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PUGET SOUND DREDGE DISPOSAL ANALYSIS (PSDDA) DISPOSAL SITE INVESTIGATIONS: PHASE II TRAWL STUDIES IN NORTH AND SOUTH PUGET SOUND

Invertebrate Resource Assessments

by

Paul A. Dinnel, David A. Armstrong, Robert R. Lauth, and Karen Larsen

FINAL REPORT

to

WASHINGTON SEA GRANT AND U.S. ARMY CORPS OF ENGINEERS

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Submitted 10-27-88 ______________ Director

ABSTRACT

The multi-agency Puget Sound Dredge Disposal Analysis 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 of PSDDA was assigned the responsibility of selecting unconfined, open water disposal sites in Puget Sound based on nineteen selection factors covering physical parameters, human uses, historical biological resource data and site-specific trawl investigations.

This document is one of two final technical reports detailing the results of the site-specific trawl surveys for Phase II PSDDA disposal sites located in North and South Puget Sound (the results of Phase I (Central Puget Sound sites) trawl surveys can be found in Dinnel et al. (1986)). The results of invertebrate resource assessments using a 3-m beam trawl are contained in this report. Results of the bottomfish investigations using a 7.6-m otter trawl are contained in a parallel report by Donnelly et al. (1988).

Phase II trawl surveys were conducted in the Nisqually Delta area of South Puget Sound and in Bellingham Bay, North Puget Sound. Trawling was conducted seasonally in and around two "non-dispersive" Zones of Siting Feasibility (ZSFs) in each area. Additionally, winter and summer trawling was also conducted in and around four tentative "dispersive" ZSFs, one located south of Point Roberts in the Strait of Georgia, one in Rosario Strait and two in the Strait of Juan de Fuca (one site each near Port Townsend and Port Angeles).

The beam trawl survey in the Nisqually area identified the following invertebrate resources of concern: Dungeness and rock crabs, pandalid shrimp, and sea cucumbers. Generally, Dungeness crab were scarce, rock crab (especially the purple crab, *Cancer gracilis*) were abundant, pandalid shrimp sparse, and sea cucumbers (*Parastichopus californicus*) plentiful. Of the two Nisqually ZSFs, the eastern ZSF (ZSF #2 near Ketron Island) contained fewer invertebrate resources, all of which were relatively scarce compared to the Nisqually region in general.

Beam trawling in Bellingham Bay identified the following invertebrate resources of concern: Dungeness and rock crabs, pandalid shrimp, sea cucumbers, and the large pink nudibranch, *Tritonia diomedea*, which is used as a neurophysiological research tool. Dungeness crab were more abundant than rock crab in Bellingham Bay. Several species of pandalid shrimp were abundant and served as the basis of a small commercial and sport fishery. Sea cucumbers were scarce and *Tritonia* were in low to moderate densities. Within the two proposed ZSFs, Dungeness crab and *Tritonia* densities were moderate and pandalid shrimp densities were generally high. On the basis of resource densities, neither ZSF could be recommended over the other.

Catches of invertebrate resources in the dispersive Strait of Georgia ZSF were small, being limited to a few shrimp, scallops and sea urchins. Catches in Rosario Strait consisted of moderate numbers of pink scallops and sea urchins and low numbers of pandalid shrimp. Abundances of these resources were highest in the southern half of Rosario Strait.

Invertebrate resources were similar in the dispersive Juan de Fuca ZSFs near Port Townsend and Port Angeles and consisted primarily of pandalid shrimp, pink scallops and sea urchins. Pink scallops and sea urchins were generally in high

abundance in each ZSF, while pandalid shrimp (mostly juveniles of several species) were especially abundant during the October sampling period. Additional work will be required to identify sites with low resource densities in the Strait of Juan de Fuca.

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LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

CL	carapace length
CW	carapace width
DSWG	Disposal Site Work Group
PSDDA	Puget Sound Dredge Disposal Analysis
QA/QC	Quality Assurance/Quality Control
UW	University of Washington
YOY	Young-of-the-year
ZSF	Zone of Siting Feasibility
cm	centimeter
ha	hectare
m	meters
mm	millimeters
MLLW	mean lower low water
NM	nautical mile
>	greater than
<	less than
≥	greater than or equal to
≤	less than or equal to
~	approximately

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PUGET SOUND DREDGE DISPOSAL ANALYSIS (PSDDA) DISPOSAL SITE INVESTIGATIONS: PHASE II TRAWL STUDIES IN NORTH AND SOUTH PUGET SOUND

Invertebrate Resource Assessments

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 disposal sites were selected based on information gathered from limited field studies conducted within the Zones of Siting Feasibility (ZSFs) and existing information from each ZSF. Selection of the final preferred disposal sites required more detailed evaluations of important physical factors and biological resources in and around the identified sites. Hence, trawl surveys of each of the proposed sites were conducted on a seasonal basis in 1986. These trawl data (Dinnel et al. 1986a), which provided spatial, temporal, density and life cycle information on important demersal invertebrate and epibenthic fishery resources, were used to help select final disposal sites that would least impact these resources.

A similar siting process (Phase II) was initiated in late 1986 to select another group of disposal sites in the north and south areas of Puget Sound. Once again, seasonal trawl surveys were conducted in 1987 in and around two sites in each area designated as "non-dispersive" (near Nisqually Delta and Bellingham Bay) and four sites designated "dispersive" (near Point Roberts in Georgia Strait, Rosario Strait, and two sites near Port Angeles and Port Townsend in the Strait of Juan de Fuca; Figure 1).

This report describes the findings of the trawling studies conducted in and around the Phase II disposal sites during February, April-May, July and October 1987. The findings of the beam trawl surveys, which primarily focused on demersal invertebrate resources, are summarized. A related report (Donnelly et al. 1988) describes the findings of the otter trawl surveys for these same areas. The otter trawl primarily targeted bottomfish resources but also provided some information on invertebrates. Additionally, a rock dredge was used in Rosario Strait owing to the very rocky bottom. The fish and invertebrate data obtained from the rock dredge are summarized in their respective reports.

METHODS

General

All trawling was conducted from the 16-m research vessel Kittiwake. The otter trawl is described in Donnelly et al. (1988). Descriptions of the beam trawl and rock dredge follow below. In addition to trawling, surface and bottom water samples were collected by Niskin Sampler and measured for temperature, salinity and dissolved oxygen. These data are summarized in Donnelly et al. 1988. Trawl cruises were conducted on the following dates: 9 Feb-1 March (non-dispersive sites only); 6-20 April (dispersive sites only); 6-13 May (non-dispersive sites); 8-24 July (non-dispersive sites); and 12-31 Oct (all sites).

Gear

Beam trawl. Demersal invertebrate fauna were sampled with a 3-m beam trawl (Figure 2; Gunderson and Ellis 1986) previously used elsewhere in Puget Sound (Armstrong et al. 1987; Dinnel et al. 1985a, 1985b, 1986a, 1986b, 1987, 1988; Weitkamp et al. 1986). The beam trawl was towed approximately 232 meters (1/8 nautical mile (NM)) at a target ground speed of 2.5 km/hr (1.4 knots), which yielded an area swept by the net (opening = 2.3 m) of 534 m^2. All crabs caught in the trawls were measured for carapace width (CW), sexed, assessed for molt condition (degree of shell softness) and reproductive condition (females with or without eggs), and returned to the water. Catches of shrimp were preserved for later processing in the laboratory, where all pandalid shrimp were identified and measured for carapace length (CL). Other demersal resources such as scallops, sea cucumbers, sea urchins, mussels and starfish were counted and returned to the water.

Rock dredge. A rock dredge (86-cm wide x 38-cm high; Figure 3) was used to sample Rosario Strait and a few stations in the Strait of Georgia owing to the presence of rock and/or cobble on the bottom. The dredge was towed approximately 185 m (0.1 NM) unless obstacles necessitated a shorter distance. The large mesh of the rock dredge bag was lined with a beam trawl cod-end liner (5 mm mesh). The catches made with the rock dredge are considered qualitative since sampling efficiency is unknown and probably quite variable depending on bottom type. All animals caught in the rock dredge were processed as noted above for the beam trawl.

Sample Sites

Beam trawl sample sites in the Nisqually area consisted of six stations in each ZSF (ZSF 2 and 3) and stations at selected depths (typically 10, 20, 40, 60 and 80 m) along five arbitrarily chosen transects in the Nisqually Delta/Anderson Island area (Figure 4). Four additional stations (A-D) were also added to provide better coverage in the deep-water areas between some of the transects. Otter trawl stations were a subset of the beam trawl stations and included all of the ZSF 2 and ZSF 3 stations.

Bellingham Bay sampling stations were selected to give general coverage to the entire bay, since the selected ZSFs in this location were tentative. Stations stratified by depth (10, 15, 20, 25 and 30 m) were established along four transects and an additional 10 stations (A-J) were randomly chosen in the deeper portion of Bellingham Bay (the most probable area for location of a disposal site; Figure 5). Otter trawl stations consisted of the randomly chosen stations (A-J) and a subset of the beam trawl transect stations.

Sampling stations in the Point Roberts dispersive ZSF area included five stations (1-5) within the preliminary ZSF boundary, one station to the north (6) and one station to the south (7) of the ZSF; four stations (8-11) were selected for data continuity since these same stations were sampled by beam trawl in 1985-1986 as part of a University of Washington/Sea Grant project (Dinnel, unpublished data). All 11 stations in this area were sampled with both the beam and otter trawls except Stations 5 and 7, which were sampled with the rock dredge owing to a rocky bottom.

Beam trawl and otter trawl sampling was originally planned for six stations in Rosario Strait. However, since initial sampling with the beam trawl showed that the bottom was rocky (demolished nets and chains), the rock dredge was used and the number of stations increased to 11 to provide better spatial coverage (Figure 7).

Sample locations in and around the Port Townsend ZSF included four stations (1-4) inside the ZSF boundaries, one station to the northeast (5) and one station to the southeast (6; Figure 8). All six stations were scheduled to be sampled by both beam and otter trawls, but rough weather caused the cancellation of beam trawls at three stations in April.

Samples were collected near Port Angeles from four stations (1-4) within the ZSF boundaries and from two stations (5 and 6) east of the ZSF (Figure 9). All six stations were sampled with both beam and otter trawls.

The exact locations and depths for all sampling stations in each of the six regions are recorded in Appendix Tables 1-6.

Quality Assurance/Quality Control (QA/QC)

The location of each trawl station was found using a combination of radar ranges to permanent features and fathometer readings. When available, stations were located with LORAN C coordinates.

Once the stations were located, the beam trawl was deployed at a target boat speed (relative to the bottom) of about 1.5 knots. Winch "wire out" at each station was set by precalculated ratios (ranging from 3:1 to 10:1, wire out:depth) that were dependent on depth and gear type. Each beam trawl was towed at a target ground speed of 1.4 knots for 1/8 NM (232 m) following pre-specified depth contours (for slopes) or compass headings (for flat bottoms). Elapsed time for each tow was monitored and the tow discarded if the elapsed time was 25% more or less than expected (i.e., <1.05 or >1.75 knots). Tows were also discarded and repeated if any other significant discrepancies were noted (e.g., gear hang-ups, tangled, torn or unexpectantly empty net, etc.).

Data Analyses

All beam trawl catches of demersal invertebrates were converted to estimated densities based on calculations of the area swept by the beam trawl. Area swept was estimated from previous underwater measurements of net opening (2.3 m), observations of net behavior, and measurements of actual "net on bottom" times using ultrasonic transmitters on the net (Gunderson, unpublished data).

In this report, the term "density" or "estimated density" (e.g., crab/ha) has been used without any corrections for net capture efficiency. Therefore, "densities" reported herein specifically refer to an <u>index</u> of estimated densities that should provide the best <u>relative</u> measures of demersal resources present as well as trends in abundances between areas, between seasons and between years.

RESULTS

Nisqually

The Nisqually region of Puget Sound is extremely rich and diverse in invertebrate fauna. The habitat types are also diverse and include rocky areas around Ketron Island, current-swept sand bottoms off the Nisqually Delta, low current areas near several coves on Anderson Island and silty bottoms in and around the two ZSFs (Figure 4). Resources of potential fisheries importance included Dungeness (*Cancer magister*) and rock (*C. productus* and *C. gracilis*) crabs, pandalid shrimp and sea cucumbers. The area was also very rich in other invertebrate fauna, including starfish (a wide variety of species), sessil tunicates, anemones, brachiopods and gastropods. An occasional pink scallop was also caught along the west side of Ketron Island.

Dungeness crab. Dungeness crab were caught in small numbers in front of and on either side of the Nisqually Delta (Figure 10). The average estimated density of crab for all seasons and stations combined (n = 214 beam trawl tows) was 3 crab/ha, decreasing from 5 crab/ha in February to 1 crab/ha in October (Figure 11). Analyses of the basic biological data for this species (Figure 12) shows that all crab caught were large, mature individuals over 120 mm carapace width (CW). Females slightly outnumbered males in the catches except in October, when only several males were caught. Possibly, females were not caught in October because they had extruded new egg masses and were buried in the substrate (thus, unavailable to the trawl gear; Dinnel et al. 1988). A few gravid females were found in February with eggs ranging in age from medium to spent. The shell conditions of all Dungeness crab were hard to very hard (= old to very old) except in May, when about one-third of females had recently molted (and probably mated during molting). The depth distribution of Dungeness crab varied by sex and season. Males were usually caught in shallow water (≤20 m) except for October. Females were caught at all depths in February, in shallow water during molting and mating in May and to intermediate depths in July. The location of the females in October is unknown, but information from other areas (Armstrong et al. 1987, Dinnel et al. 1988) suggests that females (probably gravid) move to relatively shallow areas during the fall/early winter.

Rock crabs. Rock crabs (*Cancer productus* and *C. gracilis*) were much more plentiful (average for all beam trawls = 156 crab/ha) in the Nisqually region than were Dungeness crab (average = 3 crab/ha). In general, *C. gracilis* outnumbered *C. productus* by roughly 10-fold in the catches.

The basic biological information for *C. productus* caught in the Nisqually area is summarized in Figure 13. Generally, females were more abundant in the catches than males except for October. Gravid females were most prevalent in the February samples, and the age of the egg masses varied from new to spent. Recruitment of juveniles started in about July. The young-of-the-year (YOY) dominated the catches in October and had grown to a size ranging from 10 to 30 mm. Both male and female *C. productus* occurred to depths >100 m, with little clear indication that a specific depth interval was favored.

Similar biological data are summarized for *C. gracilis* in Figure 14. Males and females were caught in essentially equal numbers in February and May, while the catches were dominated by males in July and October. Gravid females and juvenile crab were caught during each season. The age of the egg masses also varied during each season. Hence, the spawning and settlement times for this species are distinctly less seasonal than for *C. magister* or *C. productus*. *Cancer gracilis* was found to depths of 100 m but generally favored depths <60 m.

Pandalid shrimp. Small numbers of pandalid shrimp were caught throughout the Nisqually region in all seasons (average of all 214 beam trawl tows = 75 shrimp/ha; Figure 15). The highest shrimp catches were in July and October and were mostly young *Pandalus danae* (Figure 16). The pink shrimps, *P. jordani* and *P. borealis*, were caught in small numbers with only an occasional individual of the other pandalid species being caught. Size-frequency distributions for each species are shown in Figures 17-23. Size distributions for the most plentiful species show that *P. danae* (Figure 19) YOY settled between May and July and grew to a size ranging from 9 to 15 mm carapace length (CL) by October. Settlement of *P. jordani* YOY (Figure 20) was evident in the July trawls and the age group present in the February trawls had grown from ~11-12 mm in February to ~17-18 mm in October. *Pandalus borealis* settlement (Figure 21) appeared slightly later than *P. jordani*, with 1-year-old individuals growing from ~9-10 mm in February to ~15-17 mm by October. For the other species, settlement times (although sparse in numbers caught) appeared to be the following: *Pandalopsis dispar* = June-July (Figure 18) and *P. hypsinotus* = April-May (Figure 23). Gravid females of *P. danae* and *P. borealis* were found only in the February trawls (Figure 24).

Sea cucumbers. The commercial sea cucumber, *Parastichopus californicus*, was plentiful (overall average estimated density = 131 cucumbers/ha, n = 214 beam trawl tows) throughout the Nisqually area (Figure 25) with little change in either its distribution or abundance with season (Figure 26). While the largest catches of this species were generally made at the 10-40 m depths, substantial catches were made to 110 m along Transect 2 (Figure 25) near the south end of ZSF 2.

Other invertebrates. The estimated densities of "other" (other than crab and shrimp) invertebrates of potential fisheries resource importance are shown in Figure 26. This figure shows the relative importance of sea cucumbers and starfish (starfish are included in this discussion because they often dominated the catch biomass in certain areas and because they can be a nuisance by-catch species in some fish trawling areas, especially *Luidia* in Bellingham Bay). The starfish caught in the Nisqually area were widespread and represented about a dozen species, each species preferring different habitats and depths.

Nisqually disposal areas. Six stations each were sampled by beam and otter trawl in each of the two Nisqually ZSFs during each season. The overall (all seasons and stations combined, n = 24 beam trawl tows for each ZSF) average estimated densities for the various resources (Table 1) show that Dungeness crab were absent from both ZSFs, sea cucumbers were largely absent from both ZSFs, and that the faunal densities of rock crab, shrimp and starfish were substantially less in ZSF 2 compared to either ZSF 3 or the average abundances for all Nisqually stations combined. Comparisons of the average catches between the two ZSFs are graphically represented for the beam trawl (Figure 27) and the otter trawl (Figure 28). These figures emphasize the density differences between these two sites, especially for rock crab, shrimp and starfish. ZSF 3 is a distinctly richer area than the deeper ZSF 2. Comparison of the catches for these two ZSFs by type of trawl gear shows that the beam trawl was a much better sampling gear for crab and starfish while the otter trawl was as efficient at sampling shrimp and, perhaps, sea cucumbers.

Table 1. Summary of the average density (#/ha, all stations and seasons combined) of major biological resources caught within the two Nisqually Zones of Siting Feasibility (ZSF) and at all stations combined.

Resource	ZSF #2	ZSF #3	All stations
Dungeness crab	0	0	3
Rock crab	30	168	156
Pandalid shrimp	15	46	75
Sea cucumbers	7	3	131
Starfish	14	220	192

Bellingham Bay

Bellingham Bay is a relatively shallow bay (maximum depth about 30-40 m) in North Puget Sound that receives the runoff from the Nooksack River (Figure 5). The substrate gradient ranges from sand at the shallowest (0-20 m) depths to sand/silt and silt in the deeper mid-portions of the Bay. A few shallow rocky areas occur near Chuckanut Bay.

Bellingham Bay proved to be a rich area for several resources, especially bottomfish, Dungeness crab, shrimp and the nudibranch, *Tritonia diomedea*, which is used by UW Friday Harbor Laboratory for neurophysiological research.

Dungeness crab. Dungeness crab were generally abundant in most areas of Bellingham Bay (Figure 29) and averaged (all seasons and stations combined, n = 155 beam trawl tows) 83 crab/ha (range of 56 crab/ha in February to 108/ha in May; Figure 11). The highest catches of Dungeness crab were consistently made at 10-20 m depths on Transect 1 near Post Point (north of Chuckanut Bay) and Portage Island (Figure 29). The lowest crab catches were generally at the mid-bay stations, especially south of Transect 1 and in the general area of the south ZSF. Dungeness crab outnumbered both species of rock crab in the Bellingham Bay beam trawl catches by about 3-4:1 (except October when a relatively large number of YOY *C. gracilis* were caught; Figure 11).

The basic biological data for Dungeness crab in Bellingham Bay are illustrated in Figure 30. This figure shows that females dominated the catches in all seasons by a factor of about 2-4 times the catch of males, and that gravid females were caught in February. Male crab showed some molting activity (i.e., soft shells) from February through May while the females showed only slight signs of molting in July. Very few juvenile Dungeness crab were caught. Those caught in February were 1986 YOY that averaged about 15 mm CW. The 1987 settlement took place between the July and October sampling with the average YOY CW being about 10-

12 mm. Conspicuously absent from all samples were the 1- to 2-year-old crabs in the size range of 20-90 mm.

Dungeness crab inhabited all depths in Bellingham Bay (Figure 30), but the females favored the deeper area during February and the shallower areas (15-20 m, especially off Post Point) in October. Males were caught only in shallow nearshore areas in May but at all depths during the other three seasons.

Rock crab. Rock crab (*C. productus* and *C. gracilis*) were roughly one-half as abundant (overall average of 40 crab/ha, n = 155 beam trawl tows) in Bellingham Bay as Dungeness crab (Figure 11). Relatively few *C. productus* were caught in Bellingham Bay (especially in February and May), and sexes were fairly even for this species (Figure 31). The only gravid female in the samples was caught in May and had a spent egg mass. Several 1986 YOY crabs caught in February were 10-20 mm CW. Settlement of the 1987 YOY occurred between July and October, when they again averaged 10-20 mm CW. The bulk of *C. productus* were caught at shallow (10-15 m) nearshore depths.

The majority of the rock crabs caught in Bellingham Bay were *C. gracilis* (Figure 11). The sexes were equally abundant and gravid females were found only in February (all with new egg masses; Figure 32). Settlement of YOY in 1987 began in July while the previous years settlement had grown to about 40-50 mm CW by this season. Relatively few *C. gracilis* >60 mm were found in Bellingham Bay in contrast to a relatively healthy population >60 mm in the Nisqually area (Figure 14). The reason(s) for the different age structure between the two areas is presently unknown. The distribution of *C. gracilis* was limited primarily to shallow areas in February and May, but covered all depths in July and October, in large part due to the wide distribution of the newly settled YOY (Figure 32).

Tanner crab. Tanner crab (*Chionoecetes bairdi*—also commercially known as snow crab) were found in small numbers in the Bellingham Bay samples but would have to be considered more of an "incidental observation" since this species does not support any fishery in the inland waters. The individuals caught in Bellingham Bay were mostly juveniles that probably settled from November-January and grew to an average size of ~50 mm CW by October (Figure 33). Males slightly outnumbered the females (except in February) and their overall distribution was deep (25-30 m) and restricted to the mid-bay area.

Pandalid shrimp. Bellingham Bay proved to be relatively rich in commercial shrimp resources compared to many other areas of Puget Sound. All seven species of pandalid shrimp recorded in this study occurred in Bellingham Bay, although the spot prawn, *P. platyceros*, and the pink shrimp, P. *jordani*, were scarce (Figure 16). Bellingham Bay was especially rich in *P. hypsinotus*, *P. danae*, and *P. borealis:* The overall average (all seasons, stations and species combined; n = 155 beam trawl tows) estimated density was 600 shrimp/ha with a seasonal range of 413 shrimp/ha (May) to 942 shrimp/ha (February).

Shrimp were caught at most stations in Bellingham Bay, with the highest densities generally being caught in the deeper (25-30 m) mid-portions of the bay (Figure 34). The one exception to this was substantial catches of juvenile *P. danae* in July and October at some of the shallow areas (10-20 m), especially in the Post Point area.

Relatively few *P. platyceros* and *P. jordani* were caught; hence, little information is available regarding timing of egg extrusion and juvenile recruitment. For the other shrimp species, egg-bearing females were only caught in the February trawls excepting a few gravid *P. danae* also found in the May trawls (Figure 24). No gravid *P. dispar* were caught. Recruitment of juvenile YOY shrimp was first noted for most species in the July trawls, except *P. hypsinotus*, which were not caught as YOY until October (Figures 17-23).

Besides providing estimates of shrimp densities, the trawl sampling also produced information on the age structure of shrimp populations in Bellingham Bay. For some species (*P. platyceros, P. dispar* and *P. jordani*), only one year-class of shrimp was evident in the trawls at any one time. For several other species (*P. borealis, P. goniurus* and *P. hypsinotus*), two year-classes were generally present while three year-classes were evident for *P. danae* (Figures 17-23). From these size-frequency plots, growth and relative abundances of each of the year-classes can be traced.

Other invertebrates. The large pink nudibranch, *Tritonia diomedea*, is considered a valuable neurophysiological research tool because of its large nerve fibers. Consequently, this species has been "harvested" in Bellingham Bay by researchers from Friday Harbor Laboratory and elsewhere. Bellingham Bay is a favored collection site because this somewhat ephemeral animal can usually be obtained there. Our trawl sampling showed that the average estimated density of *Tritonia* in Bellingham Bay in 1987 was 13 animals/ha with a seasonal range from 21/ha (February) to 6/ha (October). The distribution patterns for *Tritonia* catches (Figure 35) showed that it was not abundant anywhere in Bellingham Bay, but that the bulk of the animals caught were found at the deeper (20-30 m) stations in the mid-portions of the bay.

Compared to the Nisqually area, Bellingham Bay was relatively poor in starfish diversity. However, there was a high biomass of the fragile starfish, *Luidia foliolata*. This species is singled out for two reasons: (1) it occurred in large numbers and biomass in some of the trawls and (2) this species has been reported to be a nuisance by-catch in the bottomfish trawl fishery in this area, so much so that some areas of the bay are avoided by the fishermen (Gary Davis, pers. comm.).

The seasonal distribution patterns of the *Luidia* catches (Figure 36) show that this species was caught at most stations in the bay, but that the highest catches were generally from the southern, mid-portion of the bay. The average overall estimated density of starfish for all trawls (n = 155 beam trawl tows) in Bellingham Bay in 1987 was 256 starfish/ha, of which 242/ha was *Luidia.* The *Luidia* population was relatively stable between seasons, ranging from a low of 198 individuals/ha (October) to a high of 319/ha (July). By-station and by-season densities of *Luidia* in Bellingham Bay are summarized in Appendix Table 7.

Other than *Tritonia* and *Luidia*, few other invertebrate "resources" were noted from Bellingham Bay (Figure 26).

Bellingham Bay disposal areas. Five stations were sampled each season by beam trawl in or close to each of the two proposed ZSFs in Bellingham Bay. The average annual estimated densities (all seasons and stations combined, n = 20 beam trawl tows for each ZSF) for each of the invertebrate "resources" listed in Table 2 show that Dungeness crab were least plentiful in the south ZSF, rock crabs and *Tritonia* roughly the same in each ZSF, and shrimp and starfish (essentially all *Luidia*) in greater abundance in the south ZSF. Only in the case of shrimp (south ZSF) and *Tritonia* (south ZSF) did "resource" densities in the ZSFs exceed the bay-wide averages (Table 2) and, in the case of *Tritonia*, the relatively high average was caused by a one-time peak density of about 55 *Tritonia*/ha in February.

Table 2. Summary of the average density (#/ha, all stations and seasons combined) of major biological resources caught within the Bellingham Bay zones of siting feasibility (ZSF) and at all stations combined.

Resource	North ZSF	South ZSF	All stations
Dungeness crab	46	23	83
Rock crab	9	8	40
Pandalid shrimp	488	764	600
Sea cucumbers	0	0	few
Starfish	99	212	256
Tritonia	18	26	13

Figures 37 and 38 graphically illustrate the average densities of invertebrate resources caught by beam and otter trawls in each ZSF for each season. Comparison of these two figures shows the greater efficiency of the beam trawl for sampling invertebrate resources with the exception that estimates of shrimp densities were generally higher for the otter trawl.

Strait of Georgia

The preliminary ZSF sited in the southern Strait of Georgia south of Point Roberts is located in deep water (200-210 m depth) close to the U.S.-Canada boundary and in an area of high currents, turbulence and mixing. The northern portion of the ZSF is located over a sand bottom where large catches of brittle stars were common; the southern portions of the ZSF bordered on a rocky bottom (characteristic of Alden Bank and the Patos, Sucia, and Matia islands) where catches of mussels (*Modiolus*) and sea urchins were possible (as well as rock damage to the trawls).

In general, invertebrate resources were sparse in and around the proposed ZSF. The distributions of Dungeness crab, shrimp, scallops and sea urchins are graphically presented for the April and October cruises in Figures 39 and 40.

Dungeness crab. No Dungeness crab were caught within the boundaries of the ZSF during either cruise. This species was limited to depths ≤100 m and were especially abundant at the 50-m station (Station 10) as has also been shown during previous sampling at this location (Dinnel, unpublished data). The average densities of Dungeness crab for each cruise (excluding Stations 5 and 7, n = 9 beam trawl tows each season) were 46 crab/ha in April and 17/ha in October (Figure 11). Note, however, that these averages are based on catches of crab at only 3 of 11 stations (Stations 9, 10, 11), and that the average densities for only these 3 stations would be 138 and 50 crab/ha for April and October, respectively. Hence, the preferred areas for Dungeness crab appear to be outside the ZSF.

Figure 41 details some of the basic biological data for Dungeness crab in the Strait of Georgia. Males dominated the catch by about 2:1 over the females, and juveniles were rare. The majority of the females caught in October were gravid with new egg clutches, while one female caught in April had a spent egg clutch. Shells were hard for all crabs caught in both April and October. The size-frequency plots in Figure 41 show that most crabs in the catches were mature adults over 100 mm CW with the very notable exception of a group of subadult males between 80-100 mm CW caught in April. This observation is significant because our sampling has rarely identified habitats utilized by 1- to 2-year-old crabs (i.e., 30-100 mm animals). This information—and the depth-distribution graphs of Figure 41—suggest that subadult males distinctly prefer the 50-m contour off Birch Bay.

Rock and tanner crabs. Rock and tanner crabs were relatively scarce in the Strait of Georgia samples (Figure 11).

Pandalid shrimp. Pandalid shrimp catches were spotty and relatively small. The average estimated densities for each season (excluding Stations 5 and 7; n = 9 beam trawl tows) were 44 and 71 shrimp/ha for April and October, respectively. The catches primarily contained *P. danae* at the shallower stations and *P. borealis* at the deeper stations, with an occasional *P. dispar* in the catches (Figure 16). Size-frequency distributions for each shrimp species caught in the Strait of Georgia (graphed in Figures 17-23) show that several year classes of *P. dispar, P. danae* and *P. borealis* were present.

Other invertebrate resources. Both pink scallops, *Pecten rubida,* and weathervane scallops, *P. caurinus*, were caught in very small numbers at a few stations (average of 6 and 19 scallops/ha for April and October, respectively; n = 9 beam trawl tows) each season (Figure 40). Weathervane scallops were rare compared to pink scallops.

A few sea urchins (*Strongylocentrotus pallidus*) were caught within the ZSF, indicating a hard bottom in the southern portion of the ZSF (Figure 40).

Rosario Strait

Rosario Strait is a current-swept passage lying between Decatur and Lopez Islands on the west, Fidalgo Island to the east and Cypress Island to the north. The bottom type ranges from gravel in the northern portion to cobble and rock outcroppings in the southern portion. Eleven stations in Rosario Strait were sampled by rock dredge during April and October. Each tow with the rock dredge was roughly 0.1 NM. Since the sampling efficiency of a rock dredge bouncing on a rocky bottom must be very poor, no attempts were made to estimate resource densities from the these tows .

Crabs. Dungeness and rock crabs (except for small and plentiful *Cancer oregonensis*) were completely absent from the rock dredge samples during both seasons.

Shrimp. A relatively large number of small, non-pandalid shrimp were caught in the rock dredge, but only a few pandalid shrimp (mostly small *P. danae*; Figure 19) were caught at each station (Figures 16, 42 and 43).

Other invertebrate resources. Pink scallops were fairly common in the rock dredge samples from the southern half of Rosario Strait and absent from the four northernmost stations, which typically had sand and gravel bottoms (Figures 42 and 43). Sea urchins (*S. pallidus*) and mussels (*Modiolus*) were also caught in fairly large numbers at the southern stations (Figures 42 and 43). Catches of these species at the southern stations indicates a very rocky bottom.

Port Townsend

The Port Townsend ZSF was located northeast of Port Townsend at the head of Admiralty Inlet. Six stations were sampled in and around the ZSF with both beam and otter trawls (except that three stations were not sampled by beam trawl in April because of high winds and rough seas). The station depths ranged from 70 to 150 m. The bottom was probably a mixture of sand, small gravel and shell.

Crabs. No Dungeness, rock or tanner crabs were caught in this area during either sample season.

Pandalid shrimp. A modest average density of 236 shrimp/ha (all stations combined; n = 6 otter trawl tows) was estimated for this area in April. The average density of shrimp estimated in October otter trawl catches increased dramatically to 6,802 shrimp/ha, primarily due to an influx of young *P. danae* and *P. borealis* (Figure 16). The distributions of shrimp in the Port Townsend area were similar during the two seasons sampled (Figures 44 and 45) and the highest catches were made at Stations 4 and 6 (stations closest to Port Townsend). In each case, the catches were dominated by *P. danae*. Few shrimp were caught at Stations 1 and 5. *Pandalus platyceros, P. jordani* and *P. hypsinotus* were not caught in this area, and relatively few *P. dispar* and *P. goniurus* were in the catches. The few *P. dispar* that were caught were mature shrimp averaging about 25-30 mm CL except for a few juveniles caught in October (Figure 18). The few *P. goniurus*, caught only in October, were all juveniles averaging 10 mm CL (Figure 22). *P. borealis* caught in the April sampling were of two size groups, averaging about 10-12 mm and 16-17 mm CL, while the October samples were dominated by YOYs averaging 9-10 mm (Figure 21). The size-frequency plot for *P. danae* (Figure 19) caught in April also suggests there were two size groups for this species, averaging 10-12 mm and 17-20 mm CL. The number of *P. danae* caught in October also increased roughly two orders of magnitude but, unlike *P. borealis*, the increase in numbers appeared to be due to an influx of 1- to 2-year-old animals rather than due to settlement of YOY (Figure 19).

Other invertebrates. Pink scallops were abundant at some of the Port Townsend stations, although the catches were spotty. The scallop catches (based on the October beam trawl samples—sampling with this gear was incomplete in April and the otter trawl is a poor sampling gear for scallops) were highest at Stations 1 and 4, with estimated densities of 2,172 and 8,558 scallops/ha, respectively; and lowest at Stations 2, 3 and 5, where no scallops were caught in October (Figure 44 and 45). At present, it is unknown how consistent these apparent aggregations of scallops will be in future years.

Large numbers of sea urchins (*S. pallidus*, possibly *S. droebachiensis*, and a few rare *Allocentrotus*) were caught at three of the Port Townsend stations (Stations 1, 4 and 6), which were the same stations where the highest scallop catches were made (Figures 44 and 45). The estimated urchin densities at these three stations (based on October beam trawls) ranged from 2,079 to 8,521 urchins/ha. Very few urchins were caught at the other three stations (Stations 2, 3 and 5).

