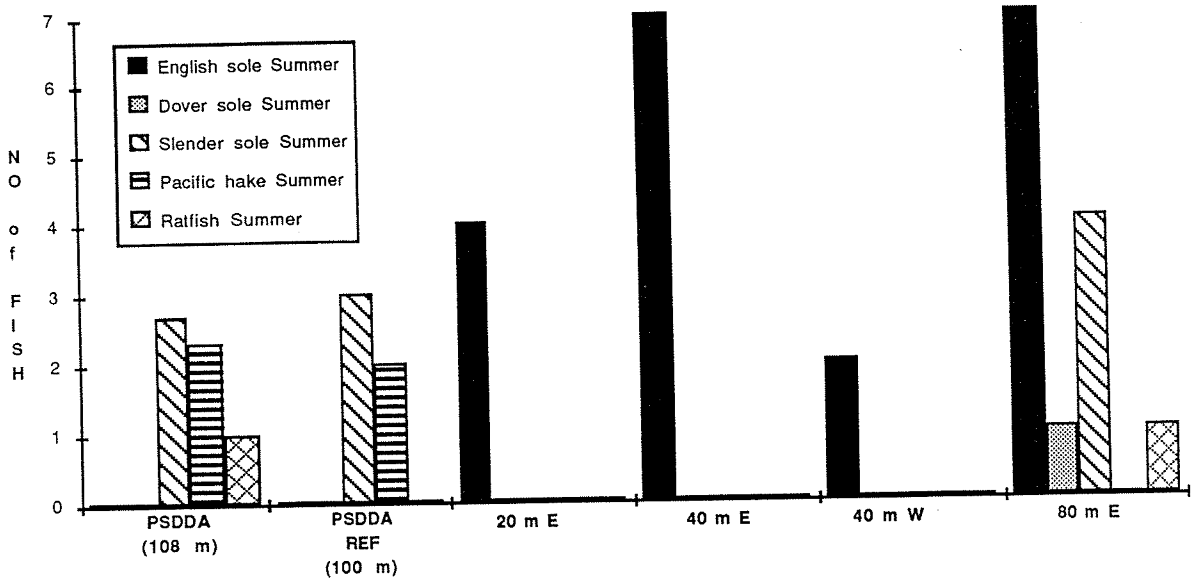


Figure 22. Number (abundance) of English sole, Dover sole, slender sole, Pacific hake and ratfish caught in Saratoga Passage during summer, shown by station. The values are based on a single sample, except for the PSDDA site, which is the average of three samples.

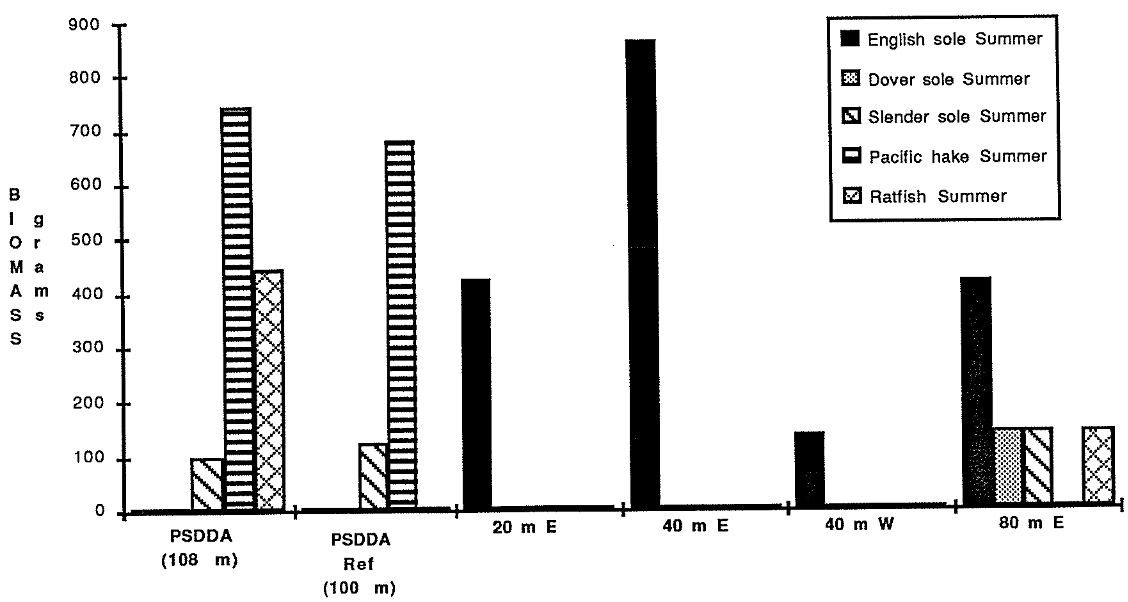


Figure 23. Biomass (in grams) of English sole, Dover sole, slender sole, Pacific hake and ratfish caught in Saratoga Passage during summer, shown by station. The values are based on a single sample, except for the PSDDA site, which is the average of three samples.

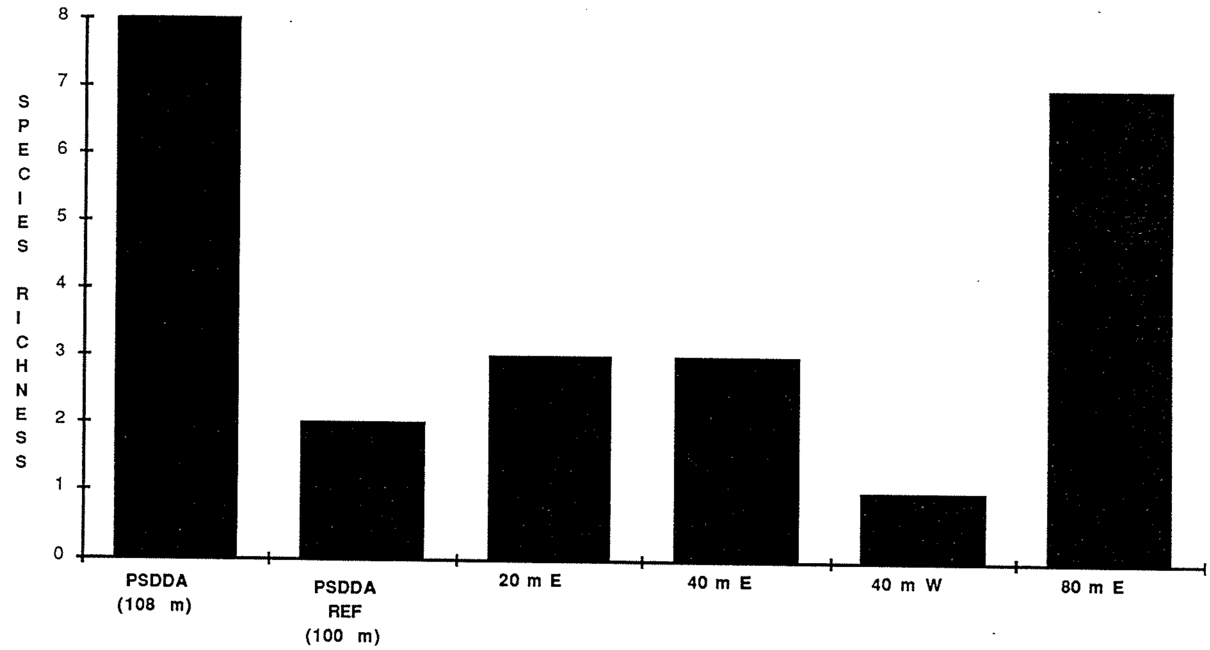


Figure 24. Species richness (total number of species) of fish caught in Saratoga Passage during summer, shown by station.

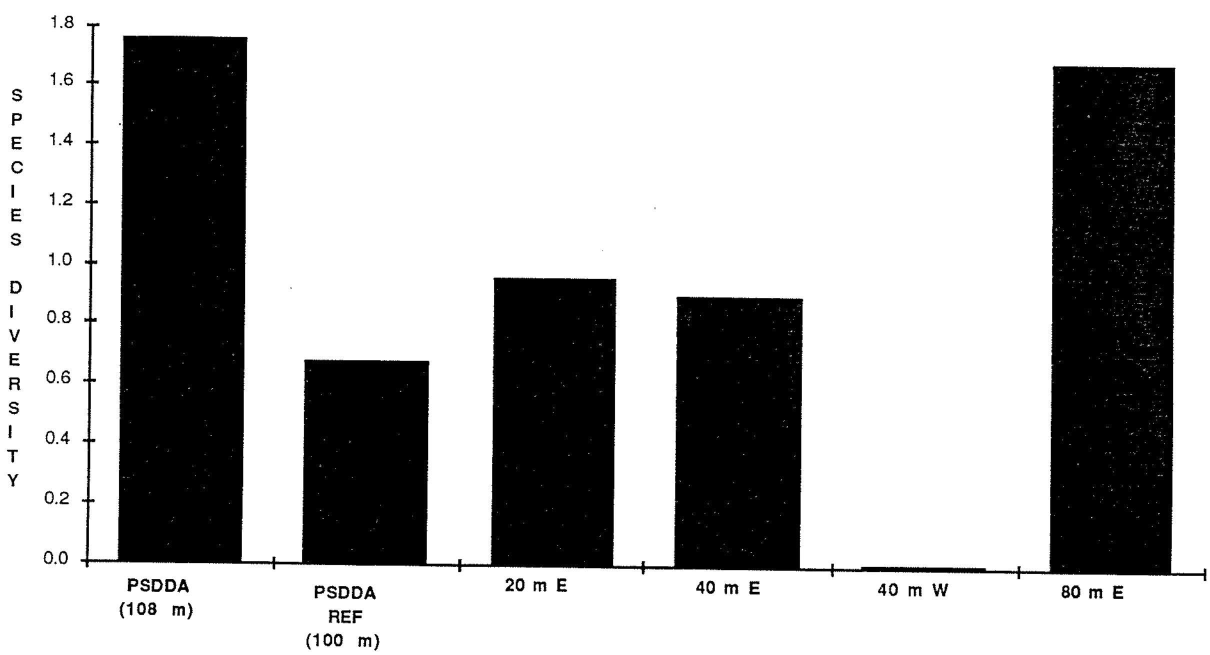


Figure 25. Species diversity (H') of fish caught in Saratoga Passage during summer, shown by station.

Table 6. Percent incidence and sample size (in parentheses) of bloodworm (Philometra sp.) infection in flatfish caught at Saratoga Passage during summer, shown by station and species.

	PSDDA (108 m)	80m E	40m E	40m W	20m E
English sole		0(7)	0(7)	0(2)	0(4)
Slender sole	0(17)	0(4)			
Dover sole		0(1)			
Rock sole		0(1)	0(6)		0(2)

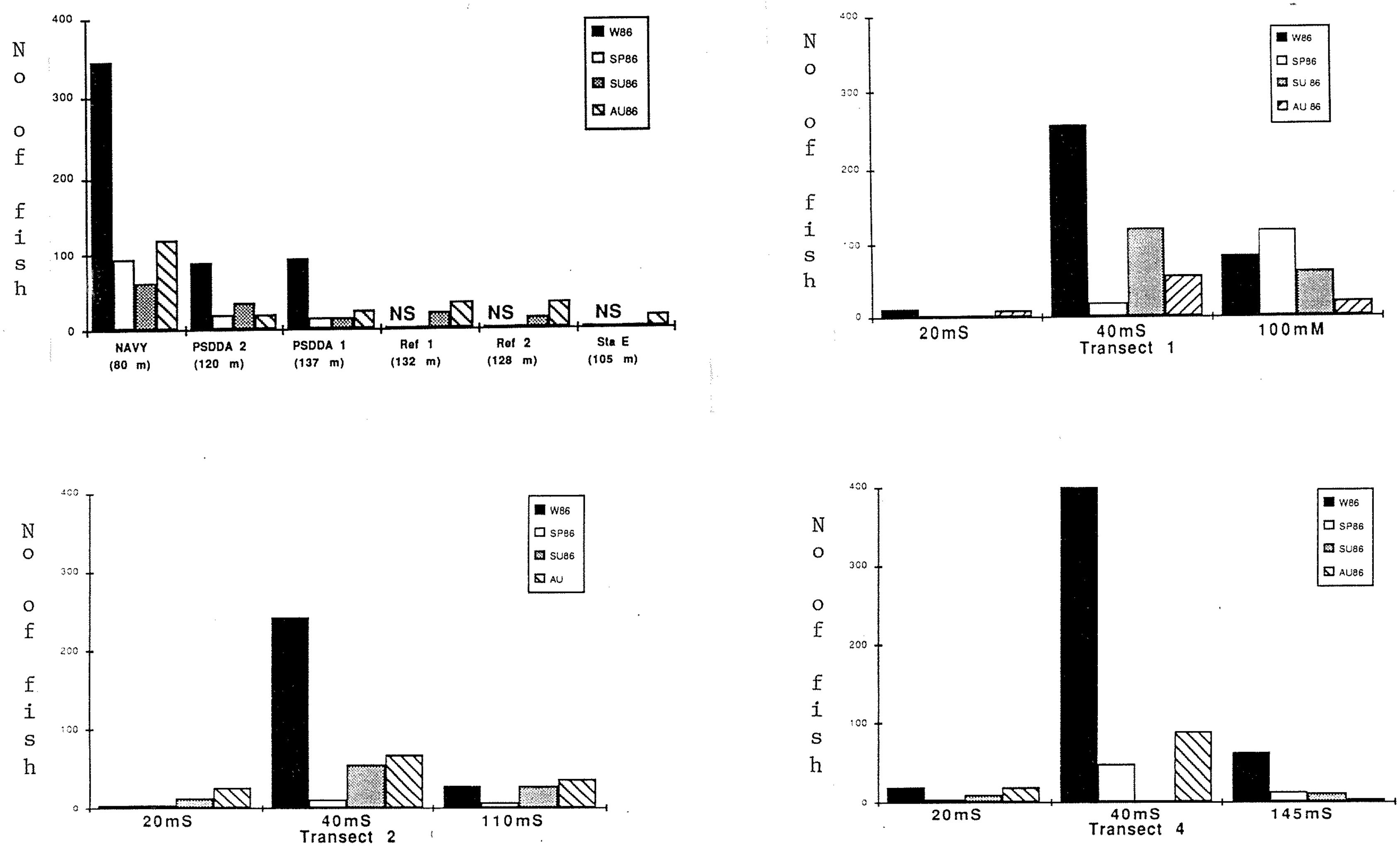


Figure 26. Number (abundance) of fish caught in Port Gardner, shown by station and season. The values are based on a single sample, except for the NAVY and PSDDA sites, which are the average of three samples. NS = not sampled.

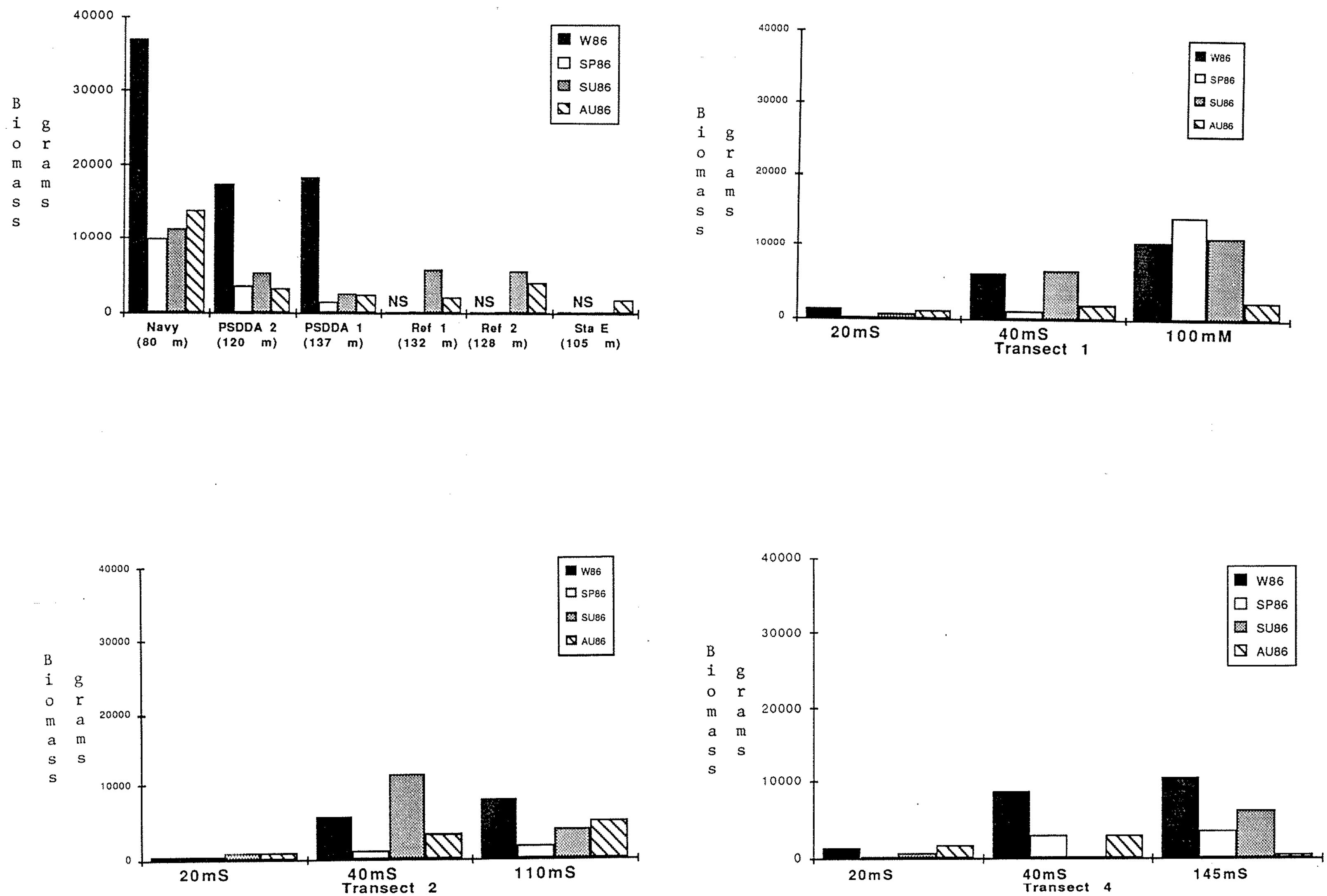


Figure 27. Biomass (in grams) of fish caught in Port Gardner, shown by station and season. The values are based on a single sample, except for the NAVY and PSDDA sites, which are the average of three samples. NS = not sampled.

(Figure 28).

Fish health. English sole, Dover sole, flathead sole, rex sole and rock sole all showed indications of blood worm infections (Table 7). Incidence varied between species, seasons, depth and station but did not show a discernable pattern. One skin tumor was noted on a slender sole caught at Station 100 mM. Incidence of fin errosion was 0%. Gross examination of flatfish livers did not reveal any evidence of liver tumors.

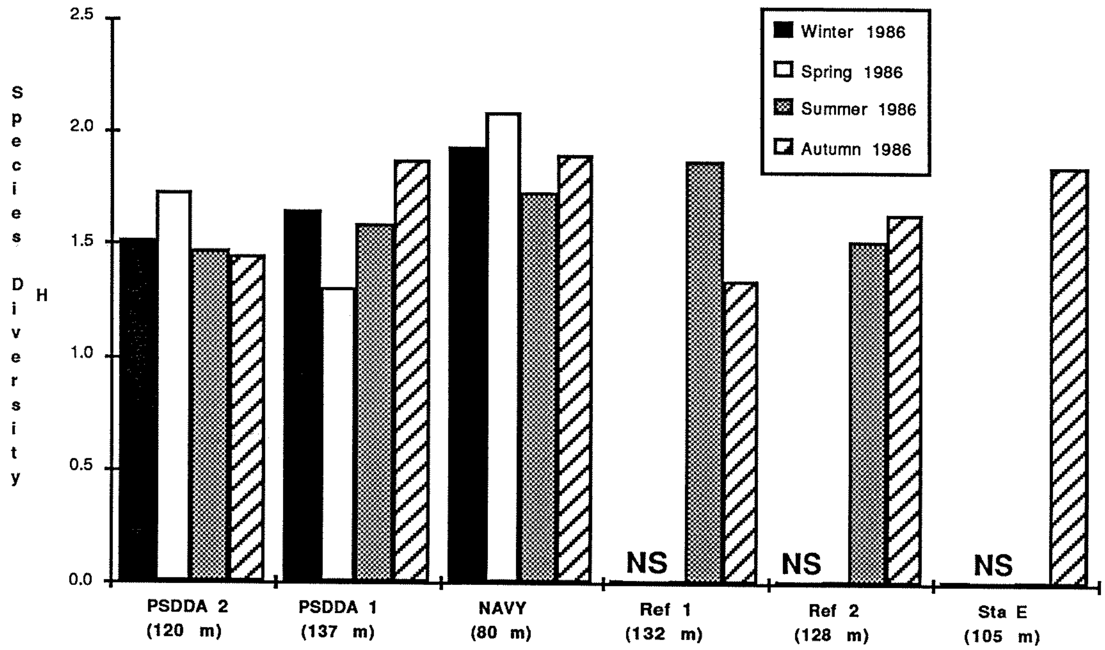
Environmental measurements. Water temperatures during winter and autumn were higher at the bottom than the surface (Table 8). Spring and summer water temperatures were the reverse with the surface warmer than the bottom. In general, salinities were lower at the surface than the bottom. Secchi disc measurements showed that the best water clarity (higher Secchi disc measurement) occurred in the winter while there were no differences between the other seasons.

DISCUSSION AND CONCLUSIONS

The Research Otter Trawl For Documenting Fish Assemblage

The 7.6 m otter trawl has been the dominant sampling gear in Puget Sound demersal fish research for about the last decade. This net is widely used by many groups for similar research in other areas of the country. Standardization of gear reduces the problems associated with comparing results between studies. In addition, the small size of the net allows for ease of use from a range of vessel sizes starting at about 6 m.

The 7.6 m otter trawl has limitations. The net is not fished commercially and due to size, shape and other differences, catches are not directly comparable to commercial otter trawl catches. Other limitations



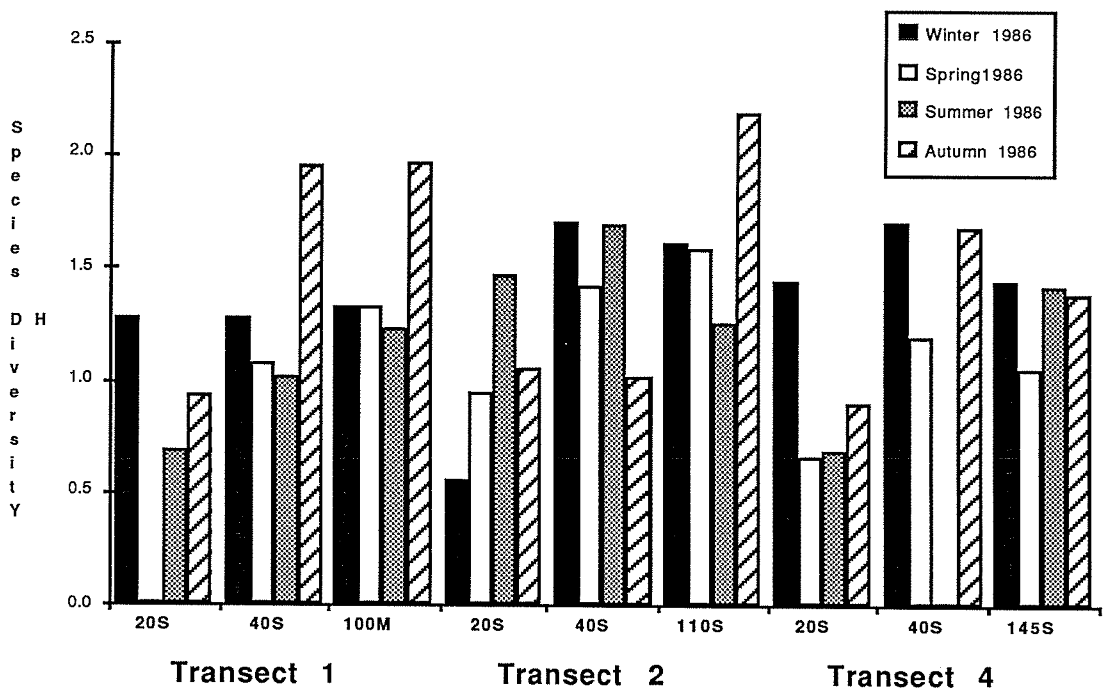


Figure 28. Species diversity of fish (H') caught in Port Gardner, shown by station and season. NS = not sampled.

Table 7. Percent incidence and sample size (in parentheses) of bloodworm (Philometra sp.) infection in flatfish, shown by species, station and season at Port Gardner. W = Winter, SP = Spring, SU = Summer, AU - Autumn.

