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USE OF THE PISCES IV SUBMERSIBLE FOR DETERMINING THE DISTRIBUTIONS OF DUNGENESS CRAB, SHRIMP, AND BOTTOMFISH IN PORT GARDNER, WASHINGTON

by

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Abstract

The Canadian sumbersible **Pisces IV** was utilized in January 1987 to observe the distribution of Dungeness crab, shrimp, and bottomfish in Port Gardner, Washington. Of primary concern was the distribution of gravid (egg-bearing) female crab relative to the location of a proposed site for disposal and capping of contaminated sediments. Female crab are known to bury in the sediments while carrying eggs and, hence, avoid capture during our routine sampling with a small beam trawl.

Six dive transects were conducted across Port Gardner by the **Pisces IV** at depths from 10 to 130 m. Observations from these dives showed that gravid Dungeness crab were highly concentrated at a depth of 20 to 40 m and that most of these crab were buried in the bottom sediments. Very few crab were observed in the vicinity of the proposed RADCAD disposal site nor was there evidence of crab burial ("burial pits") at depths greater than about 50 m.

Relatively few shrimp were seen. Common bottomfish observed included ratfish, several species of flatfish, and rockfishes, which tended to congregate around logs and debris. Sablefish were also frequently observed from the **PISCES IV** but were rarely caught in otter trawl samples in previous studies conducted in Port Gardner. Pacific hake, however, were rarely observed from the submersible but were common in otter trawl samples. Possible reasons for these observed differences include time and location of samples and differences in sampling methodology.

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The **Pisces IV** submersible, support vessel **Pender**, and crews for both vessels were loaned to the project at no cost by the Department of Fisheries and Oceans, Institute of Ocean Sciences, Sidney, British Columbia under the direction of John Davis. Frank Chambers, Chief Pilot for **Pisces IV**, and his crew provided smooth diving operations with their professional and expert services. The crew of the U.S. Navy tug **Manhattan** provided valuable towing services for the **Pisces IV** and **Pender** to and from Port Gardner.

Additional assistance with observations from the **Pisces IV** was provided by R. Stickney, R. McMillan, T. Wainwright, G. Jensen, and B. Dumbauld of the School of Fisheries, University of Washington, and by D. Heritage, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia. Docking facilities and assistance were provided by the Port of Everett.

Introduction

Port Gardner, in the vicinity of Everett, Washington, has been selected by the U.S. Navy as a proposed site for a Carrier Battle Group Homeport (Fig. 1). Present construction plans require dredging of a portion of the East Waterway and the subsequent disposal and capping of the dredged materials at a deep-water site within Port Gardner (U.S. Navy 1985; COE 1986; Malek and Palermo 1987). Concerns about both direct (physical impact and burial) and indirect (toxic contaminants in the sediments) effects of disposal caused the initiation of the trawl studies to evaluate biological resources at the deep-water site.

Trawls conducted in the original disposal site (Contained Aquatic Disposal —CAD—site; Fig. 2) situated at a depth of approximately 80 m found that relatively high densities of gravid (egg-bearing) Dungeness crab (*Cancer magister*) inhabited this site during portions of the year (up to 500 crab/ha; Dinnel et al. 1986/1987). This information led to relocation of the disposal site (Revised Application Deep Contained Aquatic Disposal—RADCAD—site; Fig. 2) downslope to an area ranging in depth from 90 to 120 m, which was found to contain substantially fewer Dungeness crab as well as shrimp and bottomfish.

Seasonal trawl sampling of the Port Gardner region during 1986 showed that relatively few female crab were caught during the December sampling period. Most adult female crab are known to be gravid during this time of the year and a previous study (Armstrong et al. 1987) had shown that these females can bury in substrate and, hence, avoid being caught in a trawl.

As a result of the low December catches and our suspicion of female burial, a shallow (0-20 m depths) dive survey using SCUBA was undertaken to help identify the location of the gravid females relative to the proposed RADCAD site. The results of the diving showed that substantial numbers of gravid females were found in the 10-20 m depth range in the north portion of Port Gardner (along the outer edge of the Snohomish River delta; Fig. 2) but that the majority of the females were congregated below 20 m on the south shore of Port Gardner (Dinnel et al. 1987).