Other invertebrate "resources" were limited primarily to modest numbers of a variety of starfish species (Figure 26).

Port Angeles

The Port Angeles ZSF is located north of Port Angeles and Ediz Hook in the middle of the Strait of Juan de Fuca and adjacent to the international boundary. The eastern portion of the ZSF is also adjacent to a rocky reef area locally known as the "rock pile" (a popular fishing spot). The station depths ranged from 110 to 136 m and the bottom type was apparently a sand/gravel mix with some shell.

Crabs. As was true for the Port Townsend site, no crabs were caught in the Port Angeles ZSF.

Pandalid shrimp. Few shrimp (average density = 53 shrimp/ha; n = 6 beam trawls) were caught in the trawls in April, and the majority (~90%) of those caught were *P. borealis* (Figure 16). However, catches of shrimp in October jumped more than two orders of magnitude (average estimated density = 6,775 shrimp/ha) owing entirely to settlement of YOY *P. borealis* averaging about 8-9 mm CL (Figure 21). Unlike Port Townsend, no *P. danae* were caught in the Port Angeles area. The balance of the shrimp catch at Port Angeles consisted of a few *P. dispar* and *P. goniurus*.

The distribution of the April shrimp catches was uniformly low at all stations and the largest catch (206 shrimp/ha) was at Station 5 (Figure 46). However, the very high catches in October were not evenly distributed; about 94% of the shrimp were caught at only 3 stations (Stations 1, 2, 3) with catches of 26,462 to 68,927 shrimp/ha (Figure 47).

Other invertebrates. Pink scallops were caught in large numbers in April (average beam trawl density = 2,781/ha) and October (average = 1,323 scallops/ ha). The highest densities (up to 4,551 scallops/ha) were caught at Stations 2, 3, 4 and 5 during each season. Scallops were essentially absent from Station 6 (Figures 46 and 47).

Sea urchins (*S. pallidus*) were also plentiful in most of the trawl samples from Port Angeles during both seasons (average densities = 1,486 and 2,260/ha for April and October, respectively). However, unlike Port Townsend, the highest sea urchin densities did not correspond to high scallop densities. The highest sea urchin catches were at Station 6, which was almost devoid of scallops. The distribution of sea urchins was fairly uniform between stations, with Stations 5 and 6 producing the largest catches during both seasons (Figure 46 and 47).

Other invertebrate "resources" caught in the Port Angeles area were limited to moderate numbers of a variety of starfish species and a few sea cucumbers (Figure 26).

DISCUSSION AND CONCLUSIONS

Nisqually Region

In 1987, the primary invertebrate species of actual or potential commercial and sport fishery concern caught in the Nisqually region were Dungeness and rock crabs, pandalid shrimp and sea cucumbers. Dungeness crab were sparse yet of concern for two reasons: (1) crab were caught near the south boundaries of both ZSFs, and (2) this population of crab supports a small sport fishery in the Nisqually Delta region (Ron Westley, per. comm.). The recruitment dynamics of Dungeness crab in this area are unknown, but larvae may come from the few local resident females or recruitment might be dependent on larvae transported southward through the Tacoma Narrows from the main basin of Puget Sound. The generally shallow distribution observed in May might be a reflection of mating and molting activities. All Dungeness crab caught in the Nisqually region were mature individuals over 120 mm CW. This size distribution suggests that these animals all came from one or two successful periods of juvenile recruitment about 3-5 years ago and that settlement has not been successful in recent years. The larger sizes of Dungeness crab from the Nisqually (especially the females), together with a general appearance of good health, suggests that the Nisqually area could support more Dungeness crab if settlement (and/or juvenile survival?) were more successful.

Other *Cancer* crabs present in the Nisqually region were the rock crabs *C. productus* and *C. gracilis*. *Cancer productus* is utilized for food by some sport crabbers and divers, while the more plentiful *C. gracilis* is less extensively fished because of its smaller size. Rock crabs tend to be more important in sport catches when Dungeness crab are unavailable. *Cancer productus* is also a potential commercial species, since the large claws of this species now appear in California fish markets.

Pandalid shrimp were generally sparse in the Nisqually region with the possible exception of *P. danae*. However, most of the *P. danae* were young individuals (CL <20 mm) caught in shallow areas away from the deeper disposal ZSFs. Shrimp caught in the deeper areas included only small numbers of pink and sidestripe shrimp. Historically, the South Puget Sound region was identified by Smith (1937) as important for smooth pink shrimp (*P. jordani*) production (Figure 48), although little information was provided that identified specific shrimp-producing areas within this region. Most of the present shrimping efforts appear to be focused in the Carr and Case Inlet areas and not in the Nisqually region (R. Baumgarner, pers. comm.).

The edible sea cucumber, *Parastichopus californicus*, was quite plentiful throughout the Nisqually area and occurred in small numbers in each of the ZSFs. The highest concentrations of cucumbers were generally found at depths ≤40 m except on Transect 2 (near the south boundary of ZSF 2), where large numbers of cucumbers were caught as deep as 110 m. This species is presently the object of a limited commercial fishery in selected areas of Puget Sound and is occasionally harvested by sport divers. This species may be of special concern relative to dredged materials disposal since it is a deposit feeder and may be especially vulnerable to contaminated sediments (conversely, it may be a good species to monitor for toxicant uptake).

Figures 27 (beam trawl) and 28 (otter trawl) present side-by-side comparisons of average estimated densities of invertebrate resources in both of the Nisqually ZSFs. These figures strongly suggest that invertebrate resources would be least impacted by location of a disposal site in the deeper ZSF 2 near Ketron Island. However, based on relatively high abundances of Dungeness crab and sea cucumbers along Transect 2, a final site selected in ZSF 2 should probably be located in the mid- to northern portion of the ZSF.

Bellingham Bay

Dungeness crab, pandalid shrimp and the nudibranch, *Tritonia diomedea*, were important invertebrate resources identified by the trawls in Bellingham Bay in 1987. The estimated densities of Dungenss crab throughout the bay and within the proposed ZSFs were high enough to be of concern in considering the final site. Most Dungeness crab caught at the deeper stations during February, May and June were females. During October, large aggregations of newly gravid females were found on the eastern end of Transect 1 (near Post Point) along the 10-20 m contour. Thus, the Post Point area appears to be a favored area for the females during the egg incubation period.

Rock crabs were also present in Bellingham Bay but generally at densities lower than Dungeness crab. As in the Nisqually, *C. productus* was generally less plentiful than *C. gracilis*. A few (mostly juvenile) tanner crab were also present in the deeper areas of the bay.

Pandalid shrimp were more abundant in Bellingham Bay than the Nisqually region (Figure 16). Three species, *P. danae, P. hypsinotus*, and *P. borealis*, were abundant enough to be considered resources with future harvest potential. Past surveys in Bellingham Bay have also noted large numbers of shrimp in the catches (Webber 1975; CH_2M Hill 1984).

The nudibranch *Tritonia* is collected in Bellingham Bay by researchers from Friday Harbor Laboratory. This animal was commonly caught in small numbers at many of the deeper stations but was not abundant anywhere.

Selection of a disposal site in Bellingham Bay is more difficult than for the Nisqually region because of two factors: (1) Dungeness crab and shrimp are generally much more plentiful, and (2) there is no clear-cut biological basis for selecting one ZSF over the other. Comparisons of the beam trawl catches between the two ZSFs (Figure 37) suggest that Dungeness crab may be more plentiful in the north ZSF but that shrimp are more abundant in the south ZSF (see also Figure 38 for the otter trawl catches). *Tritonia* catches were patchy but roughly equal between the two ZSFs. One possible deciding factor may be the relative densities of the starfish, *Luidia foliolata*, which is considered a serious nuisance by-catch of commercial fish trawls in some areas of Bellingham and Samish bays. While this starfish is ubiquitous throughout Bellingham Bay, the highest beam trawl catches were in the south-central portion of the bay (Figure 36), and the estimated densities of this animal in the two ZSFs showed its preference for the south ZSF in each of the four seasons (Figure 37). Hence, it might be preferable to the trawl industry to select a final disposal site in the south ZSF.

Strait of Georgia

Relatively few invertebrate resources were found in or nearby the proposed ZSF in the Strait of Georgia (Figures 34 and 40). Dungeness and rock crabs were caught only at stations as deep as 100 m. Only a few shrimp and scallops were caught in the ZSF. The southern portions of the ZSF bordered on a rocky bottom area where sea urchins and mussels (*Modiolus*) were caught. Future disposal within this ZSF should have little impact on fisheries resources.

Rosario Strait

Quantitative sampling was impossible in Rosario Strait's rocky bottom. However, catches with the rock dredge suggested that pink scallops, sea urchins and mussels are most abundant south of the proposed ZSF and least abundant in the area to the northwest of the western tip of Fidalgo Island (Figures 42 and 43). Small numbers of shrimp were caught at all stations except the most northerly (Station 1). These findings suggest that the best location for a disposal site would be at the north end of Rosario Strait.

Port Townsend

The Port Townsend ZSF was fairly rich in shrimp (especially juvenile *P. danae* and *P. borealis*), pink scallops and sea urchins. Shrimp densities were low during the April sample period, but heavy settlement of 1987 year class *P. danae* and P. *borealis* pushed the average October density to over 3,000 shrimp/ha. Not enough samples were collected in this area to discern any preferable areas for locating a disposal site (Figures 44 and 45).

Port Angeles

Pink scallops and sea urchins were the dominant invertebrate resources in this ZSF during both seasons (Figures 46 and 47). Shrimp densities were modest in April but skyrocketed to about 27,000/ha in October, which was primarily due to settlement of YOY *P. borealis*. As was the case with Port Townsend, not enough stations were sampled to provide enough information to fine-tune the selection of a preferred disposal site within or around the Port Angeles ZSF.

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FIGURES

PSDDA PHASE II SAMPLING AREAS

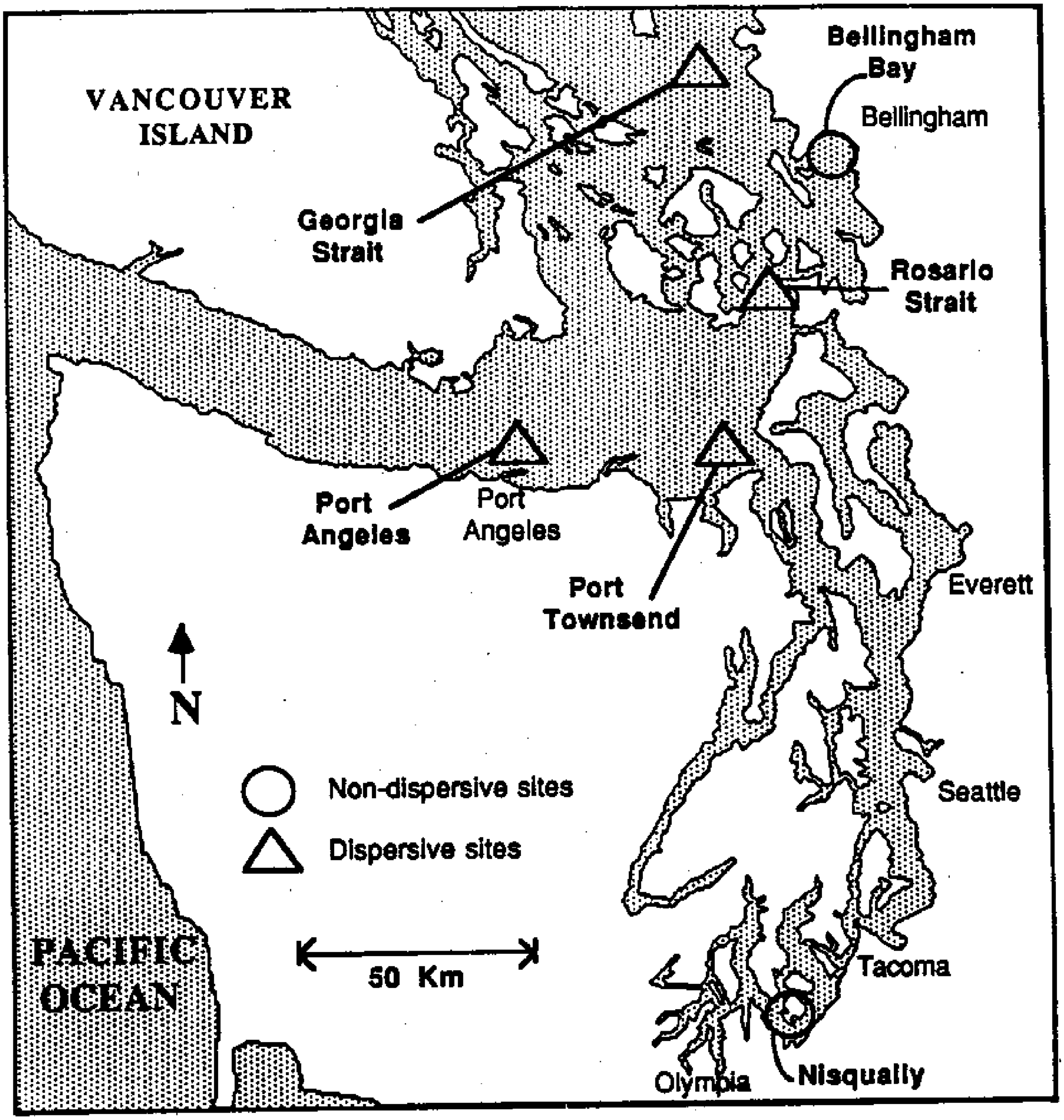

Figure 1. Map of Puget Sound showing the PSDDA II sampling locations.

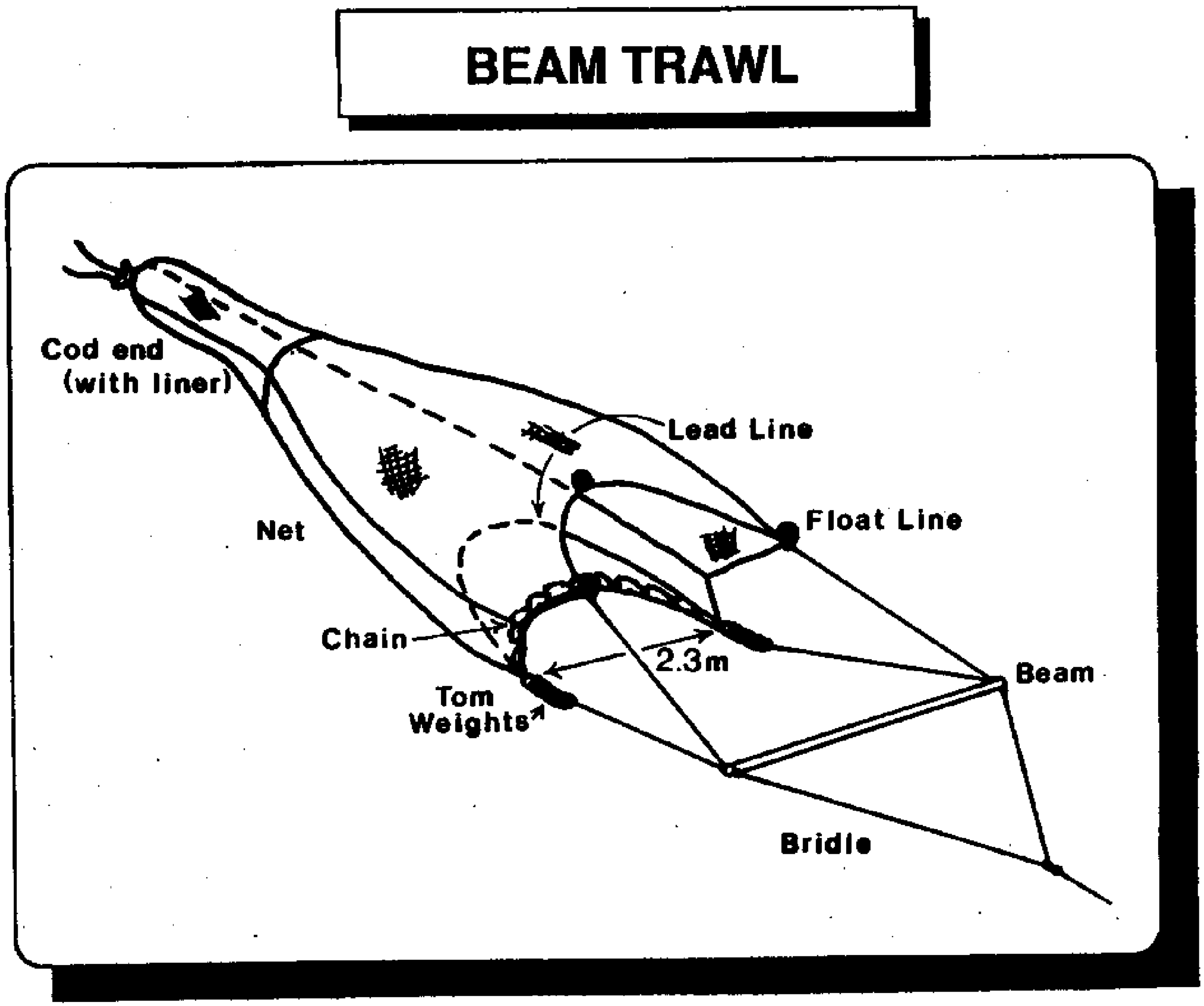

Figure 2. Diagram of the 3-m beam trawl used to sample invertebrate resources in Puget Sound. The trawl is as described by Gunderson and Ellis (1986) except that the beam was steel instead of aluminum.

Rock Dredge

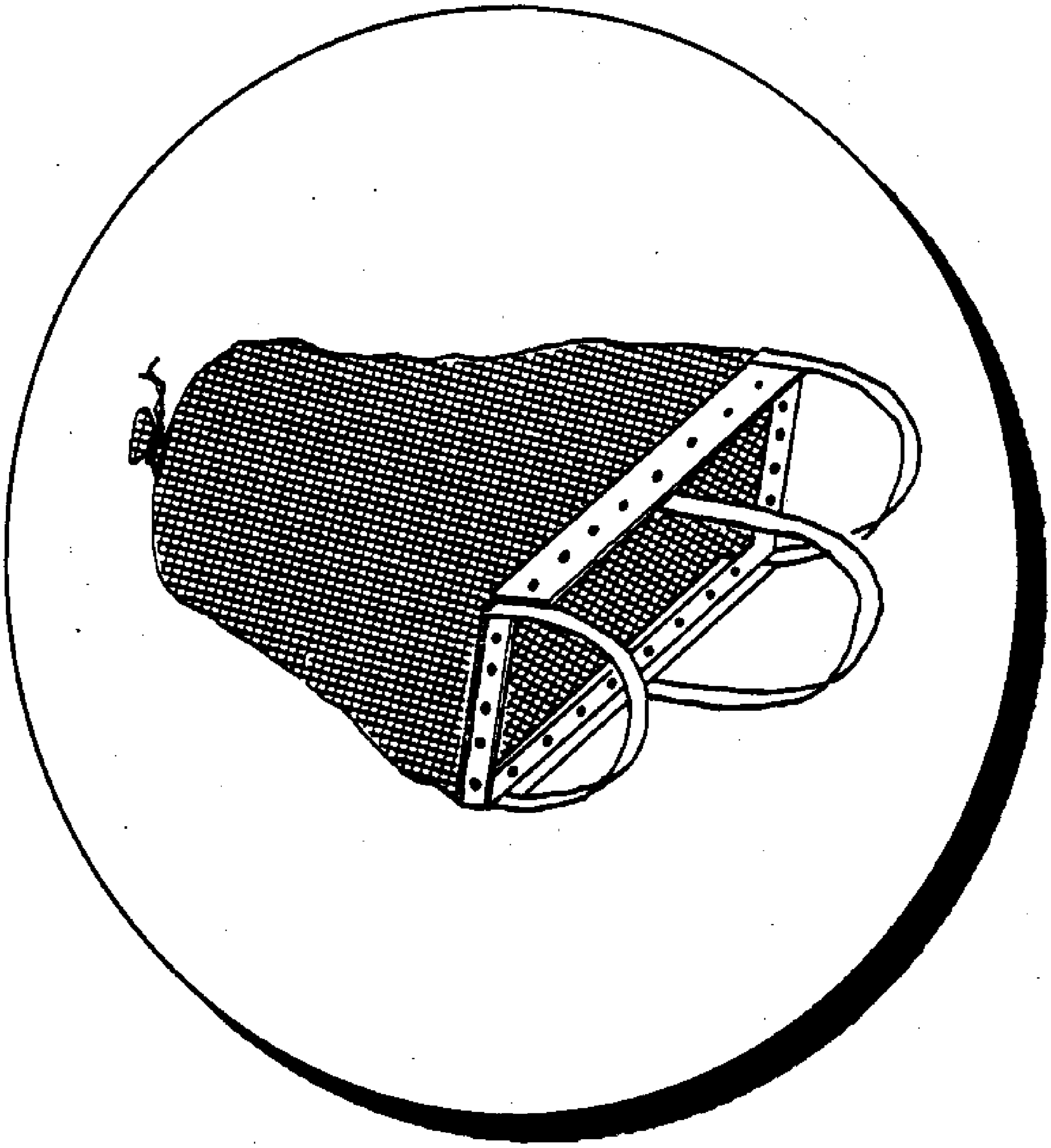

Figure 3. Diagram of the rock dredge used for sampling in Rosario Strait and a few stations in the Strait of Georgia.

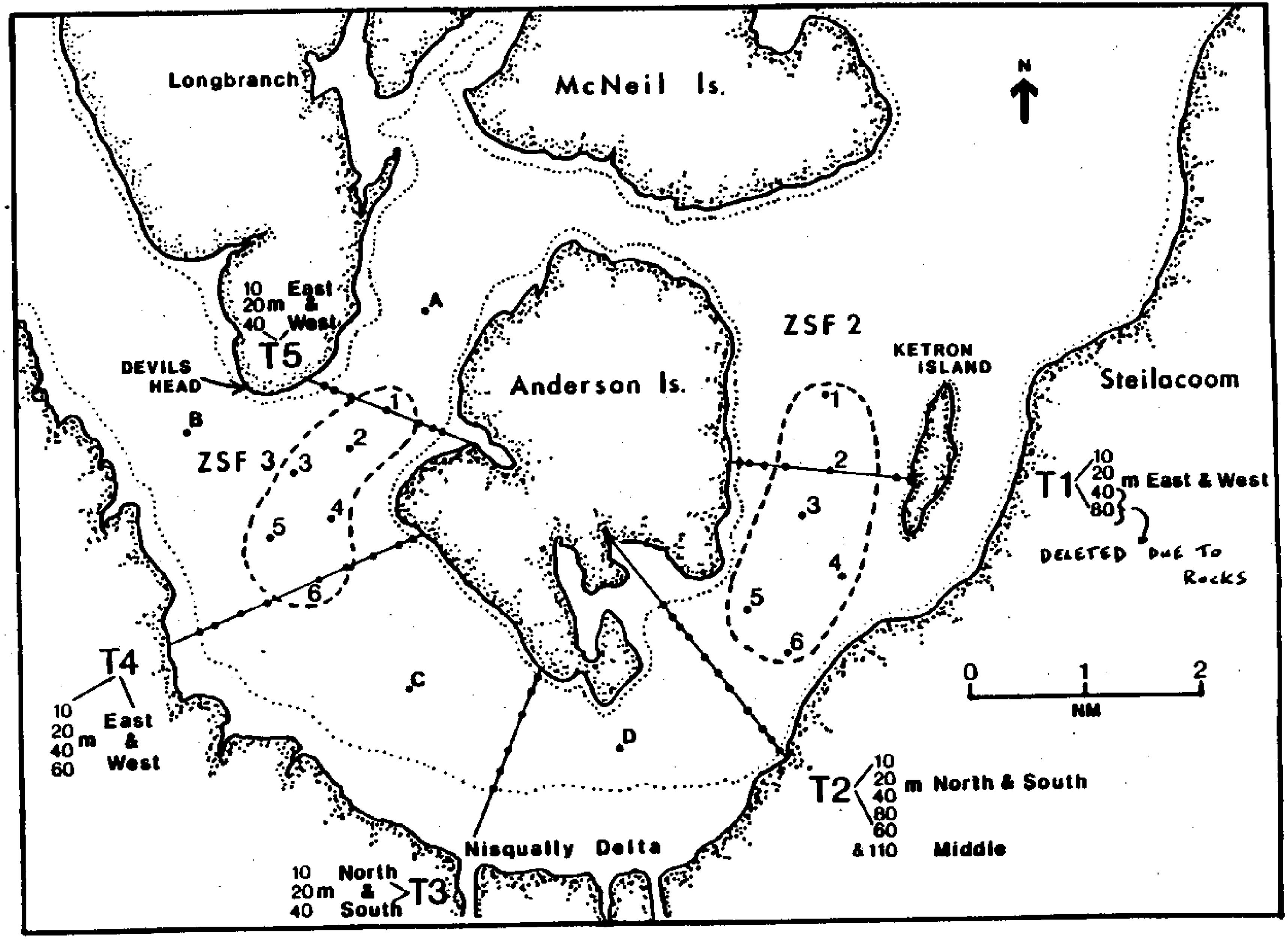

Figure 4. Map of the Nisqually region of south Puget Sound showing the locations of Zones of Siting Feasibility (ZSF) 2 and 3 and the stations sampled by beam trawl in and around the ZSF s in October 1987. The otter trawl stations were a subset of the beam trawl stations but included all ZSF 2 and 3 stations.

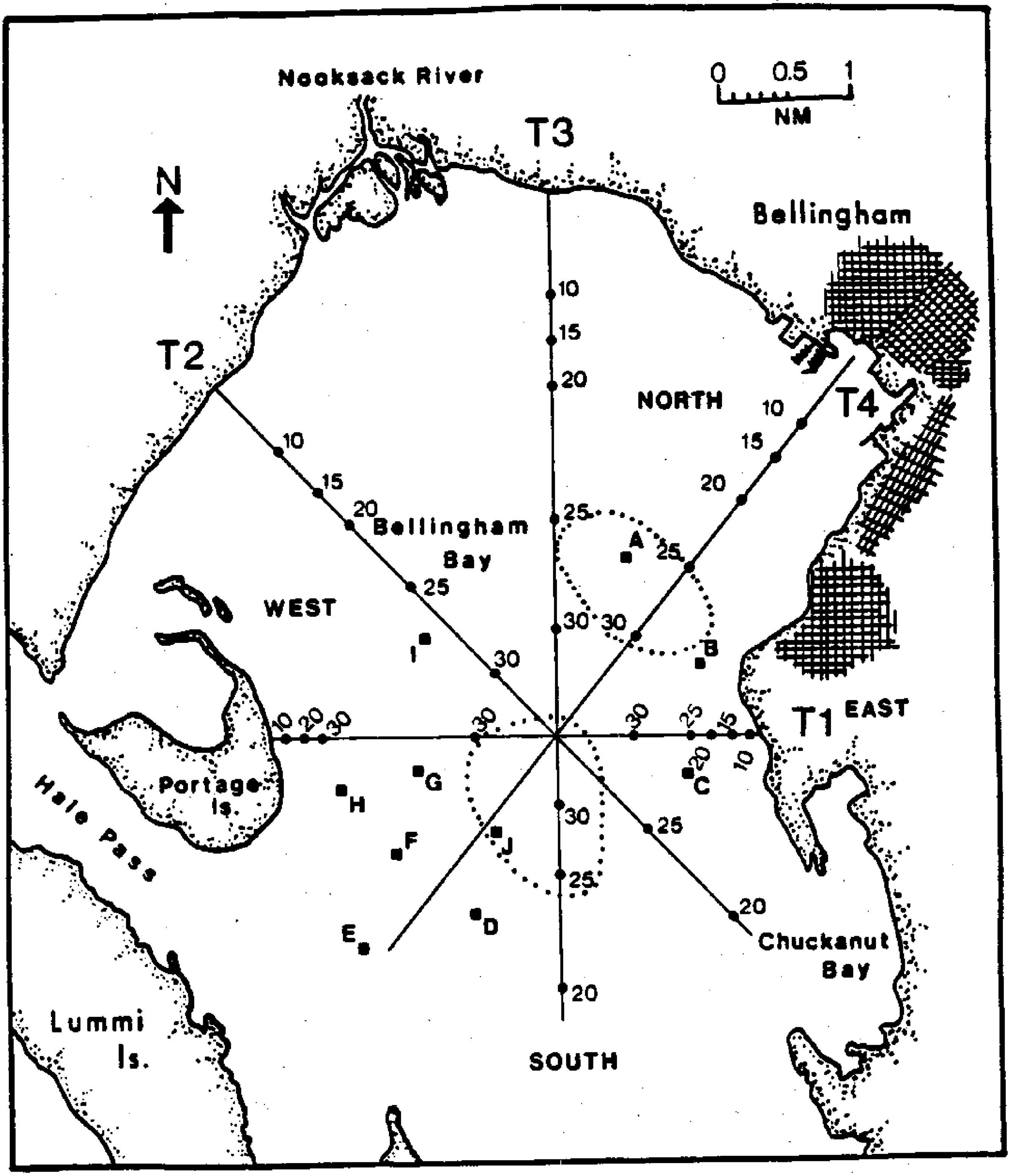

Figure 5. Map of Bellingham Bay showing the preliminary locations of two Zones of Siting Feasibility (ZSF) and the locations sampled by beam trawl in October 1987. The otter trawl stations were a subset of the beam trawl stations.

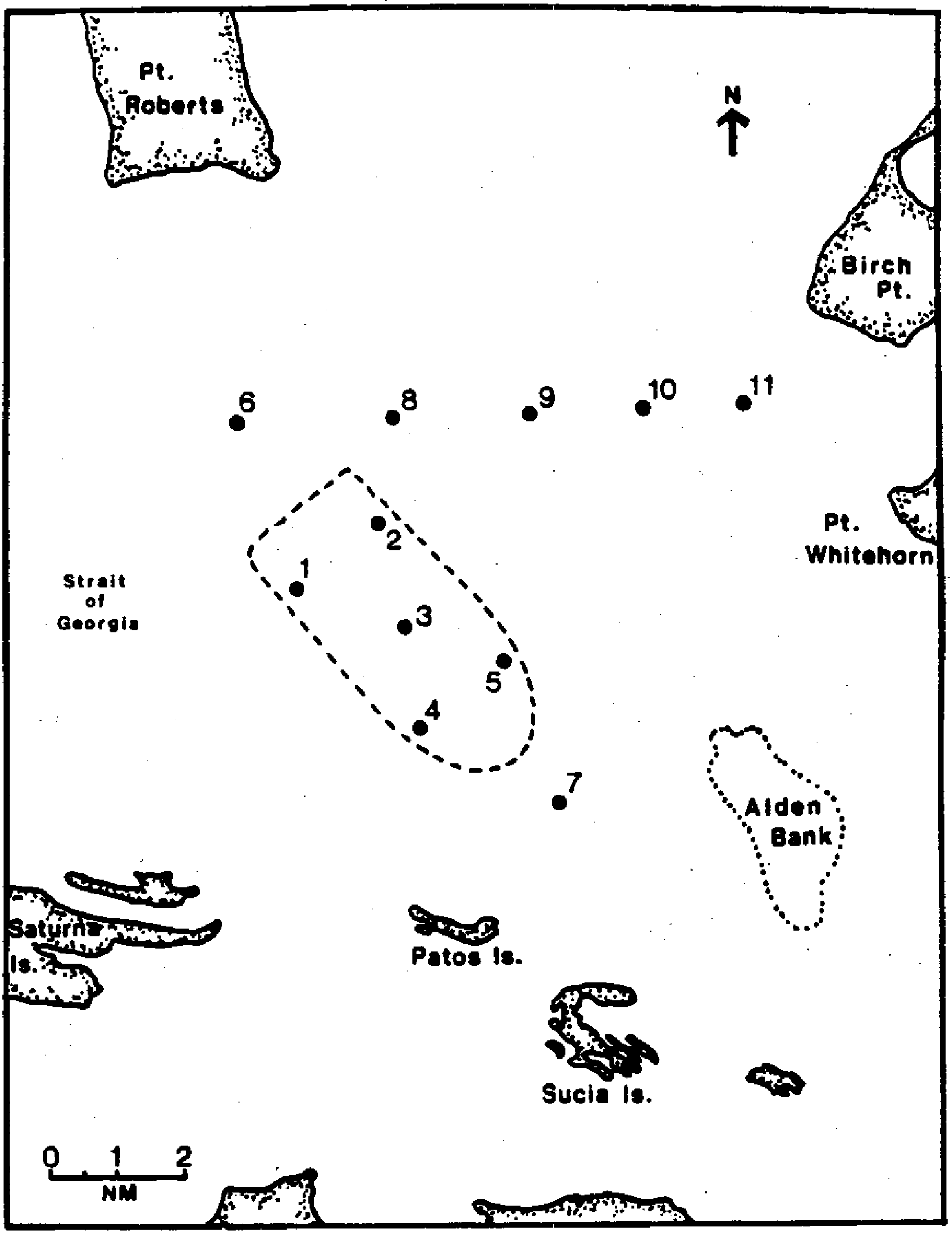

Figure 6. Map of the Point Roberts/southern Strait of Georgia area showing the preliminary location of a dispersive Zone of Siting Feasibility (ZSF) and the station locations sampled by both beam and otter trawls in October 1987.