Flatfish Species	NAVY				PSDDA 2				PSDDA 1			
	W	SP	SU	AU	W	SP	SU	AU	W	SP	SU	AU
Rex sole	50(2)	0(18)			0(1)			0(2)	0(1)	0(3)		
Flathead sole	3(77)	0(17)	0(7)	0(3)	0(1)							
Rock sole	0(1)								100(1)			
Slender sole	1(118)	4(56)	0(15)	0(66)	0(29)	0(14)	0(6)	0(23)	0(78)	0(26)	0(9)	0(23)
Dover sole	5(22)	0(9)	0(2)		0(10)	0(18)	0(21)	0(5)	0(11)	0(2)	0(14)	0(5)
English sole	10(335)	8(91)	2(86)	6(169)	0(7)	13(8)	0(37)	10(10)	5(21)	50(2)	33(1)	13(8)

	Tran 1 20S				Tran 1 40S				Tran 1 100M			
	W	SP	SU	AU	W	SP	SU	AU	W	SP	SU	AU
Rex sole								0(1)	0(3)	0(2)		0(2)
Flathead sole	0(1)				0(5)					0(2)		
Rock sole	0(4)				0(18)	0(1)	17(6)	0(7)				
Slender sole							0(1)	0(5)	100(2)	0(15)	33(3)	
Dover sole						0(12)			0(2)	0(2)	0(1)	0(2)
English sole	0(2)		0(1)	0(5)	0(174)	0(2)	0(15)	6(17)	8(26)	10(61)	0(28)	33(3)

	Tran 2 20S				Tran 2 40S				Tran 2 110S			
	W	SP	SU	AU	W	SP	SU	AU	W	SP	SU	AU
Rex sole					0(1)		0(3)		0(1)			0(1)
Flathead sole							0(1)					
Rock sole	0(3)	100(1)	0(2)	0(1)	28(18)	20(5)	0(5)	0(3)				
Slender sole				0(2)	0(6)		0(2)	0(3)	0(1)	0(2)		0(4)
Dover sole					0(1)		0(1)	8(52)	0(11)	0(1)	0(3)	0(7)
English sole			0(2)	0(3)	2(121)	66(3)	0(22)		0(54)		25(4)	0(6)

	Tran 4 20S				Tran 4 40S				Tran 4 145S			
	W	SP	SU	AU	W	SP	SU	AU	W	SP	SU	AU
Rex sole								0(3)				
Flathead sole	0(4)				0(1)							
Rock sole	100(1)	0(2)		0(5)	26(31)	38(13)						
Slender sole								0(4)	0(14)	0(1)	0(1)	0(1)
Dover sole	0(11)						0(1)	0(7)	0(28)		0(5)	
English sole	0(8)		0(6)	0(14)	2(140)	21(19)		17(6)				

	Ref 1		Ref 2		Sta E
	SU	AU	SU	AU	AU
Rex sole					
Flathead sole					
Rock sole					
Slender sole	0(2)	0(3)		0(15)	0(6)
Dover sole	0(6)	0(2)	0(4)	0(1)	0(2)
English sole	0(5)	0(4)	0(5)	14(7)	0(3)

Table 8. Measurements of temperature, salinity and water clarity by station and season at Port Gardner. W = Winter, SP = Spring, SU = Summer, AU = Autumn, NS = not sampled.

Site	Surface				Bottom			
	Temperature ºC							
	W	SP	SU	AU	W	SP	SU	AU
NAVY	7.0	10.5	11.9	14.0	7.5	9.5	11.0	12.0
PSDDA 2	6.5	10.0	15.2	15.0	8.0	9.0	11.0	13.0
PSDDA 1	6.0	10.2	15.0	14.4	7.5	9.3	9.9	12.0
Tran 1 20mS	NS	10.8	18.1	15.0	NS	9.5	11.5	13.0
Tran 2 40mS	6.5	10.5	10.5	14.0	7.5	NS	11.5	12.0
Tran 4 145mS	6.0	10.5	12.0	NS	8.0	9.0	12.5	NS
	Salinity o/oo							
NAVY	29.85	16.79	22.34	28.73	NS	29.73	NS	30.58
PSDDA 2	21.23	18.53	23.58	NS	NS	29.67	29.81	30.81
PSDDA 1	NS	22.98	24.99	28.23	NS	29.85	24.99	30.56
Tran 1 20mS	NS	NS	19.58	28.32	NS	29.16	29.58	30.07
Tran 2 40mS	NS	NS	29.81	NS	NS	29.53	29.77	30.33
Tran 4 145mS	22.01	NS	23.58	NS	NS	30.10	29.70	NS
	Secchi Disc m							
NAVY	3.50	3.00	3.00	5.00				
PSDDA 2	5.50	4.25	4.50	4.00				
PSDDA 1	8.50	7.25	4.50	NS				
Tran 1 20mS	NS	3.50	3.00	5.50				
Tran 2 40mS	3.50	3.00	3.00	5.00				
Tran 4 145mS	4.50	NS	3.50	NS				

include: 1) current and wind conditions at the time of sampling, 2) gear selectivity relative to each fish species and life history stage, and 3) variability in area swept.

Commencement Bay

Several trawling studies have previously been conducted in Commencement Bay. These studies concentrated their efforts in the nearshore areas (Becker 1984; Weitcamp and Schadt 1981; Tetra Tech 1985) and in the inner part of Commencement Bay (e.g., the old flood channels of the Puyallup River (Malins et al. 1982; Tetra Tech 1985; Weitkamp and Schadt 1981). Becker (1984) and Tetra Tech (1985) used the same otter trawl as the present study; however, sampling depths only reached 32 meters in contrast to the 175 meter depths of the proposed PSDDA sites. Weitkamp and Schadt (1981) used a different smaller otter trawl and again only sampled the nearshore shallow portions of Commencement Bay.

Data from Commencement Bay indicate that three of the four indices of site utilization by fish varied inversely with depth. As depth increased, species richness, total abundance and total biomass decreased. No correlation between depth and species diversity was evident. However, Tetra Tech (1985) found the species diversity in the inner harbor waterways to be much higher (3.5) compared to study. Results of this study suggest higher catches occurring in deeper water during autumn, while Weitkamp and Schadt (1981) found abundance in shallower areas was highest in summer and lower during other seasons of the year. Becker (1984) found that Dover sole were located at deeper stations while English sole were typically found in shallower waters, similar to the findings of the present PSDDA study.

Fish health was generally good for the flatfish caught in Commencement Bay during this study. The only disease found was blood worm infection in

English sole. Incidence for this disease reached 100% at some stations, but the sample sizes were small (less than five individuals per sample) for locations with high incidence rates. Low incidences (< 1%) of fin erosion and skin tumors have been previously found in flatfish inhabiting the inner (shallow) portions of Commencement Bay in areas known to be contaminated with industrial wastes (Malins et al. 1982, Tetra Tech 1985). Histopathological analyses of livers from flatfish found inhabiting these areas also revealed a low incidence of liver tumors (Malins et al. 1982, Tetra Tech 1985).

Environmental measurements were only available for the autumn period. Dissolved oxygen, temperature, salinity and Secchi disc measurements were all within the ranges found in other parts of Puget Sound (Stober and Chew 1984).

The preliminary PSDDA sites in Commencement Bay had the greatest depth and the lowest abundance, biomass and species richness measures of the stations sampled during this study. The number of adult and juvenile flatfish captured in the preliminary PSDDA sites was low in absolute terms and small when compared to stations outside of the PSDDA sites.

Elliott Bay

Several studies have been conducted within and adjacent to Elliott Bay (Bingham 1978; Miller et al. 1974; Miller et al. 1977; Miller 1980; Malins et al. 1982; Stober and Chew 1984). Donnelly et al. (1984) and Bingham (1978) were the only studies that sampled the same areas as the present PSDDA study.

The results of fish sampling in Elliott Bay revealed that the PSDDA sites generally had higher values of species richness than their corresponding reference stations. The PSDDA 2 (Fourmile Rock) site and the adjacent reference stations exhibited a pattern much like PSDDA 1 (inner Elliott Bay): summer season abundance, biomass and species richness figures were comparable, whereas the autumn values of biomass and species richness for the PSDDA 2 site exceeded the reference stations. Species diversity did not show any clear pattern.

PSDDA 2 samples were taken in close proximity to samples collected for the Renton Sewage Treatment Plant Project (Donnelly et al. 1984). Donnelly et al. found biomass values higher at the deeper sites in contrast to this study where the PSDDA 2 site had higher biomass values than the deeper reference stations. Donnelly et al. (1984) also indicated that species richness and species diversity increased with depth to 50 m and then decreased. This would suggest that the PSDDA 2 site would have higher species richness and species diversity values than the PSDDA 2 reference stations. Indeed, PSDDA 2 values were either comparable to, or exceeded, the reference station values for species richness and species diversity. Neither study was conducted during all four seasons, thus, results from this study should not be considered indicative of conditions at the sample sites throughout the year.

The PSDDA 1 site was compared with a report on the effects of dredged materials disposal on benthic invertebrates in inner Elliott Bay (Bingham 1978). The 1978 report found no substantial difference in infaunal (invertebrate) species richness or biomass, but did find that the shallower stations had the greatest species richness and biomass. The same observation was made at the PSDDA 1 sites (for fish) where the deeper reference station had lower species richness and biomass. Neither Bingham (1978) nor this study found any clear trend in species diversity versus depth.

Fish health was generally good. Blood worm infection in English sole was the only disease noted. The incidence was somewhat lower than the findings of Donnelly et al. (1984). Donnelly et al. also noted the presence of other diseases: skin tumors and fin erosion. Fin erosion, skin tumors and liver tumors have been found in Elliott Bay, but typically near the inner shore and the Duwamish River (Malins et al. 1982). The present study sites were located in the deeper regions away from the shore of Elliott Bay and may explain why the disease incidence was found to be lower than at previous inshore sampling locations.

Environmental measurements were available for both seasons. The dissolved oxygen values were all near saturation. Dissolved oxygen, temperature, salinity and Secchi disc measurements were all within the values found elsewhere in Puget Sound (Miller et al. 1977; Donnelly et al. 1984).

The preliminary PSDDA sites generally had the highest values for abundance, biomass and species diversity of the locations sampled in Elliott Bay. Dover sole and English sole, two commercially important flatfish, were found in higher numbers and biomass at the PSDDA 2 site and adjacent reference stations than at PSDDA 1. These results suggest that disposal of dredged materials would have less impact on commercial flatfish at the PSDDA 1 site than at PSDDA 2 site.

Saratoga Passage

The Saratoga Passage PSDDA site ecological measures were generally higher than the adjacent, shallower stations. A tagging study done by Day (1976) suggests that the deeper area of Saratoga Passage was a residence or spawning area for English sole. Day captured English sole in the deep area of Saratoga Passage where they were tagged and transported to other areas of Puget Sound. The majority of tag recoveries were within the deep area of Saratoga Passage, suggesting a homing ability to a preferred feeding location or possibly a spawning area. No English sole were caught at the PSDDA site during the sampling cruise; however, English sole were caught nearby at 80 m. Sampling was too limited to make any concluding statement about the Saratoga Passage

PSDDA site.

No diseases were found in any flatfish.

Port Gardner

English (1979) and Washington Department of Ecology (1976) sampled bottom fish at several depths along a transect line very close to Transect 2 of the PSDDA study. During the PSDDA study the catches of English sole less than 150 mm were lower than those found by English (1979). Each study used different capture gear; the earlier study used a 3 m beam trawl, while study used the 7.6 m otter trawl. Other explanations for the abundance differences may be biological or environmental in origin. Shephard et al. (1984) indicated three major reasons for variation in stock size from one year to the next: 1) annual changes in environmental conditions, 2) ecological interactions during early life history, and 3) variations in adult spawning abundance.

The results of the fish sampling in Port Gardner showed that the PSDDA sites had low abundance and biomass values when compared to other stations for spring, summer and autumn. In contrast, winter sampling at the PSDDA sites produced abundance values higher than most stations except for the NAVY and the 40 m depth. Furthermore, biomass values at the two PSDDA sites during the winter were second only to the NAVY site. These data suggest that the larger, older fish move into the preliminary PSDDA sites during the winter months and disperse during the rest of year.

Species diversity did not show any trends that could be related to differences between stations or sites.

Fish health was generally good. Malins et al (1982), using microscopic examination of flatfish livers, found only low levels of nonspecific degenerative/necrotic lesions and intracellular storage disorders in Port

Susan (adjacent to Port Gardner). Gross examination of livers for this study showed no evidence of tumors.

Washington Department of Fisheries (WDF) allows an annual commercial flatfish harvest during the spring and early summer in Port Gardner. The fishing area includes not only Port Gardner, but the adjacent main basin and the area adjoining Port Gardner to Saratoga Passage. Catches from the combined area contribute about 9% to the total annual Puget Sound flatfish harvest. Catches within Port Gardner itself contribute only a small portion of the 9% (WDF personal communication).

The preliminary PSDDA sites may be subjected to low levels of commercial trawling since they are located in the deeper portions of Port Gardner and, for most of the year, had low values for abundance and biomass relative to other stations. In contrast, winter abundance and biomass values at the preliminary PSDDA sites were much higher and second only to the NAVY site. The levels of abundance and biomass were very similar between the two PSDDA sites during every season, thus equal consideration (relative to fish resources) should be given to both preliminary PSDDA sites for disposal of dredged materials. However, data from Transect 4, Station 145 S, which is deeper and located more near the mouth of Port Gardner, show much lower abundance and biomass values than the PSDDA sites. The fish data from Port Gardner has not been fully compiled and analyzed, but when completed, will be issued as part of the Port Gardner report to the U. S. Army Corps of Engineers.

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APPENDIX

PART I

Appendix Table 1. Saratoga Passage beam trawl station location data. The trawl depths are averages from those recorded from the February and June, 1986 cruises. All trawls were 1/8 nautical miles (NM) long at approximately 1.5 knots ground speed.

	START SET OF NET			TRAWL DEPTH (m)	
Station	Depth (m)	Radar Ranges (NM) and Markers	Approximate compass bearing	Start tow	End tow
PSDDA Site:					
Station 1	113	2.4 Lowell Pt./1.25 Saratoga Pt.	200^{o}	108	106
Station 2	106	1.4 E. Pt./1.25 S. Edge Pt. N. of Mabana	25^{o}	110	118
Station 3	109	1.1 E. Pt./1.2 Pt. of Camano N. of Mabana	30^{o}	113	125
Transect #1:					
10W	11	1.56 S. Edge E. Pt.	290^{o}	10	17
20W	20	1.56 S. Edge E. Pt.	290^{o}	24	18
40W	39	1.55 E. Pt.	290^{o}	37	46
80W	79	1.55 E. Pt.	285^{o}	80	63
80E	80	2.25 S. Edge Lowell Pt./1.63 Saratoga Pt.	280^{o}	80	79
40E	39	2.20 S. Edge Lowell Pt./1.71 Saratoga Pt.	280^{o}	45	46
20E	21	2.25 S. Edge Lowell Pt./1.81 Saratoga Pt.	260^{o}	20	39
10E	11	2.13 Lowell Pt.	290^{o}	14	11
Transect #2:					
100N	102	1.2 S. Edge Lowell Pt./0.55 Pt. N. of Mabana	260^{o}	102	100
115N	117	1.65 Lowell Pt./1.15 E. Pt.	240^{o}	121	121
120N	121	1.1 S. Edge Lowell Pt./1.2 E. Pt.	265^{o}	122	116

Appendix Table 2. Summary of Port Gardner beam trawl station location data. All beam trawl tows were 1/8 nautical mile (NM) long at approximately 1.4 knots ground speed. The otter trawls were fished for 1/5 NM at a subset of these stations. Transect stations are identified by the approximate depth in meters and area of the bay where: N = north, S = south and M = middle.

Station #	Depth (m) Start set of net	Depth (m) Start tow	Depth (m) End tow	Range markers and distance (NM) (at start of net set)	Compass heading (degrees magnetic)	Approximate wire out (ft.)
Navy CAD Site (80m):						
Station 1	84	80	80	0.65 marker 4/0.72 SW. corner S. Pier	110	1100
Station 2	82	80	85	0.60 marker 4/0.72 SW. corner S. Pier	115	1100
Station 3	81	75	83	0.54 marker 4/0.70 SW. corner S. Pier	130	1100
NAVY RAD CAD Site (110m):						
PSDDA Site 2						
Station 1	105	110	112	0.9 notch W. Pier/1.0 edge S. Pier	145	1150
Station 2	113	117	118	0.92 notch W. of S. Pier/1.25 SW. corner S. Pier	145	1150
Station 3	124	127	116	0.85 bump W. of shore notch/1.5 SW. corner S. Pier	145	1200
Station 4 (A)	105	108	110	0.92 SW. corner S. Pier/0.75 shore	305	1150
Station 5 (E)	103	105	107	0.85 SW. corner S. Pier/0.75 nob on shore	135	1100
Station 6 (I)	110	122	129	1.25 SW. corner S. Pier/1.15 shore at notch	305	1200
Station 7 (J)	119	114	115	1.40 SW. corner S. Pier/1.25 shore at notch	140	1150
PSDDA Site 1 (130m):						
Station 1	128	130	133	2.10 Marker 4/1.50 Edgewater	145	1350
Station 2	133	134	135	2.30 Marker 4/1.50 Edgewater	145	1350
Station 3	136	139	140	2.50 Marker 4/1.50 Edgewater	145	1380
Transect #1:						
10S	12	12	12	0.50 SW. corner S. Pier	200	250
20S	21	23	22	0.70 SW. corner S. Pier	40	350
40S	41	45	42	0.80 SW. corner S. Pier	35	600
60S	60	62	60	0.82 SW. corner S. Pier	35	800
80S	83	82	78	0.88 SW. corner S. Pier	40	1000
100M	101	102	103	0.83 Marker 4/0.45 SW. corner S. Pier	250	1100
80N	82	80	76	0.94 Marker 4/1.50 Darlington	80	1050
60N	62	60	60	0.92 Marker 4/1.50 Darlington	75	800
40N	Station dropped due to repeated net damage.					

Appendix Table 2 (cont.)

Station #	Depth (m) Start set of net	Start tow	End tow	Range markers and distance (NM) (at start of net set)	Compass heading (degrees magnetic)	Approximate wire out (ft.)
Transect #2:						
10S	11	12	12	1.25 SW. corner S. Pier	260	250
20S	22	20	40	1.25 SW. corner S. Pier	250	350
40S	40	40	52	1.20 SW. corner S. Pier	250	600
60S	62	65	70	1.20 SW. corner S. Pier	250	800
80S	82	81	80	1.10 SW. corner S. Pier	240	1000
110S	112	110	110	1.14 SW. corner S. Pier	230	1150
110M	111	110	111	1.35 Marker 4/1.38 Darlington	155	1150
130N	136	134	125	3.5 Randall/1.6 SE. Gedney/2.0 NW S. Pier	120	1300
100N	102	95	84	1.35 Gedney/2.0 Marker 4/1.0 "RBN"	110	1050
Transect #3:						
10S	12	12	10	1.88 S. edge S. Pier	65	250
20S	23	22	21	1.87 SW. corner S. Pier	70	350
40S	41	42	46	1.85 S. edge S. Pier	75	600
60S	61	60	67	1.89 SW. corner S. Pier	70	800
80S	80	82	82	1.86 SW. corner S. Pier	75	1050
110S	112	116	116	1.88 S. edge S. Pier	65	1200
130M	129	132	134	2.09 Marker 4/1.35 Edgewater	145	1300
130N	137	131	130	2.08 Marker 4/2.08 Edgewater	145	1350
Transect #4:						
10S	11	12	11	2.57 SW. corner S. Pier	40	250
20S	22	22	21	2.57 SW. corner S. Pier	40	350
40S	41	41	42	2.63 SW. corner S. Pier	35	600
60S	62	58	62	2.65 SW. corner S. Pier	35	800
80S	79	85	83	2.68 SW. corner S. Pier	40	1050
110S	113	112	123	2.70 SW. corner S. Pier	45	1175
145S	145	147	145	2.45 SW. corner S. Pier	210	1350
135N	140	138	139	2.26 Randall Pt./2.20 Edgewater/0.85 "RBN"	140	1500
Transect #5:						
20S	21	24	22	At tip of fuel dock	60	350
40S	42	38	52	3.11 SW. corner S. Pier	40	600
60S	61	64	43	3.13 SW. corner S. Pier	45	800
80S	81	80	82	3.12 SW. corner S. Pier	45	1050
110S	119	118	106	3.19 SW. corner S. Pier	45	1200
165S	171	169	170	1.92 nearest shore Whidbey/0.63 tip fuel dock	280	1600
145M	151	152	151	1.83 Edgewater/1.83 shore Clinton Dock	125	1500

Appendix Table 2 (cont.)

Station #	Depth (m) Start set of net	Start tow	End tow	Range markers and distance (NM) (at start of net set)	Compass heading (degrees magnetic)	Approximate wire out (ft.)
Transect #6:						
80S	74	84	64	0.33 SW. tip S. Pier	165	1050
80M	80	80	71	0.50 Marker 4/0.50 SW. corner S. Pier	280	1050
60N	63	61	56	0.40 Marker 4	260	800
40N	40	42	42	0.35 Marker 4/0.70 SW. corner S. Pier	260	600
20N	21	21	21	0.37 Marker 4	250	350
10N	12	11	11	0.35 Marker 4	260	250
Transect #7:						
100S	102	98	89	0.80 SW. corner S. Pier	220	1100
100M	101	102	105	1.20 Marker 4/1.26 SW. corner S. Pier	145	1100
100N	102	101	101	1.72 "RBN"/0.33 Marker 3	155	1100
80N	80	81	64	1.5 "RBN"/0.53 Marker 3	120	1050
60N	56	62	69	1.45 "RBN"	130	800
40N	42	43	33	1.5 Marker 4/1.50 "RBN"	320	600
20N	22	29	16	1.60 "RBN"	300	350
10N	11	14	12	1.60 "RBN"	310	250
Non-Transect Stations:						
B	105	106	114	1.25 Marker 4/1.10 nearest shore E. of notch	310	1100
C	92	91	92	1.00 SW. corner S. Pier/1.34 shore Darlington	80	1050
D	104	103	101	1.30 SW. corner S. Pier/1.46 Darlington	335	1100
F	110	109	113	0.65 SW. corner S. Pier/0.40 shore at Transect 1	250	1100
G	138	128	127	1.70 Marker 4/1.50 shore at Edgewater	145	1350
H	130	128	128	1.90 Marker 4/1.50 shore at Edgewater	145	1300

Appendix Table 3. Elliott Bay beam trawl station location data. The trawl depths are averages from those recorded from the February, June and September, 1986 cruises. All trawls were 1/8 nautical miles (NM) long at approximately 1.5 knots ground speed.

	START SET OF NET			TRAWL DEPTH (m)	
Station	Depth (m)	Radar Ranges (NM) and Markers	Approximate compass bearing	Start tow	End tow
Fourmile Rock:					
Station 1	178	1.05 Shore/1.57 SW Tip Pier 91	79°	168	160
Station 2	168	0.81 Shore/1.1 SW Tip Pier 91	235°	178	181
Station 3	163	0.85 Shore/1.0 SW Tip Pier 91	220°	185	188
Inner Elliott Bay:					
Station 1	91	0.7 Shore D. Head/1.2 NW Corner #46	180°	91	90
Station 2	68	0.84 Shore D. Head/1.0 NW Corner #46	160°	62	62
Station 3	78	0.98 Shore D. Head/0.83 NW Corner #46	130°	78	73
Station 4	66	0.25 Tip Todd Drydock/0.84 NW Corner #46	65°	64	60
Station 5	81	1.6 SW Pier 91/0.95 Duw. Head (nearest)	310°	91	124
Transect #1:					
10S	12	0.5 Notch/1.28 Alki	185°	12	13
20S	21	0.5 Notch/1.23 Alki	190°	21	20
40S	39	0.5 Notch/1.34 Alki	185°	43	37
80S	82	1.3 Alki Pt.	175°	80	82
Transect #2:					
10N	12	1.1 SW Tip Pier 91	100°	11	11
20N	21	0.9 SW Tip Pier 91	285°	21	21
80N	87	0.95 SW Tip Pier 91	290°	72	68

Appendix Table 4. Commencement Bay beam trawl station location data. The trawl depths are averages from those recorded from the February, June and September, 1986 cruises. All trawls were 1/8 nautical miles (NM) long at approximately 1.5 knots ground speed.

	START SET OF NET			TRAWL DEPTH (m)	
Station	Depth (m)	Radar Ranges (NM) and Markers	Approximate compass bearing	Start tow	End tow
PSDDA Site 1:					
Station 1	168	0.98 Asarco Corner/1.82 Neill/1.35 Br. Pt.	125°	169	166
Station 2	169	1.18 Asarco Corner/2.0 Neill/1.15 Br. Pt.	140°	169	168
Station 3	173	1.4 Asarco Corner/1.8 Neill/1.0 Br. Pt.	140°	168	168
Station 4	171	1.58 Asarco Corner/1.82 Neill/0.82 Br. Pt.	130°	169	167
PSDDA Site 2:					
Station 1	163	1.35 Asarco Notch/0.65 Shore	305°	167	170
Station 2	159	1.5 Asarco Notch/2.63 Neill/1.15 Br. Pt.	305°	166	166
Station 3	158	1.65 Asarco Notch/2.62 Neill/0.93 Br. Pt.	305°	166	166
PSDDA Site 2B:					
Station 1	175	1.25 Asarco Corner/1.5 Neill/1.3 Br. Pt.	85°	174	173
Station 2	175	1.5 Asarco Corner/1.12 Br. Pt.	100°	175	174
Station 3	175	1.74 Asarco Corner/1.0 Br. Pt.	105°	175	173
Transect #1:					
10E	12	0.08 Br. Pt.	165°	11	15
20E	22	0.09 Br. Pt.	165°	20	23
40E	40	0.09 Abeam Br. Pt.	165°	38	48
80E	81	0.22 Abeam Br. Pt.	180°	86	75
40W	41	0.5 Asarco Corner	300°	60	40
20W	21	0.47 Asarco Corner	300°	22	20
10W	10	0.45 Asarco Corner	290°	11	10

Appendix Table 4 (Cont.)

	START SET OF NET			TRAWL DEPTH (m)	
Station	Depth (m)	Radar Ranges (NM) and Markers	Approximate compass bearing	Start tow	End tow
<u>Transect #2</u>:					
10S	14	0.48 End of Sitcum Waterway	120°	13	15
20S	22	0.28 Corner Pier 5	40°	25	20
40S	42	0.38 Corner Pier 5	60°	33	36
80S	82	1.0 N. Shore (E. of Br. Pt.)/0.95 S. Shore	215°	89	98
120S	120	1.0 Shore Old Tacoma/1.0 Fr "B" (Hylebos)	205°	120	120

Appendix Table 5. Dungeness crab catches/hectare in Saratoga Passage during February and June, 1986. The averages listed in the table are means ±1 standard deviation. The station numbers for the transects indicate approximate trawl depth in meters and location where N = north, E = east and W = west. N.S. = not sampled.