At this point in the study, the question remained about the limits of distribution of the gravid females at depths down to 130 m, including the RADCAD site. To solve this unknown, the Canadian submersible **Pisces IV** was

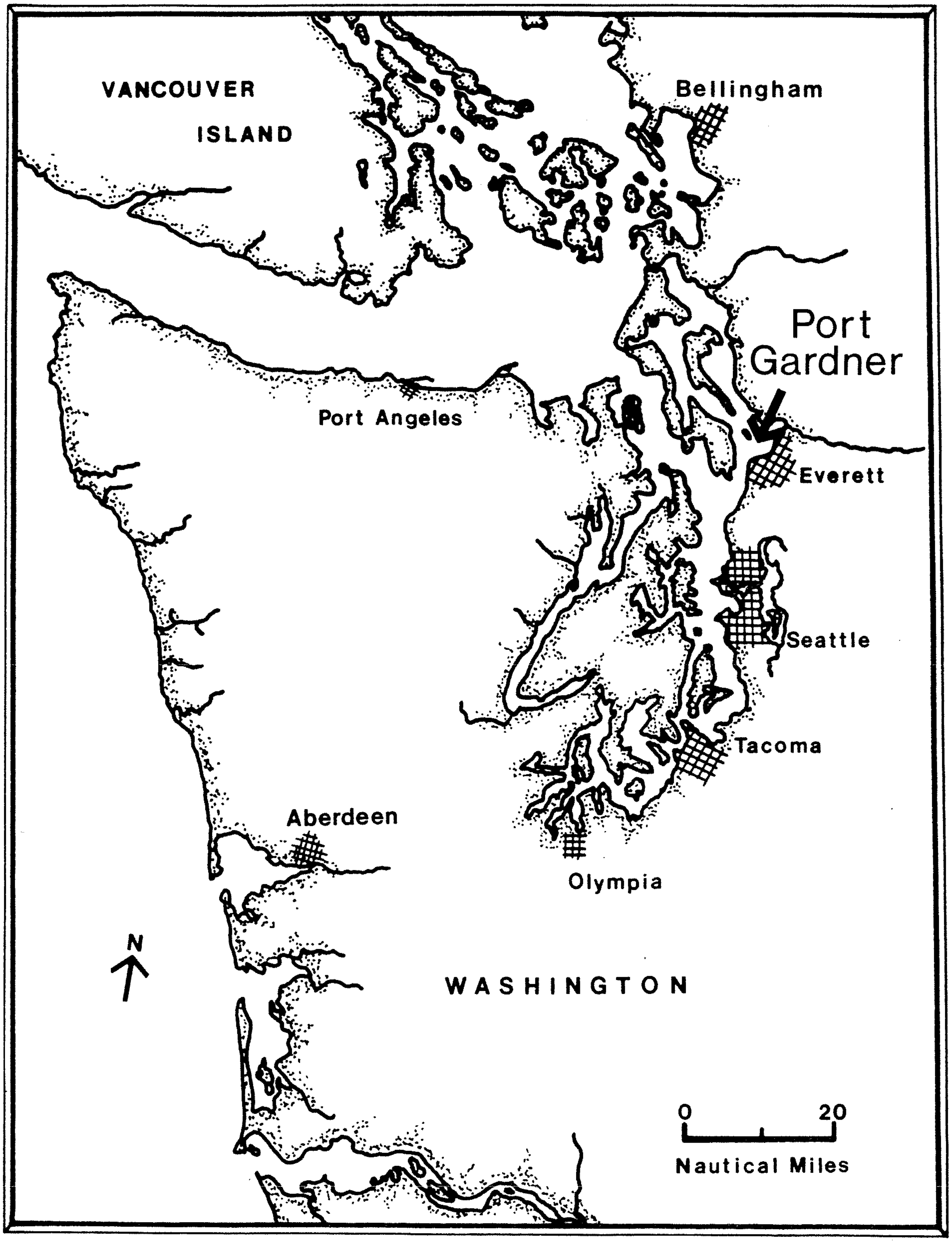


Fig. 1. Map of western Washington showing the location of Port Gardner.