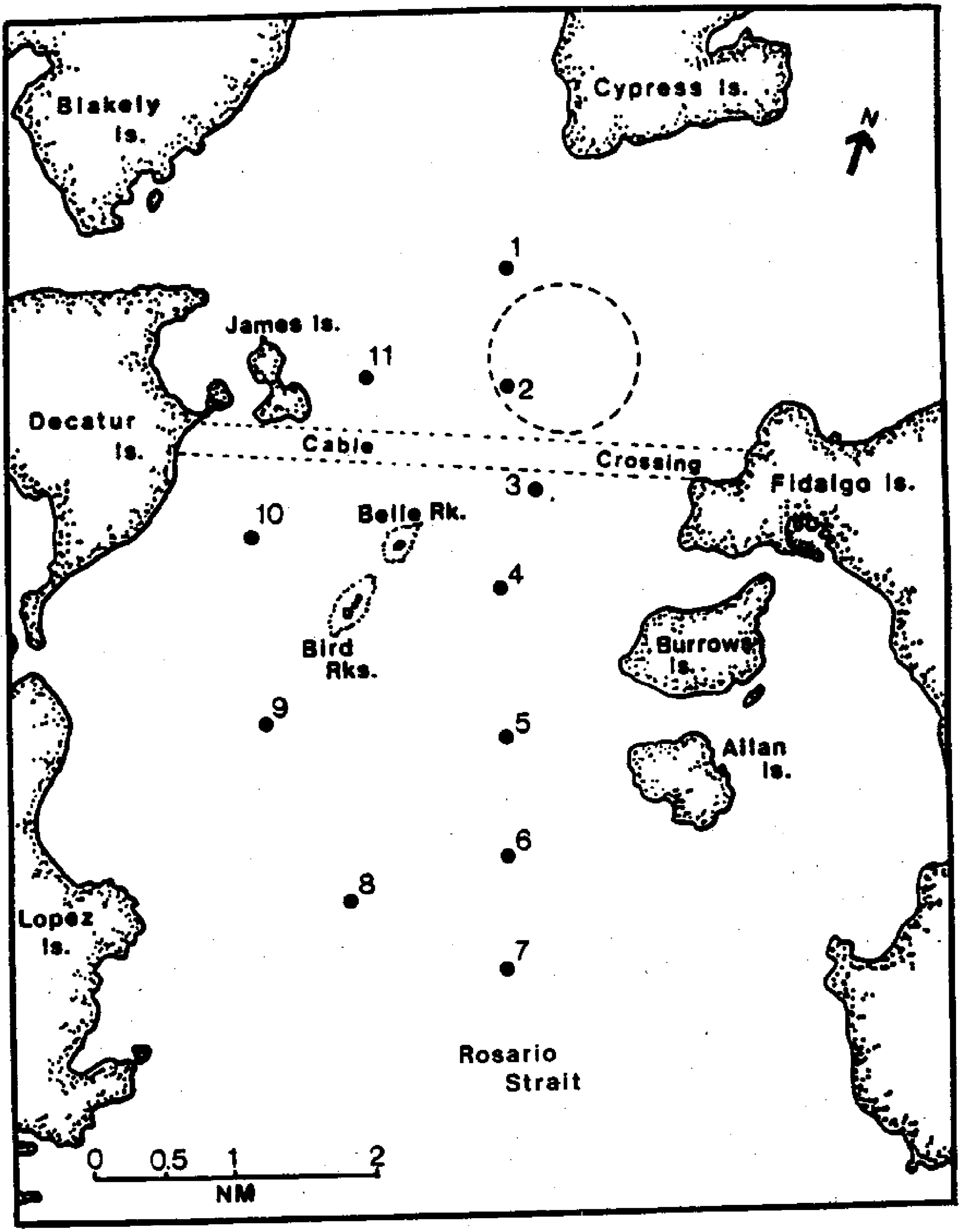

Figure 7. Map of Rosario Strait showing the preliminary location of a dispersive Zone of Siting Feasibility (ZSF) and the stations sampled by rock dredge in October 1987.

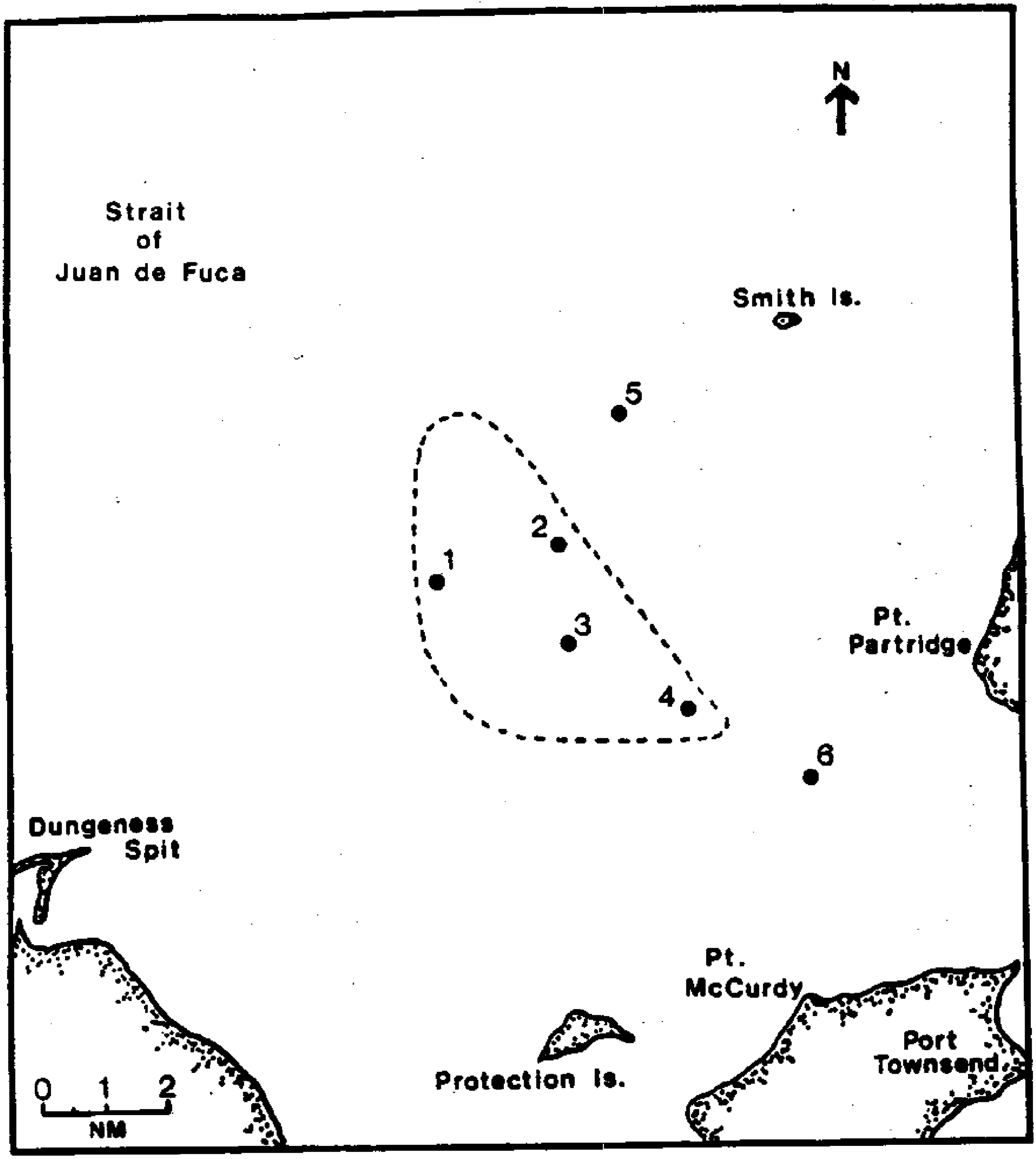

Figure 8. Map of the Port Townsend portion of the Strait of Juan de Fuca showing the preliminary location of a Zone of Siting Feasibility (ZSF) and the stations sampled by beam and otter trawls in October 1987.

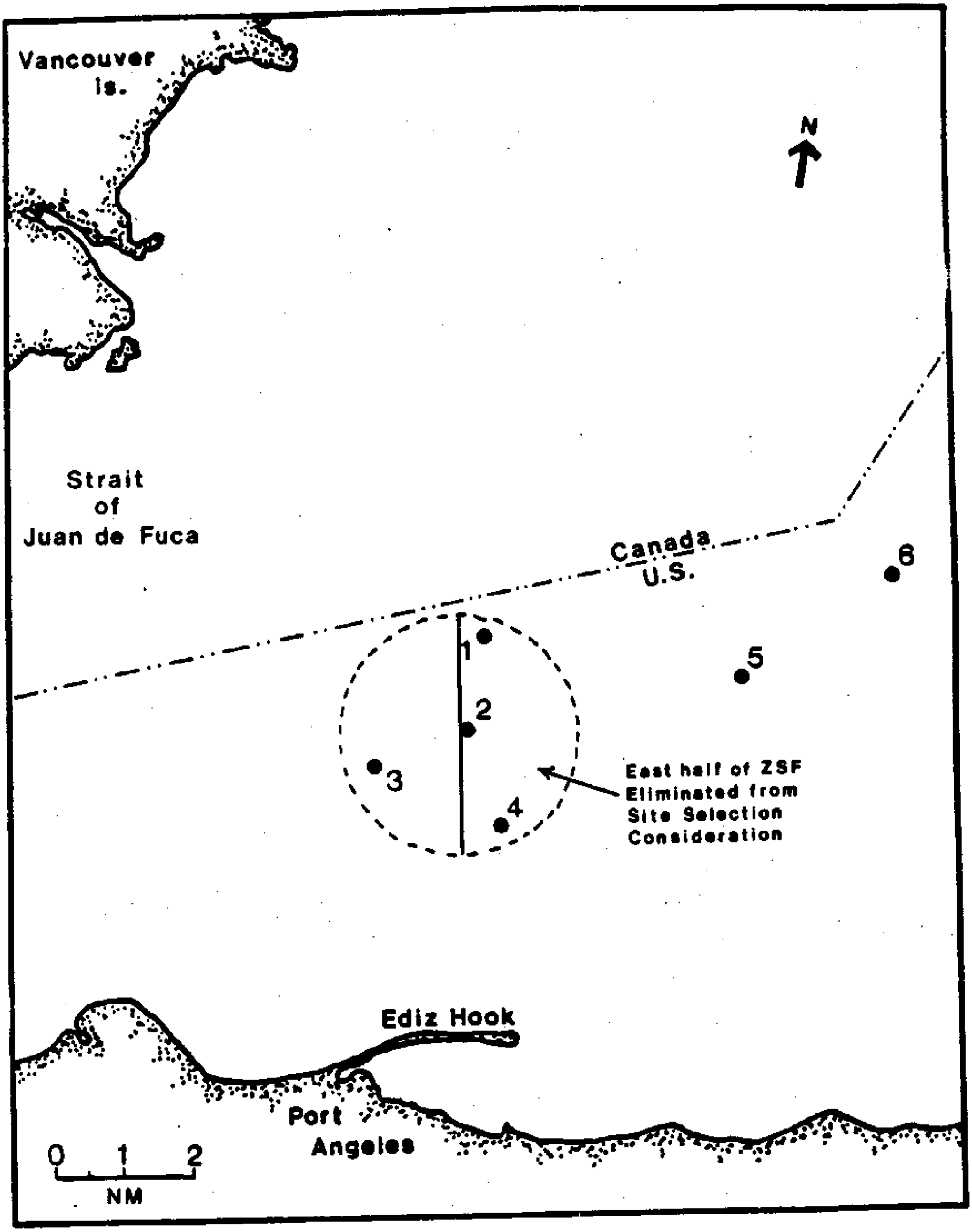

Figure 9. Map of the Port Angeles portion of the Strait of Juan de Fuca showing the preliminary location of a Zone of Siting Feasibility (ZSF) and the stations sampled by beam and otter trawls in October 1987.

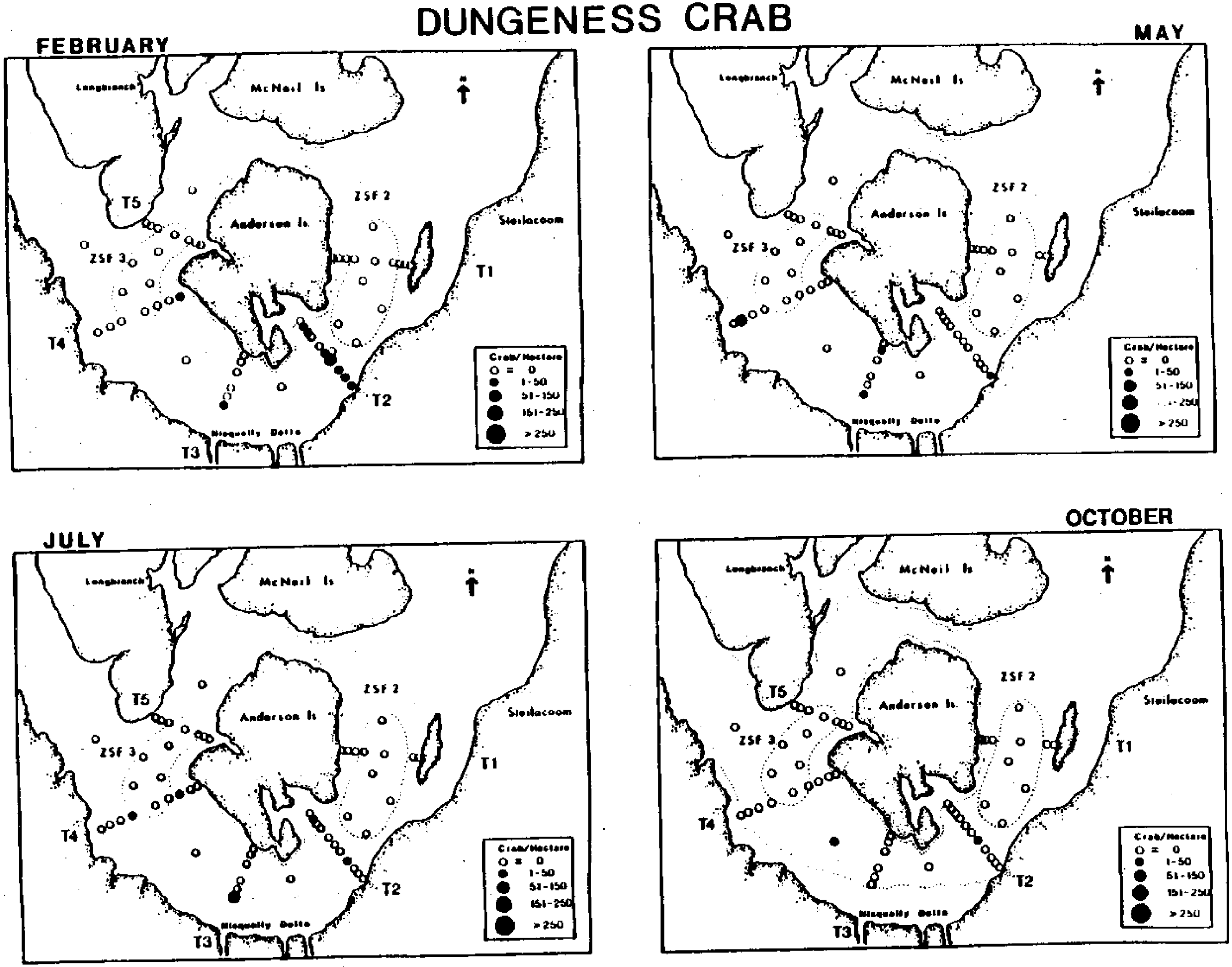

Figure 10. Maps of the Nisqually region showing the densities of Dungeness crab as estimated from beam trawl catches in February, May, July and October 1987.

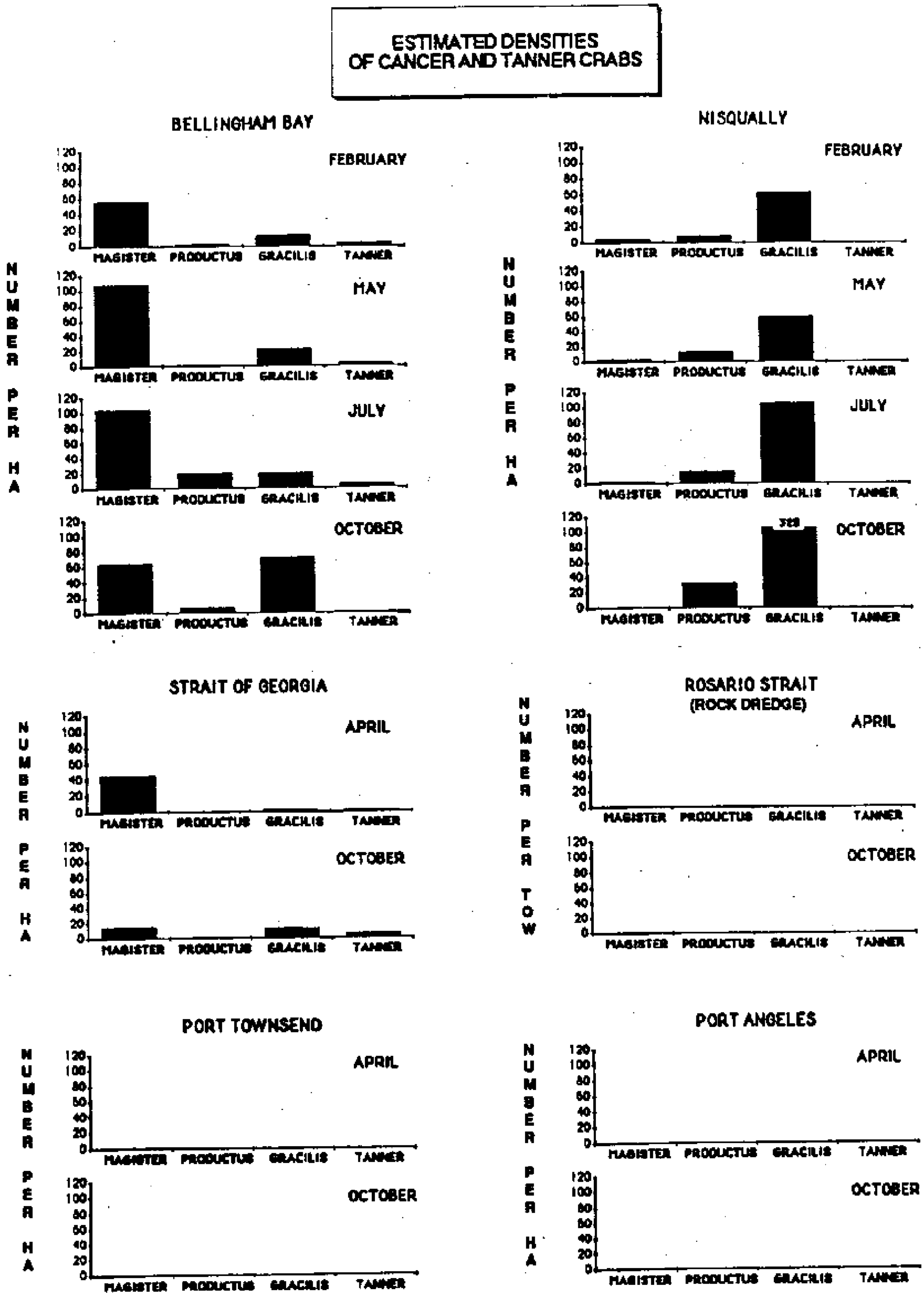

Figure 11. Summary of the estimated average densities (#/ha) of *Cancer* and tanner crabs by area, by season and by species based on the beam trawl catches (except #/tow for the rock dredge in Rosario Strait).

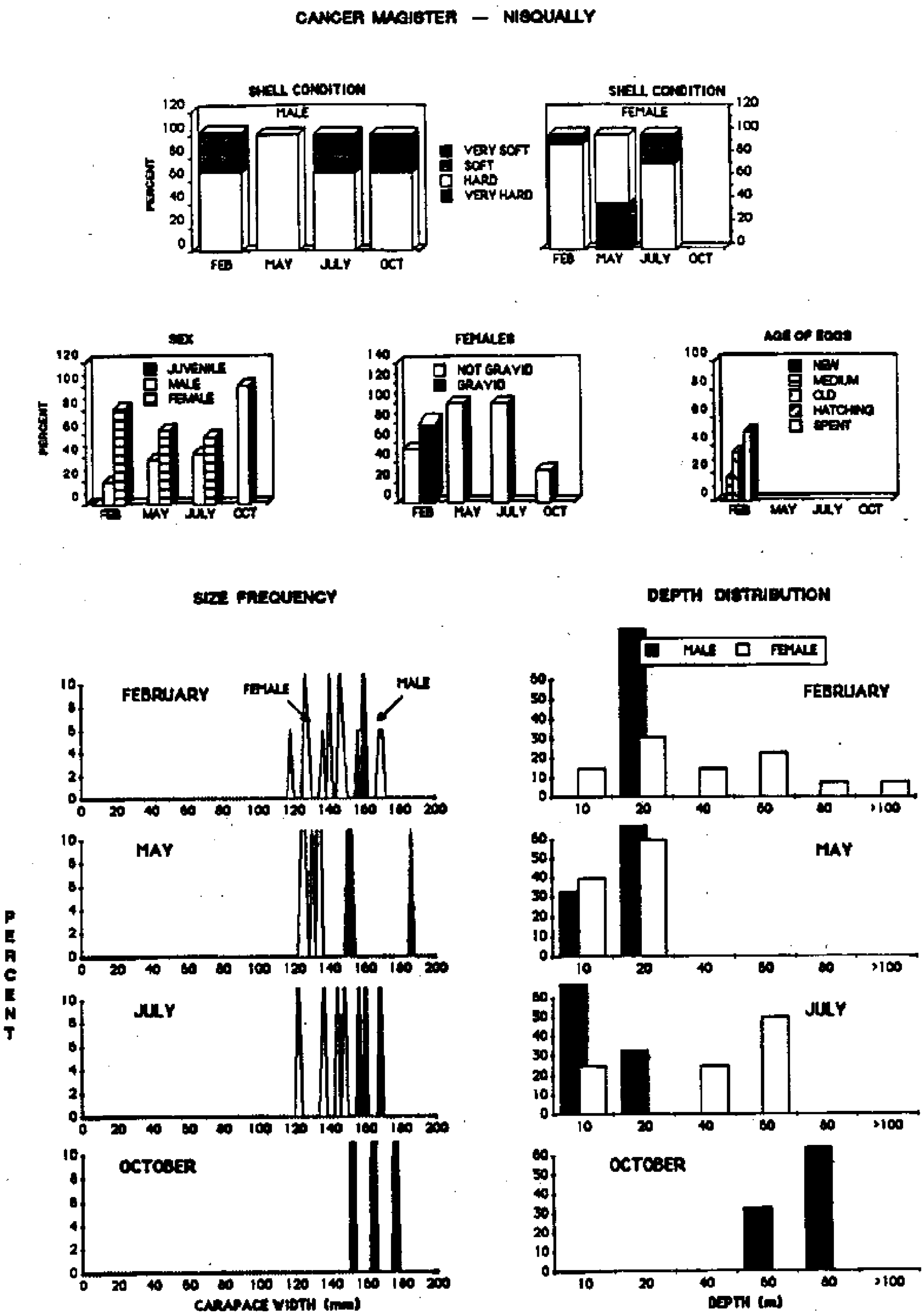

Figure 12. Summary of Dungeness crab depth distribution, size frequency, shell condition, sex composition, female reproductive condition and egg age in the Nisqually region during four seasons of 1987.

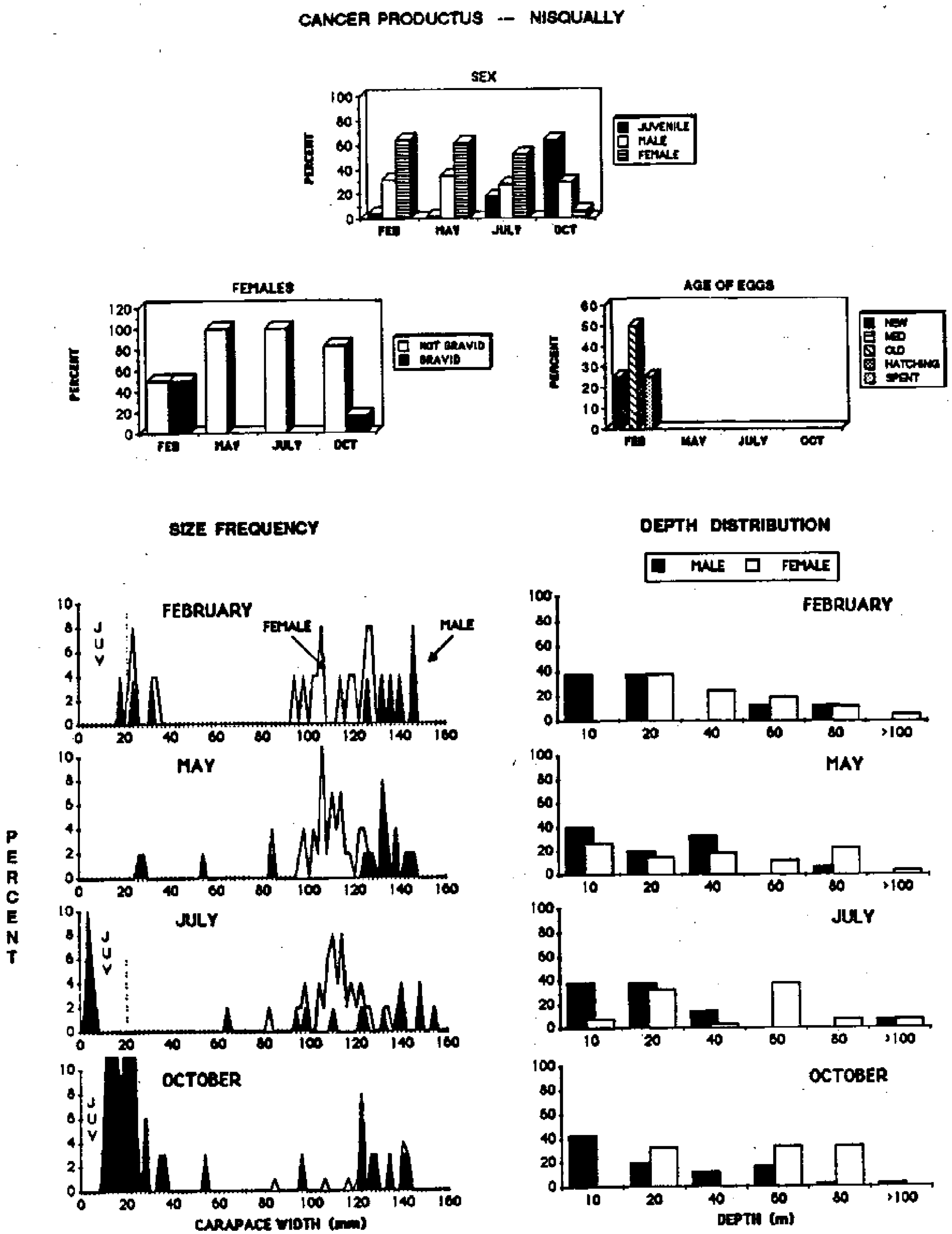

Figure 13. Summary of *Cancer productus* depth distribution, size frequency, sex composition, female reproductive condition and egg age in the Nisqually region during four seasons of 1987.

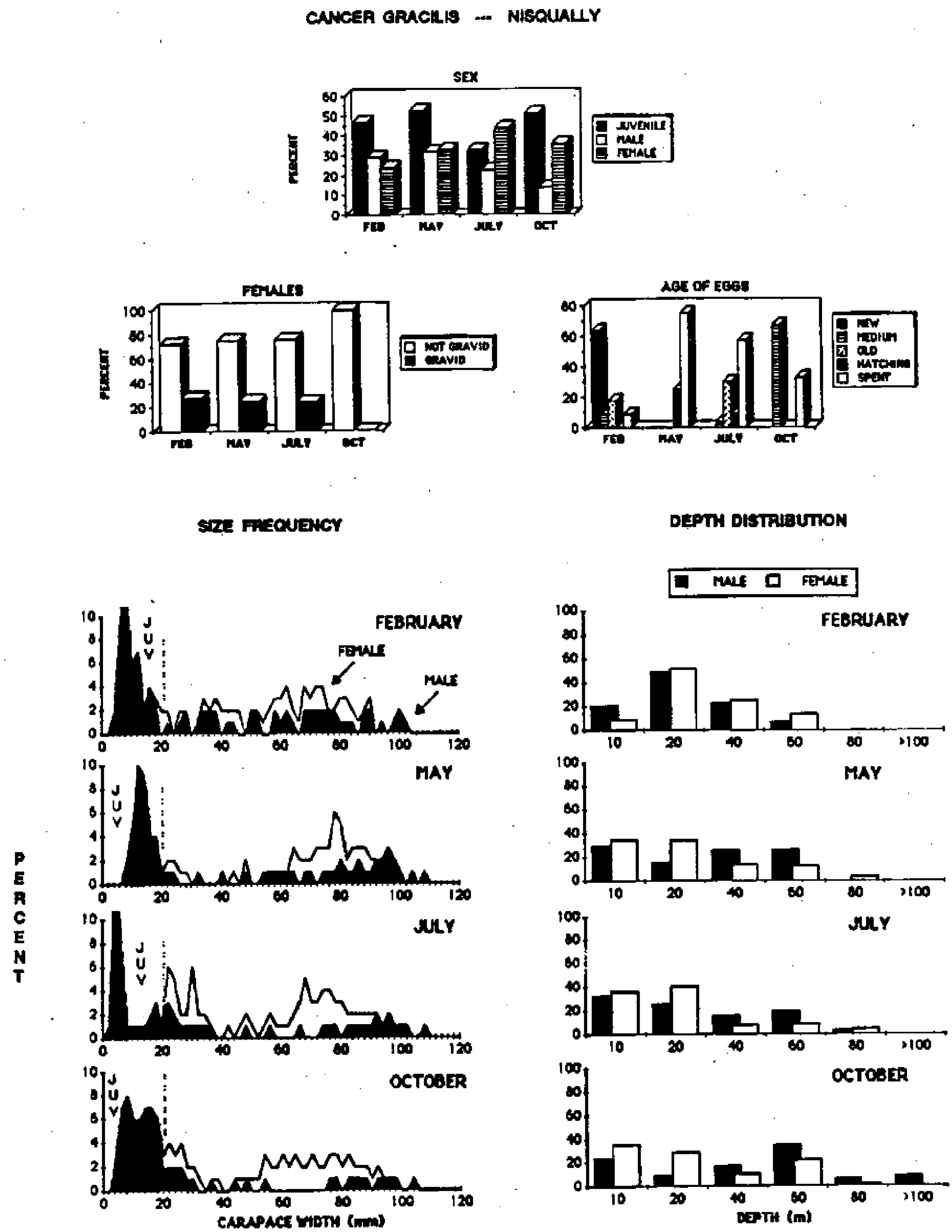

Figure 14. Summary of *Cancer gracilis* depth distribution, size frequency, sex composition, female reproductive condition and egg age in the Nisqually region during four seasons of 1987.

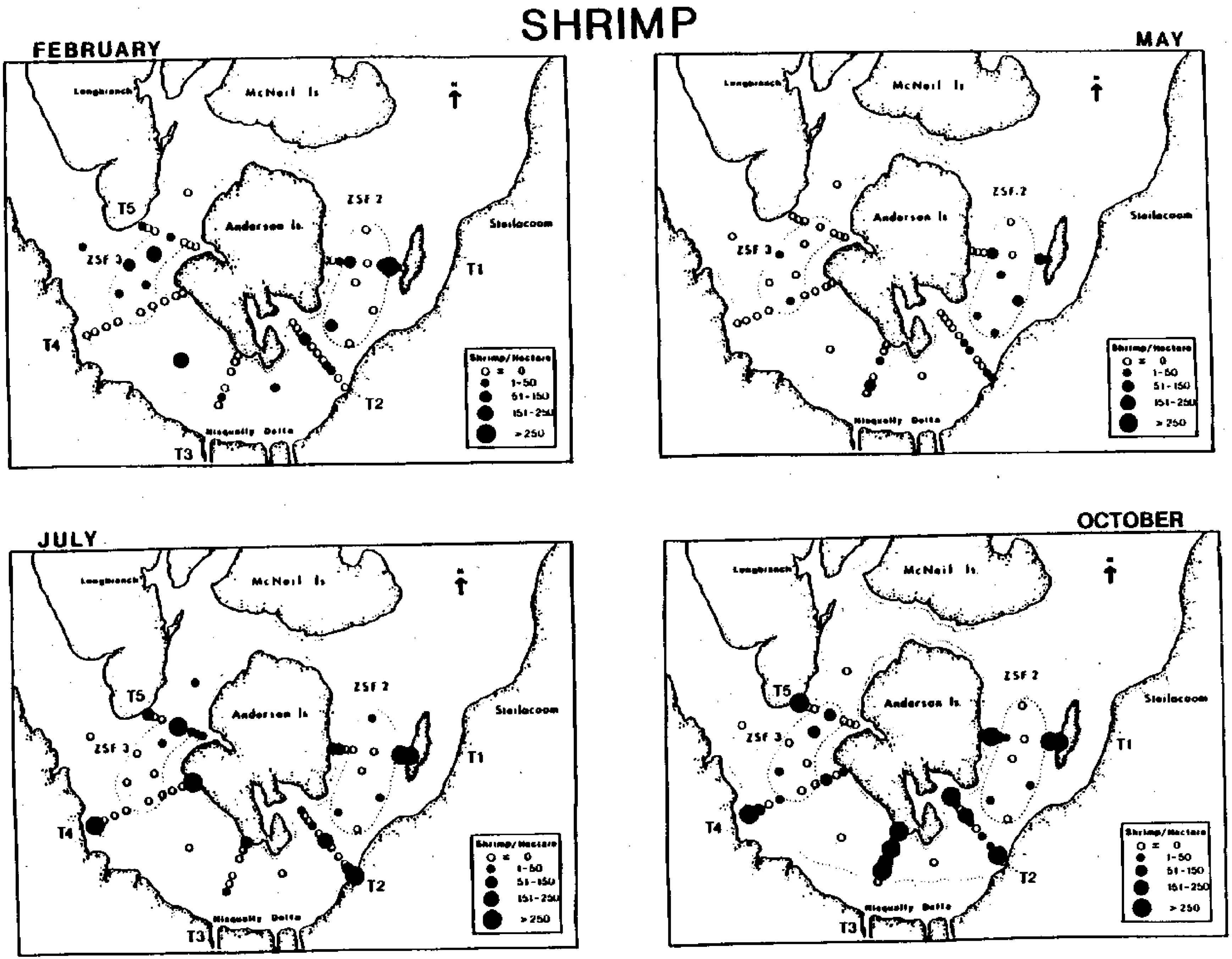

Figure 15. Maps of the Nisqually region showing the densities of commercial pandalid shrimp as estimated from beam trawl catches in February, May, July and October 1987.