	Dungeness Crab Catch/Hectare		
	February	June	
Station	Beam Trawl	Beam Trawl	Otter Trawl
PSDDA Site 2 (110M):			
Station 1	0	0	0
Station 2	0	0	0
Station 3	0	0	0
Station 4	0	N.S.	N.S.
Average	0	0	0
Transect #1:			
10E	11.2	449.4	N.S.
20E	0	0	4.5
40E	0	56.2	0
80E	0	37.5	0
80W	1.9	18.7	N.S.
40W	0	18.7	0
20W	0	0	N.S.
10W	1.9	18.7	N.S.
Average	1.9 ± 3.9	74.9 ± 152.5	1.1 ± 2.2
Transect #2:			
100N	N.S.	0	N.S.
120N	N.S.	0	N.S.
115N	N.S.	0	N.S.
Average	--	0	--
Saratoga Pass Average	1.2 ± 3.2	42.8 ± 118.3	0.6 ± 1.7

Appendix Table 6. Beam trawl shrimp catches/hectare in Saratoga Passage during February and June, 1986, and in Elliott and Commencement bays during February, June and September, 1986. The averages listed in the table are means ± 1 standard deviation. The station numbers for the transects indicate approximate depths in meters and location where N = North, E = East, W = West and S = South. N.S. = not sampled.

	FEBRUARY							JUNE							SEPTEMBER						
Area/Station	Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All	Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All	Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All
SARATOGA PASSAGE															N.S.						
PSDDA Site 2 (110M):																					
Station 1	0	18.7	0	9.4	18.7	0	46.8	0	0	0	18.7	74.9	0	93.6							
Station 2	0	37.5	0	0	0	0	37.5	0	37.5	0	0	74.9	0	112.4							
Station 3	0	37.5	0	0	18.7	0	56.2	0	0	0	0	0	0	0							
Average	0	31.2 ± 10.9	0	3.1 ± 5.4	12.5 ± 10.8	0	46.8 ± 9.4	0	12.5 ± 21.7	0	6.2 ± 10.8	49.9 ± 43.2	0	68.7 ± 60.2							
Transect #1:																					
10E	0	0	0	0	0	0	0	0	0	37.5	0	0	0	37.5							
20E	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
40E	0	0	0	93.6	56.2	0	149.8	0	0	0	0	0	0	0							
80E	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
80W	0	0	0	0	0	0	0	37.5	0	0	56.2	206.0	0	299.7							
40W	0	0	0	93.6	187.3	0	280.9	0	0	0	0	0	0	0							
20W	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
10W	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
Transect #2:																					
100N	N.S.							0	18.7	0	0	224.7	0	243.4							
120N	N.S.							0	0	0	0	0	0	0							
115N	N.S.							0	0	0	0	0	0	0							
Saratoga Bay Average	0	8.5 ± 15.4	0	17.9 ± 37.5	25.5 ± 56.4	0	51.9 ± 88.6	3.4 ± 11.3	4.0 ± 10.8	2.7 ± 10.0	5.4 ± 15.5	41.5 ± 78.5	0	56.2 ± 99.1							
ELLIOTT BAY																					
Fourmile Rock (170M):																					
Station 1	0	0	0	0	0	0	0	0	18.7	0	0	74.9	0	93.6	0	37.5	0	0	18.7	0	56.2
Station 2	0	56.2	0	0	0	0	56.2	0	74.9	0	0	168.5	0	243.4	0	0	0	0	0	0	0
Station 3	0	18.7	0	0	56.2	0	74.9	0	0	0	0	187.3	0	187.3	0	37.5	0	0	37.4	0	74.9
Average	0	25.0 ± 28.6	0	0	18.7 ± 32.4	0	43.7 ± 39.0	0	31.2 ± 39.0	0	0	143.6 ± 60.2	0	174.8 ± 75.7	0	25.0 ± 21.7	0	0	18.7 ± 18.7	0	43.7 ± 39.0
Inner Elliott Bay (75M):																					
Station 1	0	18.7	0	37.5	187.3	0	243.5	0	0	0	0	93.6	0	93.6	18.7	0	0	0	112.4	0	131.1
Station 2	0	0	0	262.2	0	0	262.2	37.5	0	0	37.5	0	0	75.0	0	0	0	18.7	0	0	18.7
Station 3	0	0	0	37.5	355.8	0	393.3	18.7	0	0	18.7	37.5	0	74.9	0	56.2	0	0	786.5	0	842.7
Station 4	N.S.							N.S.							56.2	0	0	18.7	449.4	18.7	543.0
Station 5	N.S.							N.S.							0	0	0	0	74.9	0	74.9
Average	0	6.2 ± 10.8	0	112.4 ± 129.7	181.0 ± 178.0	0	300.0 ± 81.6	18.7 ± 18.8	0	0	18.7 ± 18.8	43.7 ± 47.1	0	81.2 ± 10.8	15.0 ± 24.4	11.2 ± 25.1	0	7.5 ± 10.2	284.6 ± 329.3	3.7 ± 8.4	322.0 ± 356.9
Transect #1:																					
10S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56.2	0	0	0	56.2
20S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93.6	0	0	0	93.6
40S	0	0	18.7	0	0	0	18.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80S	N.S.							0	0	18.7	0	18.7	0	37.4	0	0	0	0	18.7	0	18.7
Transect #2:																					
10N	0	0	318.4	0	0	0	318.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20N	0	0	74.9	0	0	0	74.9	0	0	0	0	0	0	0	0	0	18.7	0	0	0	18.7
80N	N.S.							55.9	0	0	0	0	0	55.9	56.2	0	0	0	37.4	0	93.6
Elliott Bay Average	0	8.5 ± 17.5	37.5 ± 95.9	30.7 ± 78.2	54.5 ± 115.0	0	131.1 ± 144.8	8.6 ± 18.1	7.2 ± 21.0	1.4 ± 5.2	4.3 ± 11.2	44.7 ± 66.9	0	66.2 ± 76.7	8.7 ± 19.9	8.7 ± 18.6	11.2 ± 27.2	2.5 ± 6.6	102.4 ± 221.2	1.7 ± 5.0	134.8 ± 236.9

Appendix Table 6. (Continued).

Area/Station	FEBRUARY Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All	JUNE Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All	SEPTEMBER Spot	Sidestripe	Coonstripe	Smooth pink	Pink	Humpback	All
COMMENCEMENT BAY																					
PSDDA Site 1 (165M):																					
Station 1	0	0	0	0	56.2	0	56.2	74.9	0	0	0	74.9	0	149.8	0	18.7	0	0	18.7	0	37.4
Station 2	0	0	0	0	56.2	0	56.2	0	0	0	0	74.9	0	74.9	0	18.7	0	0	74.9	0	93.6
Station 3	0	0	0	0	56.2	0	56.2	0	0	0	0	0	0	0	0	0	0	0	37.5	0	37.5
Station 4	N.S.							N.S.							0	0	0	0	93.6	0	93.6
Average	0	0	0	0	56.2 ± 0.0	0	56.2 ± 0.0	25.0 ± 43.2	0	0	0	49.9 ± 43	0	74.9 ± 74.9	0	10.1 ± 10.0	0	0	56.2 ± 34.2	0	65.5 ± 32.4
PSDDA Site 2 (165M):																					
Station 1	0	0	0	0	37.4	0	37.4	N.S.							N.S.						
Station 2	0	18.7	0	0	74.9	0	93.6	N.S.							N.S.						
Station 3	0	0	0	0	0	0	0	N.S.							N.S.						
Average	0	6.2 ± 10.8	0	0	37.4 ± 37.5	0	43.7 ± 47.1	--							--						
PSDDA Site 2 (165M):																					
Station 1	N.S.							0	0	0	0	74.9	0	74.9	0	0	0	0	18.7	0	18.7
Station 2	N.S.							0	0	0	0	93.6	0	93.6	0	37.5	0	0	112.4	0	149.9
Station 3	N.S.							0	0	0	0	37.5	0	37.5	0	0	0	0	74.9	0	74.9
Average	--							0	0	0	0	68.7 ± 28.6	0	68.7 ± 28.6	0	12.5 ± 21.7	0	0	68.7 ± 47.2	0	81.2 ± 65.8
Transect #1:																					
10E	N.S.							0	0	18.7	0	0	0	18.7	0	0	1067.4	0	0	0	1067.4
20E	0	0	37.5	0	0	0	37.5	0	0	0	0	0	0	0	0	0	93.6	0	0	0	93.6
40E	N.S.							0	0	0	0	0	0	0	0	0	0	0	0	0	0
80E	N.S.							0	0	0	0	0	0	0	0	0	0	0	501.7	0	501.7
10W	0	0	56.2	0	0	0	56.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20W	0	0	56.2	0	0	0	56.2	0	0	0	0	0	0	0	0	0	56.2	0	0	0	56.2
40W	0	0	74.9	0	0	0	74.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transect #2:																					
10S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56.2	0	0	0	56.2
20S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18.7	18.7	0	0	37.4
40S	0	0	0	112.4	0	0	112.4	0	0	0	37.5	0	0	37.5	0	0	0	23.4	0	0	23.4
80S	0	18.7	0	0	37.5	0	56.2	0	0	0	37.5	0	0	37.5	0	0	0	18.7	18.7	0	37.4
120S	0	0	0	0	37.5	0	37.5	0	0	0	0	0	0	0	0	0	0	0	56.2	0	56.2
Commencement Bay Average	0	2.5 ± 6.6	15.0 ± 26.7	7.5 ± 29.0	23.7 ± 27.8	0.0	48.7 ± 32.3	4.2 ± 17.7	0.0	1.0 ± 4.4	4.6 ± 12.1	20.7 ± 33.9	0.0	29.1 ± 43.2	0.0	3.9 ± 10.0	68.3 ± 243.4	3.2 ± 7.6	53.0 ± 114.6	0.0	128.2 ± 252.7

Appendix Table 7. Number of shrimp caught/hectare by <u>otter</u> trawl in Saratoga Passage in June and Elliott and Commencement Bays in June and September 1986. The transect station numbers indicate depth in meters and location where E = East and W = West. N.S. = Not Sampled.

Station	Spot Prawn	Sidestripe Shrimp	Coonstripe Shrimp	Smooth Pink Shrimp	Pink Shrimp	Humpback Shrimp	Flexed Shrimp
Saratoga Passage, June 1986:							
PSDDA 2, Sta. 1	0	54.0	0	0	63.1	0	0
PSDDA 2, Sta. 2	0	18.0	0	0	63.1	0	0
PSDDA 2, Sta. 3	0	90.1	0	0	90.1	0	0
Transect 1, 40 W	0	0	0	0	0	0	0
Transect 1, 20 E	0	0	0	0	0	0	0
Transect 1, 40 E	0	0	0	0	4.5	0	0
Transect 1, 80 E	0	4.5	0	0	99.1	0	0
Average (± 1 S.D.)	0	23.8 ± 35.2	0	0	45.7 ± 43.4	0	0
Elliott Bay, June 1986:							
PSDDA 1, Sta. 1	36.0	0	0	301.8	126.1	4.5	0
PSDDA 1, Sta. 2	0	18.0	0	0	4.5	0	0
PSDDA 1, Sta. 3	0	0	0	0	261.3	0	0
PSDDA 2, Sta. 1	4.5	27.0	0	0	63.1	0	0
PSDDA 2, Sta. 2	0	22.5	0	0	40.5	0	0
PSDDA 2, Sta. 3	0	9.0	0	0	117.1	0	0
Average (± 1 S.D.)	6.8 ± 14.4	12.8 ± 11.5	0	50.3 ± 123.2	102.1 ± 90.5	0.8 ± 1.8	0
Elliott Bay, September 1986:							
PSDDA 1, Sta. 1	40.5	13.5	0	0	252.3	9.0	0
PSDDA 1, Sta. 2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
PSDDA 1, Sta. 3	0	0	0	0	567.6	0	0
PSDDA 1, Sta. 4	193.7	0	0	0	1,747.7	22.5	0
PSDDA 1, Sta. 5	18.0	18.0	0	9.0	680.2	0	0
PSDDA 2, Sta. 1	9.0	13.5	0	0	0	0	0

Appendix Table 7 (continued):

Station	Spot Prawn	Sidestripe Shrimp	Coonstripe Shrimp	Smooth Pink Shrimp	Pink Shrimp	Humpback Shrimp	Flexed Shrimp
PSDDA 2, Sta. 2	0	103.6	0	0	45.0	0	0
PSDDA 2, Sta. 3	4.5	76.6	0	0	31.5	0	0
Average (± 1 S.D.)	38.0 ± 70.1	32.2 ± 40.9	0	1.3 ± 3.4	474.9 ± 622.8	4.5 ± 8.6	0
Commencement Bay, June 1986:							
PSDDA 1, Sta. 1	4.5	9.0	0	4.5	220.7	0	0
PSDDA 1, Sta. 2	0	4.5	0	0	342.3	0	0
PSDDA 1, Sta. 3	0	0	0	4.5	243.2	0	0
PSDDA 2B, Sta. 1	0	4.5	0	0	130.6	0	0
PSDDA 2B, Sta. 2	0	22.5	0	0	108.1	0	0
PSDDA 2B, Sta. 3	0	13.5	0	0	436.9	0	0
Transect 1, 20 E	0	0	0	0	0	0	0
Transect 1, 40 E	0	0	0	0	0	0	0
Average	0.6 ± 1.6	6.8 ± 8.0	0	1.1 ± 2.1	185.2 ± 156.0	0	0
Commencement Bay, September 1986:							
PSDDA 1, Sta. 1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
PSDDA 1, Sta. 2	0	76.6	0	0	310.8	0	0
PSDDA 1, Sta. 3	9.0	85.6	0	0	378.4	0	0
PSDDA 1, Sta. 4	0	94.6	0	0	414.4	0	0
PSDDA 2B, Sta. 1	0	99.1	0	0	387.4	0	0
PSDDA 2B, Sta. 2	4.5	67.6	0	0	297.3	0	0
PSDDA 2B, Sta. 3	0	162.2	0	0	409.9	0	0
Transect 1, 20 E	0	0	0	0	0	0	0
Transect 1, 40 E	0	0	0	0	0	0	0
Average (± 1 S.D.)	1.7 ± 3.3	74.1 ± 52.1	0	0	274.8 ± 174.8	0	0

Appendix Table 8. Beam trawl catches of Dungeness crab (per $1000m^2$) from Port Gardner during winter (February 4-7, 1986).

Station*	Dungeness Crab/$1000m^2$ Females with eggs	Females without eggs	Males	All crabs	Comments
Navy Disposal Site: (80 m)					
Station 1	9.4	1.9	0	11.2	60 gal. mud, wood, debris
Station 2	28.1	0	0	28.1	50 gal. mud, wood, trash
Station 3	24.3	1.9	1.9	28.1	30 gal. wood, trash
Average	20.6 ± 9.9+	1.3 +1.1	0.6 ± 1.1	22.5 ± 9.8	
PSDDA Site 2: (120m)					
Station 1	0	0	0	0	5 gal. wood, debris
Station 2	0	0	0	0	2 gal. fish, detritus
Station 3	1.9	0	0	1.9	2 gal. fish, detritus
Average	0.6 ± 1.1	0.0	0.0	0.6 ± 1.1	
PSDDA Site 1: (160m)					
Station 1	0	0	0	0	1 gal. wood, detritus
Station 2	0	0	0	0	1 gal. worm tubes, detritus
Station 3	0	0	0	0	1 gal. worm tubes
Average	0.0	0.0	0.0	0.0	

Appendix Table 8 (continued)

Station*	Dungeness Crab/1000m^2 Females with eggs	Females without eggs	Males	All crabs	Comments
Transect #1					
10-S	0	1.9	13.1	15.0	1 gal. algae, detritus
20-S	1.9	0	5.6	7.5	2 gal. algae, detritus
40-S	11.2	3.7	0	15.0	15 gal. algae, wood
80-S	20.6	0	0	20.6	20 gal. algae, wood, trash
100-M	1.9	0	0	1.9	2 gal. algae, wood, detritus
80-N	7.5	1.9	0	9.4	3 gal. wood, detritus
40-N	11.8	0	0	11.8	2 gal. fish; bent beam, torn net
Average	7.8 ± 7.3	1.1 ± 1.5	2.7 ± 5.0	11.6 ± 6.1	
Transect #2:					
10-S	1.9	7.5	20.6	30.0	4 gal. crabs
20-S	5.6	5.6	5.6	16.8	25 gal. algae, eelgrass
40-S	1.9	0	0	1.9	15 gal. rock, shell
80-S	31.8	3.7	0	35.5	25 gal. wood, crabs
120-S	0	0	0	0	25 gal. mud, wood, detritus
120-M	0	0	0	0	2 gal. worm tubes, detritus
150-N	1.9	0	0	1.9	2 gal. wood, detritus, shell
100-N	1.9	0	0	1.9	3 gal. wood, detritus
Average	5.6 ± 10.7	2.1 ± 3.1	3.3 ± 7.3	11.0 ± 14.6	
Transect #3:					
10-S	0	3.7	7.5	11.2	8 gal. algae, eelgrass, shell
20-S	0	1.9	0	1.9	20 gal. wood, trash
40-S	3.7	0	0	3.7	25 gal. wood, starfish, bottles
80-S	3.7	3.7	0	7.4	7 gal. wood, starfish, bottles
120-S	9.4	3.7	1.9	15.0	30 gal. clay balls, rock, wood
150-M	0	0	0	0	2 gal. wood, worm tubes
150-N	0	0	0	0	1 gal. worm tubes
Average	2.4 ± 3.5	1.9 ± 1.9	1.3 ± 2.8	5.6 ± 5.8	

Appendix Table 8 (continued)

Station*	Dungeness Crab/1000m^2 Females with eggs	Females without eggs	Males	All crabs	Comments
Transect #4:					
10-S	0	0	1.9	1.0	2 gal. rock, algae, and large tire
20-S	30.0	11.2	13.1	54.3	5 gal. algae, wood, shell
40-S	1.9	0	1.9	3.8	2 gal. wood, starfish, bottles
80-S	16.9	0	1.9	18.8	5 gal. gravel, wood, bottles
120-S	5.6	0	0	5.6	5 gal. gravel, detritus
175-S	0	0	0	0	2 gal. worm tubes, detritus
160-N	1.9	0	0	1.9	1 gal. worm tubes
Average	8.0 ± 11.3	1.6 ± 4.2	2.7 ± 4.7	12.3 ± 19.5	
Transect #5:					
20-S	0	1.9	5.6	7.5	100 gal. wood chips
40-S	1.9	0	3.7	5.6	30 gal. wood, algae
80-S	5.6	1.9	0	7.5	40 gal. wood, starfish, trash
120-S	9.4	1.9	0	11.3	4 gal. detritus, fish
200-S	0	0	0	0	2 gal. worm tubes, detritus
175-M	0	0	0	0	2 gal. worm tubes, heart urchins
Average	2.8 ± 3.9	1.0 ± 1.0	1.6 ± 1.5	5.3 ± 4.5	
Transect #6:					
80-S	18.7	18.7	0	27.4	50 gal. wood, trash
80-M	45.0	3.7	0	48.7	10 gal. wood, cans
40-N	11.2	13.1	9.4	33.7	25 gal. wood, trash
20-N	3.7	0	5.6	9.3	2 gal. wood, debris
10-N	3.7	9.4	7.5	20.6	2 gal. wood, bottles
Average	16.5 ± 7.1	9.0 ± 7.4	4.5 ± 4.3	29.9 ± 15.3	

Appendix Table 8 (continued)

Station*	Dungeness Crab/1000m² Females with eggs	Females without eggs	Males	All crabs	Comments
Transect #7:					
100-S	9.4	0	0	9.4	15 gal. wood, detritus, cans
100-M	1.9	0	0	1.9	3 gal. worm tubes, wood
100-N	5.6	0	0	5.6	2 gal. wood, debris
80-N	8.5	0	0	8.5	2 gal. gravel, crabs
40-N	54.3	3.7	1.9	59.9	20 gal. wood, crabs
20-N	43.1	7.5	1.9	52.5	10 gal. wood, crabs
10-N	7.5	13.1	1.9	22.5	2 gal. crabs
Average	18.6 ± 20.9	3.5 ± 5.1	0.8 ± 1.0	22.9 ± 23.7	

*Station numbers for the transects indicate depth in meters plus location where N=north, S=south, and M=middle

†Mean ± 1 standard deviation.

Appendix Table 9. Dungeness Crab Densities Per Hectare Calculated From Beam Trawl Catches In Port Gardner During April, 1986.

Station [1]	Females	Males	All Crabs	Substrate Comments
Navy Disposal Site (80m)				
Station 1	477	19	496	20 gal. Wood, Debris, Bottles
Station 2	439	0	439	20 gal. Wood, Bark, Cans
Station 3	229	0	229	10 gal. Wood, Shell, Debris
Average	382 ± 134[2]	6 ± 11	388 ± 141	
PSDDA Site 2 (110m)				
Station 1	38	0	38	5 gal. Wood, Detritus
Station 2	19	0	19	30 gal. Wood
Station 3	0	0	0	3 gal. Wood Chips
Average	19 ± 19	0.0	19 ± 19	
PSDDA Site 1 (130m)				
Station 1	0	0	0	2 gal. Wood, Detritus, Worm Tubes
Station 2	0	0	0	1 gal. Detritus
Station 3	0	0	0	1 gal. Worm Tubes
Average	0.0	0.0	0.0	

Table Appendix 9. (continued) Dungeness Crab Densities Per Hectare Calculated From Beam Trawl Catches In Port Gardner During April, 1986.

Station	Females	Males	All Crabs	Comments
<u>Transect #1</u>				
10-S	38	38	76	1 gal. <u>ULVA</u>, Wood Chips
20-S	19	19	38	1 gal. <u>ULVA</u>, Wood Chips
40-S	19	0	19	6 gal. <u>ULVA</u>, Wood Chips
80-S	95	0	95	10 gal. <u>ULVA</u>, Wood, Bottles
100-M	0	0	0	12 gal. Wood, Mud
80-N	57	0	57	2 gal. Detritus, Wood Chips
40-N	N.S.[3]	N.S.	N.S.	N.S.
Average	38 ± 34	10 ± 16	48 ± 36	
<u>Transect #2</u>				
10-S	57	19	76	5 gal. <u>Zostera</u>, <u>ULVA</u>
20-S	57	0	57	20 gal. <u>ULVA</u>
40-S	38	0	38	4 gal. <u>ULVA</u>, Wood, Shell
80-S	76	0	76	8 gal. Wood, Debris, Cans
110-S	0	0	0	5 gal. Wood, Detritus
110-M	0	0	0	2 gal. Detritus
130-N	0	0	0	2 gal. Wood, Detritus, Cans
100-N	19	0	19	1 gal. Wood
Average	31 ± 30	2 ± 7	33 ± 33	

Table Appendix 9. (continued) Dungeness Crab Densities Per Hectare Calculated From Beam Trawl Catches In Port Gardner During April, 1986.

Station	Females	Males	All Crabs	Comments
Transect #3				
10-S	38	19	57	6 gal. ULVA, Shell, Bottles
20-S	38	0	38	40 gal. ULVA, Wood
40-S	115	0	115	30 gal. Wood, Rock, Bottles
80-S	95	0	95	7 gal. Wood
110-S	0	0	0	20 gal. Clay Balls, Wood
130-M	0	0	0	1 gal. Detritus, Worm Tubes
130-N	19	0	19	1 gal. Worm Tubes
Average	44 ± 45	3 ± 7	46 ± 45	
Transect #4				
10-S	19	38	57	2 gal. Zostera, ULVA, Shell
20-S	0	0	0	/ gal. ULVA, Wood, Shell
40-S	19	0	19	50 gal. ULVA, Wood, Bottles
80-S	191	19	210	3 gal. ULVA, Wood, Cans
110-S	19	0	19	7 gal. Rock, Wood, Gravel
145-S	0	0	0	2 gal. Detritus, Worm Tubes
135-N	0	0	0	2 gal. Wood, Detritus, Worm Tubes
Average	35 ± 69	8 ± 15	44 ± 76	
Transect #5				
20-S	57	0	57	30 gal. ULVA, Tire, Wood, Shell, Gravel
40-S	19	19	38	50 gal. Wood Chips
80-S	115	0	115	60 gal. Rock, Gravel, Bottles
110-S	0	0	0	3 gal. Mud, Pea Gravel, Wood
165-S	0	0	0	2 gal. Wood Chips, Worm Tubes
145-M	0	0	0	2 gal. Heart Urchins, Worm Tubes
Average	32 ± 46	3 ± 3	35 ± 46	

Table Appendix 9. (continued) Dungeness Crab Densities Per Hectare Calculated From Beam Trawl Catches In Port Gardner During April, 1986.

Station	Females	Males	All Crabs	Comments
Transect #6				
80-S	191	0	191	60 gal. ULVA, Wood, Shell
80-M	573	19	592	25 gal. Wood, Debris, Bottles
40-N	248	57	305	20 gal. Wood, Bottles
20-N	210	19	229	4 gal. Wood, Detritus
10-N	229	19	248	2 gal. Wood Chips
Average	290 ± 160	23 ± 21	313 ± 161	
Transect #7				
100-S	57	0	57	4 gal. ULVA, Wood Chips
100-M	38	0	38	2 gal. Detritus, Worm Tubes
100-N	38	0	38	2 gal. Detritus
80-N	76	0	76	2 gal. Detritus, Wood Chips
40-N	153	0	153	3 gal. Wood Chips
20-N	114	0	114	4 gal. Wood
10-N	19	19	33	0.1 gal. Detritus, Shell
Average	71 ± 47.7	3 ± 7	73 ± 45	
Grand Average	79 ± 122	6 ± 12	85 ± 127	

1 Station numbers for the transects indicate depth in meters plus location where N = North, M = Middle, S = South

2 Mean ± 1 Standard Diviation

3 N.S. = Not Sampled

Appendix Table 10. Dungeness crab densities per hectare calculated from <u>beam trawl</u> catches in Port Gardner during June, 1986.