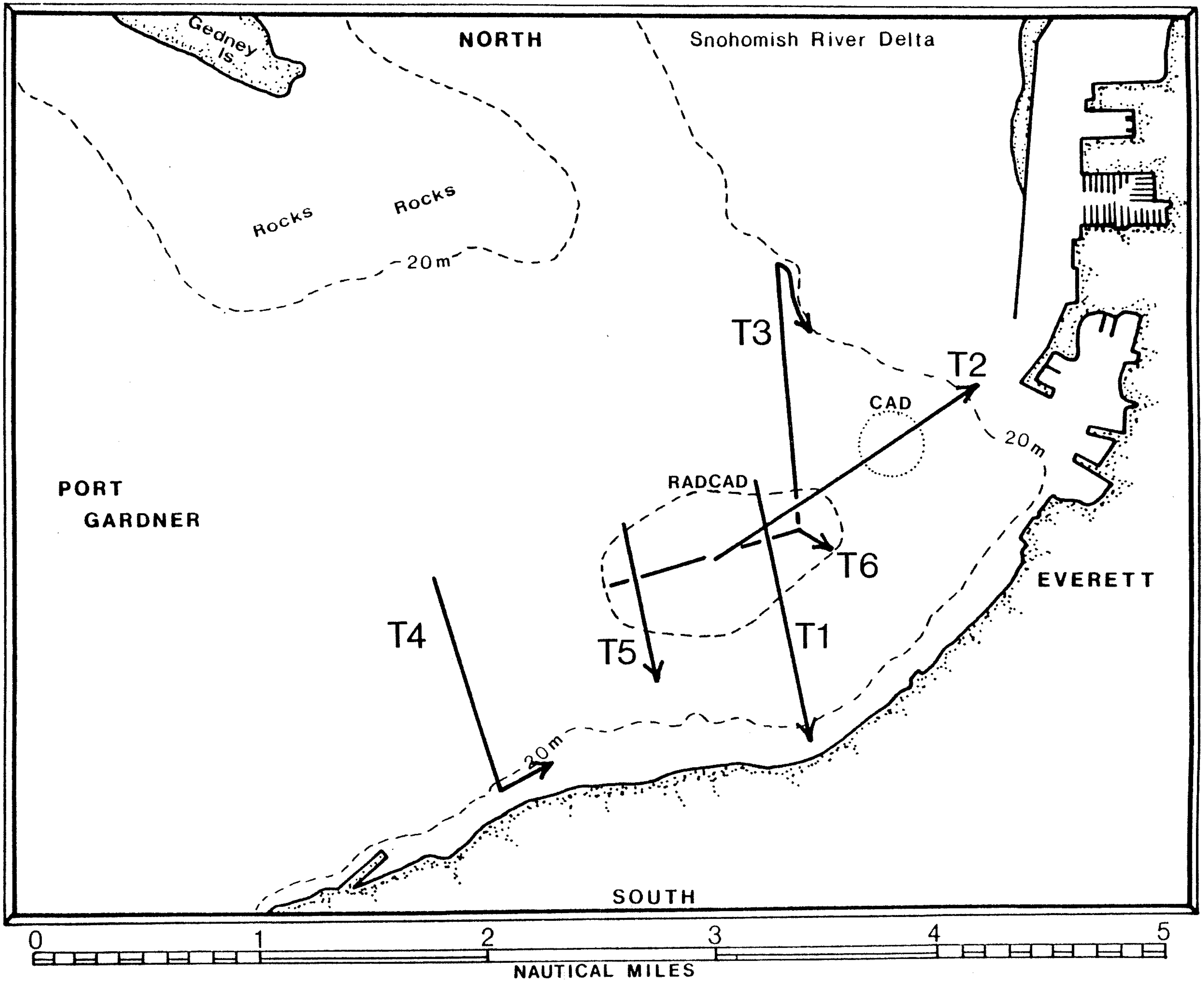


Fig. 2. Map of Port Gardner showing the locations of proposed dredged materials disposal sites (CAD and RADCAD) and the paths of the dive transects covered by **Pisces IV** in January 1987.