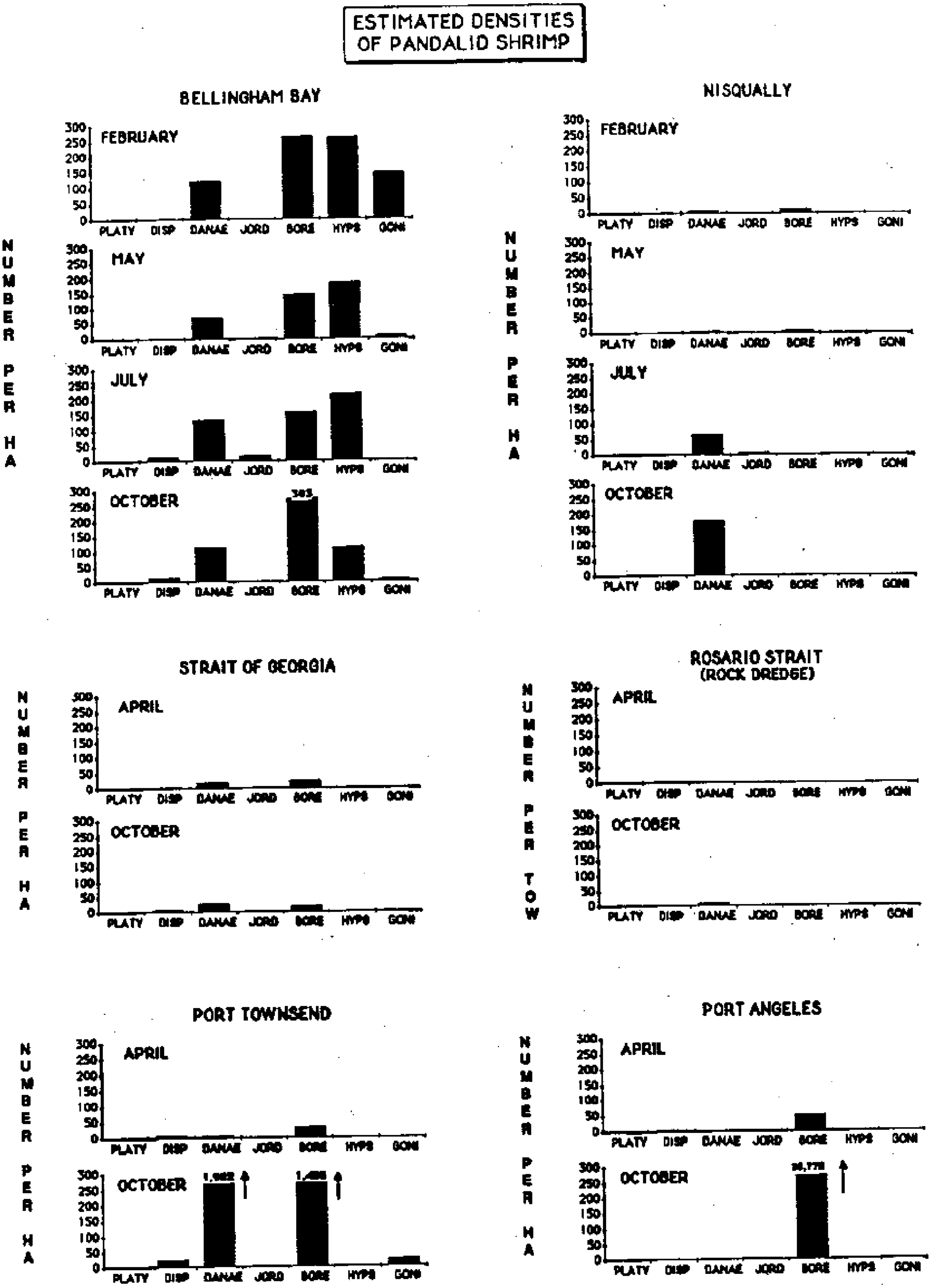

Figure 16. Summary of estimated average densities (#/ha) of pandalid shrimp by area, by season and by species based on the beam trawl catches (except #/tow for the rock dredge used in Rosario Strait).

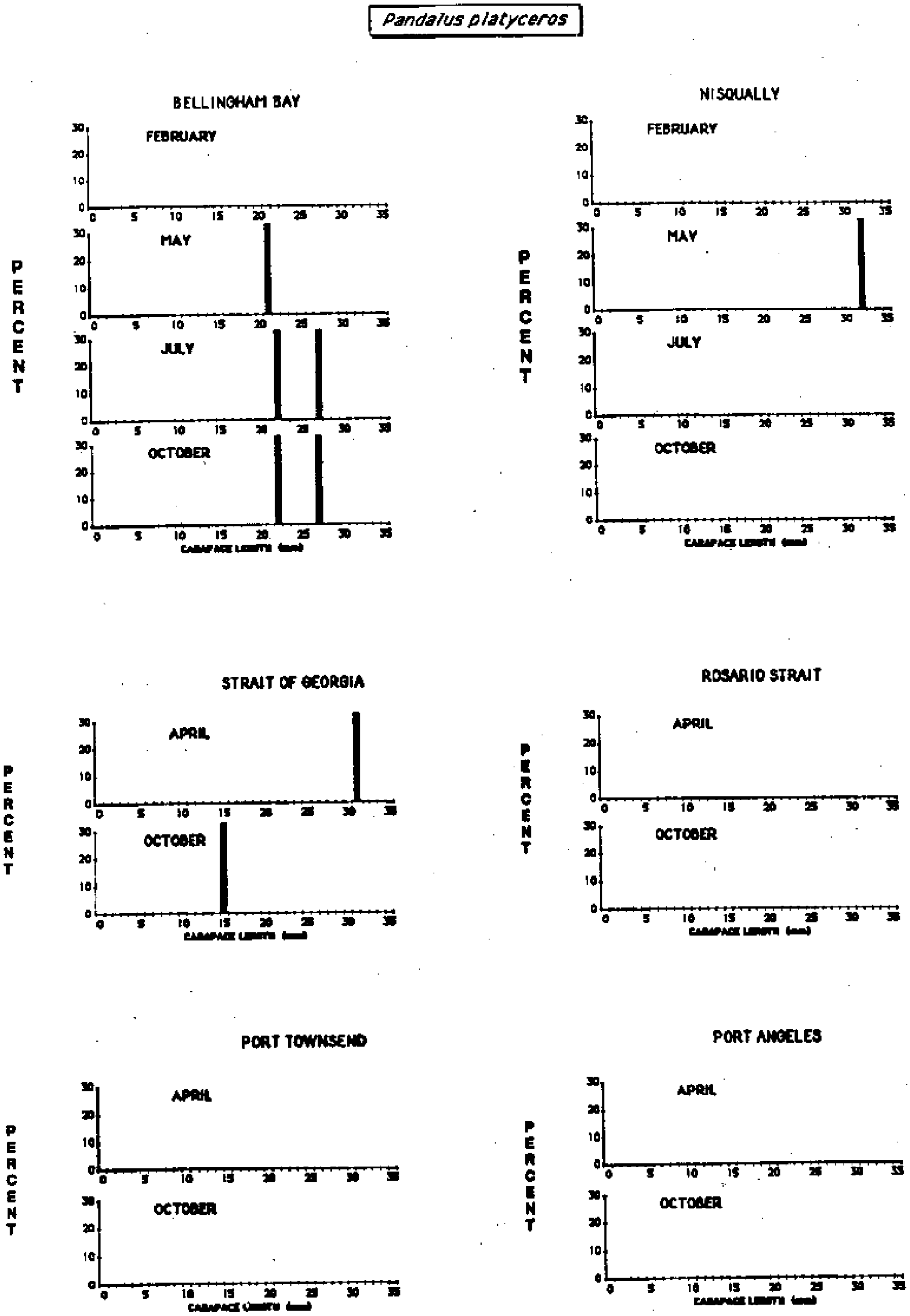

Figure 17. Size frequency distributions for spot prawn, *Pandalus platyceros*, caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season for 1987.

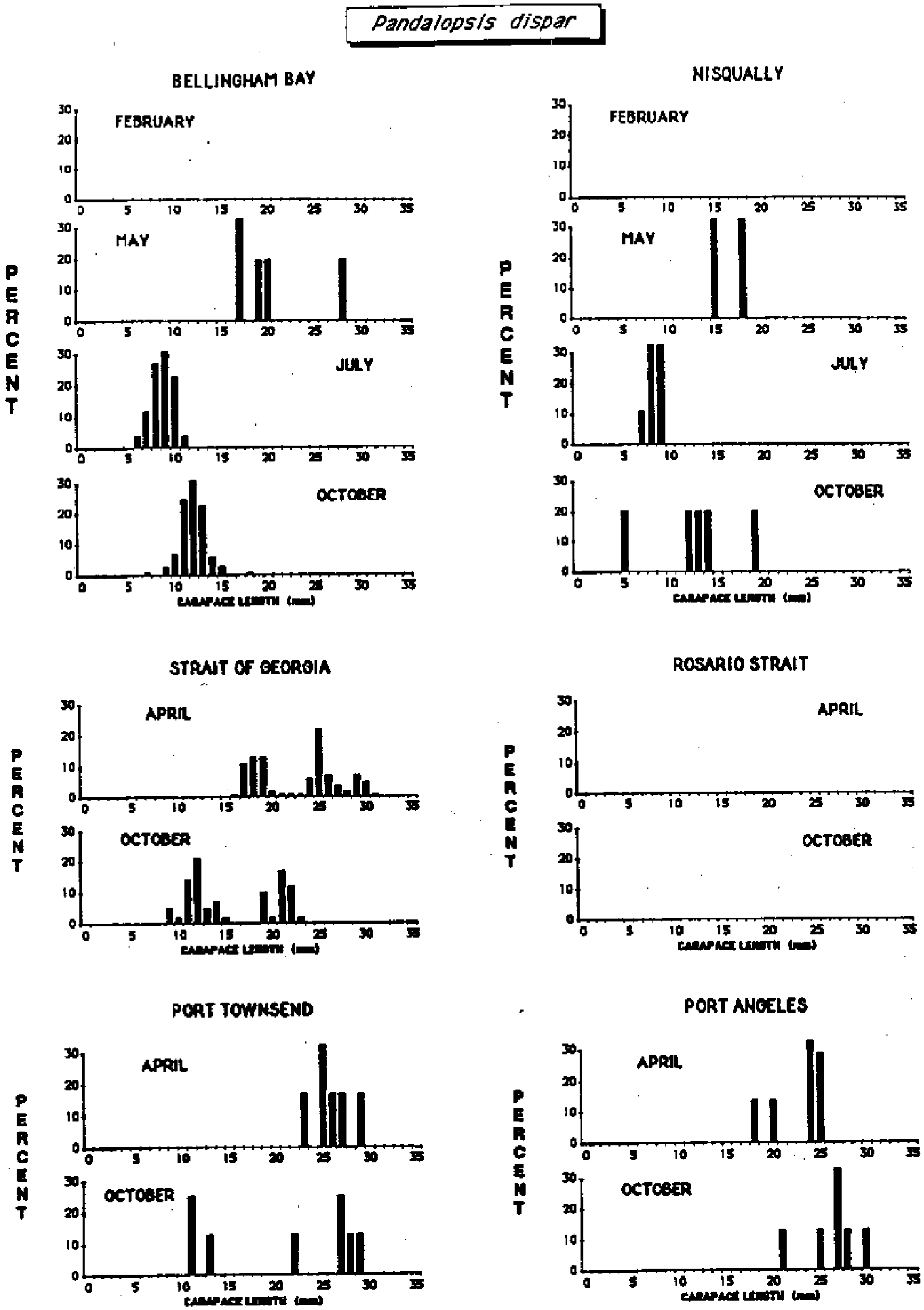

Figure 18. Size frequency distributions for sidestripe shrimp, *Pandalopsis dispar*, caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season for 1987.

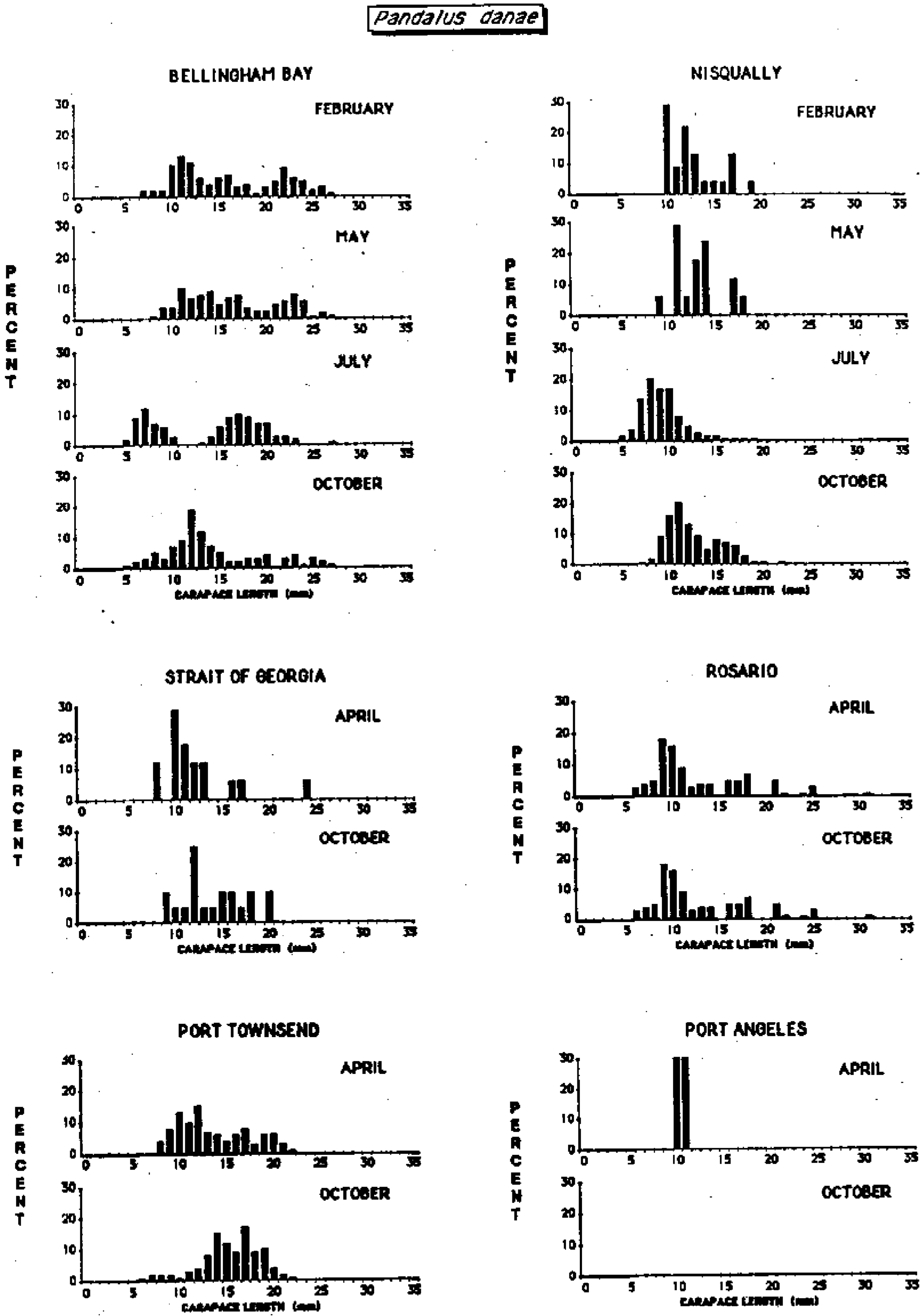

Figure 19. Size frequency distributions for coonstripe shrimp, *Pandalus danae*, caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season for 1987.

Pandalus jordani

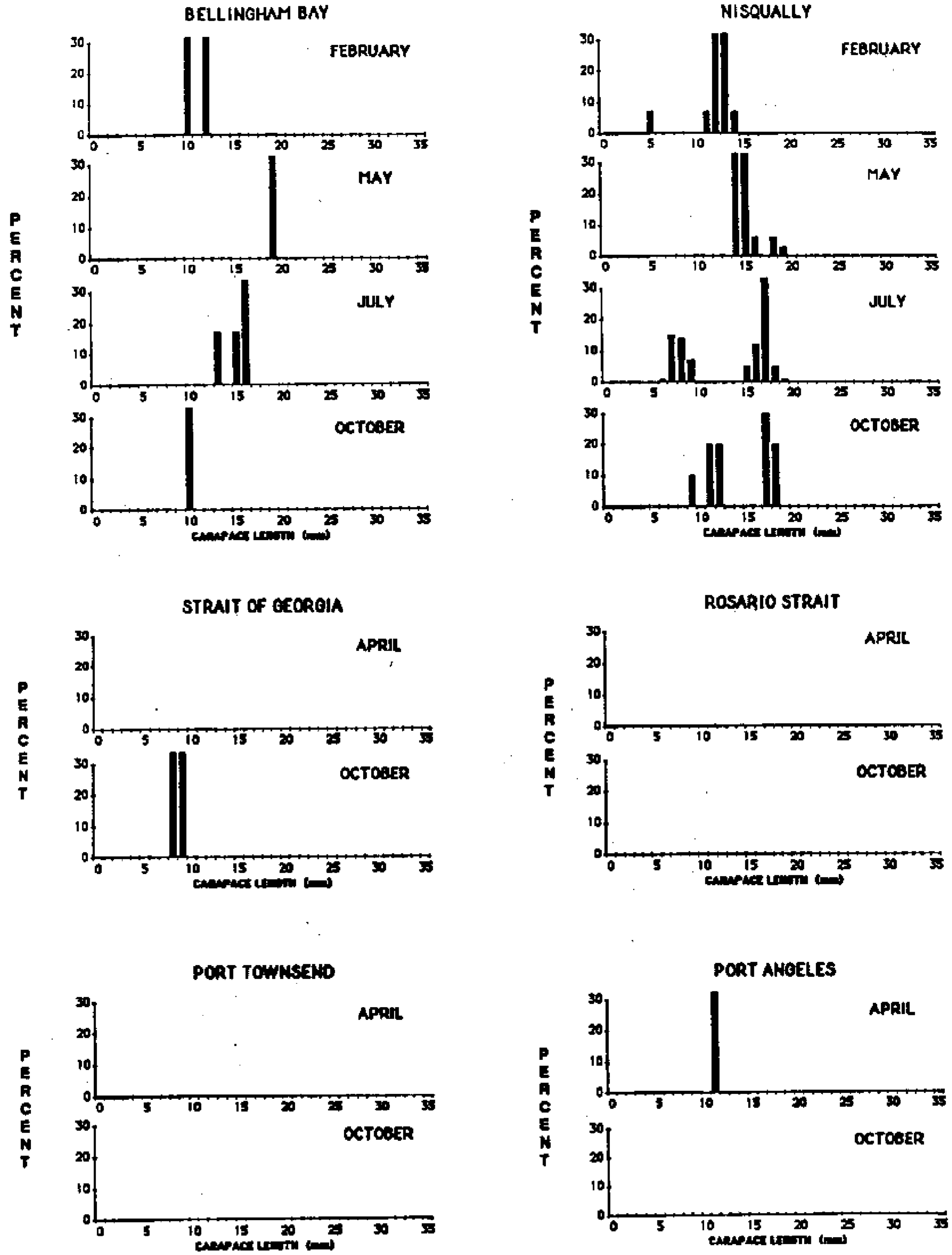

Figure 20. Size frequency distributions for the pink shrimp, *Pandalus jordani*, caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season in 1987.

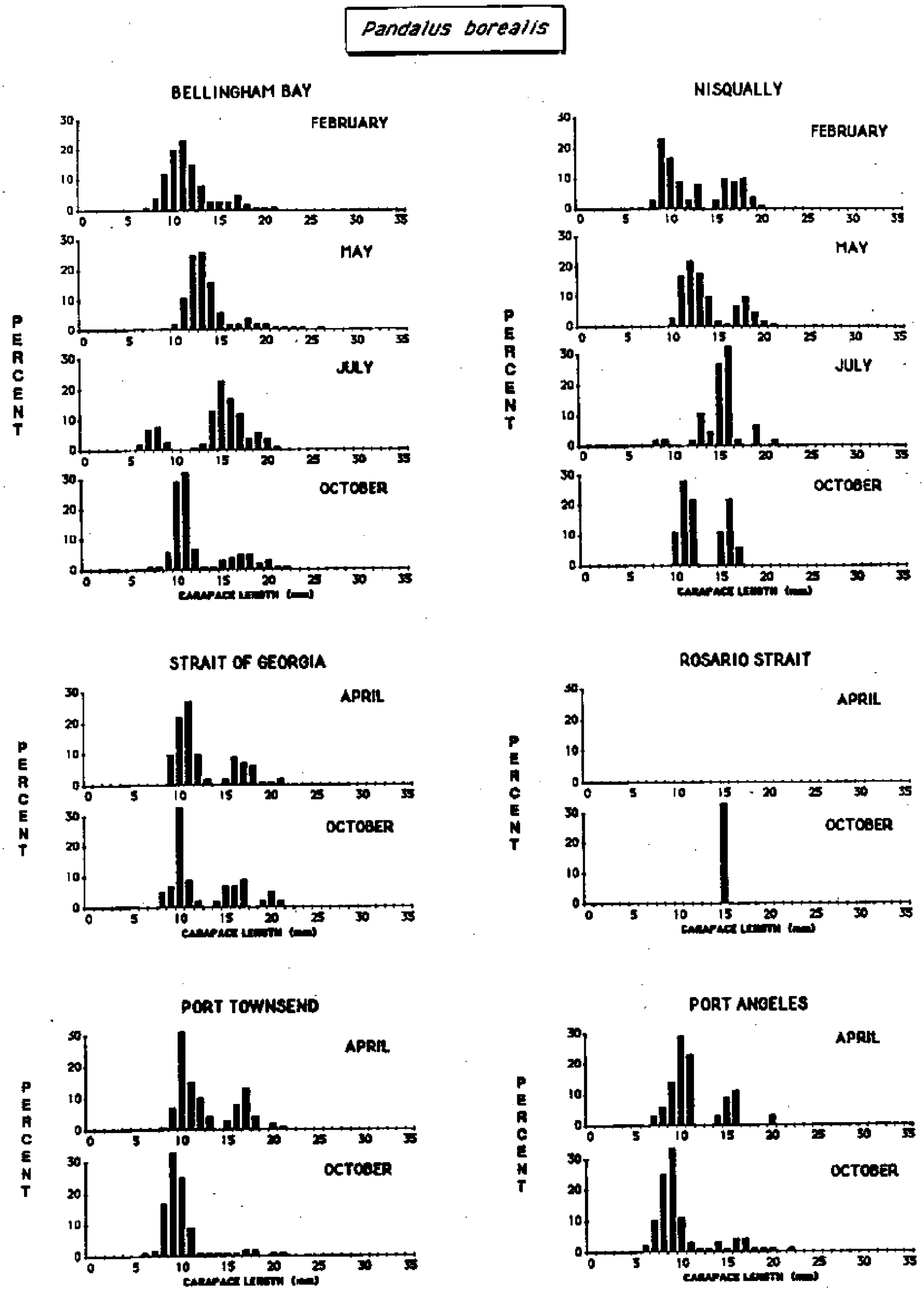

Figure 21. Size frequency distributions for the pink shrimp, *Pandalus borealis,* caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season in 1987.

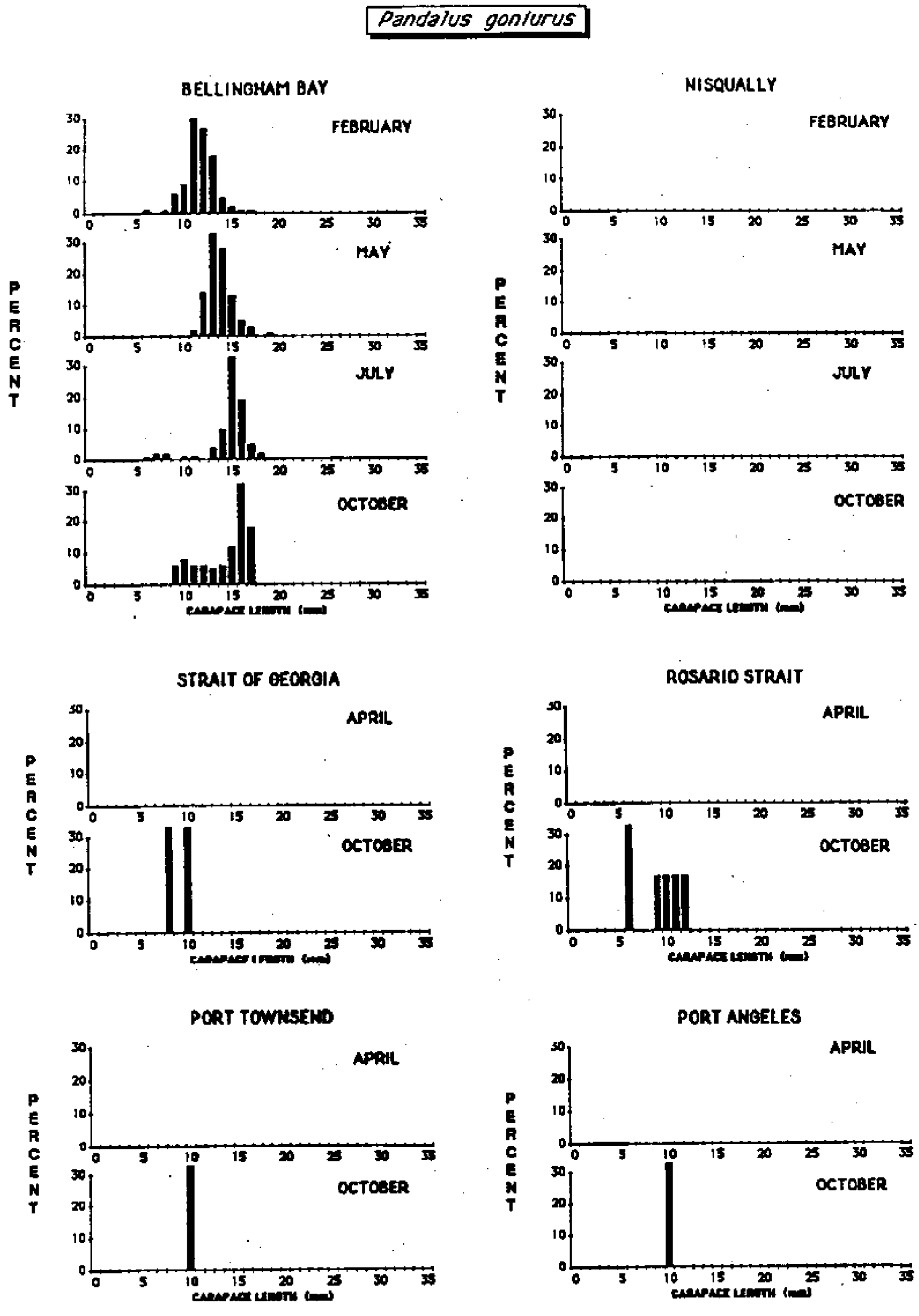

Figure 22. Size frequency distributions for *Pandalus gonlurus* caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season in 1987.

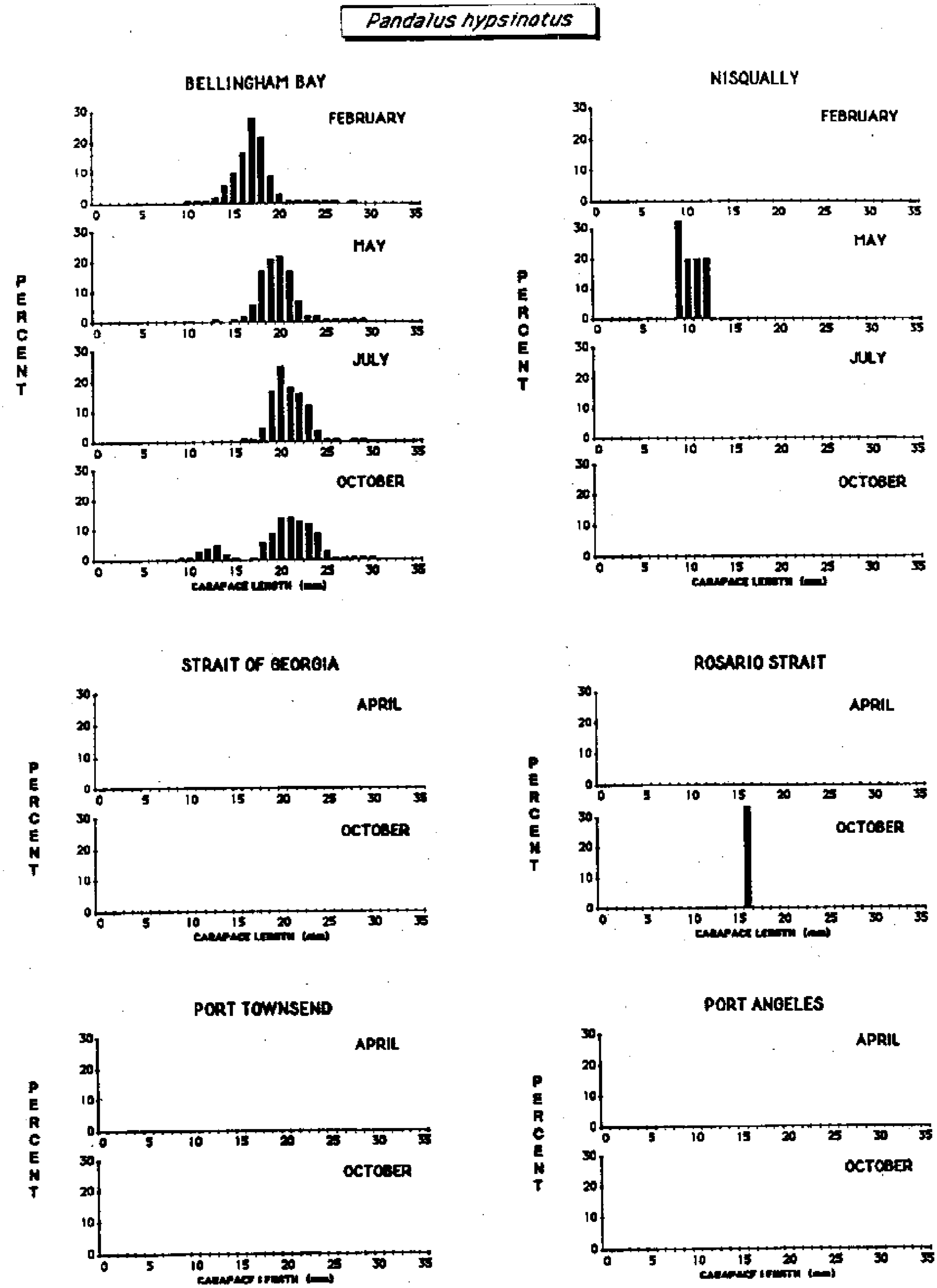

Figure 23. Size frequency distributions for humpback shrimp, *Pandalus hypsinotus*, caught by both beam and otter trawls combined (except rock dredge in Rosario Strait) by area and by season in 1987.

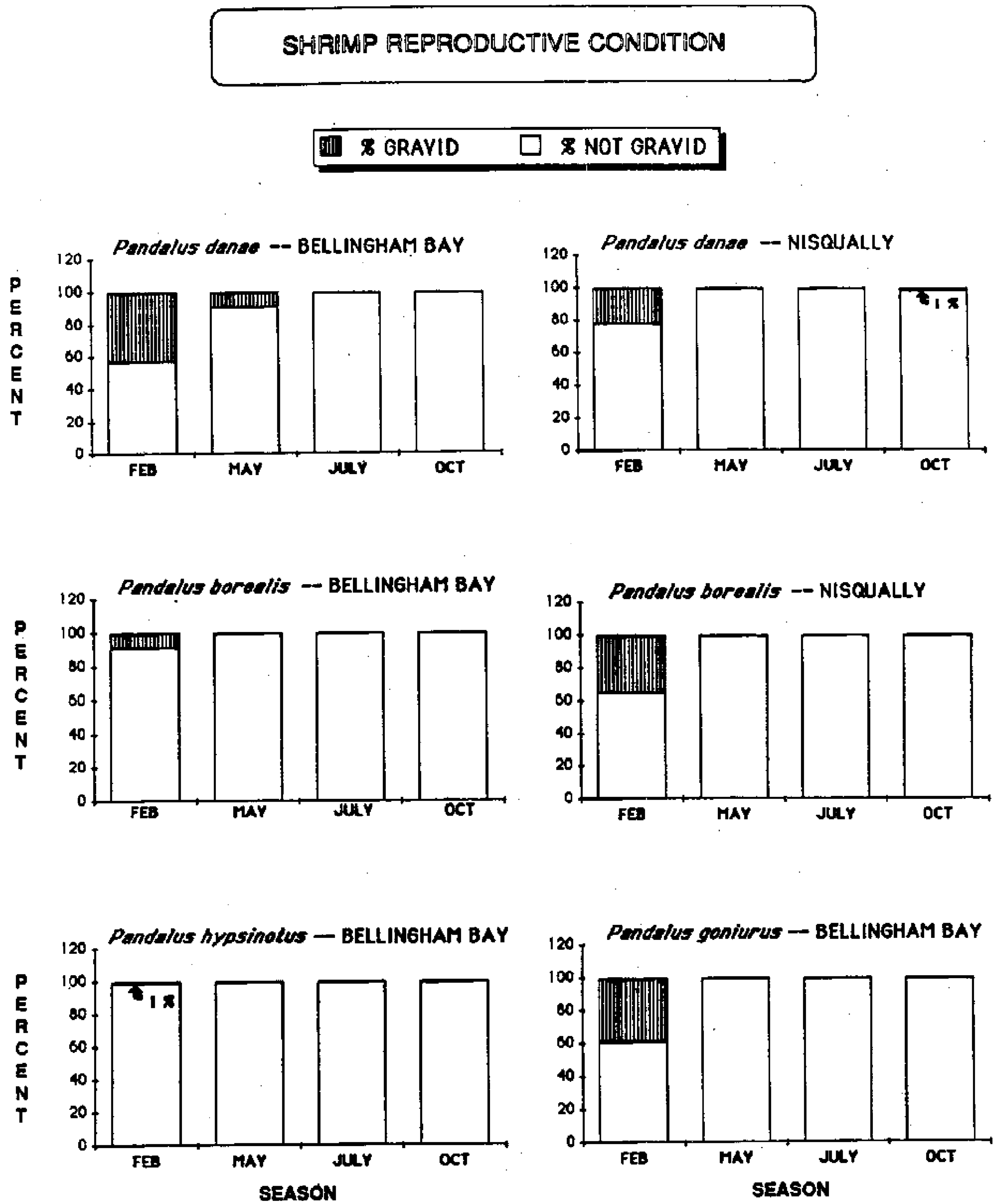

Figure 24. Selected shrimp reproductive conditions by area, by season and by species.