Station[1]	Density/Hectare: Females	Males	All crabs	Substrate comments
Navy Disposal Site (80m)				
Station 1	375	47	421	40 gal. wood, cans, crabs, debris
Station 2	543	75	618	50 gal. wood, cans, crabs
Station 3	431	37	468	10 gal. wood, crabs, debris
Average	450 $\pm$ 86[2]	53 $\pm$ 20	502 $\pm$ 103	
PSDDA Site 2 (110m)				
Station 1	0	0	0	1 gal. wood, detritus
Station 2	0	0	0	1 gal. worm tubes, wood
Station 3	0	0	0	1 gal. wood, detritus
Average	0	0	0	
PSDDA Site 1 (130m)				
Station 1	0	0	0	2 gal. worm tubes, detrital kelp
Station 2	0	0	0	1 gal. worm tubes
Station 3	0	0	0	2 gal. worm tubes
Average	0	0	0	

Appendix Table 10 (Continued)

	Females	Males	All Crabs	Comments
Transect #1				
10-S	0	56	56	3 gal. Ulva, wood
20-S	19	37	56	20 gal. Ulva
40-S	19	0	19	10 gal. wood, Ulva
80-S	169	0	169	6 gal. wood, Ulva
100-M	0	0	0	2 gal. detritus
80-N	918	0	918	8 gal. detritus
40-N	N.S.[3]	N.S.	N.S.	
Average	188 ± 364	16 ± 25	203 ± 355	
Transect #2				
10-S	19	0	19	15 gal. Ulva, wood
20-S	19	0	19	20 gal. Ulva, wood
40-S	19	0	19	5 gal. wood, shell, Ulva
80-S	94	0	94	20 gal. wood, gravel
110-S	112	0	112	10 gal. pea gravel, wood
110-M	19	0	19	2 gal. Ulva, wood, worm tubes
130-N	37	0	37	2 gal. wood chips, worm tubes
100-N	56	0	56	1 gal. wood chips, detritus
Average	47 ± 37	0	47 ± 37	

Appendix Table 10 (Continued)

	Females	Males	All crabs	Comments
Transect #3				
10-S	0	0	0	3 gal. wood, *Ulva*, shell
20-S	37	0	37	25 gal. wood chips, *Ulva*
40-S	56	19	75	15 gal. wood chips
80-S	56	0	56	5 gal. wood chips, cans, bottles
110-S	37	0	37	8 gal. clay balls
130-M	0	0	0	1 gal. wood, worm tubes
130-N	0	0	0	2 gal. wood, worm tubes, kelp
Average	27 ± 26	3 ± 7	29 ± 30	
Transect #4				
10-S	19	37	56	3 gal. *Ulva*, detritus
20-S	0	37	37	15 gal. wood, *Ulva*, shell
40-S	56	19	75	30 gal. wood, bottles
80-S	75	0	75	4 gal. wood, cans
110-S	37	19	56	2 gal. pea gravel, wood
145-S	0	0	0	2 gal. worm tubes, wood
135-N	0	0	0	1 gal. worm tubes, heart urchins
Average	27 ± 30	16 ± 17	43 ± 32	

Appendix Table 10 (Continued)

	Females	Males	All crabs	Comments
Transect #5				
20-S	94	37	131	20 gal. pea gravel, Ulva
40-S	75	0	75	40 gal. wood, bottles, gravel, debris
80-S	56	0	56	25 gal. wood, bottles, gravel
110-S	19	0	19	3 gal. worm tubes, wood, pea gravel
165-S	0	0	0	2 gal. worm tubes, wood, heart urchins
145-M	0	0	0	2 gal. worm tubes, heart urchins
Average	41 ± 40	6 ± 15	47 ± 51	
Transect #6				
80-S	56	19	75	50 gal. wood
80-M	262	0	262	15 gal. wood, cans
40-N	206	0	206	20 gal. wood
20-N	281	19	300	4 gal. wood chips
10-N	112	19	131	3 gal. bottles, wood
Average	183 ± 97	11 ± 10	195 ± 92	

Appendix Table 10 (Continued)

Transect #7				
100-S	104	52	156	10 gal. wood, cans
100-M	0	0	0	2 gal. worm tubes, wood chips
100-N	449	19	468	4 gal. detritus
80-N	206	0	206	2 gal. wood chips, cans
40-N	225	19	244	10 gal. wood chips
20-N	337	0	337	7 gal. wood
10-N	19	0	19	1/2 gal. detritus
Average	191 ± 165	13 ± 19	204 ± 167	
GRAND AVERAGE	104 ± 171	10 ± 18	114 ± 178	

[1] Station numbers for the transects indicate depth in meters plus location where N = north, M = middle, and S = south.

[2] Mean ± 1 standard deviation.

[3] N.S. = not sampled.

Appendix Table 11. Dungeness crab densities per hectare calculated from beam trawl catches in Port Gardner during September, 1986. Station numbers for the transects indicate depth in meters plus location where N=North, M=Middle, and S=South. The averages are means ± 1 standard deviation.

Station	Density/Hectare Females	Males	All Crabs	Substrate Comments
Navy Disposal Site (80m)				
Station 1	95	0	95	20 gal. wood, debris
Station 2	115	0	115	10 gal. wood, debris
Station 3	19	0	19	15 gal. wood, debris
Average	76 ± 51	0	76 ± 51	
PSDDA 2 (110m)				
Station 1	19	0	19	15 gal. wood
Station 2	19	0	19	1 gal. worm tubes wood chips
Station 3	0	0	0	2 gal. wood, shell
Average	13 ± 11	0	13 ± 11	
PSDDA 1 (130m)				
Station 1	0	0	0	1 gal. worm tubes, shell
Station 2	57	0	57	1 gal. worm tubes, shell
Station 3	19	0	19	0.5 gal. worm tubes, wood
Average	25 ± 29	0	25 ± 29	
Transect #1				
10-S	19	38	57	3 gal. algae, wood, detritus
20-S	57	19	76	
40-S	191	0	191	30 gal. algae, wood
80-S	248	19	267	15 gal. wood, algae
100-M	95	0	95	20 gal. wood, debris
80-N	0	0	0	5 gal. wood, debris
40-N	-	not sampled	-	
Average	102 ± 99	13 ± 16	114 ± 97	

Appendix Table 11 (continued)

Station	Density/Hectare Females	Males	All Crabs	Substrate Comments
Transect #2				
10-S	19	19	38	1 gal. algae, detritus
20-S	210	19	249*	15 gal. algae, shell
40-S	153	0	153	15 gal. algae, wood
80-S	305	0	305	25 gal. wood, algae, clay balls
110-S	0	0	0	3 gal. detritus, algae wood
110-M	38	0	38	1 gal. worm tubes, wood chips
130-N	38	0	38	1 gal. detritus, shell
100-N	0	0	0	2 gal. wood chips
Average	95 ± 114	5 ± 9	103 ± 119	
Transect #3				
10-S	0	19	19	6 gal. algae, shell
20-S	38	0	38	50 gal. wood, algae
40-S	553	19	572	30 gal. bark
80-S	95	0	95	8 gal. rock, algae, detritus
110-S	57	0	57	3 gal. wood, algae
130-M	76	0	76	1 gal. worm tubes, wood, shell
130-N	19	0	19	1 gal. worm tubes
Average	120 ± 194	5 ± 9	125 ± 199	
Transect #4				
10-S	19	0	19	1 gal. algae, shell
20-S	38	38	76	6 gal. algae, wood, shell
40-S	172	38	210	30 gal. wood chips, bottles
80-S	115	0	115	4 gal. wood, algae, cans
110-S	153	0	153	4 gal. detritus, wood, gravel
145-S	38	19	57	2 gal. algae, worm tubes
135-N	0	0	0	1 gal. worm tubes, wood chips
Average	76 ± 69	14 ± 18	90 ± 75	

Appendix Table 11 (continued)

Station	Density/Hectare Females	Density/Hectare Males	All Crabs	Substrate Comments
Transect #5				
20-S	76	57	133	20 gal. algae, gravel, wood, shell
40-S	496	57	553	30 gal. wood, rock, algae
80-S	95	19	114	40 gal. wood, algae, rock, debris
110-S	153	0	153	3 gal. wood, detritus
165-S	0	0	0	1 gal. worm tubes
145-M	0	0	0	1 gal. worm tubes
Average	137 ± 186	22 ± 28	159 ± 204	
Transect #6				
80-S	76	19	95	50 gal. algae, wood, cans
80-M	191	0	191	20 gal. wood, debris, cans
40-N	76	0	76	10 gal. wood, debris
20-N	19	0	19	2 gal. wood, detritus
10-N	38	0	38	1 gal. detritus, wood
Average	80 ± 67	4 ± 8	84 ± 67	

Appendix Table 11(continued)

Station	Density/Hectare Females	Males	All Crabs	Substrate Comments
Transect #7				
100-S	76	0	76	40 gal. wood chips, bottles, cans
100-M	38	0	38	2 gal. wood chips
100-N	0	0	0	2 gal. wood, detritus
80-N	210	19	229	3 gal. wood, cans
40-N	229	0	229	1 gal. wood, detritus, shell
20-N	95	0	95	4 gal. wood, shell
10-N	76	0	76	0.5 gal. detritus, shell
Average	103 ± 85	3 ± 7	106 ± 89	
GRAND AVERAGE	92 ± 113	8 ± 15	100 ± 119	

*Includes 1 young-of-the-year (unsexed) crab, 9.0mm carapace width.

Appendix Table 12. Dungeness crab densities per hectare calculated from beam trawl catches at extra stations in Port Gardner during September, 1986. The averages are means ± 1 standard deviation.

Station	Density/Hectare Females	Males	All Crabs	Substrate Comments
West of Navy Site				
Station A (105m)	19	0	19	8 gal. wood chips
Station B (110m)	0	0	0	1 gal. worm tubes, wood
Station C (90m)	38	0	38	1 gal. detritus, wood chips
Station D (105m)	38	0	38	1 gal. detritus, wood chips
Station E (115m)	0	0	0	1 gal. worm tubes, wood
Station F (110m)	38	0	38	7 gal. wood, debris
Average	22 ± 19	0	22 ± 19	
East of PSDDA Site 1				
Station G (130m)	19	0	19	3 gal. wood, shell
Station H (130m)	0	0	0	4 gal. wood, shell
Between Mukilteo and Picnic Point				
Station 1 - 40m	19	0	19	3 gal. wood, detritus
Station 2 - 40m	0	0	0	5 gal. wood, algae
Station 3 - 40m	0	0	0	5 gal. wood, algae, bottles
Station 4 - 10m	0	0	0	10 gal. sand, algae
Station 4 - 20m	38	0	38	3 gal. algae
Station 4 - 40m	0	0	0	5 gal. clay balls, algae
Station 4 - 80m	0	0	0	20 gal. clay balls, algae
Average	8 ± 15	0	8 ± 15	

Appendix Table 13. Commercial shrimp densities per hectare in Port Gardner calculated from beam trawl catches in February and April, 1986.

STATION [1]	FEBRUARY	APRIL
Navy Disposal Site (80m)		
Station 1	95	0
Station 2	1,069	0
Station 3	935	0
Average	700 ± 528	0
PSDDA Site 2 (110m)		
Station 1	76	19
Station 2	76	0
Station 3	95	19
Average	82 ± 11	13 ± 11
PSDDA Site 1 (130m)		
Station 1	0	38
Station 2	0	95
Station 3	0	57
Average	0	63 ± 29
Transect #1		
10-S	0	0
20-S	0	0
40-S	57	0
80-S	57	38
100-M	19	57
80-N	248	0
40-N	95	N.S.[3]
Average	68 ± 87	16 ± 25
Transect #2		
10-S	0	0
20-S	95	19
40-S	0	0

Appendix Table 13. (Cont'd.) Commercial shrimp densities per hectare in Port Gardner calculated from beam trawl catches in February and April, 1986.

STATION [1]	FEBRUARY	APRIL
Transect #2		
80-S	229	0
110-S	57	19
110-M	38	19
130-N	76	19
100-N	267	19
Average	95 ± 100	12 ± 10
Transect #3		
10-S	0	0
20-S	0	0
40-S	0	0
80-S	0	0
110-S	134	57
130-M	76	19
130-N	57	19
Average	38 ± 53	14 ± 21
Transect #4		
10-S	95	0
20-S	0	0
40-S	19	0
80-S	191	0
110-S	115	115
145-S	76	38
135-N	95	0
Average	84 ± 63	22 ± 43

Appendix Table 13. (Cont'd.) Commercial shrimp densities per hectare in Port Gardner calculated from beam trawl catches in February and April, 1986.

STATION[1]	FEBRUARY	APRIL
Transect #5		
10-S	229	0
40-S	897	38
80-S	153	115
110-S	38	30
165-S	38	19
145-M	0	38
Average	226 ± 340	40 ± 39
Transect #6		
80-S	57	38
80-M	172	0
40-N	76	19
20-N	19	0
10-N	0	0
Average	65 ± 67	11 ± 17
Transect #7		
100-S	267	0
100-M	57	19
100-N	210	38
80-N	195	0
40-N	0	0
20-N	19	0
10-N	0	0
Average	107 ± 113	8 ± 15
Grand Average	123 ± 218	19 ± 28

1 Station numbers for the transects indicate depth in meters plus locations where N = North, M = Middle, S = South.

Appendix Table 13. (Cont'd.) Commercial shrimp densities per hectare in Port Gardner calculated from beam trawl catches in February and April, 1986,

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2 Mean ± 1 Standard Diviation

3 N.S. = Not Sampled

Appendix Table 14. Densities per hectare of Dungeness crabs and commercial shrimp calculated from otter trawl catches from the February and April cruises in Port Gardner.

Station[1]	Feburary 1986 Cancer magister	Feburary 1986 Commercial shrimp	April 1986 Cancer magister	April 1986 Commercial shrimp
Navy Disposal Site (80m)				
Station 1	27	239	0	90
Station 2	9	108	14	131
Station 3	27	216	32	117
Average	21 ± 10[2]	138 ± 70	15 ± 6	113 ± 21
PSDDA Site 2 (110m)				
Station 1	0	505	0	50
Station 2	0	410	0	36
Station 3	0	149	0	27
Average	0	355 ± 184	0	38 ± 12
PSDDA Site 1 (130m)				
Station 1	5	86	0	36
Station 2	0	162	0	27
Station 3	0	158	0	9
Average	2 ± 3	135 ± 43	0	24 ± 14
Transect 1				
20-S	5	0	9	0
40-S	18	54	0	0
100-M	9	441	5	27
Average	11± 7	165 ± 241	5 ± 5	9 ± 16

Appendix Table 14(con't).

Station[1]	February 1986 *Cancer magister*	February 1986 Commercial shrimp	April 1986 *Cancer magister*	April 1986 Commercial shrimp
Transect 2				
20-S	18	0	5	5
40-S	18	0	0	0
110-S	0	99	9	27
Average	12 ± 10	33 ± 57	5 ± 5	11 ± 14
Transect 4				
20-S	9	0	0	0
40-S	5	0	9	0
145-S	9	225	0	18
Average	8 ± 2	75 ± 130	3 ± 5	6 ± 10
Grand Average	9 ± 9	158 ± 158	5 ± 8	33 ± 40

[1]Station numbers for the transects indicate depth in meters plus locations where N=north, M=middle, and S=south.

[2]Mean ± 1 standard deviation.

Appendix Table 15. Dungeness crab densities per hectare calculated from otter trawl catches in Port Gardner in June and early July, 1986.

Station[1]	Density/Hectare		
	Females	Males	All crabs
Navy Site (80m)			
Station 1	9	0	9
Station 2	14	4	18
Station 3	0	0	0
Average	7 ± 7[2]	1 ± 2	9 ± 9
PSDDA Site 2 (110m)			
Station 1	4	0	4
Station 2	0	0	0
Station 3	0	0	0
Average	1 ± 2	0	1 ± 2
PSDDA Site 1 (130m)			
Station 1	0	0	0
Station 2	0	0	0
Station 3	0	0	0
Average	0	0	0
Transect #1			
20-S	0	0	0
40-S	0	4	4
100-M	18	4	22
Average	6 ± 10	3 ± 2	9 ± 12
Transect #2			
20-S	0	0	0
40-S	4	0	4
110-S	14	0	14
Average	6 ± 7	0	6 ± 7

Appendix Table 15 (Continued)

Station	Females	Males	All crabs
Transect #4			
20-S	0	0	0
40-S	0	0	0
145-S	0	0	0
Average	0	0	0
Grand Average	4 ± 6	1 ± 2	4 ± 7

[1] Station numbers for the transects indicate depth in meters plus locations where S = south and M = middle.

[2] Mean ± 1 standard deviation.

Appendix Table 16. Commercial shrimp densities per hectare calculated from beam and otter trawls in Port Gardner in June and early July, 1986.

Station[1]	Density/Hectare	
	Beam trawl	Otter trawl
Navy Disposal Site (80m)		
Station 1	19	9
Station 2	0	0
Station 3	0	4
Average	6 ± 11[2]	4 ± 5
PSDDA Site 2 (110m)		
Station 1	0	228
Station 2	0	41
Station 3	0	23
Average	0	117 ± 148
PSDDA Site 1 (130m)		
Station 1	0	131
Station 2	19	59
Station 3	0	50
Average	6 ± 11	80 ± 44
Transect #1		
10-S	0	N.S.
20-S	19	0
40-S	19	0
80-S	75	N.S.
100-M	0	221
80-N	0	N.S.
40-N	N.S.[3]	N.S.
Average	19 ± 29	74 ± 128

Appendix Table 16 (Continued)

Station	Beam trawl	Otter trawl
Transect #2		
10-S	0	N.S.
20-S	19	0
40-S	19	0
80-S	0	N.S.
110-S	75	27
110-M	0	N.S.
130-M	0	N.S.
100-N	0	N.S.
Average	14 ± 26	9 ± 16
Transect #3		
10-S	0	N.S.
20-S	0	N.S.
40-S	0	N.S.
80-S	0	N.S.
110-S	0	N.S.
130-M	19	N.S.
130-N	0	N.S.
Average	3 ± 7	--
Transect #4		
10-S	0	N.S.
20-S	0	0
40-S	0	4
80-S	0	N.S.
110-S	0	N.S.

Appendix Table 16 (Continued)

Station	Beam trawl	Otter trawl
Transect #4 - Continued		
145-S	0	36
135-N	37	N.S.
Average	5 ± 14	13 ± 20
Transect #5		
20-S	0	N.S.
40-S	787	N.S.
80-S	281	N.S.
110-S	19	N.S.
165-S	19	N.S.
145-M	0	N.S.
Average	184 ± 315	--
Transect #6		
80-S	112	N.S.
80-M	19	N.S.
40-N	19	N.S.
20-N	0	N.S.
10-N	0	N.S.
Average	30 ± 47	--
Transect #7		
100-S	0	N.S.
100-M	0	N.S.
100-N	56	N.S.
80-N	19	N.S.
40-N	0	N.S.

Appendix Table 16 (Continued)

Station	Beam trawl	Otter trawl
Transect #7 - Continued		
20-N	0	N.S.
10-N	0	N.S.
Average	11 ± 21	--
Grand Average	30 ± 112	50 ± 82

[1] Station numbers for the transects indicate depth in meters plus locations where N = north, M = middle, and S = south.

[2] Mean ± standard deviation.

[3] N.S. = not sampled.

Appendix Table 17. Shrimp densities per hectare calculated from both beam and otter trawl catches in Port Gardner during September, 1986. Station numbers for the transects indicate depths in meters and location where N = North, S = South, E = East, and W = West. The averages are means ± 1 standard deviation. N.S. = not sampled. Estimated crab densities are also given for the otter trawl.

	Beam Trawl	Otter Trawl	
Station	Shrimp/hectare	Shrimp/hectare	Crab/hectare
Navy Disposal Site (80 m)			
Station 1	581	387	5
Station 2	169	536	0
Station 3	131	405	0
Average	294 ± 250	443 ± 81	2 ± 3
PSDDA Site 2 (110 m)			
Station 1	19	77	14
Station 2	0	72	18
Station 3	0	108	27
Average	6 ± 11	86 ± 20	20 ± 7
PSDDA Site 1 (130 m)			
Station 1	19	81	9
Station 2	38	104	14
Station 3	38	117	5
Average	32 ± 11	101 ± 18	12 ± 4
Transect #1			
10-S	0	N.S.	N.S.
20-S	375	0	0
40-S	1760	5	9
80-S	375	N.S.	N.S.
100-M	187	198	0
80-N	131	N.S.	N.S.
40-N	N.S.	N.S.	N.S.
Average	471 ± 648	68 ± 113	3 ± 5

Appendix Table 17 (cont.)

Station	Beam Trawl	Otter Trawl	
	Shrimp/hectare	Shrimp/hectare	Crab/hectare
Transect #2			
10-S	0	N.S.	N.S.
20-S	300	0	18
40-S	356	0	18
80-S	730	N.S.	N.S.
110-S	38	68	5
110-M	19	N.S.	N.S.
130-N	38	N.S.	N.S.
100-N	38	N.S.	N.S.
Average	190 ± 258	23 ± 39	14 ± 8
Transect #3			
10-S	0	N.S.	N.S.
20-S	0	N.S.	N.S.
40-S	131	N.S.	N.S.
80-S	206	N.S.	N.S.
110-S	38	N.S.	N.S.
130-M	75	N.S.	N.S.
130-N	56	N.S.	N.S.
Average	72 ± 74		
Transect #4			
10-S	0	N.S.	N.S.
20-S	56	0	9
40-S	0	5	5
80-S	75	N.S.	N.S.
110-S	56	N.S.	N.S.
145-S	56	45	0
135-N	0	N.S.	N.S.
Average	35 ± 33	17 ± 25	5 ± 5
Transect #5			
20-S	0	N.S.	N.S.
40-S	150	N.S.	N.S.
80-S	936	N.S.	N.S.
110-S	131	N.S.	N.S.
165-S	0	N.S.	N.S.
145-M	75	N.S.	N.S.
Average	215 ± 359		

Appendix Table 17. (cont.)

	Beam Trawl	Otter Trawl	
Station	Shrimp/hectare	Shrimp/hectare	Crab/hectare
Transect #6			
80-S	655	N.S.	N.S.
80-M	1292	N.S.	N.S.
40-N	243	N.S.	N.S.
20-N	0	N.S.	N.S.
10-N	0	N.S.	N.S.
Average	438 ± 547		
Transect #7			
100-S	262	N.S.	N.S.
100-M	412	N.S.	N.S.
100-N	393	N.S.	N.S.
80-N	1049	N.S.	N.S.
40-N	3127	N.S.	N.S.
20-N	0	N.S.	N.S.
10-N	0	N.S.	N.S.
Average	749 ± 1106		
Port Gardner Average	269 ± 527	123 ± 159	9 ± 8

Appendix Table 18. Shrimp densities/hectare calculated from both beam and otter trawl catches at extra stations in Port Gardner during September, 1986. The averages are means ± 1 standard deviation. N.S. = not sampled.

Station	Shrimp Density/Hectare: Beam trawl	Shrimp Density/Hectare: Otter trawl
West of Navy Site		
Station A (105 m)	19	N.S.
Station B (110 m)	0	N.S.
Station C (90 m)	94	N.S.
Station D (105 m)	75	N.S.
Station E (115 m)	38	68
Station F (110 m)	94	N.S.
Average	53 ± 40	68 ± 0
East of PSDDA Site 1		
Station G (130 m)	38	N.S.
Station H (130 m)	19	N.S.
Average	28 ± 13	
Between Mukilteo and Picnic Point		
Station 1 (40 m)	0	N.S.
Station 2 (40 m)	0	N.S.
Station 3 (40 m)	0	N.S.
Station 4 (10 m)	0	N.S.
Station 4 (20 m)	0	N.S.
Station 4 (40 m)	0	N.S.
Station 4 (80 m)	0	N.S.
Average	0	

APPENDIX

PART II

APPENDIX A

Analyses of fish data collected by

beam trawls in Commencement Bay, Elliott Bay

and Saratoga Passage during 1986.

Commencement Bay

Abundance and biomass. The samples collected during the summer cruise were the only ones available for analyses. Abundance values ranged from 1 to 43 individuals per location, while biomass values ranged from 45 to 4,191 grams per location (Appendix A, Table 1). At locations where fish were captured, the two PSDDA sites had by far the lowest value of either measure. Sample sizes were too small to determine dominant species at each site.

Species richness. Species richness values ranged from 1 to 8 showing a similar pattern to the abundance and biomass results. The deeper PSDDA sites had the lowest values. The 20 m station had a much higher value (Appendix A, Table 1).

Species diversity. Species diversity values ranged from 0.0 to 0.71 (Appendix A, Table 1). The distribution of values among sites was identical to species richness. The deeper PSDDA sites had the lowest values, while the 20-m station had the highest value.

Elliott Bay

Abundance and biomass. Total abundance ranged from 3 to 22 fish per location, and total biomass ranged from 69 to 1,595 grams per location (Appendix A, Table 2). The results did not suggest any patterns, seasonally or by station.

Species richness. Species richness values ranged from 2 to 6 (Appendix A, Table 2). The distribution among locations was similar to abundance and biomass, and no seasonal or location patterns were evident.

Species diversity. Species diversity values ranged from 0.2 to 0.9 (Appendix A, Table 2), and as with species richness, no pattern by season or location was apparent.

Appendix A, Table 2. Abundance, biomass, species richness and species diversity of fish caught by beam trawl in Elliott Bay by season.