utilized to provide visual surveys of the bottom at all depths in and around the RADCAD site. The primary object of this report is to describe the distribution of gravid female Dungeness crab as observed from the **Pisces IV** during January 1987. A secondary objective was the enumeration of pandalid shrimp and bottomfish, resources that have also been monitored by the seasonal trawl sampling during 1986.

Materials and Methods

Six dive transects were conducted in and around the RADCAD site by an operator and two observers aboard the **Pisces IV** from 6 to 9 January 1987. The **Pisces IV** (Fig. 3) is a 3-person research submersible constructed in 1972 by International Hydrodynamics of North Vancouver, B.C. and owned and operated by the Canadian Department of Fisheries and Oceans, Sidney, B.C. The **Pisces IV** has a maximum operating depth of 2,000 m with a working time of up to about 10 hr. Observations are made through three ports with external lighting provided by a series of 500-1,000 watt lights. In addition to visual observations, **Pisces IV** is equipped with an externally mounted video camera, a hydraulic manipulator arm and specimen tray, and a suction sampler (Mackie and Mills 1983).

The locations of the six dive transects in Port Gardner are shown in Figure 2. All transects except one (T4) covered a portion of the RADCAD site. All dives were approximately 1-4 hr in duration and proceeded from depths of 90 to 140 m up the nearshore slope to a minimum depth of 10 m. Transect 5 was terminated early due to low battery power and Transect 6 was terminated when a line and buoy from a derelict crab pot became entangled in one of the drive propellers.

Visual observations on crab, shrimp, and bottomfish were made on each dive by the port and starboard observers, each with a view of the bottom extending from the front of the **Pisces IV** to slightly less than 90° to either side. The amount of bottom visible at any one time was controlled by the turbidity of the water, which varied from 1-3 m in deep areas and 4-6 m at the shallow depths. Because of the constantly changing visibility (and, hence, area observed), we did not attempt to quantify the fauna per unit of area, but rather by unit of bottom time.