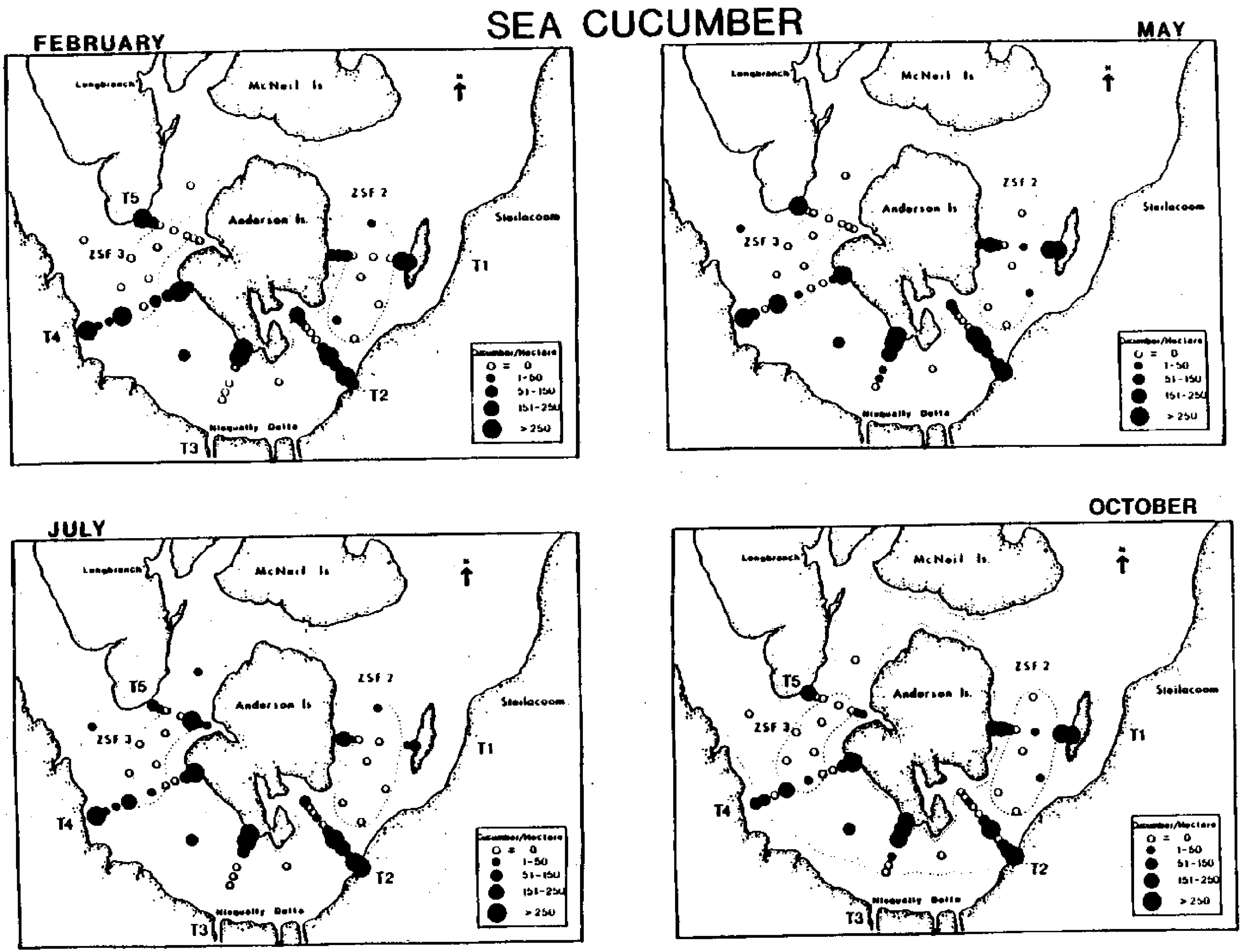

Figure 25. Maps of the Nisqually region showing sea cucumber densities as estimated from beam trawl catches in February, May, July and October 1987.

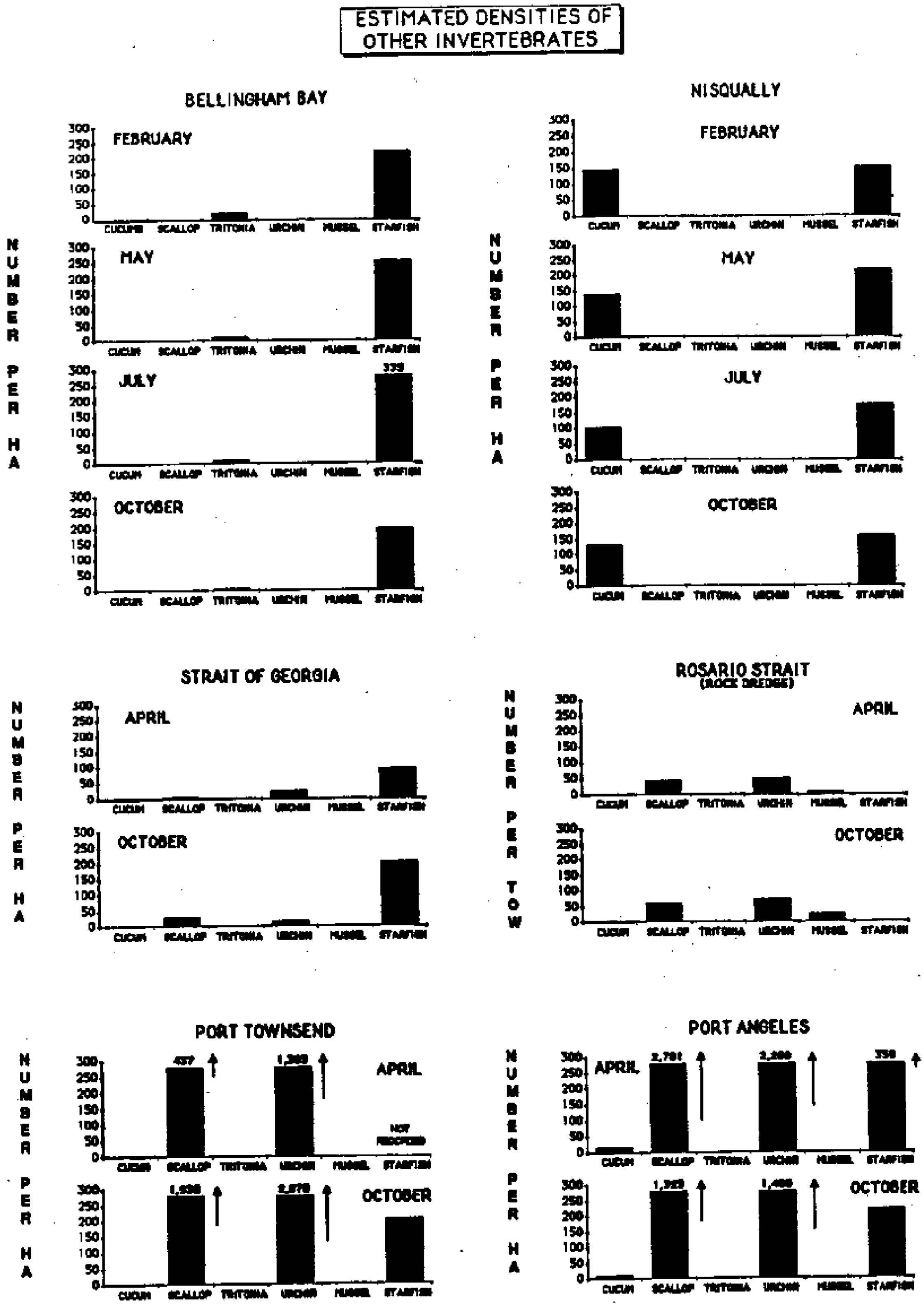

Figure 26. Estimated average densities (#/ha) of various invertebrate species caught by beam trawl (except #/tow for rock dredge in Rosario Strait) in 1987 by area, by season and by faunal group.

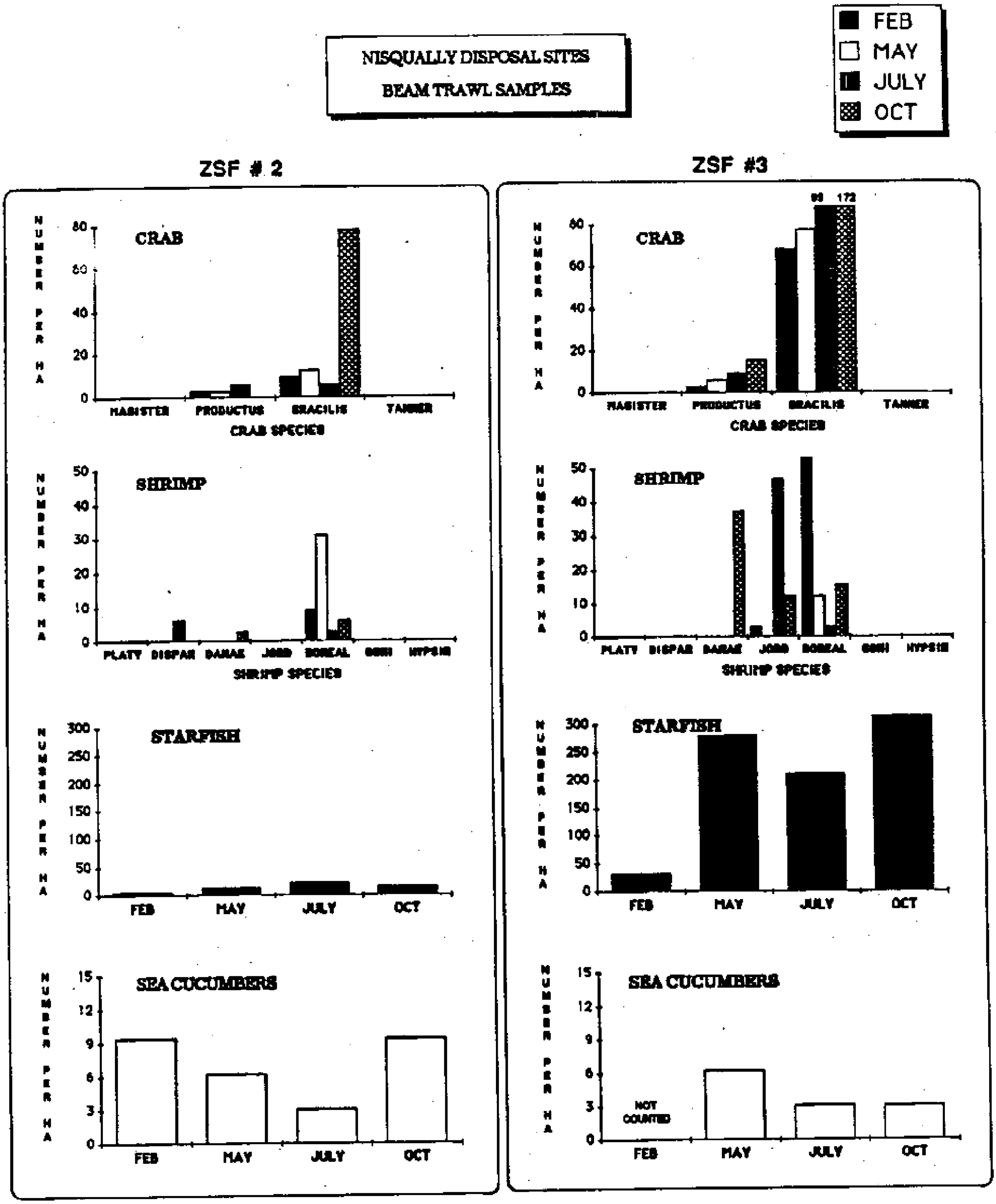

Figure 27. Comparison of average beam trawl catches (estimated #/ha) by species and by season between Nisqually ZSF 2 and ZSF 3.

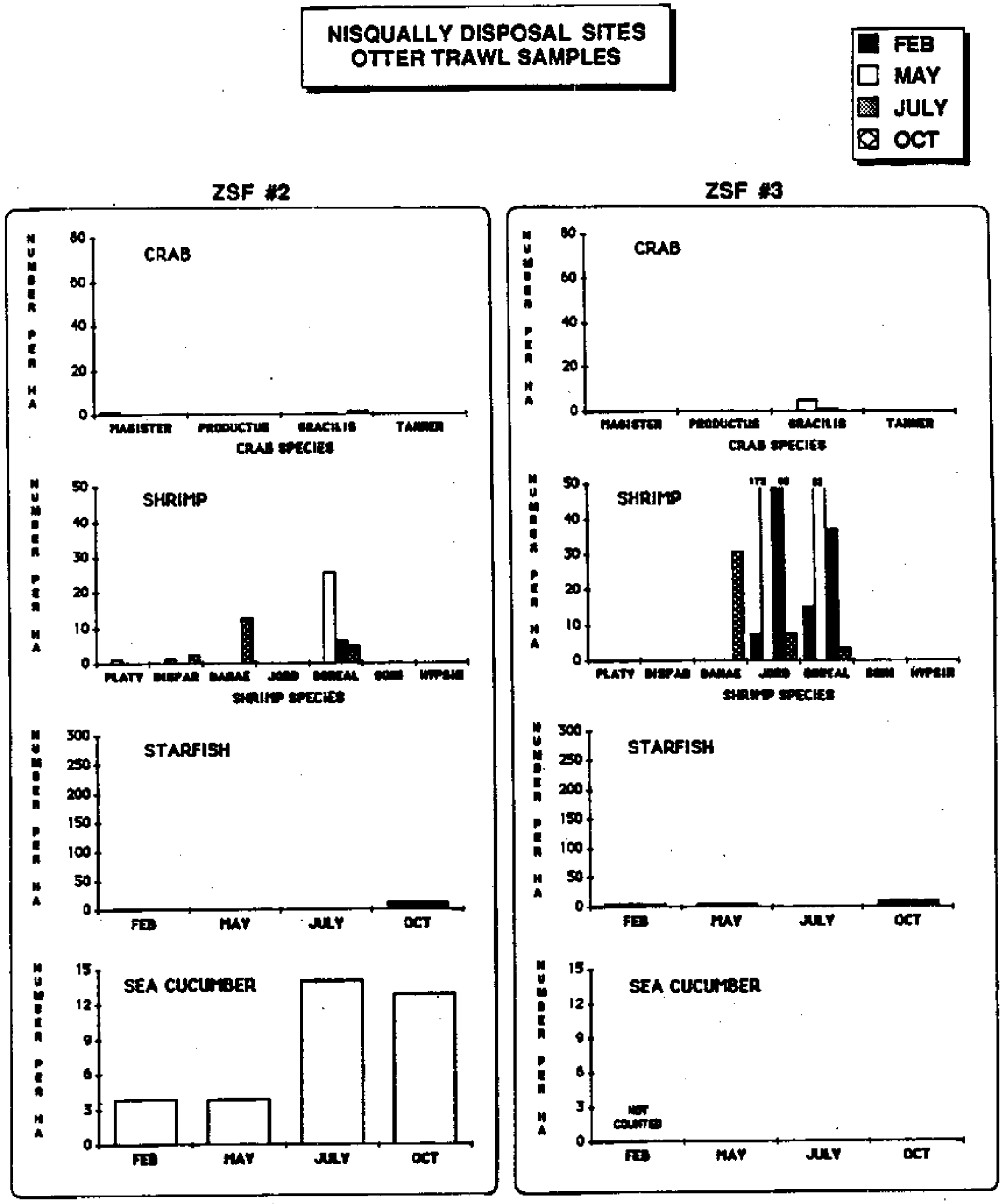

Figure 28. Comparison of average otter trawl catches (estimated #/ha) by species and by season between Nisqually ZSF 2 and ZSF 3.

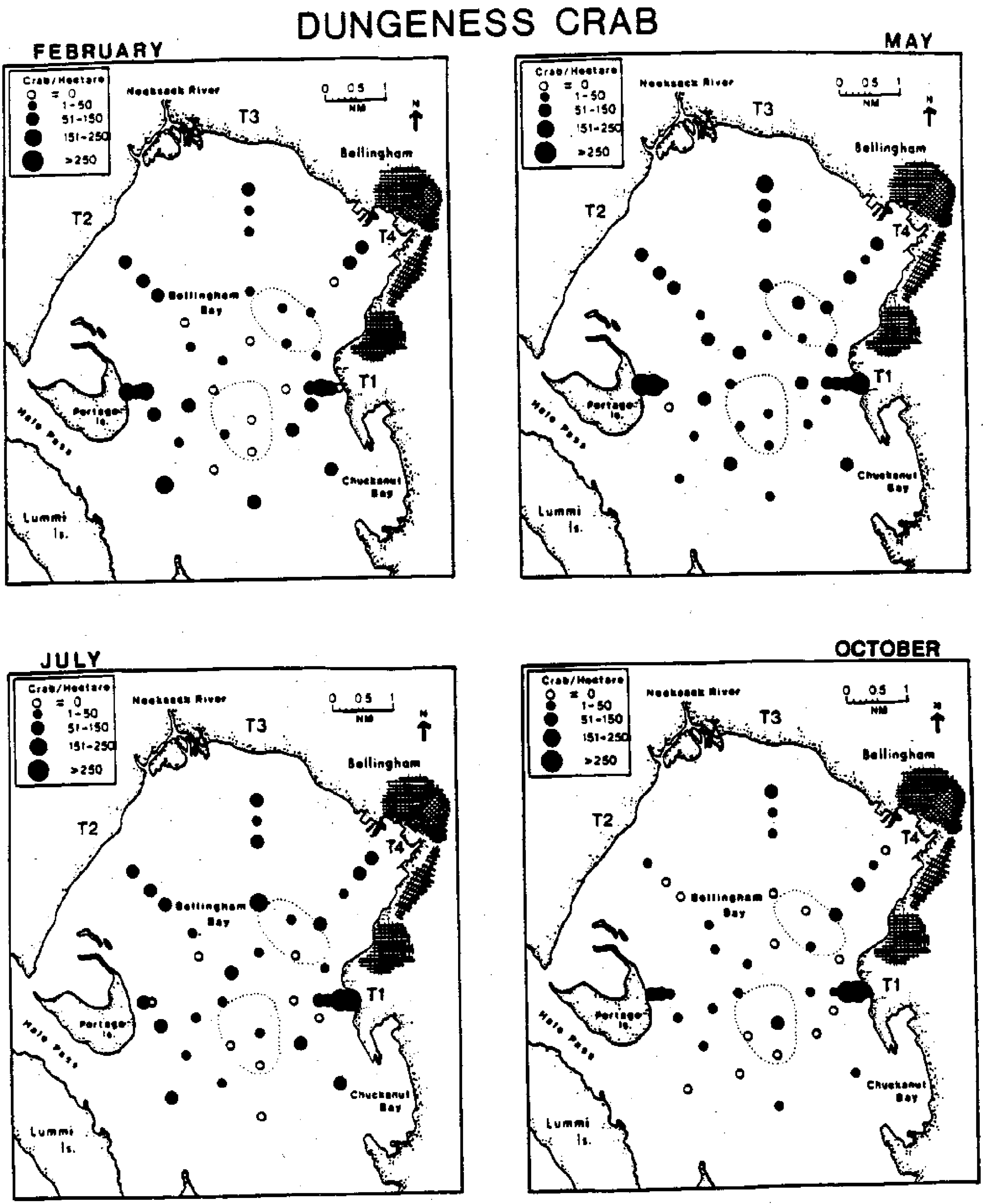

Figure 29. Maps of Bellingham Bay showing Dungeness crab densities as estimated from beam trawl catches in February, May, July and October 1987.

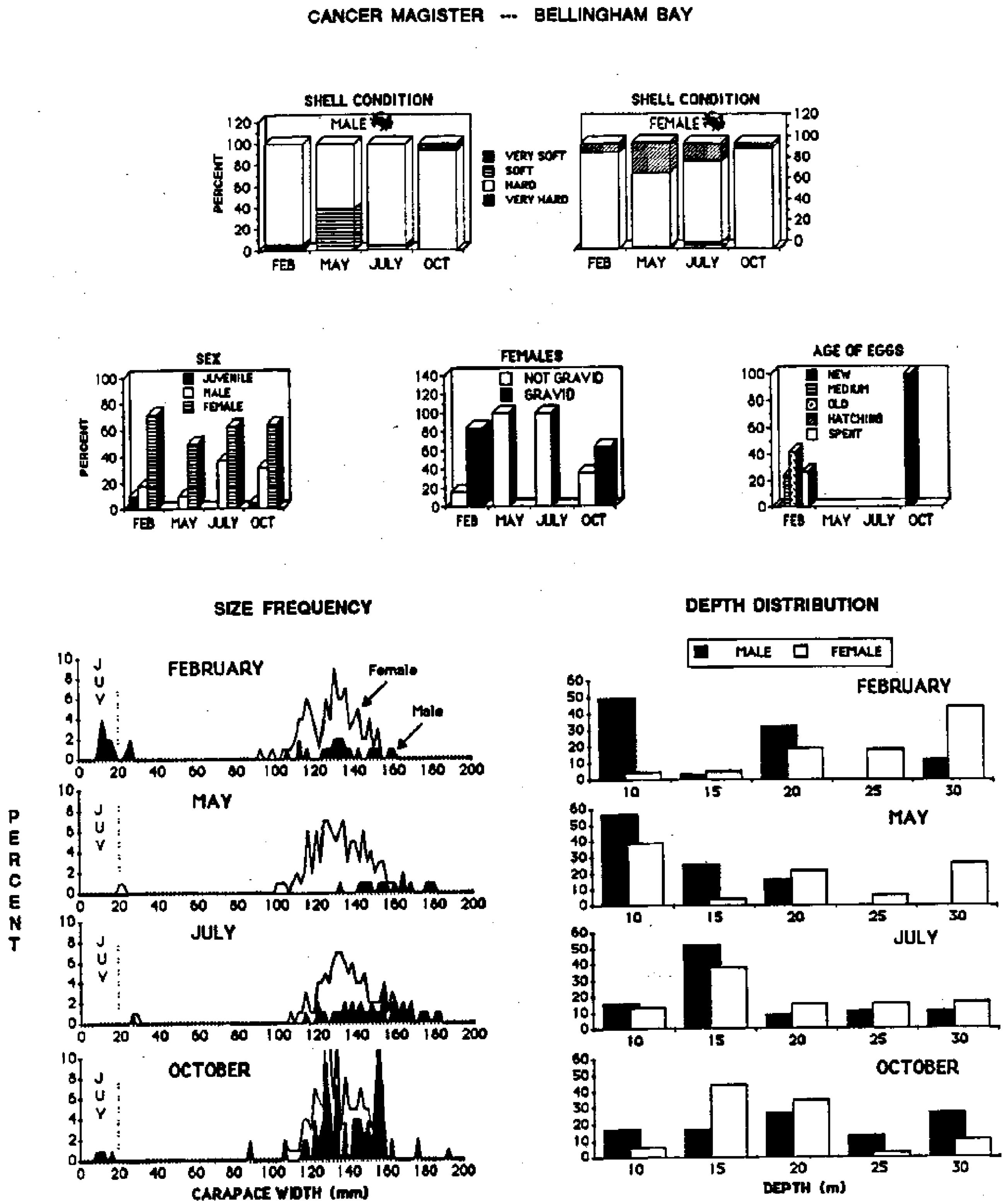

Figure 30. Summary of Dungeness crab depth distribution, size frequency, shell condition sex composition, female reproductive condition and egg age in Bellingham Bay during four seasons of 1987.

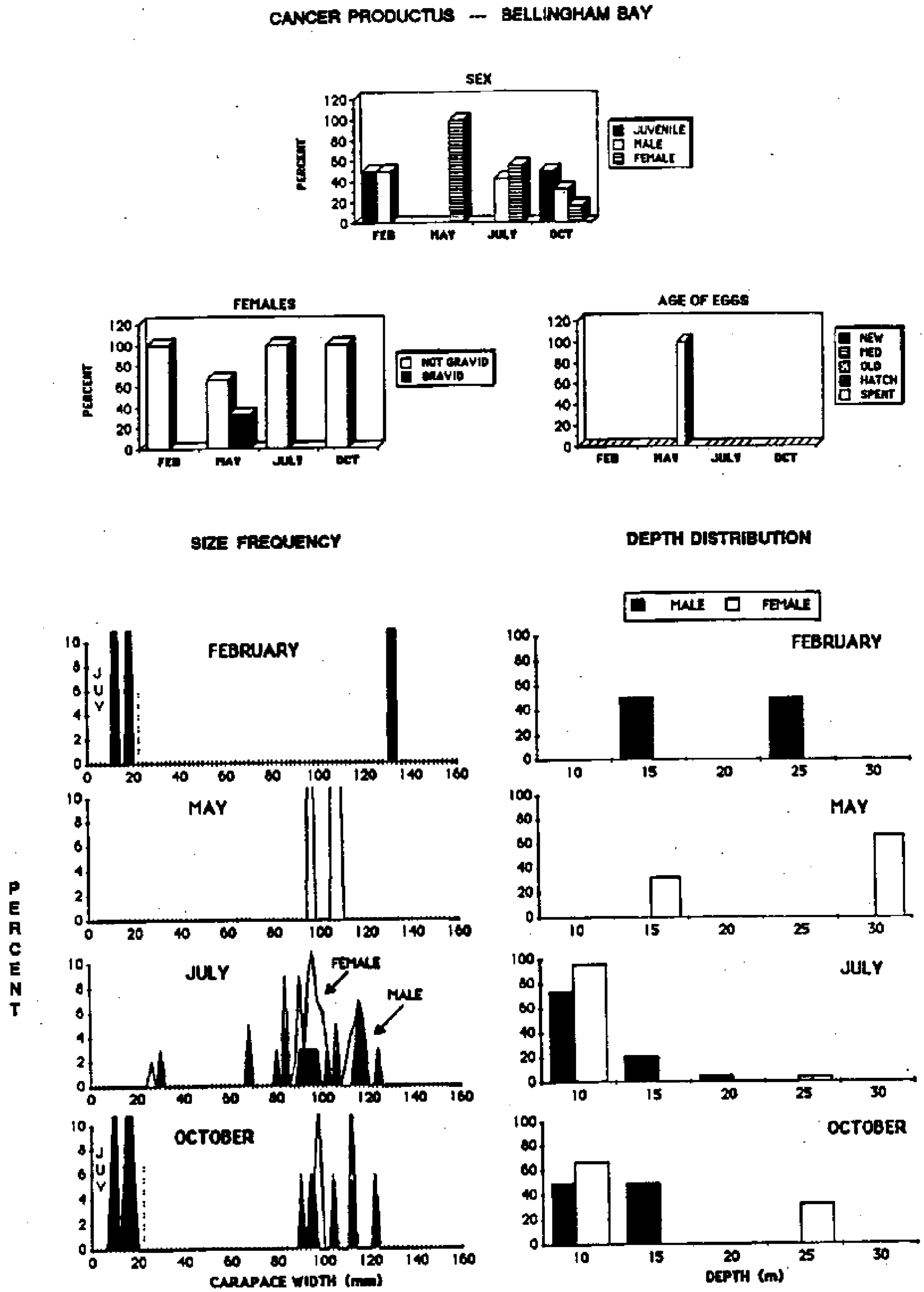

Figure 31. Summary of *Cancer productus* depth distribution, size frequency, sex composition, female reproductive condition and egg age in Bellingham Bay during four seasons of 1987.

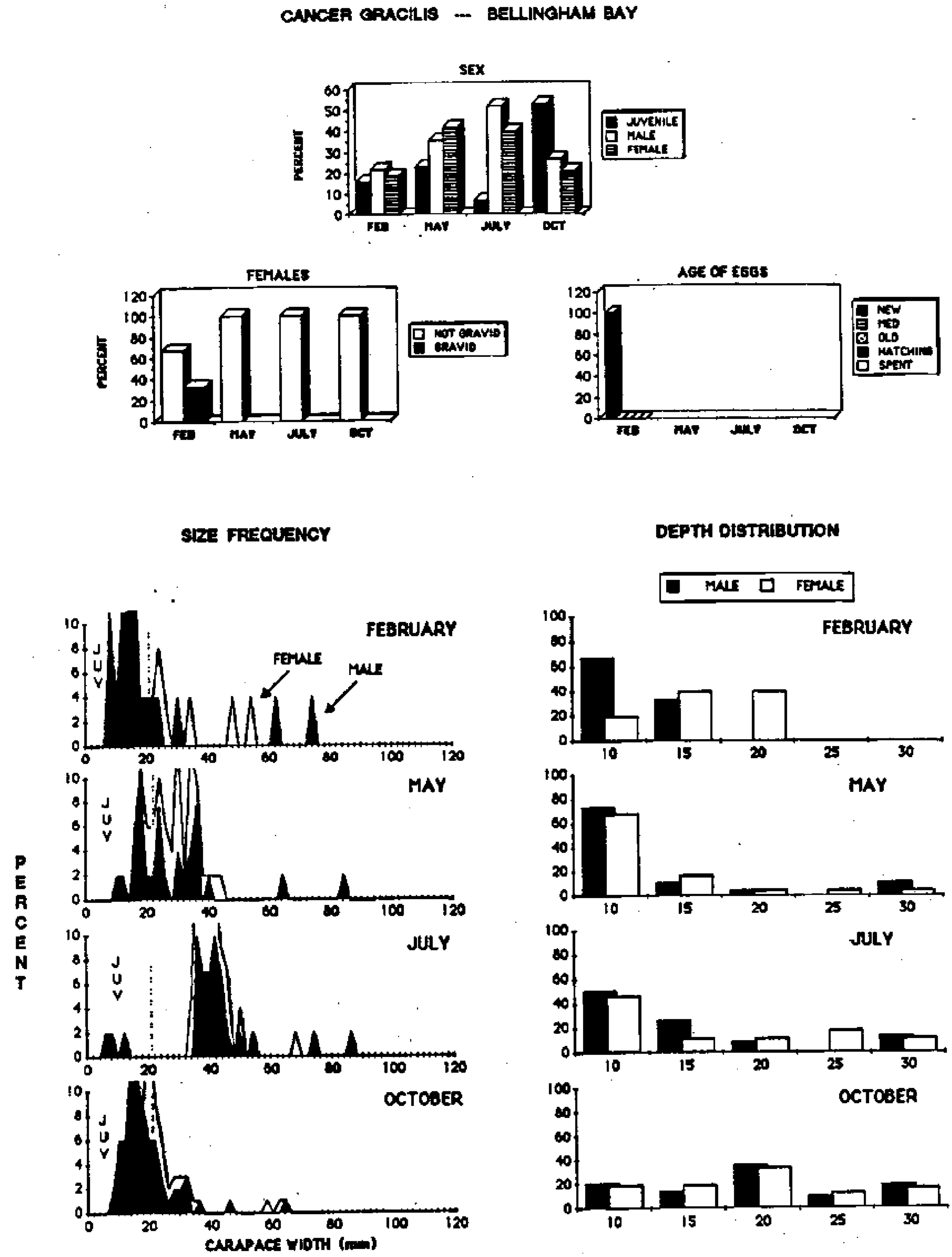

Figure 32. Summary of *Cancer gracilis* depth distribution, size frequency, sex composition, female reproductive condition and egg age in Bellingham Bay during four seasons in 1987.

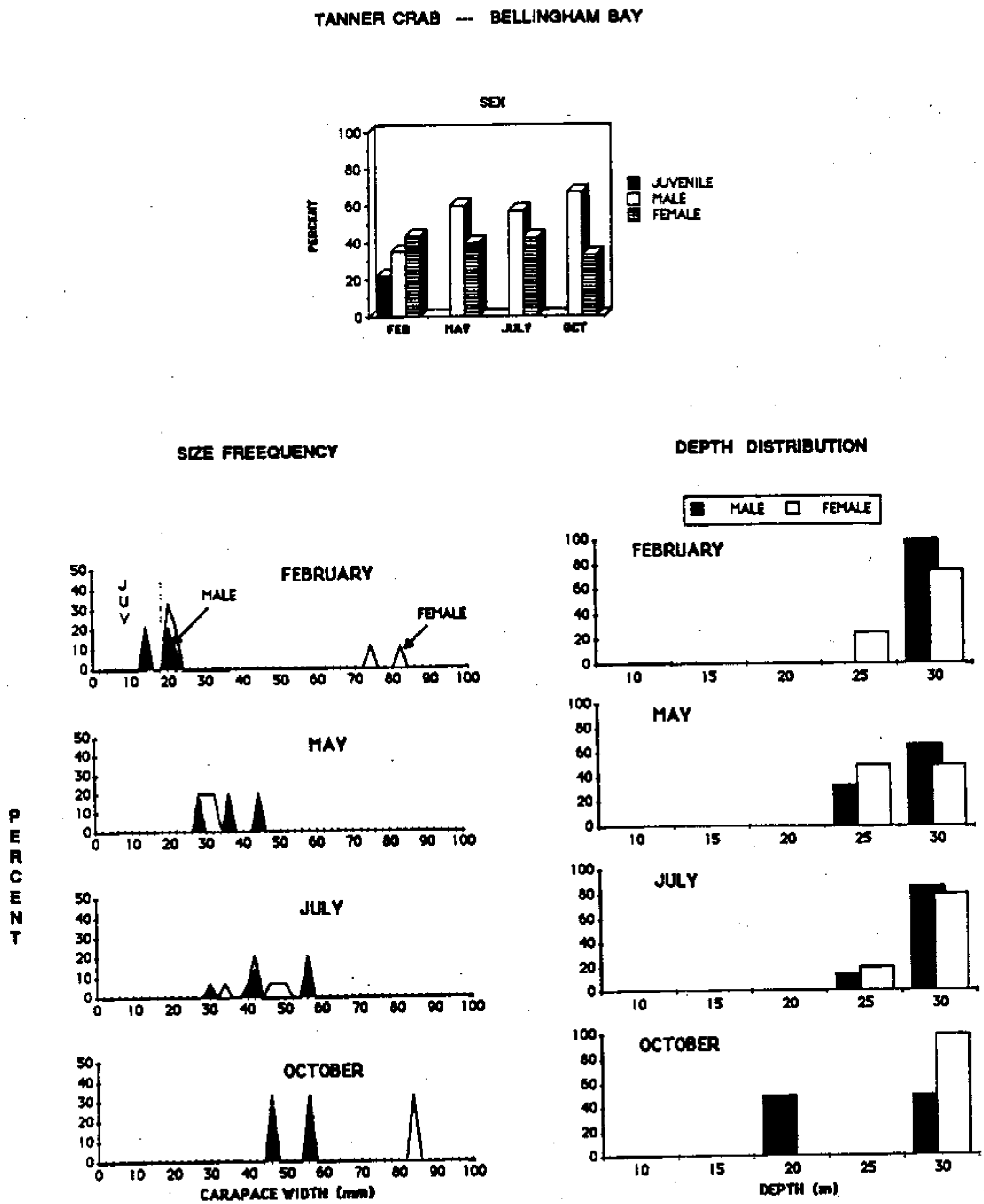

Figure 33. Summary of tanner crab, *Chionoecetes bairdi*, depth distribution, size frequency and sex composition in Bellingham Bay during four seasons of 1987.