Location	Abundance		Biomass (gm)		Species richness		Species diversity	
	Summer	Autumn	Summer	Autumn	Summer	Autumn	Summer	Autumn
PSDDA 1 Site	8	22.3	602.2	416.5	5	6	0.63	0.90
PSDDA 1 Reference Station	7	3	1595.0	68.6	5	2	0.64	0.22
PSDDA 2 Site	3.7	2.7	823.7	111 3	-	6	--	0.77

Appendix A, Table 1. Abundance, biomass, species richness and species diversity of fish caught by beam trawl in Commencement Bay during summer, 1986.

Location	Abundance	Biomass (gm)	Species richness	Species diversity
PSDDA 1 Site	1	212	1	0.0
PSDDA 2 Site	1	45	3	0.47
20 m Station	43	4,191	8	0.71

Saratoga Passage

Abundance and biomass. Saratoga Passage was not sampled during the autumn, therefore only the summer data were analyzed. Total abundance values ranged from 3 to 12 fish per location; total biomass values ranged from 51 to 1,004 grams per location (Appendix A, Table 3). The PSDDA site was the deepest and had the highest values of both abundance and biomass. The abundance and biomass values diminished as station depth decreased.

Species richness. Species richness ranged from 1 to 7 (Appendix A, Table 3). The pattern was the same as that of abundance and biomass: the deeper PSDDA site had the highest values then values diminished as station depth decreased.

Species diversity. Species diversity values ranged from 0.0 to 0.5 (Appendix A, Table 3). The highest values were at the deepest PSDDA location, then values decreased with decreasing depth at all other locations.

Appendix A, Table 3. Abundance, biomass, species richness and species diversity of fish caught by beam trawl in Saratoga Passage during summer.

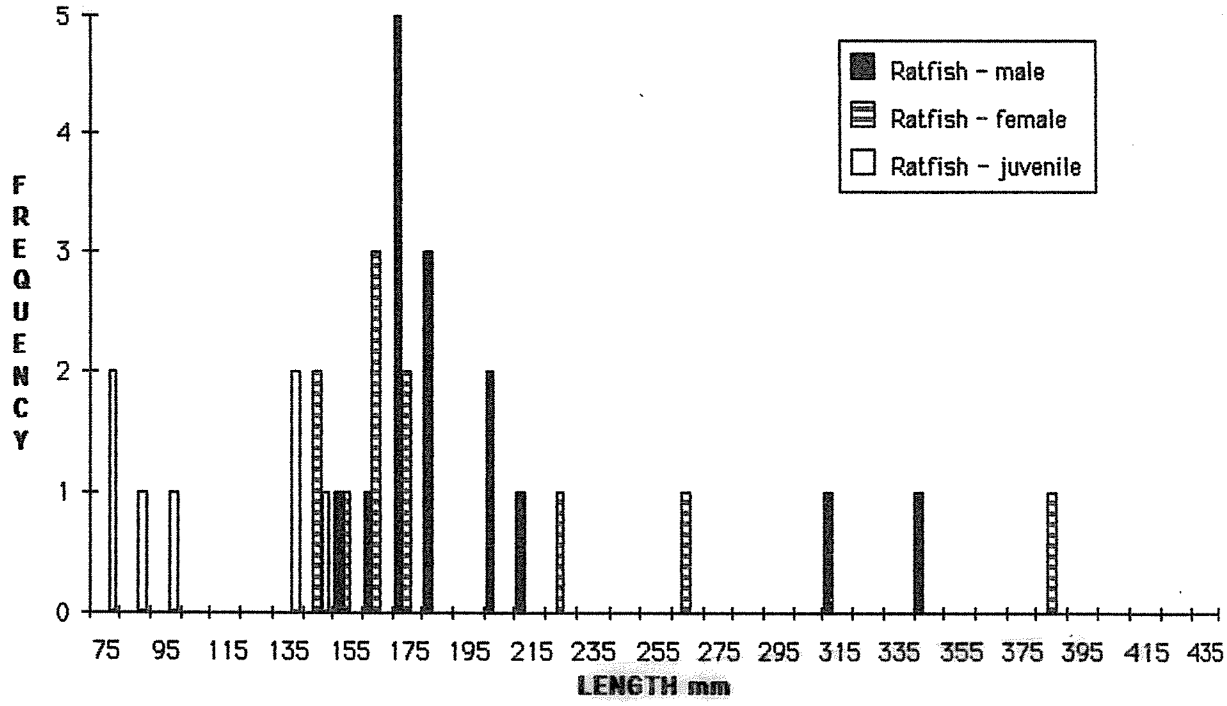
Location	Abundance	Biomass (gm)	Species richness	Species diversity
PSDDA Site	11.7	1,004.2	7	0.46
80 m E Station	7.0	109.5	3	0.41
40 m E Station	6.0	51.0	3	0.38
20 m E Station	3.0	52.0	1	0.00

APPENDIX B

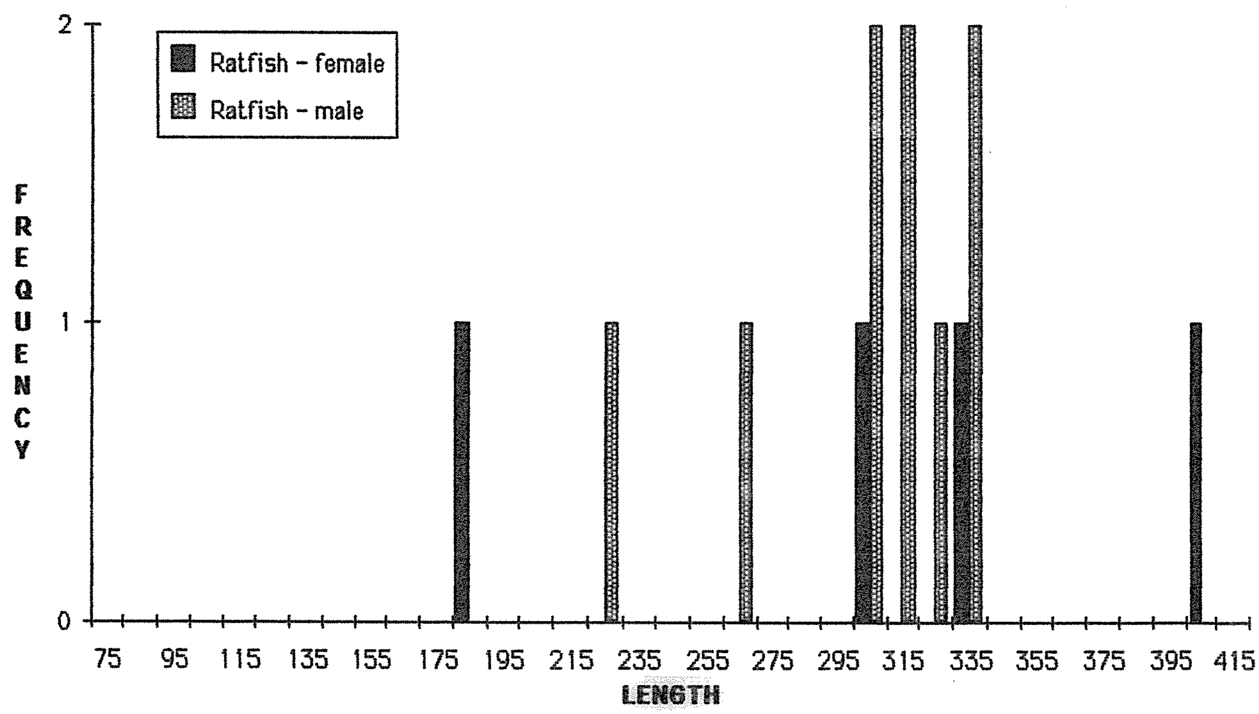
Length frequency histograms of abundant,

non-commercially or recreationally important,

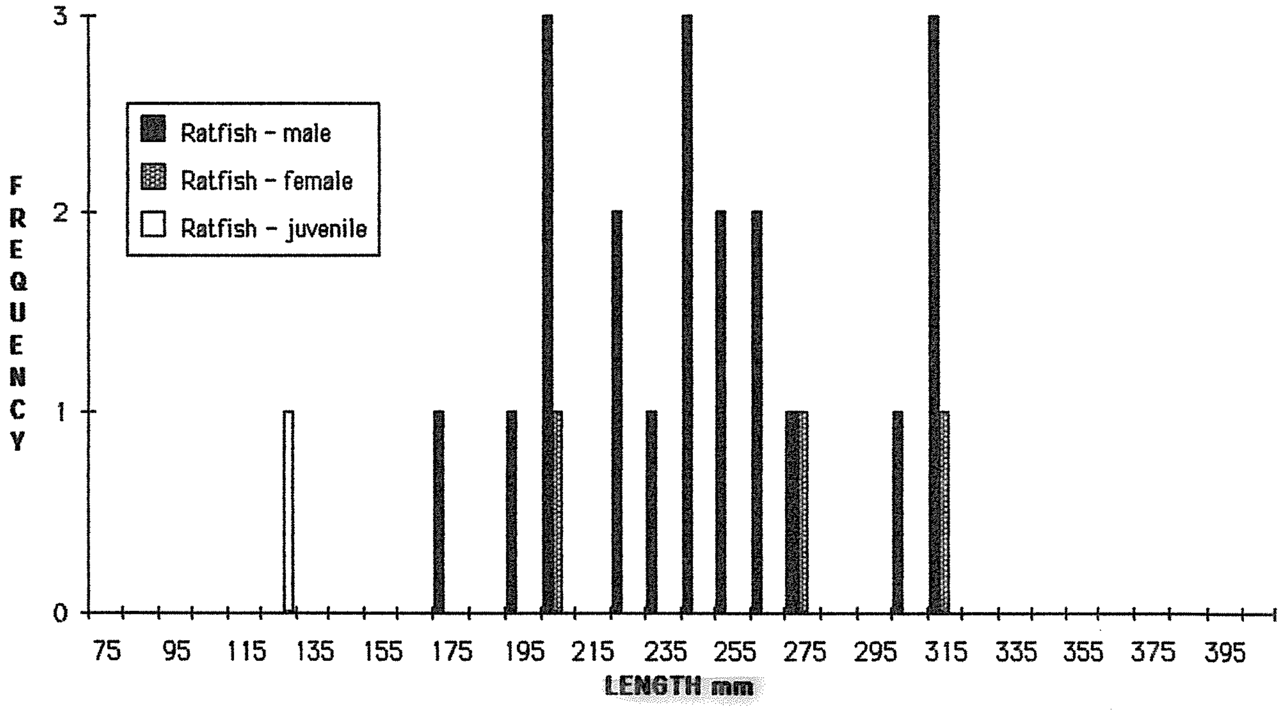
fish caught in Commencement Bay and Elliott Bay.



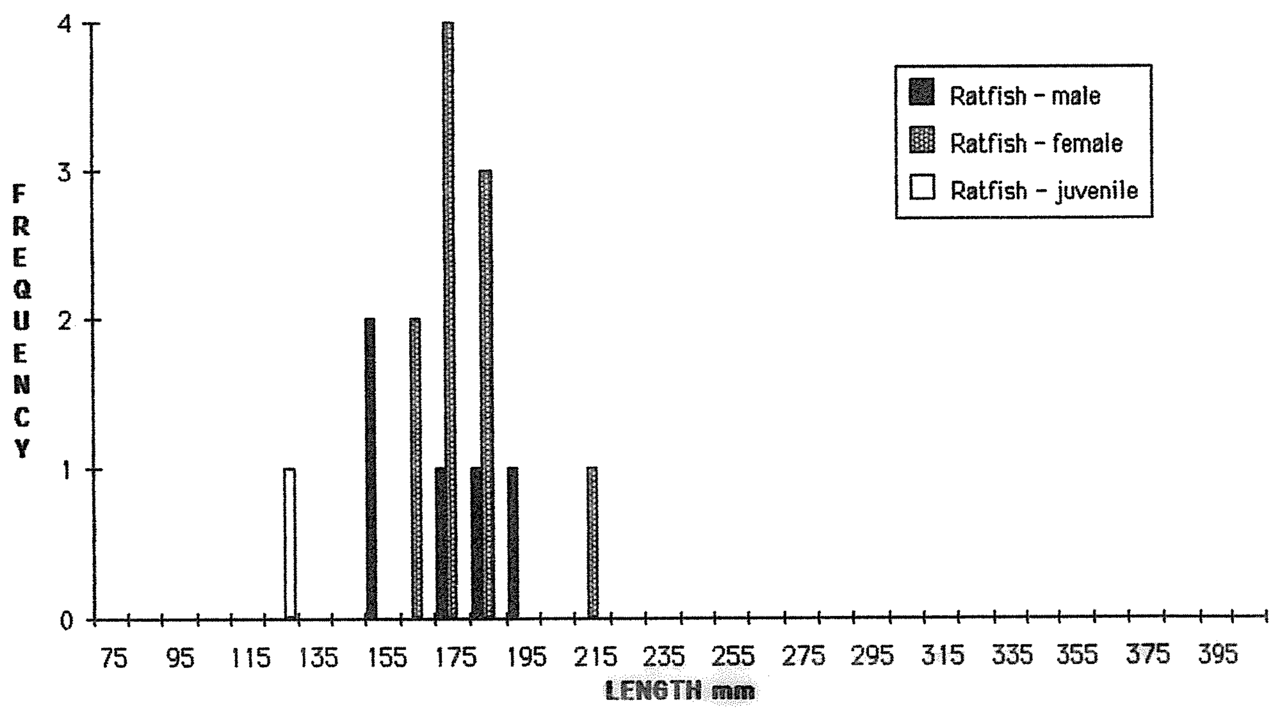
Appendix B, Figure 1. Length frequency of otter trawl caught ratfish, shown by sex and life history stage, during summer at 156 m in Commencement Bay.



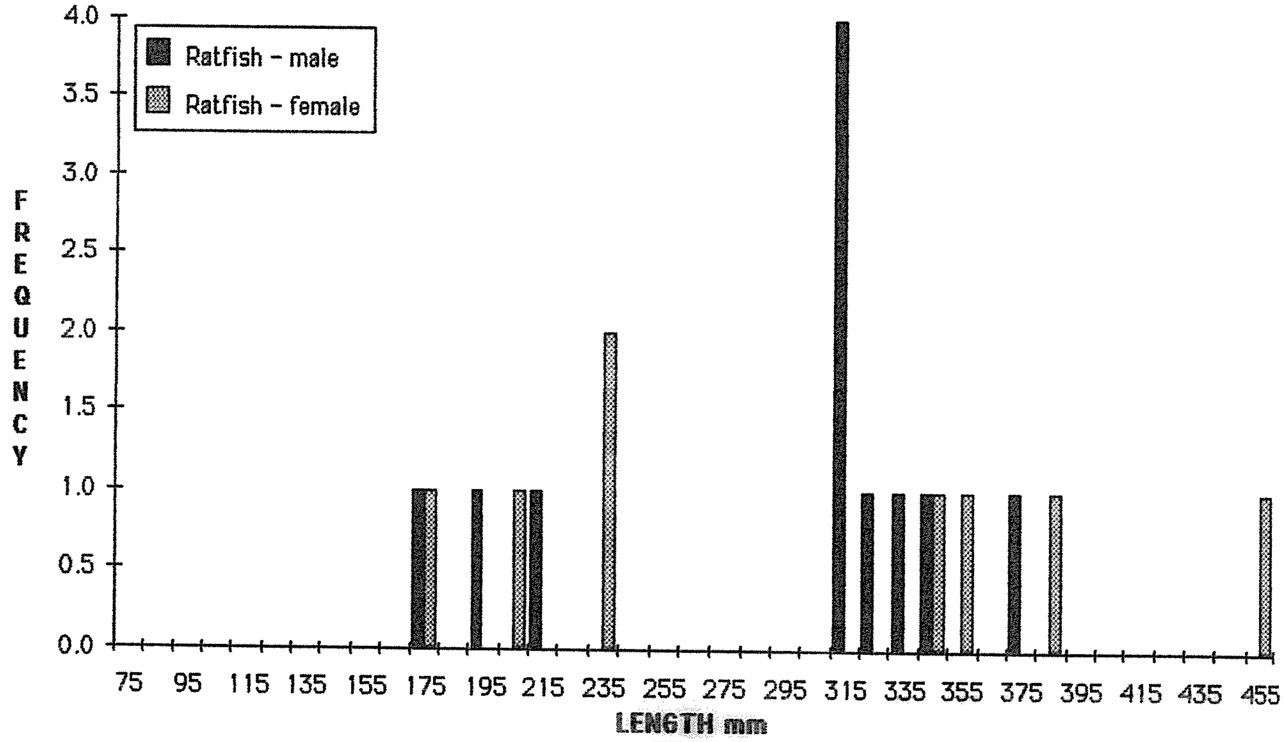
Appendix B, Figure 2. Length frequency of otter trawl caught ratfish, shown by sex, during summer at PSDDA 1 in Commencement Bay.



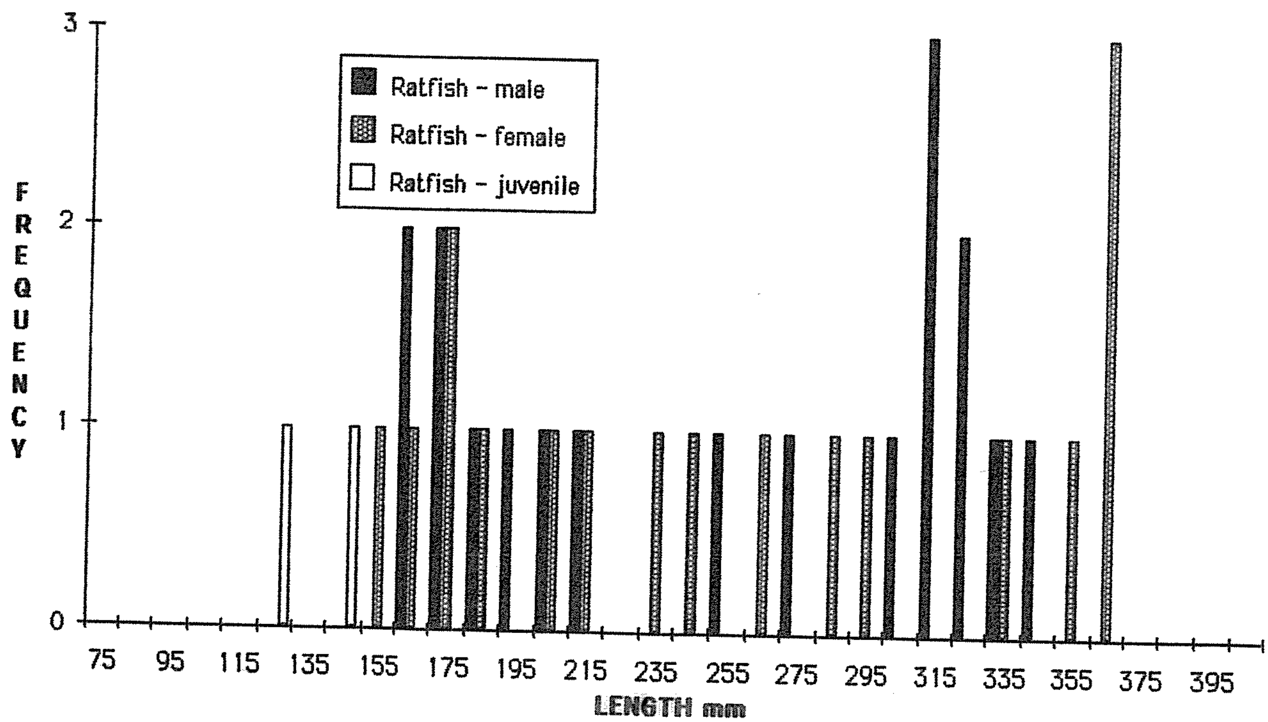
Appendix B, Figure 3. Length frequency of otter trawl caught ratfish, shown by sex and life history stage, during autumn at PSDDA 1 in Commencement Bay.



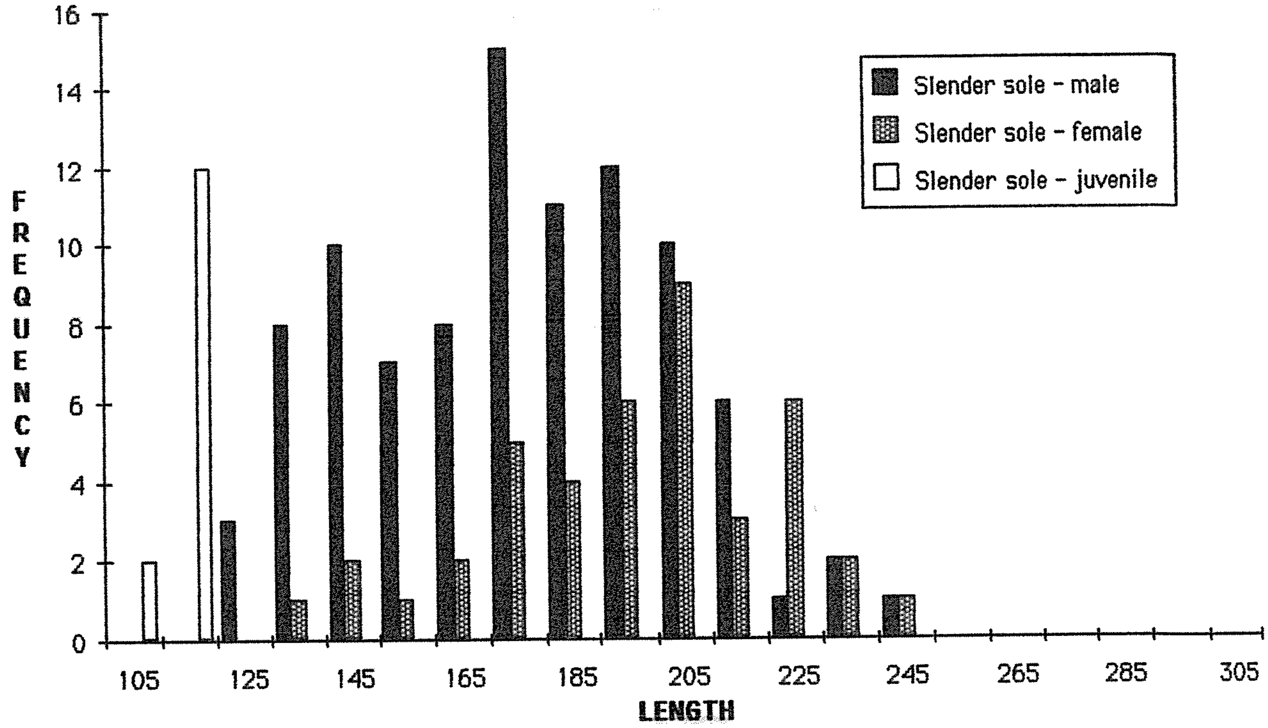
Appendix B, Figure 4. Length frequency of otter trawl caught ratfish, shown by sex and life history stage, during summer at PSDDA 1 reference site in Elliott Bay.



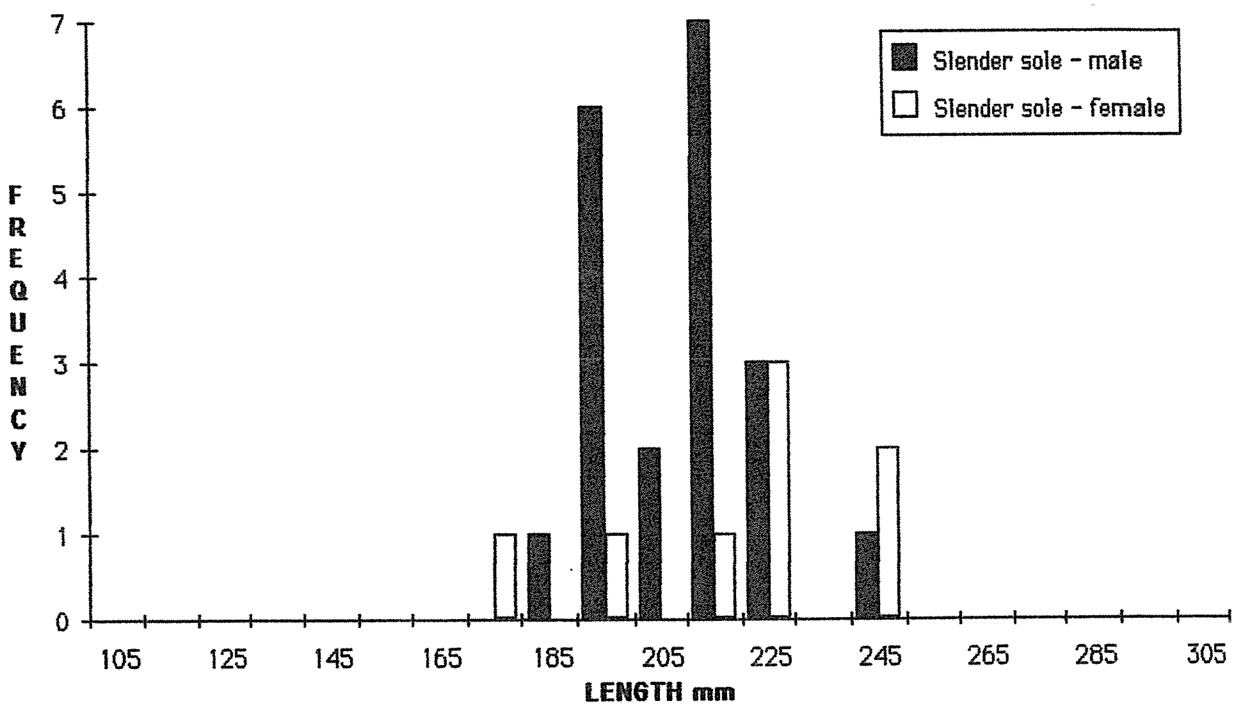
Appendix B, Figure 5. Length frequency of otter trawl caught ratfish, shown by sex, during autumn at PSDDA 2, reference site 1 in Elliott Bay.



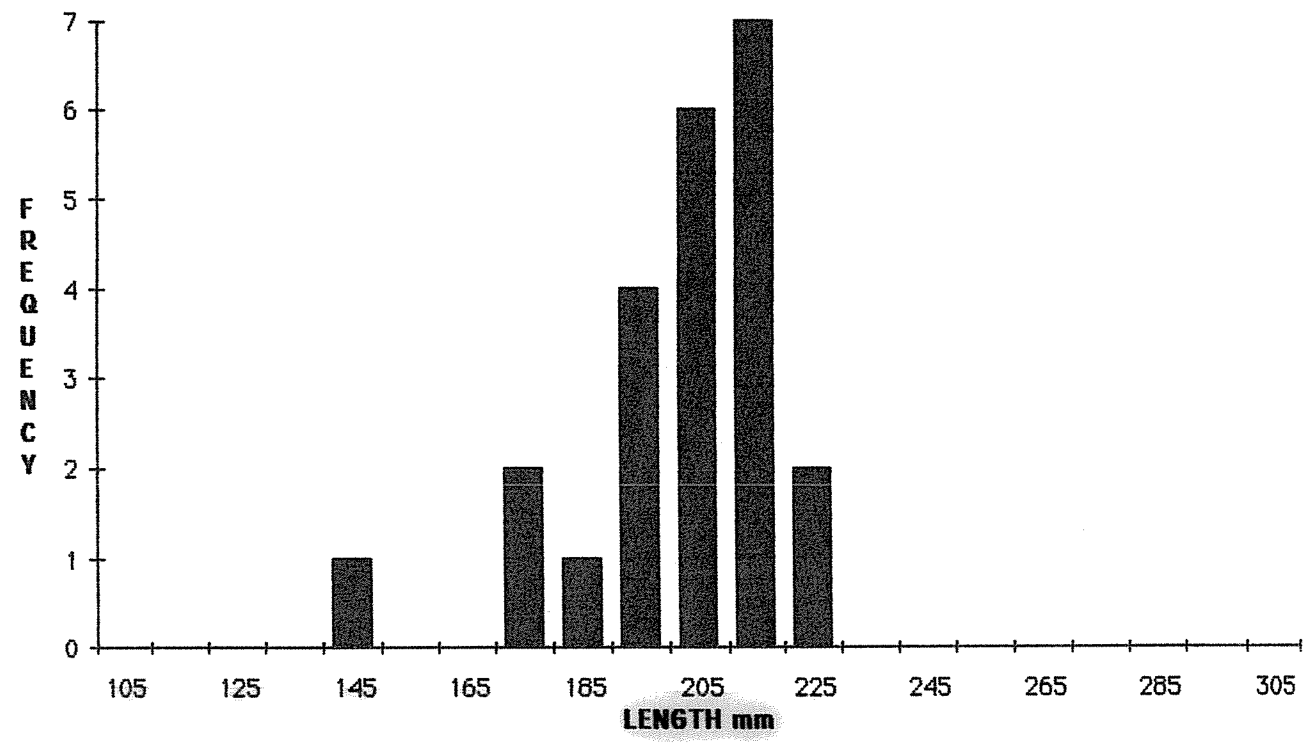
Appendix B, Figure 6. Length frequency of otter trawl caught ratfish, shown by sex and life history stage, during autumn at PSDDA 2, reference site 2 in Elliott Bay.



Appendix B, Figure 7. Length frequency of otter trawl caught slender sole, shown by sex and life history stage, during autumn at PSDDA 1 in Elliott Bay.



Appendix B, Figure 8. Length frequency of otter trawl caught slender sole males during summer at PSDDA 2 in Elliott Bay.



Appendix B, Figure 9. Length frequency of otter trawl caught slender sole, shown by sex, during autumn at PSDDA 2 in Elliott Bay.

APPENDIX C

Abundance and biomass (and range at multiple sample stations) of otter trawl caught fish by station and species in Commencement Bay, Elliott Bay, Saratoga Passage, and Port Gardner

Appendix C, Table 1. Abundance and range at multiple sample stations of otter trawl-caught fish by station and species in Commencement Bay on June 13, 1986.

Species	Location PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
Spiny dogfish- adult	0.3	0-1	0.3	0-1			
" " juvenile							
Longnose skate							
Ratfish- adult	4.7	1-9	1.3	0-3			6.0
" juvenile							1.0
Pacific herring						5.0	
Longfin smelt							
Plainfin midshipman- adult						1.0	
" " - juvenile							
Pacific cod- adult						24.0	
" " - juvenile						4.0	
Pacific hake- adult	0.3	0-1					
" " - juvenile							
Pacific tomcod- adult							
" " - juvenile							
Walleye pollock- adult							
" " - juvenile							
Red brotula							
Pallid eelpout	0.3	0-1					
Shortfin eelpout							
Black eelpout- adult							
" " - juvenile							
Blackbelly eelpout- adult						1.0	
" " - juvenile							
Shiner perch- adult							
" " - juvenile							
Pile perch- adult							
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult							
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult			0.3	0-1		3.0	
" " - juvenile							
Canary rockfish							
Rockfish UID- juvenile							
Sablefish- adult							
" - juvenile							
Lingcod							
Roughback sculpin							
Spinyhead sculpin							
Soft sculpin							
Tadpole sculpin							
Northern spearnose poacher							

Appendix C, Table 1. (Continued)

Species	Location: PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							
Speckled sanddab- adult							
" " - juvenile							
Arrowtooth flounder							
Rex sole- adult						6.0	
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult						2.0	
" " - juvenile							
Slender sole- adult	1.0	0-2	0.3	0-1			
" " - juvenile							
Dover sole- adult	1.3	1-2	1.0	0-3		5.0	6.0
" " - juvenile							
English sole- adult			0.3	0-1		40.0	
" " - juvenile							
C-O sole- adult							
" " - juvenile							
Totals	6.9		3.5			91	13

Appendix C, Table 2. Biomass (in grams) and range at multiple sample stations of otter trawl-caught fish by station and species in Commencement Bay on June 13, 1986.

Species	Location						
	PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
Spiny dogfish- adult	16.7	0-50	456.7	0-1,370			
" " juv.							
Longnose skate							
Ratfish- adult	1,357.7	940-2,923	444.0	0-1,012			2,085.0
" juvenile							6.0
Pacific herring						45.0	
Longfin smelt							
Plainfin midshipman- adult						108.0	
" " - juv.							
Pacific cod- adult						549.0	
" " - juvenile						52.0	
Pacific hake- adult	13.5	0-40.5					
" " - juvenile							
Pacific tomcod- adult							
" " - juvenile							
Walleye pollock- adult							
" " - juvenile							
Red brotula							
Pallid eelpout	1.7	0-5.0					
Shortfin eelpout							
Black eelpout- adult							
" " - juvenile							
Blackbelly eelpout- adult						9.0	
" " - juv.							
Shiner perch- adult							
" " - juvenile							
Pile perch- adult							
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult							
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult			643.3	0-970		501.0	
" " - juv.							
Canary rockfish							
Rockfish UID- juvenile							
Sablefish- adult							
" - juvenile							
Lingcod							
Roughback sculpin							
Spinyhead sculpin							
Soft sculpin							
Tadpole sculpin							
Northern spearnose poacher							

Appendix C, Table 2. (Continued)

Species	PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
	Location						
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							
Speckled sanddab- adult							
" " - juv.							
Arrowtooth flounder							
Rex sole- adult						161.0	
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult						114.0	
" " - juvenile							
Slender sole- adult	74.7	0-174	40.2	0-92.5			
" " - juvenile							
Dover sole- adult	587.7	360-1,013	1,203.0	0-2,700		399.0	2,718.0
" " - juvenile							
English sole- adult			122.7	0-368		5,824.0	
" " - juvenile							
C-O sole- adult							
" " - juvenile							
Totals	2052		2909.9			7762	4809

Appendix C, Table 3. Abundance and range at multiple sample stations of otter trawl-caught fish by station and species in Commencement Bay on September 8, 1986.

Species	PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
	Location						
Spiny dogfish- adult							
" " juvenile							
Longnose skate							
Ratfish- adult	8.0	5-13	5.0	3-8	1	2	26
" juvenile	0.3	0-1					7
Pacific herring							
Longfin smelt	0.3	0-1					
Plainfin midshipman- adult						6	
" " - juvenile							
Pacific cod- adult	0.7	0-1	0.3	0-1			
" " - juvenile							
Pacific hake- adult	0.3	0-1					
" " - juvenile			0.3	0-1			
Pacific tomcod- adult						7	
" " - juvenile						34	
Walleye pollock- adult	0.7	0-2	0.7	0-1			
" " - juvenile							
Red brotula							
Pallid eelpout							
Shortfin eelpout							
Black eelpout- adult	0.3	0-1					1
" " - juvenile							
Blackbelly eelpout- adult						7	
" " - juvenile							
Shiner perch- adult					2	1	
" " - juvenile							
Pile perch- adult						1	
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult					2		
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult			0.7	0-1	8		2
" " - juvenile							
Canary rockfish							
Rockfish UID- juvenile							1
Sablefish- adult							
" - juvenile							
Lingcod							
Roughback sculpin						16	
Spinyhead sculpin			0.7	0-1			
Soft sculpin	0.3	0-1					
Tadpole sculpin							
Northern spearnose poacher						1	

Appendix C, Table 3. (Continued)

Species	Location PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							1
Speckled sanddab- adult					2		
" " - juvenile							
Arrowtooth flounder						2	
Rex sole- adult			0.3	0-1		8	3
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult					16	10	
" " - juvenile							
Slender sole- adult	3.7	0-6	1.3	1-2		12	3
" " - juvenile							
Dover sole- adult	8.3	5-10	3.3	1-8		15	12
" " - juvenile						3	
English sole- adult	0.7	0-1			19	182	3
" " - juvenile							
C-O sole- adult					1		
" " - juvenile							
Totals	23.6		12.6		51	307	59

Appendix C, Table 4. Biomass (in grams) and range at multiple sample stations of otter trawl-caught fish by station and species in Commencement Bay on September 8, 1986.

Species	Location PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
Spiny dogfish- adult							
" " juv.							
Longnose skate							
Ratfish- adult	1,830.0	720-3,610	1,533.3	850-2,550	635	290	3140.0
" juvenile	7.7	0-23					550.0
Pacific herring							
Longfin smelt	0.7	0-2					
Plainfin midshipman- adult						219.2	
" " - juv.							
Pacific cod- adult	1,573.3	0-4,200	180	0-540			
" " - juvenile							
Pacific hake- adult	140.0	0-420					
" " - juvenile			0.5	0-1.5			
Pacific tomcod- adult						355	
" " - juvenile						210	
Walleye pollock- adult	53.3	0-160	134	0-212			
" " - juvenile							
Red brotula							
Pallid eelpout							
Shortfin eelpout							
Black eelpout- adult	1.2	0-3.5					4.5
" " - juvenile							
Blackbelly eelpout- adult						116.5	
" " - juv.							
Shiner perch- adult					57	22	
" " - juvenile							
Pile perch- adult						300	
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult					820		
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult			301.7	0-565	1,190	2,480	1,180
" " - juv.							
Canary rockfish							
Rockfish UID- juvenile							12.5
Sablefish- adult							
" - juvenile							
Lingcod							
Roughback sculpin						177.5	
Spinyhead sculpin			5.0	0-8.0			
Soft sculpin	1.8	0-5.5					
Tadpole sculpin							
Northern spearnose poacher						33.4	

Appendix C, Table 4. (Continued)

Species	PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m	40 m	156 m
			Location				
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							5
Speckled sanddab- adult					21		
" " - juv.							
Arrowtooth flounder						330	
Rex sole- adult			36.3	0-109		308	285
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult					490	519	
" " - juvenile							
Slender sole- adult	170	65-360	129.3	98-190		443.7	110
" " - juvenile							
Dover sole- adult	28,533	1,970-4,460	1,238.3	390-2,810		1,210	3975
" " - juvenile						50	
English sole- adult	190	0-290			4,890	29,865	855
" " - juvenile							
C-O sole- adult					240		
" " - juvenile							
Totals	6,821.3		3,558.4		8,343	36,929.3	10,117

Appendix C, Table 5. Abundance and range of multiple sample stations for otter trawl-caught fish by station and species in Elliott Bay on July 3, 1986.

Species	PSDDA 1				PSDDA 1 Reference site		PSDDA 2				PSDDA 2 Reference site 1		PSDDA 2 Reference site II
			Range						Range				
	SU	AUT	SU	AUT	SU	AUT	SU	AUT	SU	AUT	SU	AUT	AUT
Spiny dogfish- adult	1.0	15.3	0-3	2-42	1.0	10.0							
" " juvenile													
Longnose skate								0.3		0-1			
Ratfish- adult	2.3	4.7	0-5	0-11	16.0	2.0	5.0	23.7	2-7	9-34	8.0	20.0	36.0
" juvenile	0.3	0.7	0-1	0-2			0.3	3.3	0-1	0-7	1.0		4.0
Pacific herring													
Longfin smelt													
Plainfin midshipman- adult		6.0		5-8									
" " - juv.													
Pacific cod- adult	0.3	0.7	0-1	0-1				1.7		1-2			
" " - juvenile													
Pacific hake- adult	2.0	17.0	0-5	2-44	2.0	2.0	0.3	0.3	0-1	0-1			
" " - juvenile		1.0		0-3				2.0		0-6			
Pacific tomcod- adult	0.3	5.3	0-1	0-12									
" " - juvenile						1.0		1.3		0-2			3.0
Walleye pollock- adult													
" " - juvenile													
Red brotula											1.0	4.0	
Pallid eelpout							0.7	1.3	0-2	0-4		1.0	7.0
Shortfin eelpout													
Black eelpout- adult								2.0		0-5		2.0	1.0
" " - juvenile													
Blackbelly eelpout- adult	13.7	93.3	3-22	67-137	13.0	2.0							
" " - juv.													
Shiner perch- adult		1.3		0-4									
" " - juvenile													
Pile perch- adult													
" " - juvenile													
Bluebarred prickleback	2.7	9.7	0-5	8-13	3.0	1.0							
Copper rockfish- adult													
" " - juvenile													
Splitnose rockfish												1.0	
Quillback rockfish- adult		6.0		2-12	1.0	3.0		0.7		0-2			
" " - juv.													
Canary rockfish	0.3	1.3	0-1	0-4									
Rockfish UID- juvenile													
Sablefish- adult								0.7		0-1			
" - juvenile													
Lingcod													
Roughback sculpin												1.0	
Spinyhead sculpin		0.3		0-1									
Soft sculpin		0.3		0-1		1.0							
Tadpole sculpin											7.0		
Northern spearnose poacher													
Sturgeon poacher	0.3		0-1										
Bluespotted poacher		0.3		0-1									
Snailfish UID													
Speckled sanddab- adult													
" " - juv.													
Arrowtooth flounder													
Rex sole- adult	1.3	2.3	0-4	0-7	1.0			0.3		0-1			
" " - juvenile		1.3		0-3									
Flathead sole- adult	5.7	24.7	0-12	15-42	15.0	1.0							
" " - juvenile													
Rock sole- adult		0.3		0-1									
" " - juvenile													
Slender sole- adult	15.7	46.7	14-18	33-54	12.0	8.0	6.0	9.3	4-9	2-15	3.0	8.0	9.0
" " - juvenile	2.3	7.3	0-5	5-9	1.0								
Dover sole- adult	2.3	2.3	0-3	0-7	1.0		4.3	6.7	3-6	4-11	9.0	2.0	3.0
" " - juvenile	1.0		0-2										
English sole- adult	0.3		0-1				0.3	16.3	0-1	0-29	1.0	28.0	33.0
" " - juvenile													
C-O sole- adult													
" " - juvenile													
Totals	51.8	248.1			66.0	30.0	16.9	69.9			30.0	67.0	95.0

Appendix C, Table 6. Biomass (in grams) and range at multiple sample stations for otter trawl-caught fish by station and species in Elliott Bay on July 3, 1986.

Species	PSDDA 1				PSDDA 1 Reference Site		PSDDA 2				PSDDA 2 Reference site 1	
			Range						Range			
	SU	AUT	SU	AUT	SU	AUT	SU	AUT	SU	AUT	SU	AUT
Spiny dogfish- adult	615.0	1,675.0	0-1,845.0	270-4,230.0	448.5	1000.0						
" " juvenile												
Longnose skate								25.3		0-76.0		
Ratfish- adult	318.2	423.3	0-822.0	0-835.0	1195.5	550.0	1684.2	7066.7	1682.0-1707.5	590.0-11070.0	3704.0	4440.0
" juvenile	12.2	16.0	0-36.5	0-48.0			15.8	100.0	0-47.5	0-200.0	20.0	
Pacific herring												
Longfin smelt												
Plainfin midshipman- adult		621.7		510.0-715.0								
" " - juv.												
Pacific cod- adult	137.7	504.0	0-413.0	0-1,090.0				1958.3		410.0-4005.0		
" " - juvenile												
Pacific hake- adult	130.4	3,788.3	0-204.5	490.0-10,210.0	443.0	510.0	108.5	126.7	0-325.5	0-380.0		
" " - juvenile	12.5			0-37.5				4.0		0-11.9		
Pacific tomcod- adult	22.7		0-68.0			3.0						
" " - juvenile		28.3		0-45.0				3.6		0-5.5		
Walleye pollock- adult												
" " - juvenile												
Red brotula											292.0	550.0
Pallid eelpout							3.5	6.1	0-10.5	0-18.2		1.5
Shortfin eelpout												
Black eelpout- adult								19.1		0-53.4		110.0
" " - juvenile												
Blackbelly eelpout- adult	224.8	1,641.0	100.3-462.0	690.0-2,733.0	407.0	67.0						
" " - juv.												
Shiner perch- adult		29.8		0-89.5								
" " - juvenile												
Pile perch- adult												
" " - juvenile												
Bluebarred prickleback	91.8	52.3	0-260.0	45.0-60.0	13.5	3.5						
Copper rockfish- adult												
" " - juvenile												
Splitnose rockfish												
Quillback rockfish- adult		1,625.0		840.0-2,045.0	330.0	110.0		360.0		0-1080.0		
" " - juv.												
Canary rockfish	666.7	4,916.7	0-2,000.0	0-14,750.0								
Rockfish UID- juvenile												
Sablefish- adult								866.7		0-1750.0		
" - juvenile												
Lingcod												
Roughback sculpin												
Spinyhead sculpin		0.8		0-2.5								18.5
Soft sculpin		1.3		0-4.0		2.5						
Tadpole sculpin												
Northern spearnose poacher											25.0	
Sturgeon poacher	9.0		0-27									
Bluespotted poacher		6.7		0-20.0								
Snailfish UID												
Speckled sanddab- adult												
" " - juv.												
Arrowtooth flounder												
Rex sole- adult	103.0	205.0	0-309	0-615.0	88.5			3.7		0-11.0		
" " - juvenile		8.0		0-15.0		110.0						
Flathead sole- adult	410.8	2,850.3	0-774.5	1,860.0-4,315.0	1,481.0							
" " - juvenile												
Rock sole- adult		48.3		0-145.0								
" " - juvenile												
Slender sole- adult	854.2	1,770.0	461.5-1292.0	870.0-2320.0	441.0	445.0	893.9	613.3	200.0-443.0	170.0-1,020.0	206.0	745.0
" " - juvenile	17.2	56.5	0-39.5	32.0-72.0	6.5							
Dover sole- adult	280.7	361.7	143.0-435.0	0-1,085.0	138.5		4,277.0	2,533.3	491.0-2,132.0	980.0-5,300.0	4,291.0	620.0
" " - juvenile	5.3		0-9.0									
English sole- adult	57.7		0-173.0				100.3	3,810.0	0-301.0	0-6,280.0	252.0	5,280.0
" " - juvenile												
C-O sole- adult												
" " - juvenile												
Totals	3,969.9	20,630			4,993	2,801	7,083.2	17,496.8			8,790	12,255

Appendix C, Table 7. Abundance and range at multiple sample stations of otter trawl-caught fish by station and species in Saratoga Passage on July 1, 1986.

Species	PSDDA	PSDDA (range)	PSDDA reference	20m E	40m E	40m W	80m E
			Location				
Spiny dogfish- adult	0.3	0-1					3
" " juvenile							
Longnose skate							
Ratfish- adult	1	1-1					1
" juvenile							
Pacific herring							
Longfin smelt							
Plainfin midshipman- adult							
" " - juvenile							
Pacific cod- adult							
" " - juvenile							
Pacific hake- adult	2.3	0-4	2				
" " - juvenile							
Pacific tomcod- adult							
" " - juvenile					1		
Walleye pollock- adult							
" " - juvenile							
Red brotula							
Pallid eelpout							
Shortfin eelpout	0.7	0-2					
Black eelpout- adult							
" " - juvenile							
Blackbelly eelpout- adult							2
" " - juvenile							
Shiner perch- adult							
" " - juvenile							
Pile perch- adult							
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult							
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult	0.3	0-1					
" " - juvenile							
Canary rockfish							
Rockfish UID- juvenile							
Sablefish- adult							
" - juvenile							
Lingcod	0.3	0-1					
Roughback sculpin					1		
Spinyhead sculpin							
Soft sculpin							
Tadpole sculpin	3	0-9					
Northern spearnose poacher							

Appendix C, Table 7. (Continued)

Species	PSDDA	PSDDA (range)	PSDDA reference	20m E	40m E	40m W	80 m E
			Location				
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							
Speckled sanddab- adult							
" " - juvenile							
Arrowtooth flounder							
Rex sole- adult							1
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult				2	5		
" " - juvenile					1		
Slender sole- adult	2.7	0-7	3				4
" " - juvenile							
Dover sole- adult							1
" " - juvenile							
English sole- adult				4	7	2	7
" " - juvenile							
C-O sole- adult							
" " - juvenile							
Totals	10.60		5	6	15	2	19

Appendix C, Table 8. Biomass (in grams) and range at multiple sample stations of otter trawl caught fish by station and species in Saratoga Passage on July 1, 1986.

	Location						
Species	PSDDA	PSDDA (range)	PSDDA Reference	20m E	40m E	40m W	80m E
Spiny dogfish- adult	351.7	0-1055					978
" " juvenile							
Longnose skate							
Ratfish- adult	441.7	255-695					142
" juvenile							
Pacific herring							
Longfin smelt							
Plainfin midshipman- adult							
" " - juvenile							
Pacific cod- adult							
" " - juvenile							
Pacific hake- adult	741.5	0-1,381.5	678				
" " - juvenile							
Pacific tomcod- adult					1.5		
" " - juvenile							
Walleye pollock- adult							
" " - juvenile							
Red brotula							
Pallid eelpout							
Shortfin eelpout	15.2	0-45.5					
Black eelpout- adult							56
" " - juvenile							
Blackbelly eelpout- adult							
" " - juvenile							
Shiner perch- adult							
" " - juvenile							
Pile perch- adult							
" " - juvenile							
Bluebarred prickleback							
Copper rockfish- adult							
" " - juvenile							
Splitnose rockfish							
Quillback rockfish- adult	34.7	0-104					
" " - juvenile							
Canary rockfish							
Rockfish UID- juvenile							
Sablefish- adult							
" - juvenile							
Lingcod	1,666.7	0-5,000					
Roughback sculpin				9.5			
Spinyhead sculpin							
Soft sculpin							
Tadpole sculpin	119.0	0-357					

Appendix C, Table 8. (Continued)

Species	PSDDA	PSDDA (range)	PSDDA Reference	20m E	40m E	40m W	80m E
			Location				
Northern spearnose poacher							
Sturgeon poacher							
Bluespotted poacher							
Snailfish UID							
Speckled sanddab- adult							
" " - juvenile							
Arrowtooth flounder							
Rex sole- adult							107
" " - juvenile							
Flathead sole- adult							
" " - juvenile							
Rock sole- adult				65	448		
" " - juvenile					19		
Slender sole- adult	97	0-245	120				142
" " - juvenile							
Dover sole- adult							142
" " - juvenile							
English sole- adult				424	863	137	417
" " - juvenile							
C-O sole- adult							
" " - juvenile							
Totals	3,467.5		798	498.5	1,331.5	137	1,984

Appendix C, Table 9. Number (abundance) of fish, biomass (in grams) and range at Navy and PSDDA sites of otter trawl caught fish by station and species in Port Gardner on February 12 and 13, 1986 (W86).