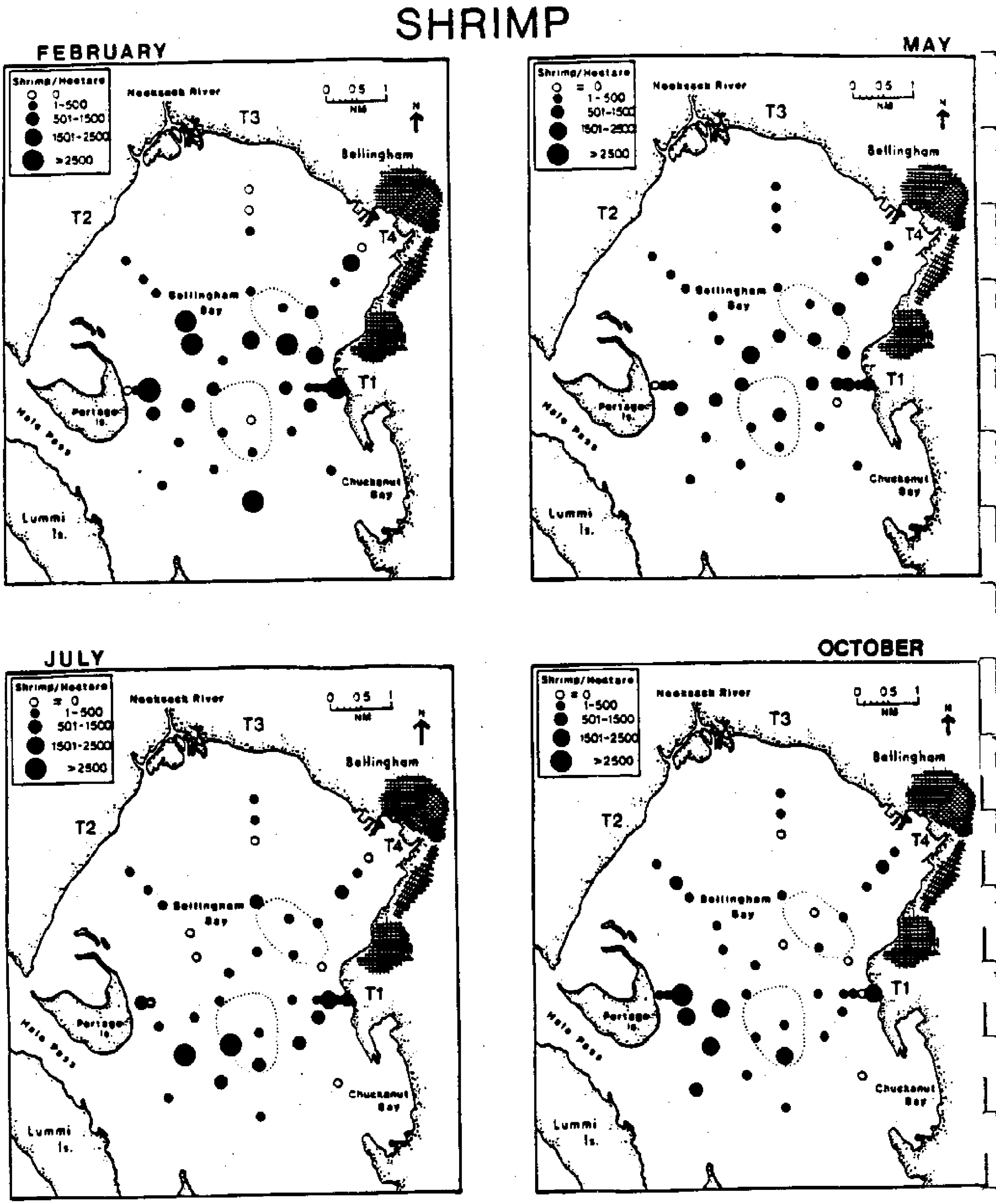

Figure 34: Maps of Bellingham Bay showing the densities of commercial pandalid shrimp as estimated from beam trawl catches in February, May, July and October 1987.

TRITONIA

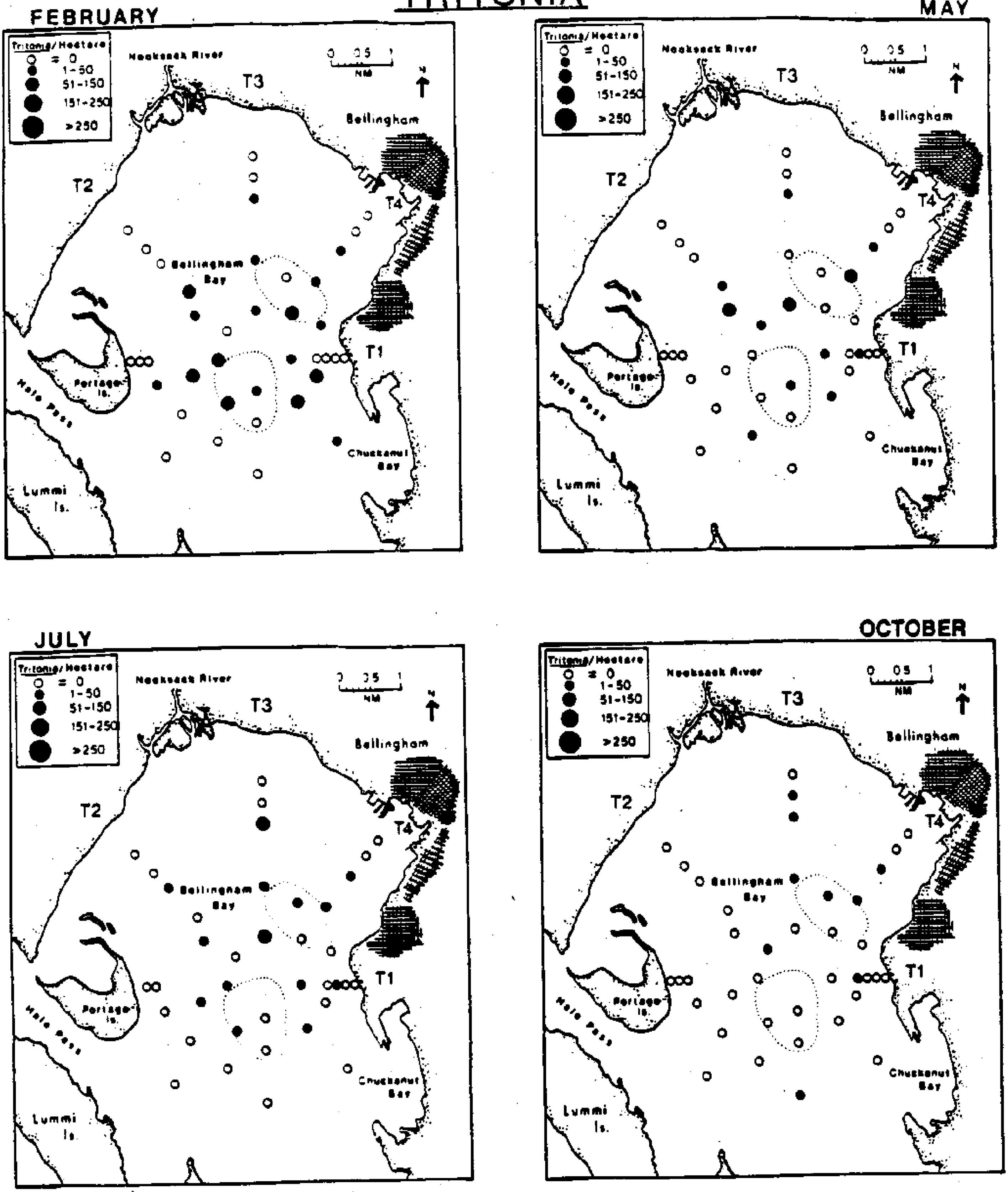

Figure 35. Maps of Bellingham Bay showing desities of the nudibranch Tritonia diomedea as estimated from beam trawl catches in February, May, July and October 1987.

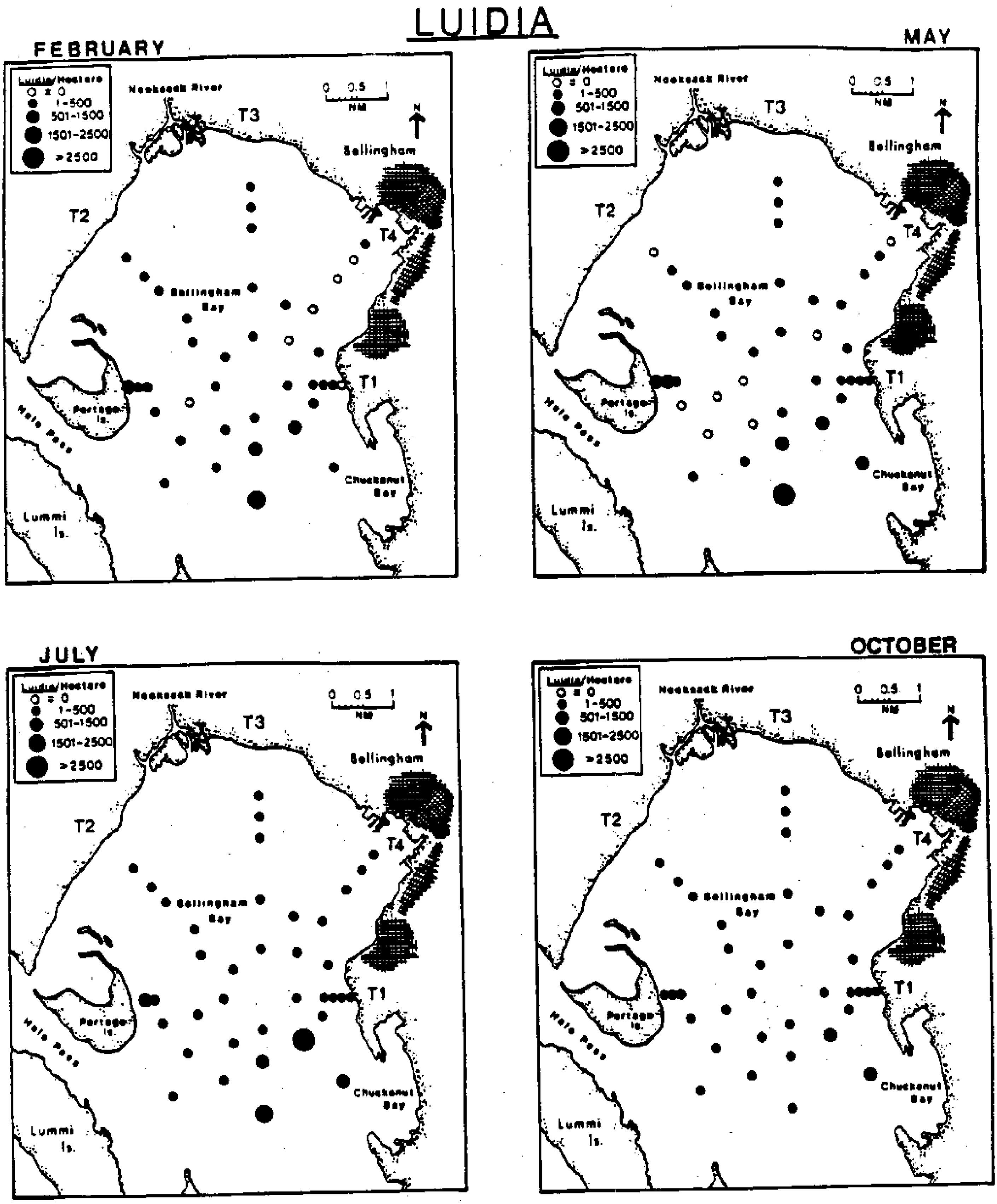

Figure 36. Maps of Bellingham Bay showing densities of the starfish, Luidea foliolata, as estimated from beam trawl catches in February, May, July and October 1987.

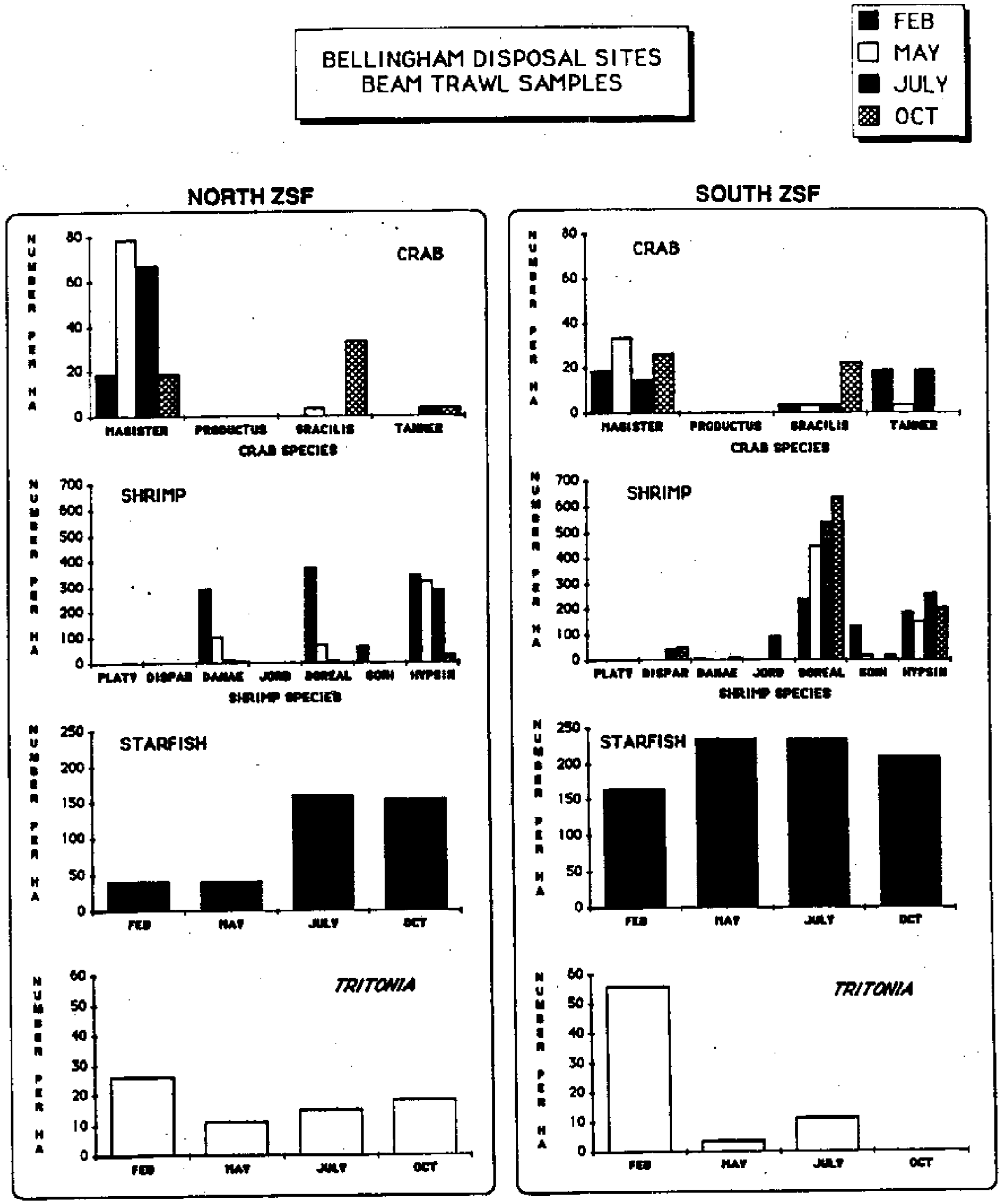

Figure 37. Comparison of average beam trawl catches (estimated #/ha) by species and by season in the North and South ZSFs in Bellingham Bay.

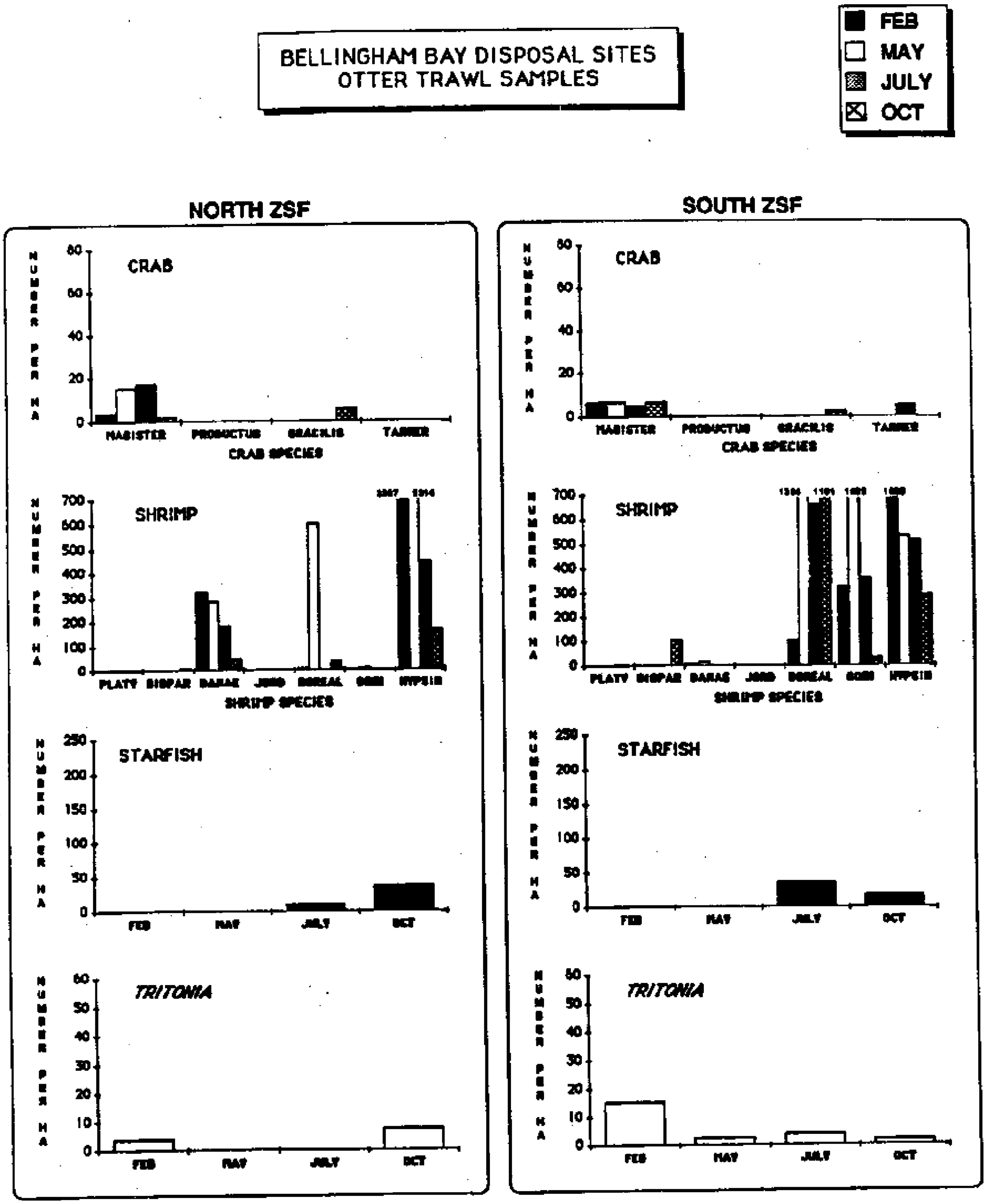

Figure 38. Comparison of average otter trawl catches (estimated #/ha) by species and by season between the North and South ZSFs in Bellingham Bay.

GEORGIA STRAIT – APRIL 1987

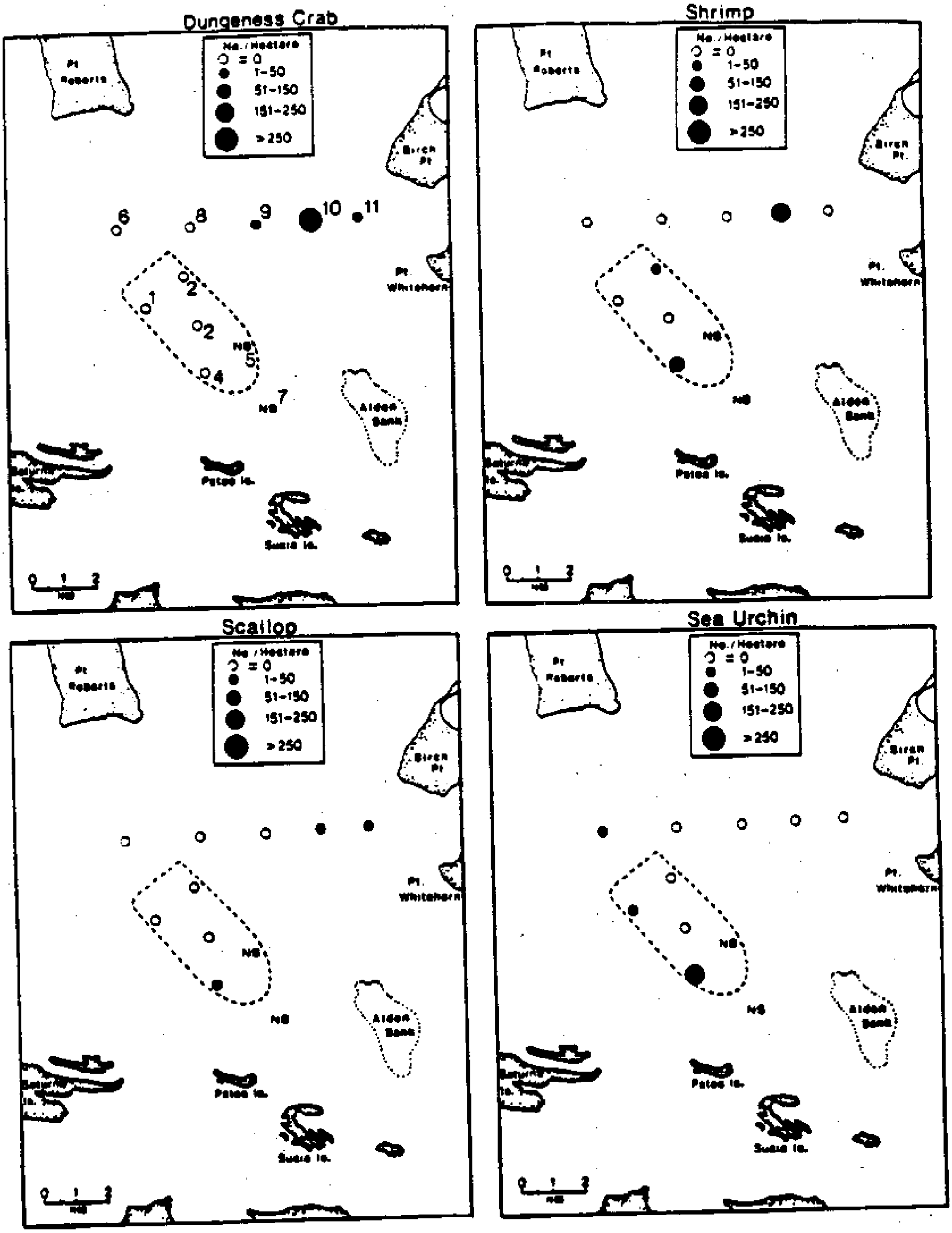

Figure 39. Maps of the southern Strait of Georgia area showing densities of Dungeness crab, commercial pandalid shrimp, scallops and sea urchins as estimated from beam trawl catches in April 1987.

GEORGIA STRAIT - OCTOBER 1987

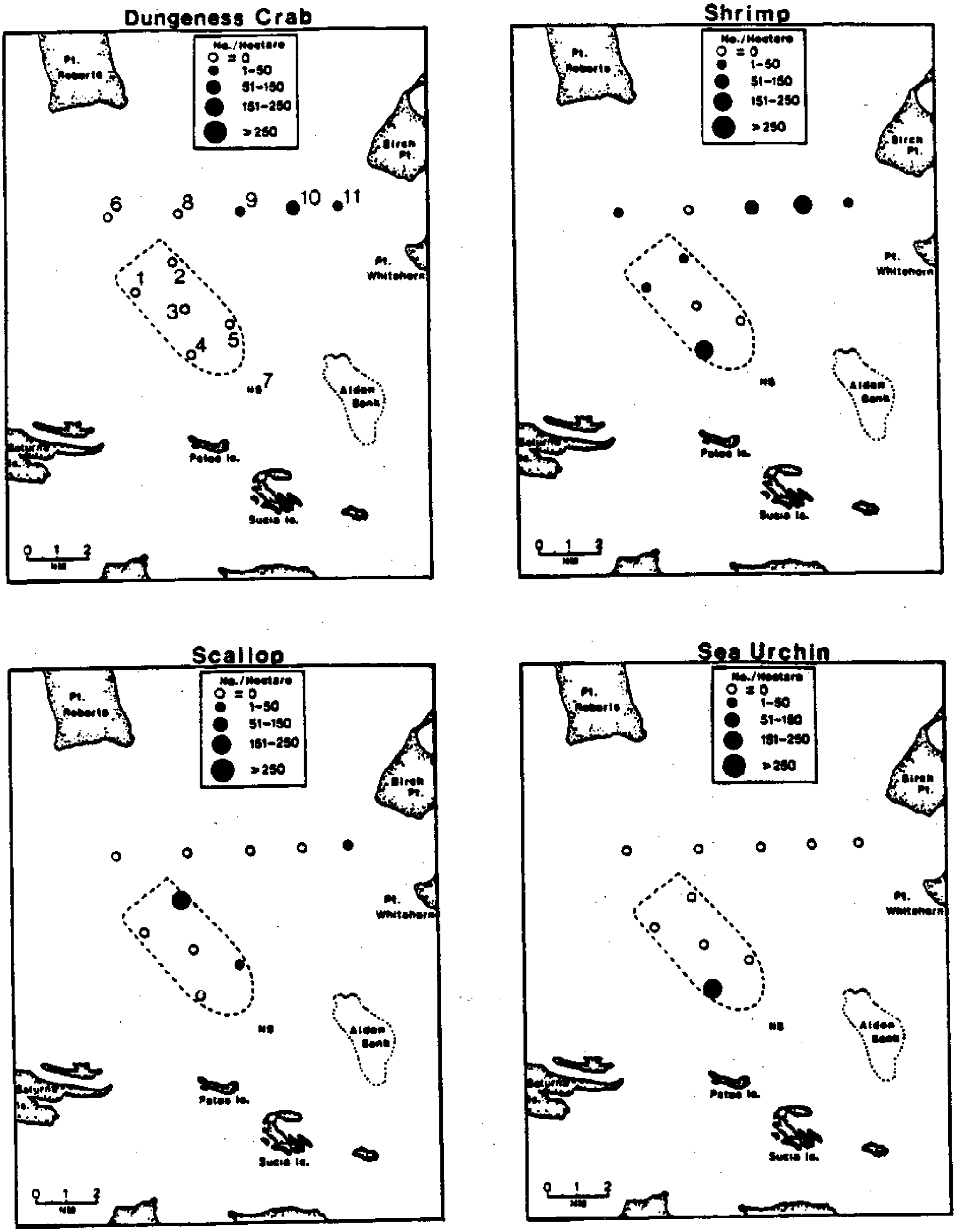

Figure 40. Maps of the southern Strait of Georgia area showing the densities of Dungeness crab, commercial pandalid shrimp, scallops and sea urchins as estimated from beam trawl catches in October 1987.

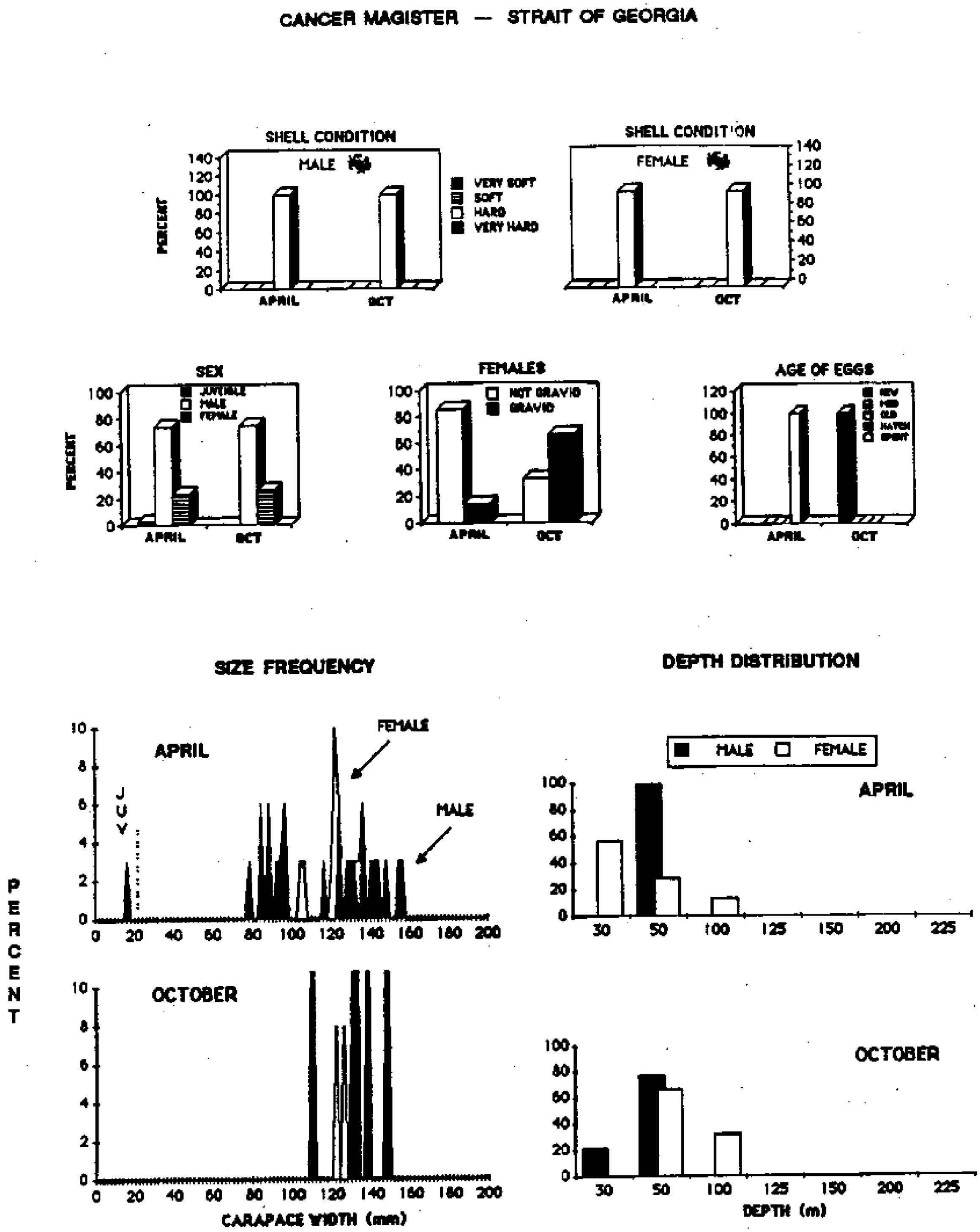

Figure 41. Summary of Dungeness crab depth distribution, size frequency, shell condition, sex composition, female reproductive condition and egg age in the Strait of Georgia during four seasons of 1987.

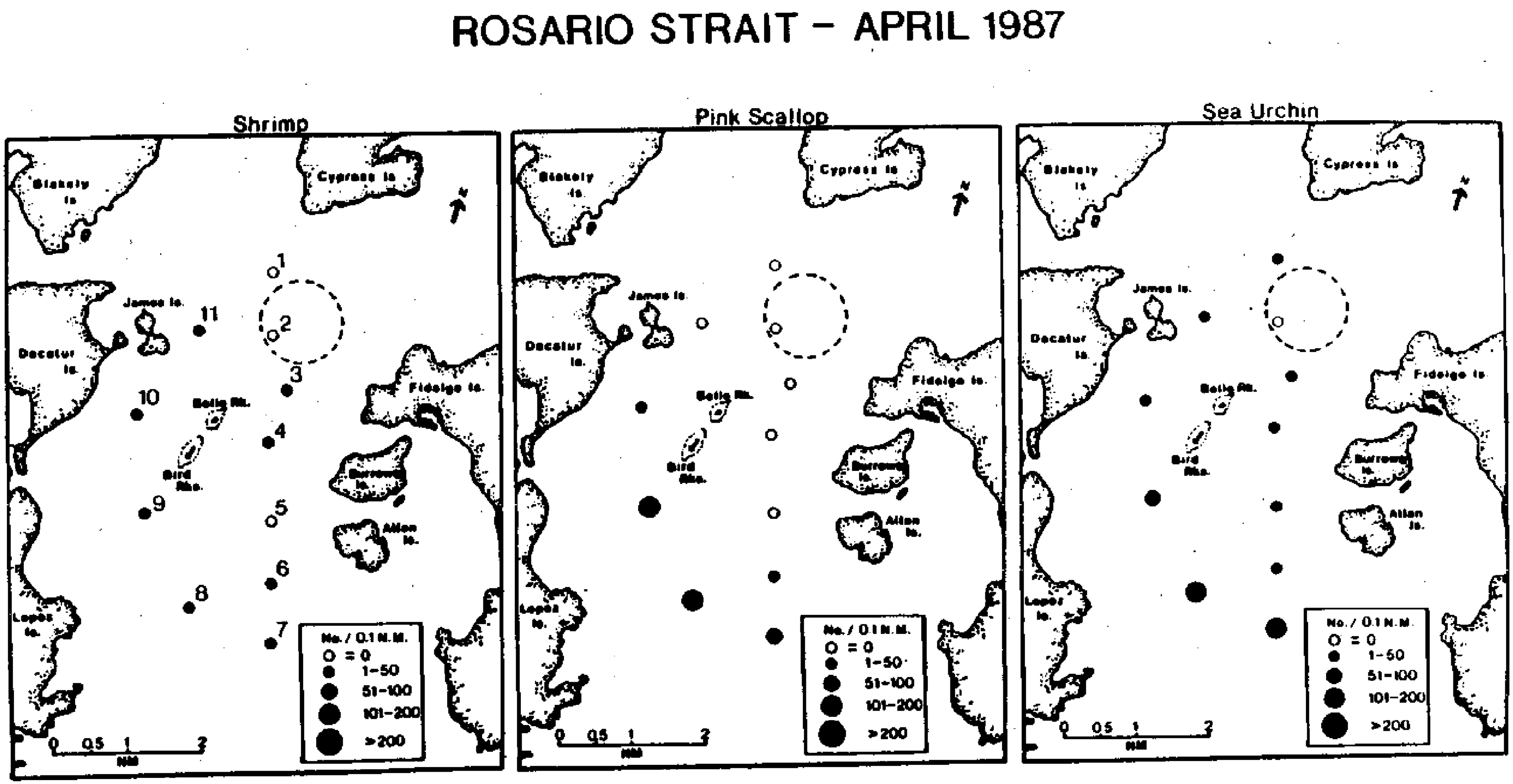

Figure 42. Maps of Rosario Strait showing the number of commercial pandalid shrimp, pink scallops and sea urchins caught per 0.1 nautical mile (N.M.) by the rock dredge in April 1987.

ROSAIRO STRAIT– OCTOBER 1987

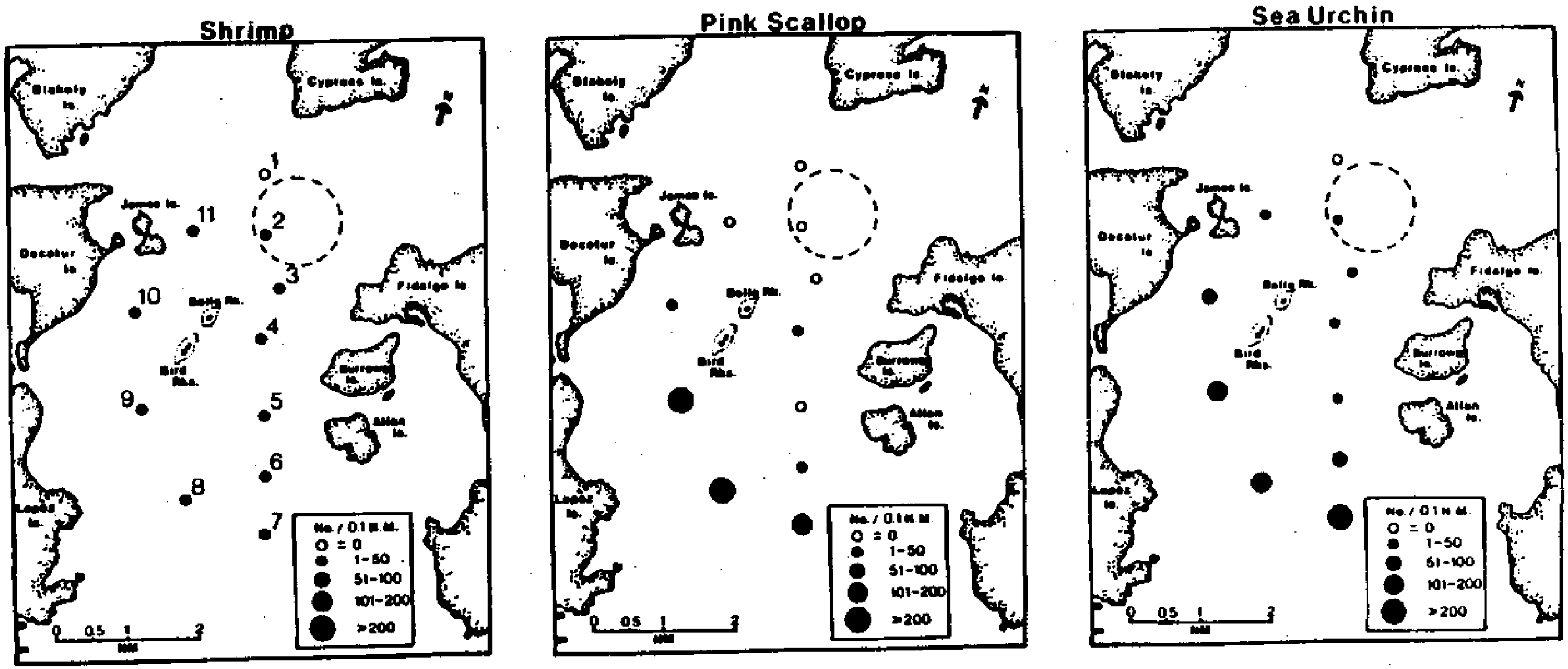

Figure 43. Maps of Rosario Strait showing the number of commercial pandalid shrimp, pink scallops and sea urchins caught per 0.1 nautical mile (N.M.) by the rock dredge in October 1987.

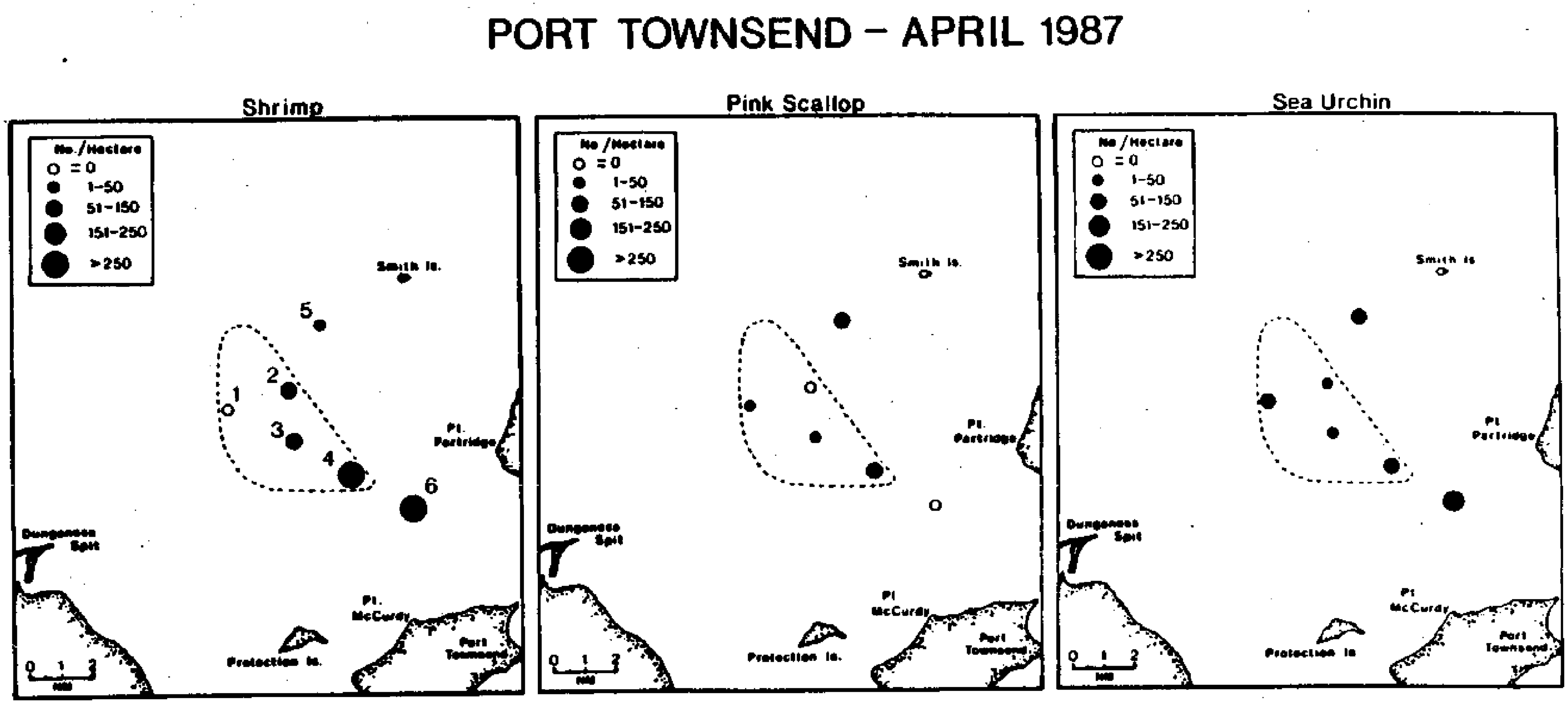

Figure 44. Maps of the Port Townsend region of the Strait of Juan de Fuca showing the densities of commercial pandalid shrimp, pink scallops and sea urchins as estimated from otter trawl catches in April 1987.

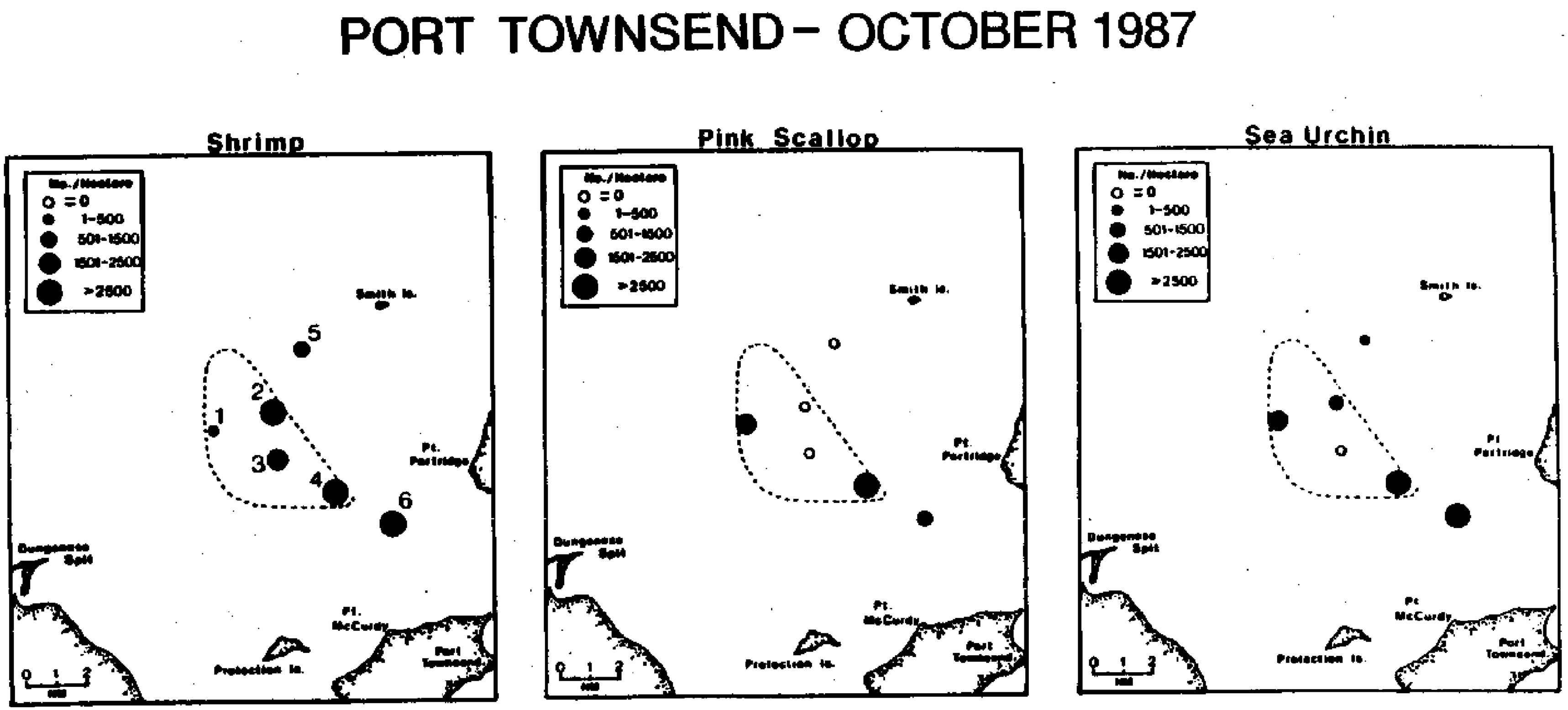

Figure 45. Maps of the Port Townsend region of the Strait of Juan de Fuca showing the densities of commercial pandalid shrimp, pink scallops and sea urchins as estimated from beam trawl catches in October 1987.

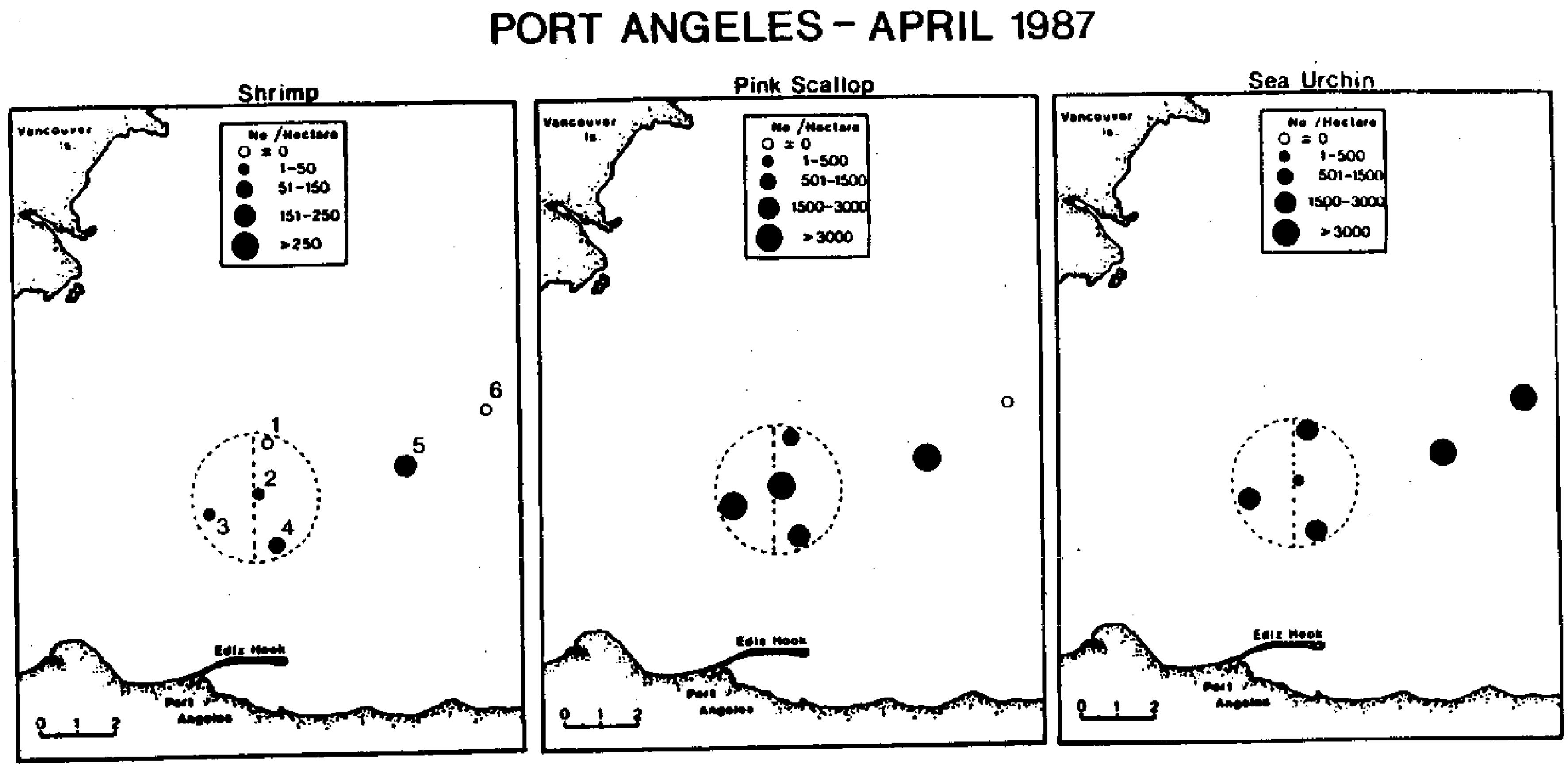

Figure 46. Maps of the Port Angeles region of the Strait of Juan de Fuca showing the densities of commercial pandalid shrimp, pink scallops and sea urchins as estimated from beam trawl catches in April 1987.

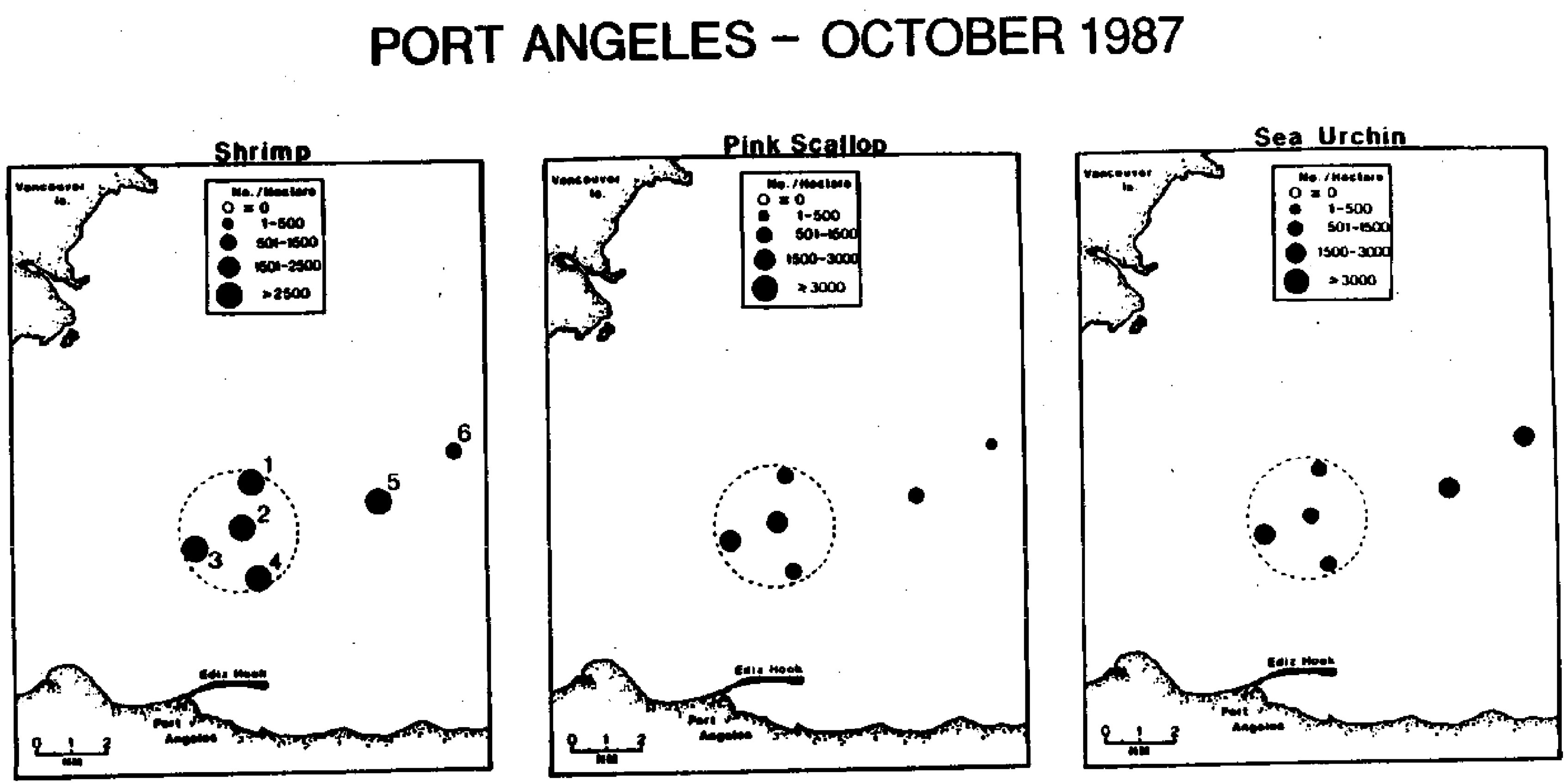

Figure 47. Maps of the Port Angeles region of the Strait of Juan de Fuca showing densities of commercial pandalid shrimp, pink scallops and sea urchins, as estimated from beam trawl catches in October 1987.

APPENDIX TABLES

Appendix Table 1. Summary of the Nisqually area station location data.

Station number	Depth (m) Start	End	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)	LORAN C
ZSF #2					
1	142	141	1.60 McNeil Is./0.75 Ketron Is.	210	27882.0/42204.3
2	137	138	0.80 Ketron Is./1.50 Tatsolo Pt.	200	27879.4/42202.7
3	132	132	0.55 Sandy Pt./0.75 Cole Pt.	20	27877.2/42201.2
4	108	110	0.60 Ketron Is./0.50 Tatsolo Pt.	200	27872.0/42202.0
5	129	129	1.50 S. Ketron Is./0.38 Cole Pt.	50	27874.8/42197.9
6	108	116	1.50 S. Ketron Is./0.38 East Shore	20	27871.0/42198.6
ZSF #3					
1	56	55	2.50 McNeil Is./0.60 Shore N. of Devils Hd.	10	27902.9/42187.4
2	60	56	2.90 McNeil Is./0.62 Treble Pt. Shore	15	27903.1/42185.4
3	74	73	1.00 Treble Pt./0.72 Devils Hd.	85	27904.1/42183.1
4	73	73	0.65 Treble Pt./1.25 Devils Hd.	320	27899.1/42183.9
5	70	70	1.05 Treble Pt./1.35 Devils Hd.	335	27900.2/42182.3
6	70	71	0.95 Treble Pt./1.65 Devils Hd.	330	27897.1/42183.2
Transect #1					
10E	11	11	1.15 Tatsolo Pt.	335	27874.8/42205.4
20E	21	27	1.15 Tatsolo Pt.	340	27873.7/42205.2
40E	42	51	1.15 Tatsolo Pt.	350	27874.0/42205.0
80E	80	93	1.13 Tatsolo Pt.	330	27874.1/42204.8
80W	82	130	0.35 Sandy Pt.	340	27881.4/42200.0
40W	44	104	0.35 Sandy Pt.	355	27881.9/42199.7

Appendix Table 1, cont'd

Station number	Depth (m) Start	End	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)	LORAN C
20W	21	34	0.35 Sandy Pt.	0	27882.4/42199.7
10W	9	11	0.50 Sandy Pt.	170	27883.0/42199.9
Transect #2					
10N	13	9	0.36 Oro Bay Penin.	90	27880.0/42195.4
20N	24	12	0.34 Oro Bay Penin.	60	27879.6/42195.0
40N	43	41	0.20 Lyle Pt. Shore	40	27877.9/42194.3
60N	61	85	0.15 Base of Dupont Wharf	40	27876.7/42195.7
80N	81	100	1.00 Lyle Shore	230	27870.7/42197.2
110M	110	107	0.60 Base of Dupont Wharf	65	27873.5/42196.2
80S	83	79	0.47 Base Depont Wharf/1.00 Lyle Pt. Shore	230	27870.7/42197.5
60S	62	73	0.15 Base Dupont Wharf	15	27867.9/42197.6
40S	43	50	0.17 Base Dupont Wharf	20	27867.5/42197.9
20S	17	21	0.17 Base Dupont Wharf	20	27867.2/42198.2
10S	13	11	0.17 Base Dupont Wharf	30	None
Transect #3					
10N	11	11	2.10 S. Dupont Shore	130	27882.6/42189.7
20N	24	21	2.10 S. Dupont Shore	120	27882.4/42189.8
40N	40	40	2.35 S. Dupont Shore	120	27884.4/42189.3
40S	42	40	2.12 S. Dupont/0.89 Shore Anderson Is.	115	27881.0/42186.6
20S	20	20	2.15 S. Dupont Shore	100	27880.9/42185.8
10S	10	10	2.15 S. Dupont Shore	100	None

Appendix Table 1, cont'd

Station number	Depth (m) Start	Depth (m) End	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)	LORAN C
Transect #4					
10E	12	12	1.70 Devils Head	275	27893.8/42187.6
20E	21	19	1.70 Devils Head	280	27893.5/42187.5
40E	43	33	1.70 Devils Head	295	None
60E	61	53	1.75 Devils Head	295	None
60W	59	67	1.50 Treble Pt./0.70 T4 Knob	45	27898.3/42180.9
40W	43	44	0.60 T4 Knob/1.95 Devils Hd./1.67 Treble Pt.	305	27898.8/42180.1
20W	24	17	2.10 Devils Dead	300	27900.5/42178.4
10W	13	13	0.35 S. T4 Notch	315	27899.8/42178.2
Transect #5					
10E	13	12	2.40 Shore N. of T4 West	195	27898.9/42188.2
20E	22	20	2.40 Shore N. of T4 West	210	27898.9/42189.1
40E	42	37	2.40 Shore N. of T4 West	195	27905.4/42187.8
40W	39	43	2.45 McNeil Is.	50	27905.3/42186.5
20W	23	21	2.50 McNeil Is.	30	27906.5/42186.0
10W	12	13	2.50 McNeil Is.	35	27906.9/42185.9
Other Stations					
A	60	59	1.75 McNeil Is. Shore/0.50 Spit N. of Devils Hd	10	27904.6/42190.0
B	89	89	0.60 Devils Hd. Shore/1.85 Treble Pt. Shore	95	27911.8/42180.6
C	66	66	1.00 S. Shore Knob/2.10 Devils Head	325	27892.4/42184.2
D	70	61	0.42 Lyle Pt./1.42 Dupont Dock Tip/1.10 Tip of South Deck	80	27874.7/42191.1

Appendix Table 2. Summary of the Bellingham Bay station location data.

Station number	Depth (m) Start	End	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)
Transect #1				
10W	12	12	2.0 Buoy "RB"/2.85 N. Eliza Is.	145
20W	22	22	2.0 Buoy "RB"/0.22 Pt. Francis Shore/2.85 N. Eliza Is.	140
30W	30	29	2.0 Buoy "RB"/0.30 Pt. Francis Shore/2.85 N. Eliza Is.	135
30M	31	31	3.0 Governors Pt./1.8 Post Pt.	60
30E	31	31	2.5 Governors Pt./0.60 "R2"	25
25E	27	26	0.50 Chuckanut Knob/0.20 Shore	145
20E	21	24	0.50 Chuckanut Knob/0.14 Shore	155
15E	17	18	2.38 Governors Pt.	160
10E	11	13	2.38 Governors Pt.	160
Transect #2				
10W	12	11	1.5 N. Portage Is./1.13 T2 Knob	180
15W	17	16	1.5 Brant Pt./1.45 T2 Knob	210
20W	22	22	1.5 N. Portage Is./1.75 T2 Knob	200
25W	28	27	1.75 N. Portage Is./2.5 T2 Knob	225
30M	31	31	1.5 Post Pt./3.0 Governors Pt.	295
25E	28	29	1.54 Governors Pt./0.75 Chuckanut Knob	30
20E	22	23	0.75 Governors Pt.	350
Transect #3				
10N	11	12	2.60 S. Bellingham (Edgemoor)/1.50 Nearest Shore	215
15N	17	18	2.28 S. Bellingham/1.75 Shore (W. Bell. Knob)	215
20N	21	22	1.80 Edgemoor/1.85 W. Bell. Knob	95
25N	27	28	1.5 Edgemoor/2.5 W. Bell. Knob	80

Appendix Table 2, cont'd

Station number	Depth (m) Start	End	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)
30N	31	31	3.2 Governors Pt./0.85 Buoy "R2"	85
30M	30	31	2.5 Governors Pt./1.42 Chuckanut Pt.	60
25S	27	28	1.5 Chuckanut Knob/ 0.80 Governors Pt.	60
20S	22	22	1.5 Governors Pt./2.2 Chuckanut Knob	35
Transect #4				
10N	11	11	1.25 Edgemoor/0.80 E. Shore	115
15N	17	17	0.85 Bellingham Shore/1.0 S. Ent. to Marina	110
20N	22	23	0.75 Edgemoor/1.46 S. Ent. to Marina	100
25N	27	27	0.75 Edgemoor/0.75 Buoy "R2"	90
30N	31	31	3.0 Governors Pt./0.85 Post Pt.	50
Other Stations				
A	29	29	1.0 Post Pt./2.3 S.W. Marina Breakwater	112
B	32	33	0.35 Post Pt./2.50 S.W. Marina Breakwater	?
C	29	30	2.0 Governors Pt./0.45 Chuckanut Pt.	325
D	28	29	1.7 N. Eliza Is./2.0 Francis Pt. Shore	265
E	39	41	1.0 N. Eliza Is./2.70 Governors Pt.	155
F	30	30	1.5 Pt. Francis Shore/1.85 N. Eliza Is.	175
G	29	30	2.5 N. Eliza Is./1.3 Pt. Francis Shore	170
H	29	30	2.50 N. Eliza Is./0.70 Pt. Francis Shore	160
I	29	29	1.5 Portage Is./2.75 T2 Knob	220
J	29	30	2.50 Governors Pt./1.85 Chuckanut Knob	65

Appendix Table 3. Summary of the Point Roberts (Strait of Georgia) Dispersive Site station location data.

Station number	Depth (m)	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)	LORAN C
1	210	4.65 Savage Pt./5.0 Alden Pt.	140	28816.6/42333.9
2	212	5.5 Pt. Rob/6.0 Alden Pt./7.2 Birch Pt.	155	28828.7/42344.1
3	225	4.5 Alden Pt./5.2 Savage Pt./ 7.5 Pt. White Horn	160	28813.0/42342.3
4	225	2.70 Alden Pt./4.30 Savage Pt.	345	28794.8/42338.7
5	210	4.2 Patos Is. (NE Pt.)/ 6.2 Pt. White Horn	155	28802.5/42349.1
6	150	4.0 Pt. Roberts/8.85 Birch Pt.	60	28849.0/42334.2
7	195	2.0 NE Patos Is./5.6 Turnbo Pt.	230	28774.0/42347.7
8	126	4.05 Pt. Roberts/6.53 Birch Pt.	120	28843.8/42348.7
9	100	5.45 Pt. Roberts/4.70 Birch Pt.	270	28833.0/42360.1
10	55	3.42 Birch Pt./6.60 Kwomais Pt.	350	28832.4/42368.3
11	31	2.20 Birch Pt./2.50 Pt. White Horn	285	28821.1/42378.8

Appendix Table 4. Summary of the Rosario Strait Dispersive Site station location data.

Station number	Depth (m)	Range markers and distance (N.M.) (at start of net set)	Compass heading[1] (degrees magnetic)	LORAN C
1	70	1.35 Reef Pt./1.70 Fauntleroy (Decatur Is.)	170	28571.9/42342.1
2	75	1.1 James Is./1.1 Belle Rock	350	28562.8/42340.4
3	52	1.80 Buoy "RB"/1.0 Belle Rock	340	28553.6/42341.3
4	120	1.0 Burrows Is. Light/2.75 Buoy "RB"	345	28546.7/42337.1
5	82	1.0 Burrows Is. Light/1.50 Belle Rock	310	28540.3/42336.4
6	74	1.15 Allen Is./2.0 Belle Rock	315	28534.4/42333.0
7	79	1.25 "R4" (Will. Rocks)/3.0 Belle Rock	320	28524.5/42331.3
8	82	2.0 SW Burrows Is./1.75 Belle Rock	345	28540.2/42329.3
9	72	2.0 Burrows Is./0.65 Bird Rock	155	No Signal
10	54	0.90 S. James Is./0.90 Belle Rock	160	No Signal
11	74	0.50 James Is./1.0 Belle Rock	155	No Signal

[1] Tow direction can depend on direction and speed of current.

Appendix Table 5. Summary of the Port Townsend Dispersive Site station location data.

Station number	Depth (m)	Range markers and distance (N.M.) (at start of net set)	Compass heading (degrees magnetic)	LORAN C
1	150	7.0 Smith Is./7.0 N. Protection Is.	80	28459.9/42253.7
2	115	7.5 Partridge Pt./ 7.2 N. Protection Is.	80	28458.6/42260.9
3	107	6.5 Partridge Pt./ 6.0 N. Protection Is.	60	28442.3/42263.2
4	76	4.22 Partridge Pt./5.00 McCurdy Pt.	70	28424.1/42271.7
5	124	6.30 Partridge Pt./3.04 Smith Is.	310	28466.9/42274.4
6	70	3.0 Partridge Pt./3.7 McCurdy Pt.	52	28406.4/42277.4

Appendix Table 6. Summary of the Port Angeles Dispersive Site station location data.

Station number	Depth (m)	Range markers and distance (N.M.) (at start of net set)	Compass heading[1] (degrees magnetic)	LORAN C
1	130	2.90 Buoy "PA"/1.88 Buoy "USN W OR"	80	28540.2/42160.0
2	128	1.70 Buoy "PA"	65	28530.0/42155.0
3	136	0.22 Buoy "PA"/4.02 Ediz Hook	130	28530.0/42145.2
4	133	2.20 Buoy "PA"/3.19 Tip Ediz Hook	255	28515.1/42155.0
5	110	2.25 Buoy "USN W OR"	60	28520.0/42182.5
6	134	None	60	28517.5/42195.0

[1]Direction of tows can depend on strength and direction of current.