Fish Species		Port Gardner W 86 NAVY OT				Port Gardner W 86 PSDDA 2				Port Gardner W 86 PSDDA 1				Port Gardner W 86 Tran 1 20S		Port Gardner W 86 Tran 1 40S		Port Gardner W 86 Tran 1 100S	
Scientific Name	Common Name	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey									0.3	0-1	3	0-9						
Squalus acanthias	spiny dogfish					0.5	0-1	115	0-230	0.3	0-1	498.3	0-1495						
Raja rhina	longnose skate																		
Hydrolagus colliei	ratfish - adult	9.7	2-22	1348.3	380-2420	33	22-44	6967.5	5920-8015	25.3	12-36	5162.6	2893-8740					37	6960
	- juvenile	0.7	0-2	11.2	0-33.6	9	5-13	197.5	145-250	9	0-27	96.7	0-290						
Alosa sapidissima	American shad	0.3	0-1	41.5	0-124.6														
Clupea pallasii	Pacific herring																		
Porichthys notatus	plainfin midshipman	0.3	0-1	35	0-105.1	0.5	0-1	100	0-200	0.3	0-1	10	0-30						
Gadus macrocephalus	Pacific cod									0.3	0-1	1333.5	0-4000.5						
Microgadus proximus	Pacific tomcod - adult	5.7	0-12	215.3	0-166					0.3	0-1	33.3	0-100						
	- juvenile	3.7	2-5	48.1	20.4-82.9											4	20		
Merluccius productus	Pacific hake - adult	46	24-58	3048.3	1425-5960	19	9-29	6105	4720-7490	18.3	5-39	6591.7	1150-9935					10	1600
	- juvenile	9.7	0-24	2006.7	0-285														
Brosmophycis marginata	red brotula																		
Lycodapus mandibularis	pallid eelpout																		
Lycodes diapterus	black eelpout																		
Lycodes pacifica	blackbelly eelpout	6.7	1-16	96.8	16.9-234											1	7.4	1	12.4
Cymatogaster aggregata	shiner perch - adult	67.7	5-187	1693.5	120.5-4660														
	- juvenile	1	0-3	15	0-45											16	90		
Damalichthys vacca	pile perch - adult															4	40		
	- juvenile																		
Ronquilus jordani	northern ronquil																		
Lumpenus sagitta	snake prickleback	0.3	0-1	5	0-15														
Sebastes maliger	quillback rockfish	2.7	1-4	491.7	150-1035	2	1-3	1110	520-1700	1	0-2	461.7	0-900			12	280	2	860
Anoplopoma fimbria	sablefish																		
Artedius sp.	sculpin																		
Dasycottus setiger	spinyhead sculpin	0.7	0-2	35	0-105					0.3	0-1	8.3	0-25						
Chitonotus pugetensis	roughback sculpin																		
Gilbertidia sigalutes	soft sculpin																		
Icelinus borealis	northern sculpin																		
Leptocottus armatus	Pacific staghorn sculpin															3	120		
Nautichthys oculofasciatus	sailfin sculpin															1	30		
Radulinus asprellus	slim sculpin																		
Bathyagonus nigripinnis	blackfin starsnout poacher																		
Xeneretmus latifrons	blacktip poacher	3.3	3-4	30.5	27.9-35	1	0-2	16	0-32	1.3	0-3	11.3	0-20					1	11.8
Xeneretmus triacanthus	bluespotted poacher																		
Citharichthys sp.	sanddab - adult													2	70	9	295		
	- juvenile													1	13.2	6	95		
Citharichthys sordidus	Pacific sanddab																		
Citharichthys stigmaeus	speckled sanddab - adult																		
	- juvenile																		
Atheresthes stomias	arrowtooth flounder									0.3	0-1	100	0-300			1	19.5		
Glyptocephalus zachirus	rex sole - adult	2	0-3	240	0-375	0.5	0-1	12	0-24	0.3	0-1	8.3	0-25					2	198.1
	- juvenile																	1	34.5
Hippoglossoides elassodon	flathead sole	25.7	17-42	3328.3	2135-5610	0.5	0-1	80	0-160					1	200	5	500		
Lepidopsetta bilineata	rock sole - adult	0.3	0-1	163.4	0-490					0.3	0-1	50	0-150	2	660	13	2080		
	- juvenile													2	7.8	5	23.1		
Lyopsetta exilis	slender sole - adult	30.3	21-45	2085	1250-3040	14.5	8-21	692.5	410-975	26	24-28	1301.7	1255-1390					1	180.1
	- juvenile	9	0-3	17.7	0-41													1	18.4
Microstomus pacificus	Dover sole	7.3	3-12	1686	910-2575	5	3-7	1215	1170-1260	3.7	0-11	818.3	0-2455					2	564
Parophyrs vetus	English sole - adult	111	58-174	20325	8170-34755	3.5	3-4	750	490-1010	7	3-14	1860	795-3805	1	320	17	970	26	NA
	- juvenile	0.7	0-1	8.3	0-13.5									1	7	157	1500		
Platichthys stellatus	starry flounder																		
Pleuronichthys coenosus	CO sole															1	60		
Psettichthys melanostictus	sand sole																		
	TOTAL	344.8		36976		89		17361		94.3		18349		10	1278	255	6130	84	10439

Appendix C, Table 9 (continued).

Fish Species: Scientific Name	Common Name	Port Gardner W 86 Tran 2 20S Abund	Biomass	Port Gardner W 86 Tran 2 40S Abund	Biomass	Port Gardner W 86 Tran 2 110S Abund	Biomass	Port Gardner W 86 Tran 4 20S Abund	Biomass	Port Gardner W 86 Tran 4 40S Abund	Biomass	Port Gardner W 86 Tran 4 145S Abund	Biomass
Lampetra tridentata	Pacific lamprey												
Squalus acanthias	spiny dogfish												
Raja rhina	longnose skate												
Hydrolagus colliei	ratfish - adult					2	580					8	3800
	- juvenile											4	35
Alosa sapidissima	American shad												
Clupea pallasii	Pacific herring												
Porichthys notatus	plainfin midshipman												
Gadus macrocephalus	Pacific cod												
Microgadus proximus	Pacific tomcod - adult			13	105								
	- juvenile									14	100		
Merluccius productus	Pacific hake - adult					5	760					1	410
	- juvenile												
Brosmophycis marginata	red brotula												
Lycodapus mandibularis	pallid eelpout												
Lycodes diapterus	black eelpout												
Lycodes pacifica	blackbelly eelpout			1	10							2	50
Cymatogaster aggregata	shiner perch - adult			2	30					1	20		
	- juvenile			41	255					34	200		
Damalichthys vacca	pile perch - adult			7	105					129	2210		
	- juvenile			1	10					26	310		
Ronquilus jordani	northern ronquil												
Lumpenus sagitta	snake prickleback									36	1065		
Sebastes maliger	quillback rockfish			8	50	2	1320					3	400
Anoplopoma fimbria	sablefish												
Artedius sp.	sculpin			2	30			1	7	5	65		
Dasycottus setiger	spinyhead sculpin												
Chitonotus pugetensis	roughback sculpin												
Gilbertidia sigalutes	soft sculpin												
Icelinus borealis	northern sculpin												
Leptocottus armatus	Pacific staghorn sculpin			7	225					2	380		
Nautichthys oculofasciatus	sailfin sculpin												
Radulinus asprellus	slim sculpin												
Bathyagonus nigripinnis	blackfin starsnout poacher												
Xeneretmus latifrons	blacktip poacher											2	30
Xeneretmus triacanthus	bluespotted poacher												
Citharichthys sp.	sanddab - adult	1	27	12	300			4	180				
	- juvenile							5	80				
Citharichthys sordidus	Pacific sanddab									1	15		
Citharichthys stigmaeus	speckled sanddab - adult									26	810		
	- juvenile									1	25		
Atheresthes stomias	arrowtooth flounder			1	145								
Glyptocephalus zachirus	rex sole - adult			1	55	1	130						
	- juvenile												
Hippoglossoides elassodon	flathead sole							4	310	1	110		
Lepidopsetta bilineata	rock sole - adult	1	230	17	1480					22	1650		
	- juvenile	2	8	1	5			1	5	9	145		
Lyopsetta exilis	slender sole - adult			6	40	1	90	3	610			14	830
	- juvenile												
Microstomus pacificus	Dover sole			1	80	11	3190					28	4900
Parophyrs vetus	English sole - adult			67	1920	8	1710			140	1490		
	- juvenile			54	590			1	7.2				
Platichthys stellatus	starry flounder												
Pleuronichthys coenosus	CO sole							1	50				
Psettichthys melanostictus	sand sole												
	TOTAL	4	265	242	5435	30	7780	20	1249.2	447	8595	62	10455

Appendix C, Table 10. Number (abundance) of fish, biomass (in grams) and range at Navy and PSDDA sites for otter trawl caught fish, by station and species in Port Gardner on April 18 and 21, 1986 (SP86).

Fish Species		Port Gardner SP 86 NAVY OT				Port Gardner SP 86 PSDDA 2				Port Gardner SP 86 PSDDA 1				Port Gardner SP 86 Tran 1 20S		Port Gardner SP 86 Tran 1 40S		Port Gardner SP 86 Tran 1 100M	
Scientific Name	Common Name	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey																		
Squalus acanthias	spiny dogfish																		
Raja rhina	longnose skate																		
Hydrolagus colliei	ratfish - adult	3.7	3-4	300	170-435	3.7	2-5	806.7	380-1330	1	0-2	438.3	0-110					20	145
	- juvenile					1	0-2	12	0-35									14	220
Alosa sapidissima	American shad																		
Clupea pallasii	Pacific herring																		
Porichthys notatus	plainfin midshipman	0.7	0-2	31.7	0-70														
Gadus macrocephalus	Pacific cod																		
Microgadus proximus	Pacific tomcod - adult	0.7	0-1	21.7	0-40													1	140
	- juvenile																		
Merluccius productus	Pacific hake - adult	6.7	4-8	390	360-420					1	0-2	195	0-405					1	85
	- juvenile																		
Brosmophycis marginata	red brotula																		
Lycodapus mandibularis	pallid eelpout																		
Lycodes diapterus	black eelpout																		
Lycodes pacifica	blackbelly eelpout	14	6-21	258.3	90-455					0.3	0-1	2.7	0-8					1	11
Cymatogaster aggregata	shiner perch - adult																		
	- juvenile																		
Damalichthys vacca	pile perch - adult																		
	- juvenile																		
Ronquilus jordani	northern ronquil																		
Lumpenus sagitta	snake prickleback	0.3	0-1	3	0-9														
Sebastes maliger	quillback rockfish	0.3	0-1	170	0-510	1	1-1	260	150-335									1	605
Anoplopoma fimbria	sablefish	0.3	0-1	143.3	0-430	0.3	0-1	166.7	0-500										
Artedius sp.	sculpin																		
Dasycottus setiger	spinyhead sculpin																		
Chitonotus pugetensis	roughback sculpin																		
Gilbertidia sigalutes	soft sculpin																		
Icelinus borealis	northern sculpin																		
Leptocottus armatus	Pacific staghorn sculpin																		
Nautichthys oculofasciatus	sailfin sculpin																		
Radulinus asprellus	slim sculpin																		
Bathyagonus nigripinnis	blackfin starsnout poacher																		
Xeneretmus latifrons	blacktip poacher	4.3	3-7	39	27-50	0.3	0-1	5.7	0-17										
Xeneretmus triacanthus	bluespotted poacher																		
Citharichthys sp.	sanddab - adult															2	50		
	- juvenile													1	1				
Citharichthys sordidus	Pacific sanddab																		
Citharichthys stigmaeus	speckled sanddab - adult																		
	- juvenile																		
Atheresthes stomias	arrowtooth flounder																		
Glyptocephalus zachirus	rex sole - adult	5.7	1-14	411.7	110-790					0.3	0-1	31.7	0-95					2	210
	- juvenile	0.3	0-1	0.3	0-1					0.7	0-1	3	0-7						
Hippoglossoides elassodon	flathead sole	5.7	0-13	781.7	0-1695													2	450
Lepidopsetta bilineata	rock sole - adult															1	145		
	- juvenile																		
Lyopsetta exilis	slender sole - adult	17	5-30	915	235-1490	4.7	3-6	243.3	150-295	8.7	7-10	411.7	255-500					15	830
	- juvenile	1.7	0-3	6.3	0-10														
Microstomus pacificus	Dover sole	3	0-9	346.7	0-1040	6	5-10	1415	885-1965	0.7	0-1	156.7	0-250			12	125	2	655
Parophyrs vetus	English sole - adult	30.3	20-36	6060	4470-7090	2.7	0-7	566.7	0-1375	0.7	0-2	110	0-330			2	455	61	10870
	- juvenile																		
Platichthys stellatus	starry flounder																		
Pleuronichthys coenosus	CO sole																		
Psettichthys melanostictus	sand sole															1	125		
	TOTAL	94.7		9878.7		19.7		3476.1		13.4		1349.1		1	1	18	900	120	14221

Appendix C, Table 10 (continued).

Fish Species		Port Gardner SP 86 Tran 2 20S		Port Gardner SP 86 Tran 2 40S		Port Gardner SP 86 Tran 2 110S		Port Gardner SP 86 Tran 4 20S		Port Gardner SP 86 Tran 4 40S		Port Gardner SP 86 Tran 4 145S	
Scientific Name	Common Name	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey												
Squalus acanthias	spiny dogfish												
Raja rhina	longnose skate												
Hydrolagus colliei	ratfish - adult					2	50					8	1610
	- juvenile												
Alosa sapidissima	American shad												
Clupea pallasii	Pacific herring												
Porichthys notatus	plainfin midshipman			1	27								
Gadus macrocephalus	Pacific cod												
Microgadus proximus	Pacific tomcod - adult												
	- juvenile												
Merluccius productus	Pacific hake - adult					2	210					4	1760
	- juvenile												
Brosmophycis marginata	red brotula												
Lycodapus mandibularis	pallid eelpout											1	2
Lycodes diapterus	black eelpout												
Lycodes pacifica	blackbelly eelpout												
Cymatogaster aggregata	shiner perch - adult									5	40		
	- juvenile												
Damalichthys vacca	pile perch - adult												
	- juvenile												
Ronquilus jordani	northern ronquil												
Lumpenus sagitta	snake prickleback												
Sebastes maliger	quillback rockfish									5	200		
Anoplopoma fimbria	sablefish												
Artedius sp.	sculpin												
Dasycottus setiger	spinyhead sculpin												
Chitonotus pugetensis	roughback sculpin												
Gilbertidia sigalutes	soft sculpin												
Icelinus borealis	northern sculpin			1	9					1	2		
Leptocottus armatus	Pacific staghorn sculpin												
Nautichthys oculofasciatus	sailfin sculpin												
Radulinus asprellus	slim sculpin									1	1		
Bathyagonus nigripinnis	blackfin starsnout poacher												
Xeneretmus latifrons	blacktip poacher			2	15								
Xeneretmus triacanthus	bluespotted poacher												
Citharichthys sp.	sanddab - adult	3	15					1	15	4	120		
	- juvenile							2	5				
Citharichthys sordidus	Pacific sanddab												
Citharichthys stigmaeus	speckled sanddab - adult												
	- juvenile												
Atheresthes stomias	arrowtooth flounder												
Glyptocephalus zachirus	rex sole - adult												
	- juvenile												
Hippoglossoides elassodon	flathead sole												
Lepidopsetta bilineata	rock sole - adult	1	300	5	600					11	830		
	- juvenile							2	5	2	15		
Lyopsetta exilis	slender sole - adult					2	55					1	10
	- juvenile												
Microstomus pacificus	Dover sole					2	1120						
Parophyrs vetus	English sole - adult			3	335	1	150			11	1420		
	- juvenile									8	90		
Platichthys stellatus	starry flounder												
Pleuronichthys coenosus	CO sole												
Psettichthys melanostictus	sand sole	1	12										
	TOTAL	5	327	12	986	9	1585	5	25	48	2718	14	3382

Appendix C, Table 11. Number (abundance) of fish, biomass (in grams) and range at Navy and PSDDA sites for otter trawl caught fish by station and species in Port Gardner on June 30 and July 2, 1986 (SU86).

Fish Species		Port Gardner SU 86 NAVY OT				Port Gardner SU 86 PSDDA 2				Port Gardner SU 86 PSDDA 1				Port Gardner SU 86 Tran 1 20S		Port Gardner SU 86 Tran 1 40S		Port Gardner SU 86 Tran 1 100M	
Scientific Name	Common Name	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey																		
Squalus acanthias	spiny dogfish	3.7	1-7	1092.5	580-1702											2	583	1	707
Raja rhina	longnose skate																		
Hydrolagus colliei	ratfish - adult	5	3-9	2339.7	376-5338	1.3	0-4	418.3	0-1255	1	0-2	316.5	0-712					8	1941.5
	- juvenile	1	0-2	5.3	0-14	10.3	1-27	148.3	21-477									14	281
Alosa sapidissima	American shad																		
Clupea pallasii	Pacific herring															5	319.5		
Porichthys notatus	plainfin midshipman															1	54.5		
Gadus macrocephalus	Pacific cod															89	3719		
Microgadus proximus	Pacific tomcod - adult																		
	- juvenile																		
Merluccius productus	Pacific hake - adult	7.3	5-9	890.5	464-1200	0.7	0-1	166.3	0-318									4	951.5
	- juvenile																		
Brosmophycis marginata	red brotula																		
Lycodapus mandibularis	pallid eelpout																		
Lycodes diapterus	black eelpout					0.3	0-1	9.3	0-28										
Lycodes pacifica	blackbelly eelpout	5.7	3-10	223	119-408														
Cymatogaster aggregata	shiner perch - adult																		
	- juvenile																	1	10.5
Damalichthys vacca	pile perch																		
Ronquilus jordani	northern ronquil																		
Lumpenus sagitta	snake prickleback																		
Sebastes maliger	quillback rockfish	1.7	0-2	479.7	120-935					0.7	0-1	212.3	0-383			2	416	1	104.5
Anoplopoma fimbria	sablefish																		
Artedius sp.	sculpin																		
Dasycottus setiger	spinyhead sculpin																		
Chitonotus pugetensis	roughback sculpin																		
Gilbertidia sigalutes	soft sculpin																		
Icelinus borealis	northern sculpin																		
Leptocottus armatus	Pacific staghorn sculpin													1	236				
Nautichthys oculofasciatus	sailfin sculpin																		
Radulinus asprellus	slim sculpin																		
Bathyagonus nigripinnis	blackfin starsnout poacher									1	0-2	20.7	0-34					2	28.5
Xeneretmus latifrons	blacktip poacher	0.3	0-1	2.5	0-7														
Xeneretmus triacanthus	bluespotted poacher																		
Citharichthys sp.	sanddab - adult															1	33		
	- juvenile																		
Citharichthys sordidus	Pacific sanddab																		
Citharichthys stigmaeus	speckled sanddab -adult																		
	- juvenile																		
Atheresthes stomias	arrowtooth flounder																		
Glyptocephalus zachirus	rex sole -adult																		
	- juvenile																		
Hippoglossoides elassodon	flathead sole	2.3	0-7	398	0-1194														
Lepidopsetta bilineata	rock sole - adult															6	239		
	- juvenile																		
Lyopsetta exilis	slender sole - adult	5	3-7	314.7	175-581	2	1-3	97.3	57-129	2.7	0-6	108	0-212					2	115
	- juvenile									0.3	0-1	2	0-6			1	5	1	6.2
Microstomus pacificus	Dover sole - adult	0.7	0-1	179.5	0-402	6.7	3-11	1927.2	1415-2355	4	2-5	1142.7	472-1772					1	582
	- juvenile					0.3	0-1	2	0-6	0.7	0-1	3.3	0-5						
Parophyrs vetlus	English sole - adult	28.7	23-25	5378.2	3837-7034	12.3	2-32	2487.2	306-6729	3	2-4	658.8	262-1088	1	249.5	15	1315.5	28	6475.5
	- juvenile																		
Platichthys stellatus	starry flounder																		
Pleuronichthys coenosus	CO sole																		
Psettichthys melanostictus	sand sole																		
	TOTAL	61.4		11304		33.9		5255.9		13.4		2464.3		2	485.5	122	6684.5	63	11203

Appendix C, Table 11 (continued).

Fish Species		Port Gardner SU 86 Tran 2 20S		Port Gardner SU 86 Tran 2 40S		Port Gardner SU 86 Tran 2 110S		Port Gardner SU 86 Tran 4 20S		Port Gardner SU 86 Tran 4 40S		Port Gardner SU 86 Tran 4 145S		Port Gardner SU 86 PSDDA Ref 1		Port Gardner SU 86 PSDDA Ref 2	
Scientific Name	Common Name	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey																
Squalus acanthias	spiny dogfish			4	7625	18	2115										
Raja rhina	longnose skate															1	1600
Hydrolagus colliei	ratfish - adult					2	522					1	3970	3	1055	1	420
	- juvenile					1	11					1	13				
Alosa sapidissima	American shad																
Clupea pallasii	Pacific herring	1	28.5														
Porichthys notatus	plainfin midshipman			1	148.5												
Gadus macrocephalus	Pacific cod															1	1500
Microgadus proximus	Pacific tomcod - adult			16	833												
	- juvenile																
Merluccius productus	Pacific hake - adult					1	143					1	181	3	711		
	- juvenile																
Brosmophycis marginata	red brotula																
Lycodapus mandibularis	pallid eelpout																
Lycodes diapterus	black eelpout											3	66				
Lycodes pacifica	blackbelly eelpout			1	7									1	19		
Cymatogaster aggregata	shiner perch - adult																
	- juvenile	7	61.5														
Damalichthys vacca	pile perch																
Ronquilus jordani	northern ronquil																
Lumpenus sagitta	snake prickleback																
Sebastes maliger	quillback rockfish					1	421							1	270	1	360.5
Anoplopoma fimbria	sablefish																
Artedius sp.	sculpin																
Dasycottus setiger	spinyhead sculpin															1	43
Chitonotus pugetensis	roughback sculpin																
Gilbertidia sigalutes	soft sculpin																
Icelinus borealis	northern sculpin																
Leptocottus armatus	Pacific staghorn sculpin																
Nautichthys oculofasciatus	sailfin sculpin																
Radulinus asprellus	slim sculpin																
Bathyagonus nigripinnis	blackfin starsnout poacher																
Xeneretmus latifrons	blacktip poacher													1	23	1	120
Xeneretmus triacanthus	bluespotted poacher																
Citharichthys sp.	sanddab - adult	1	22					2	31								
	- juvenile							3	10.5								
Citharichthys sordidus	Pacific sanddab																
Citharichthys stigmaeus	speckled sanddab -adult																
	- juvenile																
Atheresthes stomias	arrowtooth flounder																
Glyptocephalus zachirus	rex sole -adult			3	174.5												
	- juvenile																
Hippoglossoides elassodon	flathead sole			1	6.5												
Lepidopsetta bilineata	rock sole - adult	1	23.5	5	606.5												
	- juvenile	1	13														
Lyopsetta exilis	slender sole - adult			2	24.5							1	186	2	92.5		
	- juvenile																
Microstomus pacificus	Dover sole - adult			1	50	3	163			1	67.5	4	1563	6	1955	4	494.5
	- juvenile											1	4				
Parophyrs vetus	English sole - adult	2	249.5	22	1870.5	4	475	6	439.5					5	1540	5	1050
	- juvenile																
Platichthys stellatus	starry flounder	1	259.5														
Pleuronichthys coenosus	CO sole																
Psettichthys melanostictus	sand sole																
	TOTAL	14	657.5	56	11346	30	3850	11	481	1	67.5	12	5983	22	5665.5	15	5588

Appendix C, Table 12. Number (abundance) of fish, biomass (in grams) and range at Navy and PSDDA sites for otter trawl caught fish by station and species in Port Gardner on September 11 and 15, 1986 (AU86).

Fish Species		Port Gardner AU 86 NAVY OT				Port Gardner AU 86 PSDDA 2				Port Gardner AU 86 PSDDA 1				Port Gardner AU 86 Tran 1 20S		Port Gardner AU 86 Tran 1 40S		Port Gardner AU 86 Tran 1 100M	
Scientific Name	Common Name	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Range	Biomass	Range	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey																		
Squalus acanthias	spiny dogfish					0.7	0-1	298.3	0-465										
Raja rhina	longnose skate																		
Hydrolagus colliei	ratfish - adult	8.3	3-17	1032.5	412-1510	1	1-1	611.7	105-880	1	0-2	498.3	0-1390						
	- juvenile	18.3	3-36	489.2	137-1090	0.3	0-1	4.8	0-14									2	80
Alosa sapidissima	American shad																		
Clupea pallasii	Pacific herring																		
Porichthys notatus	plainfin midshipman																		
Gadus macrocephalus	Pacific cod	0.3	0-1	990	0-2970														
Microgadus proximus	Pacific tomcod - adult									0.3	0-1	0.5	0-1			12	60		
	- juvenile																	2	4
Merluccius productus	Pacific hake - adult	6.7	0-15	411.7	0-725	0.7	0-1	391.7	0-860									2	475
	- juvenile	3	0-9	233.3	0-700					6.3	5-7	8.5	7-11						
Brosmophycis marginata	red brotula																		
Lycodapus mandibularis	pallid eelpout					0.3	0-1	3	0-9	1	0-3	7.5	0-22						
Lycodes diapterus	black eelpout									1.3	0-3	25	0-71					2	55
Lycodes pacifica	blackbelly eelpout	0.7	0-1	23	0-40														
Cymatogaster aggregata	shiner perch - adult																		
	- juvenile													3	35				
Damalichthys vacca	pile perch - adult																		
	- juvenile															6	30		
Ronquilus jordani	northern ronquil																		
Lumpenus sagitta	snake prickleback																		
Sebastes maliger	quillback rockfish	1.3	0-2	385	0-610	0.7	0-1	241.7	0-385	0.3	0-1	108.3	0-325			6	350	4	665
Anoplopoma fimbria	sablefish																		
Artedius sp.	sculpin																		
Dasycottus setiger	spinyhead sculpin					0.3	0-1	23.3	0-70										
Chitonotus pugetensis	roughback sculpin															1	24		
Gilbertidia sigalutes	soft sculpin																		
Icelinus borealis	northern sculpin																		
Leptocottus armatus	Pacific staghorn sculpin																		
Nautichthys oculofasciatus	sailfin sculpin																		
Radulinus asprellus	slim sculpin																		
Bathyagonus nigripinnis	blackfin starsnout poacher	0.7	0-2	7.8	0-23	0.7	0-1	11.3	0-20	1.7	0-3	26.3	0-46					1	13.5
Xeneretmus latifrons	blacktip poacher																		
Xeneretmus triacanthus	bluespotted poacher																		
Citharichthys sp.	sanddab - adult																		
	- juvenile																		
Citharichthys sordidus	Pacific sanddab - adult																		
	- juvenile															1	8		
Citharichthys stigmaeus	speckled sanddab - adult															2	53		
	- juvenile																		
Atheresthes stomias	arrowtooth flounder																		
Glyptocephalus zachirus	rex sole - adult					0.7	0-2	83.3	0-250							1	75	2	100
	- juvenile																		
Hippoglossoides elassodon	flathead sole	1	0-2	64.3	0-110														
Lepidopsetta bilineata	rock sole - adult															5	760		
	- juvenile															2	39		
Lyopsetta exilis	slender sole - adult	22	19-26	1146.7	950-1400	7.7	7-8	471.7	425-535	7.7	2-16	353.2	69-750			4	90		
	- juvenile															1	9		
Microstomus pacificus	Dover sole					1.7	0-4	461.7	0-970	1.7	0-4	566.7	0-1610					2	405
Parophrys vetus	English sole - adult	56.3	30-72	9000	5170-10970	3.3	0-6	671.7	0-1345	2.7	2-6	761.7	540-960	5	510	17	370	3	480
	- juvenile																		
Platichthys stellatus	starry flounder													1	415				
Pleuronichthys coenosus	CO sole																		
Psettichthys melanostictus	sand sole																		
	TOTAL	118.6		13784		18.1		3274.2		24		2356		9	960	58	1868	20	2277.5

Appendix C, Table 12 (continued).