Appendix Table 7. Estimated densities (numbers/hectare) of invertebrate resources in and around each of the PSDDA Phase II proposed disposal areas as calculated from <u>beam</u> trawl catches. N. S. = station not sampled; N. M. = not measured (data not recorded).

NISQUALLY -- BEAM TRAWL -- ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB				ROCK CRAB (C. productus + C. gracilis)				PANDALID SHRIMP (ALL SPECIES COMBINED)				SEA CUCUMBER				STARFISH (ALL SPECIES COMBINED)			
	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT
ZSF #2 (110-140 m)																				
1	0	0	0	0	0	0	19	0	0	0	19	0	37	0	19	0	19	0	56	75
2	0	0	0	0	19	19	19	75	0	0	0	0	0	19	0	19	0	19	19	0
3	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	19	19	19	0
4	0	0	0	0	56	37	0	262	0	75	19	37	0	19	0	37	0	0	19	19
5	0	0	0	0	0	19	0	75	56	37	19	19	19	0	0	0	0	19	19	0
6	0	0	0	0	0	19	37	56	0	37	0	0	0	0	0	0	0	19	0	0
AVERAGE (± 1 SD)	0±0	0±0	0±0	0±0	13±23	16±14	12±15	78±96	9±23	31±28	10±10	9±16	9±15	6±10	3±8	9±14	6±10	13±10	22±18	16±30
ZSF #3 (35-70 m)																				
1	0	0	0	0	19	187	37	599	75	0	262	94	0	0	0	0	NM	19	0	0
2	0	0	0	0	225	131	0	562	19	0	37	75	0	0	0	0	NM	19	0	0
3	0	0	0	0	94	56	262	300	37	19	0	0	0	0	0	0	NM	131	75	94
4	0	0	0	0	19	0	94	56	112	0	0	0	0	0	0	0	NM	37	150	281
5	0	0	0	0	37	75	112	562	0	0	0	37	0	0	0	0	NM	281	206	356
6	0	0	0	0	37	56	131	393	94	56	0	0	0	37	19	19	187	1199	843	1404
AVERAGE (± 1 SD)	0±0	0±0	0±0	0±0	72±80	84±65	106±91	412±210	56±44	12±23	50±106	34±42	0±0	6±15	3±8	3±8	- - -	281±461	212±320	356±534
TRANSECT #1																				
10m EAST	0	0	0	0	0	56	94	37	0	19	674	974	187	581	150	356	112	131	375	262
20m EAST	0	0	0	0	19	19	19	131	37	131	281	562	899	449	94	393	225	637	356	506
40m EAST	STATION ABORTED DUE TO ROCKS																			
80m EAST	STATION ABORTED DUE TO ROCKS																			
80m WEST	0	0	0	0	0	75	37	318	94	150	0	19	0	0	0	0	468	637	337	337
40m WEST	0	0	0	0	0	56	19	56	19	0	0	112	75	56	19	112	712	843	1049	431
20m WEST	0	0	0	0	0	19	112	37	0	0	94	599	112	225	225	225	56	618	393	112
10m WEST	0	0	0	0	56	131	94	243	0	0	131	131	131	131	37	225	37	94	19	56
AVERAGE (± 1 SD)	0±0	0±0	0±0	0±0	12±22	59±42	63±42	137±119	25±37	50±71	197±256	400±375	234±332	240±230	88±87	218±147	268±269	493±307	422±338	284±176
TRANSECT #2																				
10m SOUTH	37	37	0	0	131	94	37	94	0	19	337	0	112	262	337	337	56	75	56	94
20m SOUTH	37	0	0	0	206	37	131	56	0	19	56	262	506	187	300	225	206	337	150	375
40m SOUTH	19	0	0	0	19	75	19	19	19	0	0	0	150	19	19	94	318	655	431	581
60m SOUTH	56	0	19	0	37	19	0	56	19	0	0	19	150	56	187	0	412	300	412	431
80m SOUTH	19	0	0	19	19	0	0	169	0	19	0	37	637	1142	787	1816	37	19	19	56
110m MIDDLE	0	0	0	0	0	0	19	75	0	37	169	0	112	281	56	94	75	56	56	19
80m NORTH	0	0	0	0	19	37	19	131	0	0	0	19	0	0	0	0	131	206	150	206
60m NORTH	0	0	0	0	19	56	56	131	56	0	19	169	0	0	19	0	318	75	94	112
40m NORTH	19	0	0	0	56	0	56	75	0	0	0	0	0	0	0	19	112	94	56	37
20m NORTH	37	0	0	0	356	37	94	112	0	0	0	19	19	37	0	0	318	225	262	131
10m NORTH	0	0	0	0	37	112	206	56	0	0	19	2154	169	56	56	0	262	431	56	0
AVERAGE (± 1 SD)	20±19	3±11	3±7	2±6	82±110	42±38	58±63	89±44	9±17	9±13	55±100	244±630	169±212	186±334	160±241	235±536	204±129	225±195	158±147	186±193
TRANSECT #3																				
10m SOUTH	37	19	56	0	37	56	37	487	0	0	19	0	0	0	0	0	0	0	0	0
20m SOUTH	0	0	0	0	131	19	0	0	19	75	0	318	0	19	0	0	0	0	0	0
40m SOUTH	0	0	0	0	0	19	37	19	0	0	0	243	0	19	0	37	0	19	0	150
40m NORTH	0	0	0	0	0	37	19	19	0	19	0	880	0	243	75	449	0	599	393	768
20m NORTH	0	37	0	0	19	0	0	94	0	0	0	0	1086	637	431	1011	187	356	169	487
10m NORTH	0	0	0	0	37	19	0	19	0	0	131	749	712	899	918	449	94	56	112	300
AVERAGE (± 1 SD)	6±15	9±16	9±23	0±0	37±49	25±19	16±19	106±189	3±8	16±30	25±52	365±373	300±479	303±380	237±373	324±399	47±78	172±250	112±155	284±302
TRANSECT #4																				
10m EAST	0	0	0	0	169	75	300	431	0	0	318	19	150	843	412	262	225	19	19	75
20m EAST	19	0	0	0	318	75	206	281	0	0	0	0	412	37	56	112	618	243	206	187
40m EAST	0	0	19	0	37	75	150	356	0	0	0	56	75	0	0	0	524	206	131	37

Appendix Table 7. Continued.

NISQUALLY – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB				ROCK CRAB (C. productus + C. gracilis)				PANDALID SHRIMP (ALL SPECIES COMBINED)				SEA CUCUMBER				STARFISH (ALL SPECIES COMBINED)			
	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT
60 m EAST	0	0	0	0	19	19	94	300	0	0	0	0	112	0	0	0	281	169	131	56
60 m WEST	0	0	19	0	94	56	169	862	0	0	0	19	537	262	206	225	243	206	169	431
40 m WEST	0	0	0	0	0	37	112	187	0	0	0	0	19	0	19	0	0	37	38	37
20 m WEST	0	56	0	0	94	112	300	806	0	0	0	75	19	75	38	150	19	0	0	19
10 m WEST	0	0	0	0	94	262	187	3444	0	0	1273	1217	1049	319	300	75	37	112	19	37
AVERAGE (± 1 SD)	2±7	7±20	5±9	0±0	103±102	88±75	190±77	798±1086	0±0	0±0	199±449	173±423	272±345	192±291	128±158	103±104	243±231	124±95	89±79	110±140
TRANSECT #5																				
10m EAST	0	0	0	0	187	356	1161	1573	0	0	38	0	0	0	19	37	NM	94	0	19
20m EAST	0	0	0	0	262	356	843	1386	0	0	19	0	0	0	19	19	NM	56	19	0
40m EAST	0	0	0	0	94	131	56	281	0	0	19	0	0	0	487	0	NM	0	19	56
40 m WEST	0	0	0	0	393	131	56	674	0	0	0	0	0	0	0	0	NM	0	0	0
20 m WEST	0	0	0	0	150	75	131	788	0	0	0	0	112	0	19	0	NM	0	0	19
10 m WEST	0	0	0	0	131	262	375	919	37	0	56	899	506	375	150	206	NM	0	0	0
AVERAGE (± 1 SD)	0±0	0±0	0±0	0±0	203±109	219±123	437±464	937±475	6±15	0±0	22±22	150±367	103±202	62±153	116±190	44±81	NM	25±41	6±10	16±22
NON-TRANSECT STATIONS																				
A (60 m)	0	0	0	0	37	0	94	730	0	0	56	0	0	0	19	0	NM	0	131	0
B (90 m)	0	0	0	0	75	337	375	674	37	0	0	0	0	19	19	0	880	1854	1691	112
C (95 m)	0	0	0	19	19	0	56	206	187	0	0	0	56	56	94	112	318	487	318	449
D (65 m)	0	0	0	0	0	0	19	0	19	0	0	0	0	0	0	0	0	0	0	0
GRAND AVERAGE (± 1 SD)	5±13	3±11	2±9	1±4	71±94	74±90	123±202	358±552	24±50	14±31	76±206	185±402	146±268	139±255	106±195	134±296	197±231	221±345	176±317	174±255

BELLINGHAM BAY – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB				ROCK CRAB (C. productus + C. gracilis)				PANDALID SHRIMP (ALL SPECIES COMBINED)				TRITONIA				STARFISH (ALL SPECIES COMBINED)			
	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT
TRANSECT #1																				
10m WEST	169	787	N.S.	94	0	112	N.S.	187	0	0	N.S.	37	0	0	N.S.	0	599	787	N.S.	506
20m WEST	94	487	131	56	19	0	37	56	19	37	637	225	0	0	0	0	262	787	861	225
30m WEST	225	19	0	37	0	0	0	0	3984	318	0	5187	0	0	0	0	169	56	75	56
30m MIDDLE	0	19	19	37	0	0	19	56	993	543	56	131	75	0	19	0	150	0	150	112
30m EAST	0	56	0	19	0	37	0	19	1349	1199	169	94	37	19	37	0	37	56	225	112
25m EAST	150	56	75	37	19	0	0	75	187	1282	385	393	0	0	0	19	75	37	131	19
20m EAST	206	94	149	637	0	0	23	75	37	787	1686	131	0	19	24	0	169	112	445	56
15m EAST	56	112	1536	843	75	37	75	318	19	37	56	0	0	0	0	0	468	262	464	225
10m EAST	0	637	468	150	131	131	730	468	5225	865	524	1592	0	0	0	0	206	506	412	431
AVERAGE (± 1SD)	100 ± 91	252 ±300	296 ± 534	212 ±306	27 ± 46	35 ± 52	111 ± 252	139 ± 157	1313±1664	574 ± 500	440 ± 565	874 ±1777	12 ± 26	4 ± 8	10 ± 15	2 ± 6	237 ± 183	289 ± 322	346 ± 256	194 ± 172
TRANSECT #2																				
10m WEST	56	131	112	37	56	262	56	112	112	56	412	75	0	0	0	0	169	0	75	112
15m WEST	75	56	169	0	37	75	75	206	169	94	449	1348	0	0	0	0	56	56	131	169
20m WEST	56	94	150	0	0	0	19	187	337	56	38	337	0	0	19	0	375	131	131	112
25m WEST	0	19	37	19	0	0	37	0	2753	19	0	19	56	37	0	0	131	225	94	169
30m MIDDLE	19	56	56	19	0	0	56	75	468	2022	75	56	0	19	0	19	37	75	169	112
25m EAST	112	19	56	0	19	0	0	112	262	37	618	150	75	19	19	0	1160	1273	2509	1180
20m EAST	75	94	75	19	0	0	0	37	19	19	0	0	19	0	0	0	487	618	543	599
AVERAGE (± 1SD)	56 ± 37	67 ± 42	94 ± 46	13 ± 14	16 ± 23	48 ± 98	36 ± 29	104 ± 76	589 ± 988	329 ± 747	227 ± 256	284 ± 483	21 ± 31	11 ± 16	5 ± 9	3 ± 7	345 ± 403	340 ± 460	522 ±891	350 ± 405
TRANSECT #3																				
10m NORTH	75	206	56	75	56	187	206	112	0	19	431	300	0	0	0	0	318	262	206	150
15m NORTH	19	112	19	19	0	0	75	75	0	19	56	37	0	0	0	19	243	243	337	94
20m NORTH	19	131	112	37	0	19	19	75	94	19	0	94	19	37	150	19	169	206	150	187
25m NORTH	19	56	169	0	0	19	0	56	356	181	618	56	19	0	19	37	19	56	150	225
30m NORTH	0	19	19	0	0	0	0	0	2079	599	37	0	37	56	56	0	37	0	281	131
30m SOUTH	0	37	19	56	0	0	0	0	0	1481	131	300	37	19	0	0	75	56	56	300
25m SOUTH	0	37	0	0	0	0	0	56	37	19	918	1646	0	0	0	0	524	1124	605	356
20m SOUTH	56	19	0	37	0	19	0	37	2064	19	19	112	0	0	0	19	1948	2622	1818	431
AVERAGE (± 1SD)	24 ± 26	77 ± 67	48 ± 61	28 ± 28	7 ± 20	30 ± 64	38 ± 73	51 ± 38	661 ± 1136	266 ± 545	276 ± 343	318 ± 540	14 ± 16	14 ± 22	28 ± 53	12 ± 14	417 ± 641	571 ± 903	475 ± 586	234 ± 116

Appendix Table 7. Continued.

BELLINGHAM BAY – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB FEB	MAY	JULY	OCT	ROCK CRAB (C. productus + C. gracilis) FEB	MAY	JULY	OCT
TRANSECT #4								
10m NORTH	131	75	56	0	94	37	112	150
15m NORTH	62	19	75	37	43	37	0	75
20m NORTH	0	94	37	75	19	0	0	169
25m NORTH	19	94	94	75	0	0	0	19
30m NORTH	19	37	0	19	0	0	0	19
AVERAGE (± 1SD)	46 ± 53	64 ± 34	53 ± 36	41 ± 36	31 ± 39	15 ± 20	22 ± 50	86 ± 71
NON-TRANSECT STATIONS								
A (30m)	19	112	37	0	0	0	0	56
B (30m)	19	94	37	0	0	0	0	19
C (30m)	56	19	0	0	0	19	0	37
D (30m)	0	75	37	0	0	0	0	37
E (40m)	187	37	75	0	0	0	0	37
F (30m)	37	19	19	37	0	0	19	19
G (30m)	56	56	19	37	56	0	0	0
H (30m)	56	0	75	19	0	0	0	19
I (30m)	19	94	0	19	0	0	0	19
J (30m)	37	19	0	0	0	19	0	0
AVERAGE (±1SD)	49 ± 52	52 ± 39	27 ± 30	11 ± 16	2 ± 6	4 ± 8	2 ± 6	24 ± 18
GRAND AVERAGE (±1SD)	56 ± 61	100 ± 184	104 ± 252	65 ±164	15 ± 30	26 ± 36	41 ± 122	70 ± 94

STATION	PANDALID SHRIMP (ALL SPECIES COMBINED) FEB	MAY	JULY	OCT	TRITONIA FEB	MAY	JULY	OCT	STARFISH (ALL SPECIES COMBINED) FEB	MAY	JULY	OCT
TRANSECT #4												
10m NORTH	0	37	0	206	0	0	0	0	112	0	375	94
15m NORTH	1724	225	281	1067	0	0	0	0	0	37	150	19
20m NORTH	225	936	787	243	37	19	19	37	0	94	393	206
25m NORTH	506	637	375	112	19	56	37	37	0	19	337	75
30m NORTH	2884	955	150	56	56	0	0	0	0	0	150	187
AVERAGE (± 1SD)	1068±1214	560 ± 416	319 ± 287	337 ± 418	22 ± 24	15 ± 24	11 ± 17	15 ± 20	22 ± 50	30 ± 38	281 ± 121	116 ± 79
NON-TRANSECT STATIONS												
A (30m)	431	206	440	0	0	0	19	19	75	94	150	112
B (30m)	2079	599	0	0	37	0	0	0	112	37	19	169
C (30m)	730	0	818	225	56	0	0	0	150	37	150	379
D (30m)	356	281	1366	75	0	19	0	0	37	56	75	56
E (40m)	187	412	19	693	0	0	0	0	37	131	187	131
F (30m)	356	300	3783	2060	0	0	0	0	19	0	150	131
G (30m)	1404	880	375	2266	75	0	19	0	0	0	131	56
H (30m)	1367	506	19	1001	37	0	0	0	19	0	75	94
I (30m)	2603	187	0	37	37	112	37	0	37	56	131	94
J (30m)	487	187	3221	262	94	0	19	0	75	0	37	225
AVERAGE (±1SD)	1080 ± 828	356 ± 258	987 ±1306	751 ± 836	34 ± 34	13 ± 36	10 ± 13	2 ± 6	56 ± 47	41 ± 45	111 ± 55	148 ± 97
GRAND AVERAGE (±1SD)	924 ± 1207	413 ± 466	469 ± 819	552 ± 894	21 ± 28	11 ± 23	13 ± 27	6 ± 11	220 ± 364	259 ± 497	335 ± 484	206 ± 209

STRAIT OF GEORGIA – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB APRIL	OCTOBER	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	OCTOBER	SCALLOP APRIL	OCTOBER	SEA URCHINS APRIL	OCTOBER	STARFISH (ALL SPECIES COMBINED) APRIL	OCTOBER
1	0	0	0	37	0	0	19	0	0	0
2	0	0	19	19	0	243	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	150	243	19	0	225	169	19	0
5(ROCK DREDGE)	0	0	0	0	0	19	0	0	0	0
6	0	0	0	19	0	0	37	0	19	0
7(ROCK DREDGE)	0	0	0	0	0	0	1	2	0	1
8	0	0	0	0	0	0	0	0	37	0
9	19	19	0	94	0	0	0	0	112	150
10	375	94	225	206	19	0	0	0	487	281
11	19	37	0	19	19	19	0	0	187	1610
AVERAGE (± 1SD) (EXCLUDING ROCK DREDGE)	46 ± 124	17 ± 32	44 ± 84	71 ± 92	6 ± 10	28 ± 80	31 ± 74	16 ± 56	96 ±160	227±528

ROSARIO STRAIT–ROCK DREDGE – ESTIMATED CATCHES PER 0.1 NAUTICAL MILE TOW.

STATION	ALL CRAB APRIL	OCTOBER	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	OCTOBER	PINK SCALLOP APRIL	OCTOBER	SEA URCHINS APRIL	OCTOBER	STARFISH (ALL SPECIES COMBINED) APRIL	OCTOBER
1	0	0	0	0	0	0	26	0	0	0
2	0	0	0	2	0	0	0	7	0	0
3	0	0	24	7	0	0	12	30	0	0
4	0	0	1	1	0	2	1	33	1	0
5	0	0	0	1	0	0	7	41	0	0
6	0	0	2	42	6	16	35	84	0	0
7	0	0	2	11	55	154	112	216	0	1
8	0	0	5	9	149	215	179	118	0	5
9	0	0	9	20	214	281	83	157	0	0
10	0	0	2	0	2	8	23	96	2	2
11	0	0	2	4	0	0	4	13	0	0
AVERAGE (± 1SD)	0 ± 0	0 ± 0	4 ± 7	9 ±12	39 ± 74	60 ± 100	44 ± 57	72 ± 60	0.3 ± 0.6	0.7 ± 1.6

Appendix Table 7. Continued.

PORT TOWNSEND -- BEAM TRAWL -- ESTIMATED CATCHES PER HA.

STATION	ALL CRAB APRIL	ALL CRAB OCTOBER	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	PANDALID SHRIMP (ALL SPECIES COMBINED) OCTOBER	PINK SCALLOP APRIL	PINK SCALLOP OCTOBER	SEA URCHINS APRIL	SEA URCHINS OCTOBER	STARFISH (ALL SPECIES COMBINED) APRIL	STARFISH (ALL SPECIES COMBINED) OCTOBER
1	0	0	37	318	1311	2172	4000	2079	N. M.	712
2	0	0	94	5933	0	0	94	843	N. M.	0
3	N. S.	0	N. S.	1796	N. S.	0	N. S.	0	N. S.	0
4	N. S.	0	N. S.	9382	N. S.	8556	N. S.	8521	N. S.	468
5	0	0	0	974	0	0	56	19	N. M.	0
6	N. S.	0	N. S.	4682	N. S.	899	N. S.	5885	N. S.	58
AVERAGE (± 1SD)	0 ± 0	0 ± 0	66 ± 47	3490±3332	437±760	1938±3353	1383±2266	2878±3511	----	206±308

PORT ANGELES -- BEAM TRAWL -- ESTIMATED CATCHES PER HA.

STATION	ALL CRAB APRIL	ALL CRAB OCTOBER	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	PANDALID SHRIMP (ALL SPECIES COMBINED) OCTOBER	PINK SCALLOP APRIL	PINK SCALLOP OCTOBER	SEA URCHINS APRIL	SEA URCHINS OCTOBER	STARFISH (ALL SPECIES COMBINED) APRIL	STARFISH (ALL SPECIES COMBINED) OCTOBER
1	0	0	6	68027	1236	655	1955	712	197	262
2	0	0	37	55270	4326	2322	431	593	599	314
3	0	0	19	26462	3577	2508	2622	1864	674	242
4	0	0	56	3169	2896	1330	1796	730	316	169
5	0	0	206	8002	4551	1108	3071	2080	375	262
6	0	0	0	521	0	19	3652	2865	0	56
AVERAGE (± 1SD)	0 ± 0	0 ± 0	55 ± 75	26778±26159	2781±1807	1323±869	2260±1126	1466±913	360 ± 252	222 ± 94

N. S. = Not Sampled
N. M. = Not Measured

Appendix Table 8. Estimated densities (numbers/hectare) of invertebrate resources in and around each of the PSDDA Phase II proposed disposal areas as calculated from otter trawl catches. N. S. = station not sampled; N. M. = not measured (data not recorded); REP = replicate tows.

NISQUALLY – OTTER TRAWL – ESTIMATED CATCHES PER HECTARE

	DUNGENESS CRAB				ROCK CRAB (C. productus + C. gracilis)				PANDALID SHRIMP (ALL SPECIES COMBINED)				SEA CUCUMBER				STARFISH (ALL SPECIES COMBINED)			
STATION	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT
ZSF #2 (110-140 m)																				
1	0	0	0	0	0	0	0	0	0	8	15	85	0	0	54	39	0	0	0	39
2	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	8	8	0	0	15
3	0	0	0	0	0	0	0	0	0	31	15	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	8	0	70	0	23	23	23	15	23	8	0	0	8
5	8	0	0	0	0	0	0	0	0	38	0	0	0	0	0	8	0	0	0	15
6	0	0	0	0	0	0	0	0	0	16	0	0	0	0	15	0	0	0	0	0
AVERAGE (± 1 SD)	1 ± 3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1.3 ± 3.3	0 ± 0	30 ±34	6 ±7	21 ± 33	4 ± 9	4 ± 9	14 ± 21	13 ± 15	3 ± 4	0 ± 0	0 ±0	13 ± 14
ZSF #3 (50-70 m)																				
1	0	0	0	0	0	23	0	0	0	1261	680	69	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	8	31	147	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	31	15	0	0	0	0	0	0	15	31	0	8
4	0	0	0	0	0	8	0	0	54	15	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	23	8	0	23	0	0	0	0	0	0	0	15
6	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	15	0	0	31
AVERAGE (± 1 SD)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5 ± 8	1 ± 3	0 ± 0	23 ± 19	226±517	138 ± 280	17 ± 27	0 ± 0	0 ± 0	0 ± 0	0 ± 0	5 ± 8	5 ± 13	0 ± 0	9 ± 12
TRANSECT #8																				
20 m SOUTH, REP 1	0	0	0	0	0	0	0	0	0	0	15	0	0	46	8	54	15	0	8	15
REP 2	N.S.	0	0	0	N.S.	0	0	23	N.S.	0	0	39	N.S.	39	15	31	N.S.	0	15	15
40 m SOUTH, REP 1	0	0	0	0	0	0	0	23	0	0	0	0	15	31	8	8	8	0	0	31
REP 2	N.S.	0	0	0	N.S.	0	0	62	N.S.	0	0	0	N.S.	0	0	8	N.S.	39	0	54
60 m SOUTH, REP 1	0	0	0	0	0	0	0	0	0	0	0	0	0	39	8	8	0	31	0	39
REP 2	N.S.	0	0	0	N.S.	0	0	23	N.S.	0	0	0	N.S.	23	0	0	N.S.	0	0	23
80 m SOUTH, REP 1	0	0	0	8	0	0	0	8	0	0	0	0	0	100	39	255	8	0	0	31
REP 2	N.S.	0	0	0	N.S.	0	0	15	N.S.	31	77	0	N.S.	93	39	182	N.S.	0	0	8
110 m MIDDLE, REP 1	0	0	0	0	8	0	0	0	0	15	0	0	0	93	54	54	0	0	0	8
REP 2	N.S.	0	N.S.	0	N.S.	0	N.S.	0	N.S.	15	N.S.	0	N.S.	31	N.S.	62	N.S.	0	N.S.	0
TRANSECT #6																				
40 m WEST, REP 1	0	0	0	0	23	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REP 2	N.S.	0	0	0	N.S.	0	0	0	N.S.	0	0	0	N.S.	0	0	0	N.S.	0	8	0
30 m WEST, REP 1	0	0	0	0	15	0	0	46	0	0	0	0	0	0	0	0	8	0	0	0
REP 2	N.S.	0	0	0	N.S.	0	0	15	N.S.	0	0	0	N.S.	0	0	0	N.S.	0	0	0
NON-TRANSECT STATIONS																				
A (40 m)	0	0	0	0	0	0	0	8	8	15	0	8	0	85	0	0	0	8	0	0
B (30 m)	0	0	0	0	0	0	0	0	62	0	0	0	0	0	8	15	93	0	0	247
C (65 m)	0	0	N.S.	0	8	8	N.S.	0	147	0	N.S.	0	8	0	N.S.	0	8	0	N.S.	0
GRAND AVERAGE (± 1 SD)	0.4 ± 1.7	0 ± 0	0 ± 0	0.3 ± 1.5	2 ± 6	3 ± 6	1.8 ± 3.2	8 ± 15	16 ± 34	56 ± 228	24 ± 127	11 ± 21	2 ± 6	21 ± 33	10 ± 17	25 ± 56	8 ± 20	4 ± 11	1.1 ± 3.5	21 ± 46

BELLINGHAM BAY – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

	DUNGENESS CRAB				ROCK CRAB (C. productus + C. gracilis)				PANDALID SHRIMP (ALL SPECIES COMBINED)				TRITONIA				STARFISH (ALL SPECIES COMBINED)			
STATION	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT	FEB	MAY	JULY	OCT
TRANSECT #1																				
30m MIDDLE	0	N.S.	0	0	0	N.S.	0	0	1243	N.S.	176	853	23	N.S.	0	0	N.M.	N.S.	23	16
30m EAST, REP 1	8	15	23	8	8	8	0	8	2306	7890	440	943	23	0	0	8	N.M.	N.M.	8	70
REP 2	N.S.	8	N.S.	N.S.	N.S.	8	N.S.	N.S.	N.S.	4546	N.S.	N.S.	N.S.	0	N.S.	N.S.	N.S.	N.M.	N.S.	N.S.

Appendix Table 8. Continued.

BELLINGHAM BAY – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB FEB	MAY	JULY	OCT	ROCK CRAB (C. productus + C. gracilis) FEB	MAY	JULY	OCT	PANDALID SHRIMP (ALL SPECIES COMBINED) FEB	MAY	JULY	OCT	TRITONIA FEB	MAY	JULY	OCT	STARFISH (ALL SPECIES COMBINED) FEB	MAY	JULY	OCT
25m EAST, REP 1	31	0	46	0	0	0	15	0	31	2370	1000	764	46	0	0	23	N.M.	N.M.	6	23
REP 2	N.S.	6	25	8	N.S.	0	8	8	N.S.	1035	0	614	N.S.	0	0	0	N.S.	N.M.	8	0
30m EAST, REP 1	15	0	N.S.	N.S.	0	0	N.S.	N.S.	77	0	N.S.	N.S.	0	0	N.S.	N.S.	N.M.	N.M.	N.S.	N.S.
REP 2	N.S.	0	N.S.	N.S.	N.S.	8	N.S.	N.S.	N.S.	100	N.S.	N.S.	N.S.	0	N.S.	N.S.	N.S.	N.M.	N.S.	N.S.
15m EAST, REP 1	8	6	77	15	0	0	0	16	0	0	0	47	0	0	0	0	N.M.	N.M.	23	8
REP 2	N.S.	0	64	16	N.S.	0	0	32	N.S.	0	0	44	N.S.	0	0	0	N.S.	N.M.	15	39
TRANSECT #3																				
25m NORTH	N.S.	N.S.	0	8	N.S.	N.S.	0	8	N.S.	N.S.	394	355	N.S.	N.S.	0	8	N.S.	N.S.	0	62
30m NORTH	N.S.	N.S.	0	0	N.S.	N.S.	0	8	N.S.	N.S.	201	502	N.S.	N.S.	0	8	N.S.	N.S.	54	8
TRANSECT #6																				
25m NORTH	N.S.	N.S.	31	0	N.S.	N.S.	0	8	N.S.	N.S.	1783	257	N.S.	N.S.	0	15	N.S.	N.S.	39	15
NON-TRANSECT STATIONS																				
A (30m)	0	0	16	0	0	0	0	0	5474	2022	347	203	0	0	0	0	N.M.	N.M.	0	39
B (30m)	6	31	23	0	0	0	0	0	1909	4406	8	257	8	0	0	31	N.M.	N.M.	0	31
C (30m)	23	15	N.S.	8	0	0	N.S.	0	278	1420	N.S.	433	46	0	N.S.	0	N.M.	N.M.	N.S.	31
D (30m)	0	0	8	0	0	0	0	8	448	563	2805	577	0	0	0	0	N.M.	N.M.	108	0
F (30m)	0	0	8	0	0	0	0	0	811	6486	5003	880	8	8	0	8	N.M.	N.M.	54	0
G (30m)	16	8	8	0	0	0	0	0	1663	6870	515	3080	8	8	0	0	N.M.	N.M.	23	0
H (30m)	8	23	0	0	0	0	0	0	1801	5204	54	46	31	8	0	0	N.M.	N.M.	15	15
I (30m)	8	15	15	0	0	0	0	0	1840	340	0	15	39	39	15	0	N.M.	N.M.	39	8
J (30m)	N.S.	8	6	23	N.S.	0	0	8	N.S.	178	3930	950	N.S.	0	15	4	N.S.	N.M.	62	39
GRAND AVERAGE (±1SD)	8 ± 10	0 ± 0	20 ± 22	8 ± 7	0 ± 0	0.8 ± 1.2	1.4 ± 4.4	0 ± 0	1378±1479	2737±3032	990±1526	549±690	18 ±16	4 ± 10	1.8 ± 5.0	6 ± 8	...	...	28 ± 29	22 ± 21

STRAIT OF GEORGIA – BEAM TRAWL – ESTIMATED CATCHES PER HECTARE

STATION	DUNGENESS CRAB APRIL	OCT	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	OCT	SCALLOP APRIL	OCT	SEA URCHINS APRIL	OCT	STARFISH (ALL SPECIES COMBINED) APRIL	OCT
1	0	0	55	8	0	0	0	0	0	0
2	0	0	0	8	0	0	0	0	0	0
3	8	0	0	18	0	0	0	0	0	0
4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
5	0	0	0	117	0	0	0	0	0	0
6	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
7	8	0	216	117	0	0	85	225	0	339
8	0	0	280	46	0	0	0	0	0	0
9	0	0	1027	247	0	0	0	0	24	46
10	39	31	818	65	0	0	0	0	154	24
11	31	0	15	0	0	0	0	0	31	66
AVERAGE (± 1SD)	8 ± 14	3 ± 10	235±346	67 ± 81	0 ± 0	0 ± 0	8 ± 18	25 ± 75	23 ± 50	55 ± 111

PORT TOWNSEND – BEAM TRAWL – ESTIMATED CATCHES PER HA.

STATION	ALL CRAB APRIL	OCT	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	OCT	PINK SCALLOP APRIL	OCT	SEA URCHINS APRIL	OCT	STARFISH (ALL SPECIES COMBINED) APRIL	OCT
1	0	0	0	14584	31	394	93	0	N.M.	N.M.
2	0	0	123	2840	0	282	15	108	N.M.	N.M.
3	0	0	247	8840	0	0	0	15	N.M.	N.M.
4	0	0	719	3878	255	540	216	432	N.M.	N.M.
5	0	0	86	1027	185	0	130	0	N.M.	N.M.
6	0	0	1267	8621	0	62	270	255	N.M.	N.M.
AVERAGE (± 1SD)	0 ± 0	0 ± 0	406±401	6810±5112	80 ± 111	212 ± 227	125±108	135 ± 178	...	...

Appendix Table 8. Continued.

PORT ANGELES – BEAM TRAWL – ESTIMATED CATCHES PER HA.

STATION	ALL CRAB APRIL	ALL CRAB OCT	PANDALID SHRIMP (ALL SPECIES COMBINED) APRIL	PANDALID SHRIMP (ALL SPECIES COMBINED) OCT	PINK SCALLOP APRIL	PINK SCALLOP OCT	SEA URCHINS APRIL	SEA URCHINS OCT	STARFISH (ALL SPECIES COMBINED) APRIL	STARFISH (ALL SPECIES COMBINED) OCT
1	0	0	0	3815	178	8	46	8	31	39
2	0	0	31	2547	9	39	81	39	24	39
3	0	0	0	3058	39	46	132	178	15	55
4	0	0	82	2034	39	24	70	46	93	70
5	0	0	117	788	62	108	55	132	24	86
6	0	0	0	748	0	24	154	93	0	15
AVERAGE (± 1SD)	0 ± 0	0 ± 0	38 ±46	2320±1296	54 ± 66	42 ± 36	91 ± 50	83 ± 64	31 ± 32	51 ± 25

N. S. = Not Sampled
N. M. = Not Measured
REP = Replicate