Fish Species		Port Gardner AU 86 Tran 2 20S		Port Gardner AU 86 Tran 2 40S		Port Gardner AU 86 Tran 2 110S		Port Gardner AU 86 Tran 4 20S		Port Gardner AU 86 Tran 4 40S		Port Gardner AU 86 Tran 4 145S		Port Gardner AU 86 PSDDA Ref 1		Port Gardner AU 86 PSDDA Ref 2		Port Gardner AU 86 Sta E	
Scientific Name	Common Name	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass	Abund	Biomass
Lampetra tridentata	Pacific lamprey																		
Squalus acanthias	spiny dogfish					2	825									1	510	1	400
Raja rhina	longnose skate																		
Hydrolagus colliei	ratfish - adult											1	315			3	510		
	- juvenile					8	180											1	32
Alosa sapidissima	American shad																		
Clupea pallasii	Pacific herring									1	4.5								
Porichthys notatus	plainfin midshipman																		
Gadus macrocephalus	Pacific cod					3	695												
Microgadus proximus	Pacific tomcod - adult																		
	- juvenile			2	6.5					37	165	1	3					1	3.5
Merluccius productus	Pacific hake - adult					2	1035									4	266		
	- juvenile													9	12.5				
Brosmophycis marginata	red brotula																	1	25
Lycodapus mandibularis	pallid eelpout													16	141				
Lycodes diapterus	black eelpout											1	25			2	27		
Lycodes pacifica	blackbelly eelpout					1	33												
Cymatogaster aggregata	shiner perch - adult									2	21								
	- juvenile	19	175																
Damalichthys vacca	pile perch - adult																		
	- juvenile			2	21														
Ronquilus jordani	northern ronquil			1	5.5					2	23.5								
Lumpenus sagitta	snake prickleback																		
Sebastes maliger	quillback rockfish			2	112	3	485	1	76	1	31								
Anoplopoma fimbria	sablefish																		
Artedius sp.	sculpin																		
Dasycottus setiger	spinyhead sculpin															1	76		
Chitonotus pugetensis	roughback sculpin																		
Gilbertidia sigalutes	soft sculpin					2	6.5											2	7
Icelinus borealis	northern sculpin																		
Leptocottus armatus	Pacific staghorn sculpin																		
Nautichthys oculofasciatus	sailfin sculpin																		
Radulinus asprellus	slim sculpin									2	4.5								
Bathyagonus nigripinnis	blackfin starsnout poacher																		
Xeneretmus latifrons	blacktip poacher																		
Xeneretmus triacanthus	bluespotted poacher									1	3								
Citharichthys sp.	sanddab - adult																		
	- juvenile																		
Citharichthys sordidus	Pacific sanddab - adult																		
	- juvenile			2	30														
Citharichthys stigmaeus	speckled sanddab - adult	2	48	1	36			1	23.5	2	60								
	- juvenil	1	17																
Atheresthes stomias	arrowtooth flounder																		
Glyptocephalus zachirus	rex sole - adult					1	na			3	220								
	- juvenile																		
Hippoglossoides elassodon	flathead sole																		
Lepidopsetta bilineata	rock sole - adult			3	255			3	125	5	250								
	- juvenile	1	12					2	30										
Lyopsetta exilis	slender sole - adult	2	115	3	36	4	185			4	120	1	75	3	125	8	400	6	240
	- juvenile															7	7.5		
Microstomus pacificus	Dover sole					7	575			1	39.5			2	575	1	445	2	220
Parophyrs vetus	English sole - adult	3	325	52	2685	6	915	13	1300	28	1755			4	1105	7	1730	3	660
	- juvenile							1	8.5										
Platichthys stellatus	starry flounder																		
Pleuronichthys coenosus	CO sole																		
Psettichthys melanostictus	sand sole																		
	TOTAL	28	692	68	3187	39	4934.5	21	1563	89	2697	4	418	34	1958.5	34	3971.5	17	1587.5

APPENDIX D

Abundance and biomass (and range of multiple sample stations) of beam trawl-caught fish by station and species in Commencement Bay, Elliott Bay and Saratoga Passage.

Appendix D, Table 1. Abundance and range at multiple sample stations of beam trawl-caught fish by station and species in Commencement Bay during July 1986.

Species	Location PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m
Ratfish- adult	0.67	0-1			2
" - juvenile					
Plainfin midshipman- adult					9
" " - juv.					
Pacific cod- adult					1
" " - juvenile					
Pacific hake- adult					
" " - juvenile					
Pallid eelpout					
Blackfin eelpout					
Blackbelly eelpout					
Snake prickleback					
Bluebarred prickleback					
Quillback rockfish- adult					1
" " - juvenile					
Roughback sculpin			0.3	0-1	
Tadpole sculpin					
Slim sculpin					
Bigeye poacher			0.3	0-1	
Blackfin poacher					
Arrowtooth flounder	0.3	0-1			
Flathead sole- adult					
" " - juvenile					
Rock sole- adult					7
" " - juvenile					5
Slender sole- adult			0.3	0-1	
" " - juvenile					
Dover sole- adult					
" " - juvenile					1
English sole- adult					17
" " - juvenile					
Total	1		1		43

Appendix D, Table 2. Biomass (in grams) and range at multiple sample stations of beam trawl-caught fish by station and species in Commencement Bay during July 1986.

Species	Location PSDDA 1	PSDDA 1 (range)	PSDDA 2	PSDDA 2 (range)	20 m
Ratfish- adult	143.7	0-381			770.0
" - juvenile					
Plainfin midshipman- adult					406.5
" " - juv.					
Pacific cod- adult					106.0
" " - juvenile					
Pacific hake- adult					
" " - juvenile					
Pallid eelpout					
Blackfin eelpout					
Blackbelly eelpout					
Snake prickleback					
Bluebarred prickleback					
Quillback rockfish- adult					175.0
" " - juvenile					
Roughback sculpin			3.3		
Tadpole sculpin					
Slim sculpin					
Bigeye poacher			6.7	0-20	
Blackfin poacher					
Arrowtooth flounder	68.3	0-205			
Flathead sole- adult					
" " - juvenile					
Rock sole- adult					304.5
" " - juvenile					52.5
Slender sole- adult			35.0	0-105	
" " - juvenile					
Dover sole- adult					
" " - juvenile					7.5
English sole- adult					2,369.5
" " - juvenile					
Total	212.0		45.0		4,191.5

Appendix D, Table 3. Abundance and range at multiple sample stations of beam trawl-caught fish by station and species in Elliott Bay during June 1986.

	Location				
Species	PSDDA 1	PSDDA 1 (range)	PSDDA 1-Ref	PSDDA 2	PSDDA 2 (range)
Ratfish- adult				2.7	2-4
" - juvenile					
Plainfin midshipman- adult	0.3	0-1			
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult			1		
" " - juvenile					
Pallid eelpout					
Blackfin eelpout				0.3	0-1
Blackbelly eelpout	0.7	0-2	1		
Snake prickleback	1.7	0-4			
Bluebarred prickleback	1.0	0-3			
Quillback rockfish- adult					
" " - juvenile					
Roughback sculpin					
Tadpole sculpin				0.3	0-1
Slim sculpin					
Bigeye poacher					
Blackfin poacher					
Arrowtooth flounder					
Flathead sole- adult			1		
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	2.0	0-5	3		
" " - juvenile	2.3	0-5			
Dover sole- adult			1	0.3	0-1
" " - juvenile					
English sole- adult					
" " - juvenile					
Total	8		7	3.7	

Appendix D, Table 4. Biomass (in grams) and range at multiple sample stations of beam trawl-caught fish by station and species in Elliott Bay during June 1986.

Species	PSDDA 1	PSDDA 1 (range)	PSDDA 1-Ref	PSDDA 2	PSDDA 2 (range)
			Location		
Ratfish- adult				632.3	386-1,102
" - juvenile					
Plainfin midshipman- adult	4.3	0-13.0			
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult			258.0		
" " - juvenile					
Pallid eelpout					
Blackfin eelpout				5.7	0-17
Blackbelly eelpout	2.5	0-7.5	41.0		
Snake prickleback	5.4	0-13.1			
Bluebarred prickleback	4.4	0-13.3			
Quillback rockfish- adult					
" " - juvenile					
Roughback sculpin					
Tadpole sculpin				1.0	0-3
Slim sculpin					
Bigeye poacher					
Blackfin poacher					
Arrowtooth flounder					
Flathead sole- adult			147.0		
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	58.3	0-153.0	191.0		
" " - juvenile	9.9	0-23.3			
Dover sole- adult			950.0	184.7	0-554
" " - juvenile					
English sole- adult					
" " - juvenile					
Total	602.2		1595.0	823.7	

Appendix D, Table 5. Abundance and range at multiple sample stations of beam trawl-caught fish by station and species at Elliott Bay during September 1986.

Species	Location				
	PSDDA 1	PSDDA 1 (range)	PSDDA 1-Ref	PSDDA 2	PSDDA 2 (range)
Ratfish- adult					
" - juvenile			2	1	0-2
Plainfin midshipman- adult					
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult					
" " - juvenile					
Pallid eelpout				0.3	0-1
Blackfin eelpout				0.7	0-2
Blackbelly eelpout	5.0	1-12			
Snake prickleback					
Bluebarred prickleback	3.3	0-5			
Quillback rockfish- adult					
" " - juvenile					
Roughback sculpin					
Tadpole sculpin					
Slim sculpin					
Bigeye poacher					
Blackfin poacher					
Arrowtooth flounder					
Flathead sole- adult	1.3	0-3			
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	5.3	2-9		0.3	0-1
" " - juvenile	7.0	0-14	1		
Dover sole- adult	0.3	0-1		0.3	0-1
" " - juvenile					
English sole- adult					
" " - juvenile					
Total	22.3		3	2.7	

Appendix D, Table 6. Biomass (in grams) and range at multiple sample stations of beam trawl-caught fish by station and species in Elliott Bay during September 1986.

Species	PSDDA 1	PSDDA 1 (range)	PSDDA 1-Ref	PSDDA 2	PSDDA 2 (range)
Ratfish- adult					
" - juvenile			61	14.1	0-24.9
Plainfin midshipman- adult					
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult					
" " - juvenile					
Pallid eelpout				1.7	0-5.2
Blackfin eelpout				2.4	0-7.3
Blackbelly eelpout	75.6	1.5-210			
Snake prickleback					
Bluebarred prickleback	15.9	14.5-17.9			
Quillback rockfish- adult					
" " - juvenile					
Roughback sculpin					
Tadpole sculpin					
Slim sculpin					
Bigeye poacher					
Blackfin poacher					
Arrowtooth flounder					
Flathead sole- adult	131.3	0-330			
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	97.5	26.5-175		24.8	0-74.5
" " - juvenile	25.5	0-45.6	7.6		
Dover sole- adult	70.7	0-212		68.3	0-205
" " - juvenile					
English sole- adult					
" " - juvenile					
Total	416.5		68.6	111.3	

Appendix D, Table 7. Abundance and range of multiple sample stations of beam trawl-caught fish by station and species in Saratoga Passage during June 1986.

Species	PSDDA	PSDDA range	Location 80 m E	40 m E	20 m E
Ratfish- adult	1	0-3			
" - juvenile					
Plainfin midshipman- adult					
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult	0.3	0-1			
" " - juvenile					
Pallid eelpout					
Blackfin eelpout	0.3	0-1			
Blackbelly eelpout	0.3	0-1	1		
Snake prickleback					
Bluebarred prickleback			4		
Quillback rockfish- adult	0.3	0-1			
" " - juvenile					
Roughback sculpin					
Tadpole sculpin					
Slim sculpin				4	
Bigeye poacher					
Blackfin poacher	1	0-2			
Arrowtooth flounder					
Flathead sole- adult					
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	8.0	4-13	2	1	
" " - juvenile				1	
Dover sole- adult					
" " - juvenile	0.3	0-1			
English sole- adult					3
" " - juvenile					
Total	11.7		7	6	3

Appendix D, Table 8. Biomass (in grams) and range at multiple sample stations of beam trawl-caught fish by station and species in Saratoga Passage during June 1986.

	Location				
Species	PSDDA	PSDDA (range)	80 m E	40 m E	20 m E
Ratfish- adult	421.7	0-1,265			
" - juvenile					
Plainfin midshipman- adult					
" " - juv.					
Pacific cod- adult					
" " - juvenile					
Pacific hake- adult	228.7	0-686			
" " - juvenile					
Pallid eelpout					
Blackfin eelpout	4.3	0-13			
Blackbelly eelpout			27.0		
Snake prickleback					
Bluebarred prickleback			19.5		
Quillback rockfish- adult	65.3	0-196			
" " - juvenile					
Roughback sculpin					
Tadpole sculpin					
Slim sculpin				10.5	
Bigeye poacher					
Blackfin poacher	6.7	0-15			
Arrowtooth flounder					
Flathead sole- adult					
" " - juvenile					
Rock sole- adult					
" " - juvenile					
Slender sole- adult	276.3	117-483	63.0	21.0	
" " - juvenile				21.5	
Dover sole- adult					
" " - juvenile	1.2	0-3.5			
English sole- adult					52.0
" " - juvenile					
Total	1,004.2		109.5	51.0	52.0

APPENDIX E

Number of flatfish per hectare caught by otter trawl in Commencement Bay, Elliott Bay, Saratoga Passage and Port Gardner, shown by season, station and species.

Appendix E, Table 1. Number of each flatfish species per hectare caught by otter trawl at each station in Commencement Bay during summer and autumn, 1986.

	PSDDA 1		PSDDA 2		20m		40m		156m	
Flatfish Species	SU86 Fish/Ha	AU86 Fish/Ha	SU86 Fish/Ha	AU86 Fish/Ha	SU86 Fish/Ha	AU86 Fish/Ha	SU86 Fish/Ha	AU86 Fish/Ha	SU86 Fish/Ha	AU86 Fish/Ha
speckled sanddab -adult						9				
arrowtooth flounder				1.35			27	9		13.5
rex sole -adult								36		
flathead sole -adult						72				
rock sole - adult							9	45		
slender sole - adult	4.5	16.65	1.35	5.85				54		13.5
Dover sole - adult	5.85	37.35	4.5	14.85			22.5	67.5	27	54
- juvenile								13.5		
English sole - adult		3.15	1.35			85.5	180	819		13.5
CO sole - adult						4.5				
TOT. FLATFISH/Ha	**10.35**	**57.15**	**7.2**	**22.05**	**0**	**171**	**238.5**	**1044**	**27**	**94.5**

Appendix E, Table 2. Number of each flatfish species per hectare caught by otter trawl at each station in Elliott Bay during summer and autumn, 1986.

	PSDDA 1		PSDDA 1 Ref		PSDDA 2		PSDDA 2 Ref 1		PSDDA 2 Ref 2
	SU86	AU86	SU86	AU86	SU86	AU86	SU86	AU86	AU86
Flatfish Species	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha	Fish/Ha
rex sole -adult	5.85	10.35	4.5			1.35			
- juvenile		5.85							
flathead sole -adult	25.65	111.15	67.5	4.5					
rock sole - adult		1.35							
slender sole - adult	70.65	210.15	54	36	27	41.85	13.5	36	40.5
- juvenile	10.35	32.85	4.5						
Dover sole - adult	10.35	10.35	4.5		19.35	30.15	40.5	9	13.5
- juvenile	4.5								
English sole - adult	1.35				1.35	73.35	4.5	126	148.5
TOT. FLATFISH/Ha	128.7	382.05	135	40.5	47.7	146.7	58.5	171	202.5

Appendix E, Table 3. Number of each flatfish species per hectare caught by otter trawl at each station in Saratoga Passage during summer, 1986.

Flatfish Species	PSDDA SU86 Fish/Ha	PSDDA Ref SU86 Fish/Ha	20mE SU86 Fish/Ha	40mE SU86 Fish/Ha	40mW SU86 Fish/Ha	80mE SU86 Fish/Ha
rex sole -adult						4.5
flathead sole -adult						
rock sole - adult			9	22.5		
slender sole - adult	12.15	13.5		4.5		18
Dover sole - adult						4.5
English sole - adult			18	31.5	9	31.5
TOT. FLATFISH/Ha	**12.15**	**13.5**	**27**	**58.5**	**9**	**58.5**

Appendix E, Table 4. Number of each flatfish species per hectare caught by otter trawl at each station in Port Gardner during winter, 1986.

Common Name	Navy Fish/Ha	PSDDA 2 Fish/Ha	PSDDA 1 Fish/Ha	Transect 1 20S Fish/Ha	Transect 1 40S Fish/Ha	Transect 1 100M Fish/Ha	Transect 2 20S Fish/Ha	Transect 2 40S Fish/Ha	Transect 2 110S Fish/Ha	Transect 4 20S Fish/Ha	Transect 4 40S Fish/Ha	Transect 4 145S Fish/Ha
sanddab - adult	0	0	0	9	40.5	0	4.5	54	0	18	0	0
- juvenile	0	0	0	4.5	37	0	0	0	0	22.5	0	0
Pacific sanddab	0	0	0	0	0	0	0	0	0	0	4.5	0
speckled sanddab - adult	0	0	0	0	0	0	0	0	0	0	117	0
- juvenile	0	0	0	0	0	0	0	0	0	0	4.5	0
arrowtooth flounder	0	0	1.35	0	4.5	0	0	4.5	0	0	0	0
rex sole - adult	9	2.25	1.35	0	0	9	0	4.5	4.5	0	0	0
- juvenile	0	0	0	0	0	4.5	0	0	0	0	0	0
flathead sole	115.65	2.25	0	4.5	22.5	0	0	0	0	18	4.5	0
rock sole - adult	1.35	0	1.35	9	58.5	0	4.5	76.5	0	0	99	0
- juvenile	0	0	0	9	22.5	0	9	4.5	0	4.5	40.5	0
slender sole - adult	136.5	65.25	117	0	0	4.5	0	27	4.5	13.5	0	63
- juvenile	40.5	0	0	0	0	4.5	0	0	0	0	0	0
Dover sole	32.85	22.5	16.65	0	0	9	0	4.5	49.5	0	0	126
English sole - adult	499.5	15.75	31.5	4.5	76.5	117	0	301.5	36	0	630	0
- juvenile	3.15	0	0	4.5	706.5	0	0	243	0	4.5	0	0
starry flounder	0	0	0	0	0	0	0	0	0	0	0	0
CO sole	0	0	0	0	4.5	0	0	0	0	4.5	0	0
sand sole	0	0	0	0	0	0	0	0	0	0	0	0
TOT. FLATFISH/Ha	838.5	108	169.2	45	973	148.5	18	720	94.5	85.5	900	189

Appendix E, Table 5. Number of each flatfish species per hectare caught by otter trawl at each station in Port Gardner during spring, 1986.

Common Name	NAVY Fish/Ha	PSDDA 2 Fish/Ha	PSDDA 1 Fish/Ha	Transect 1 20S Fish/Ha	Transect 1 40S Fish/Ha	Transect 1 100M Fish/Ha	Transect 2 20S Fish/Ha	Transect 2 40S Fish/Ha	Transect 2 110S Fish/Ha	Transect 4 20S Fish/Ha	Transect 4 40S Fish/Ha	Transect 4 145S Fish/Ha
sanddab - adult	0	0	0	0	9	0	13.5	0	0	4.5	18	0
- juvenile	0	0	0	4.5	0	0	0	0	0	9	0	0
Pacific sanddab	0	0	0	0	0	0	0	0	0	0	0	0
speckled sanddab - adult	0	0	0	0	0	0	0	0	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0
arrowtooth flounder	0	0	0	0	0	0	0	0	0	0	0	0
rex sole - adult	25.65	0	1.35	0	0	9	0	0	0	0	0	0
- juvenile	1.35	0	3.15	0	0	0	0	0	0	0	0	0
flathead sole	25.65	0	0	0	0	9	0	0	0	0	0	0
rock sole - adult	0	0	0	0	4.5	0	4.5	22.5	0	0	49.5	0
- juvenile	0	0	0	0	0	0	0	0	0	9	9	0
slender sole - adult	76.5	21.15	39.15	0	0	67.5	0	0	9	0	0	4.5
- juvenile	7.65	0	0	0	0	0	0	0	0	0	0	0
Dover sole	13.5	27	3.15	0	54	9	0	0	9	0	0	0
English sole - adult	136.35	12.15	3.15	0	9	274.5	0	13.5	4.5	0	49.5	0
- juvenile	0	0	0	0	0	0	0	0	0	0	36	0
starry flounder	0	0	0	0	0	0	0	0	0	0	0	0
CO sole	0	0	0	0	0	0	0	0	0	0	0	0
sand sole	0	0	0	0	4.5	0	4.5	0	0	0	0	0
TOT. FLATFISH/Ha	286.65	60.3	49.95	4.5	81	369	22.5	36	22.5	22.5	162	4.5

Appendix E, Table 6. Number of each flatfish species per hectare caught by otter trawl at each station in Port Gardner during summer, 1986.

Common Name	NAVY Fish/Ha	PSDDA 2 Fish/Ha	PSDDA 1 Fish/Ha	Transect 1 20S Fish/Ha	Transect 1 40S Fish/Ha	Transect 1 100M Fish/Ha	Transect 2 20S Fish/Ha	Transect 2 40S Fish/Ha	Transect 2 110S Fish/Ha	Transect 4 20S Fish/Ha	Transect 4 40S Fish/Ha	Transect 4 145S Fish/Ha	PSDDA Ref 1 Fish/Ha	PSDDA Ref 2 Fish/Ha
sanddab - adult	0	0	0	0	4.5	0	4.5	0	0	9	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	13.5	0	0	0	0
Pacific sanddab	0	0	0	0	0	0	0	0	0	0	0	0	0	0
speckled sanddab -adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0
arrowtooth flounder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rex sole -adult	0	0	0	0	0	0	0	13.5	0	0	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0
flathead sole	10.35	0	0	0	0	0	0	4.5	0	0	0	0	0	0
rock sole - adult	0	0	0	0	27	0	4.5	22.5	0	0	0	0	0	0
- juvenile	0	0	0	0	0	0	4.5	0	0	0	0	0	0	0
slender sole - adult	22.5	9	12.15	0	0	9	0	9	0	0	0	4.5	9	0
- juvenile	0	0	1.35	0	4.5	4.5	0	0	0	0	0	0	0	0
Dover sole - adult	3.15	30.15	18	0	0	4.5	0	4.5	12	0	4.5	18	27	18
- juvenile	0	1.35	3.15	0	0	0	0	0	0	0	0	4.5	0	0
English sole - adult	129.15	55.35	13.5	4.5	67.5	126	9	99	18	27	0	0	22.5	22.5
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0
starry flounder	0	0	0	0	0	0	4.5	0	0	0	0	0	0	0
CO sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sand sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT. FLATFISH/Ha	165.15	95.85	48.15	4.5	103.5	144	27	153	30	49.5	4.5	27	58.5	40.5

Appendix E, Table 7. Number of each flatfish species caught by otter trawl at each station in Port Gardner during autumn, 1986.

Common Name	NAVY Fish/Ha	PSDDA 2 Fish/Ha	PSDDA 1 Fish/Ha	Transect 1 20S Fish/Ha	Transect 1 40S Fish/Ha	Transect 1 100M Fish/Ha	Transect 2 20S Fish/Ha	Transect 2 40S Fish/Ha	Transect 2 110S Fish/Ha	Transect 4 20S Fish/Ha	Transect 4 40S Fish/Ha	Transect 4 145S Fish/Ha	PSDDA Ref 1 Fish/Ha	PSDDA Ref 2 Fish/Ha	PSDDA Sta E Fish/Ha
sanddab - adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pacific sanddab - adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- juvenile	0	0	0	0	4.5	0	0	9	0	0	0	0	0	0	0
speckled sanddab - adult	0	0	0	0	9	0	9	4.5	0	4.5	9	0	0	0	0
- juvenile	0	0	0	0	0	0	4.5	0	0	0	0	0	0	0	0
arrowtooth flounder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rex sole - adult	0	3.15	0	0	4.5	9	0	0	4.5	0	13.5	0	0	0	0
- juvenile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
flathead sole	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rock sole - adult	0	0	0	0	22.5	0	0	13.5	0	13.5	22.5	0	0	0	0
- juvenile	0	0	0	0	9	0	4.5	0	0	9	0	0	0	0	0
slender sole - adult	99	34.65	34.65	0	18	0	9	13.5	18	0	18	4.5	13.5	36	27
- juvenile	0	0	0	0	4.5	0	0	0	0	0	0	0	0	31.5	0
Dover sole	0	7.65	7.65	0	0	9	0	0	31.5	0	4.5	0	9	4.5	9
English sole - adult	253.35	14.85	12.15	22.5	76.5	13.5	13.5	234	27	58.5	126	0	18	31.5	13.5
- juvenile	0	0	0	0	0	0	0	0	0	4.5	0	0	0	0	0
starry flounder	0	0	0	4.5	0	0	0	0	0	0	0	0	0	0	0
CO sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sand sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT. FLATFISH/Ha	356.85	60.3	54.45	27	148.5	31.5	40.5	274.5	81	90	193.5	4.5	40.5	103.5	49.5