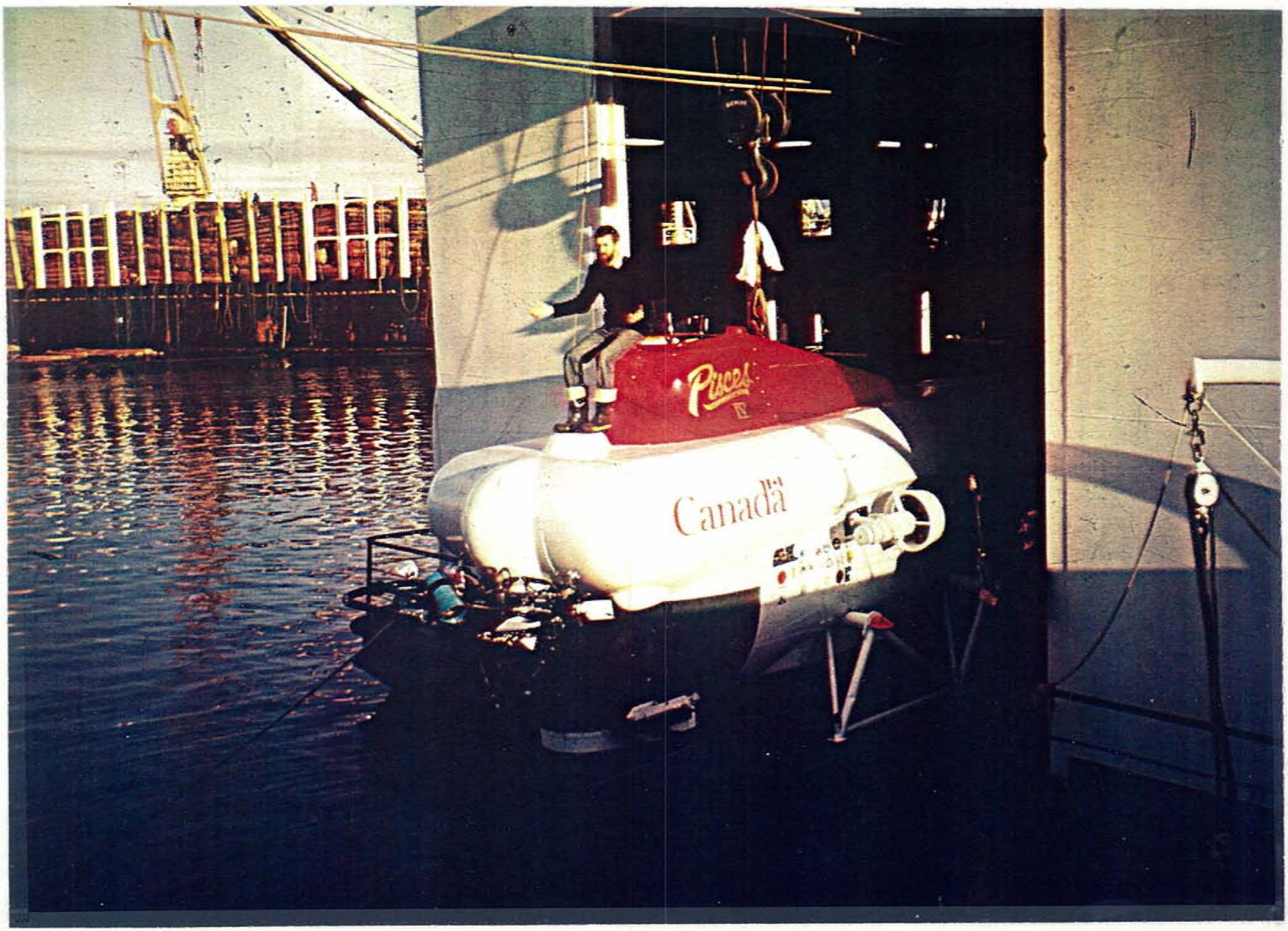


Fig. 3. Photograph of the submersible **Pisces IV**.

Results

Dungeness Crab

Dungeness crab were easily observed from the ports of the **Pisces IV** including crab moving freely over the bottom as well as buried in sediments. Buried crab were visible due to protrusion of the antennae and, often, portions of the carapace above the surface of the sediments. Buried crab also left a telltale disturbance area at the site of burial and left a distinct pit upon departure (Fig. 4).

As illustrated by Figure 5, crab were found to be very scarce at depths >90 m (only 2% of all crab observed), and none of these crab were buried (Table 1) nor were burial pits evident. Crab densities increased along the bottom half of the nearshore slope (50-90 m depths) and accounted for approximately 10% of all crab observed, with only 10% of these crab (i.e., 1% overall) being buried in the bottom sediments (Fig. 4, Table 1). Densities of crab increased dramatically in the 10-50 m depth range with crab being especially abundant between the 20-40 m depth contours. Eighty-eight percent of all crab observed were in the 10-50 m depth range with 85% of these buried in the bottom (Fig. 4, Table 1). All buried crab dislodged by the **Pisces IV**'s mechanical arm (~10) were gravid females. Additionally, numerous "pits" suspected to have been produced by crab burial were observed at this upper depth range.

Shrimp

Shrimp were relatively difficult to observe due to their small size and the limited visibility. Because of this, shrimp observations were divided between "small shrimp" (primarily pink shrimp, *Pandalus borealis* and *P. joradani*) and "large shrimp" (probably spot prawn, *P. platyceros*, or sidestripe shrimp, *Pandalopsis dispar*).

The most complete observations on shrimp were from Transect 4 and are summarized below:

Depth	No. shrimp observed/hr		Total observation time (min.)
	Small shrimp	Large shrimp	
10-50 m	1	0	46
50-90 m	56	4	15
>90 m	35	10	65

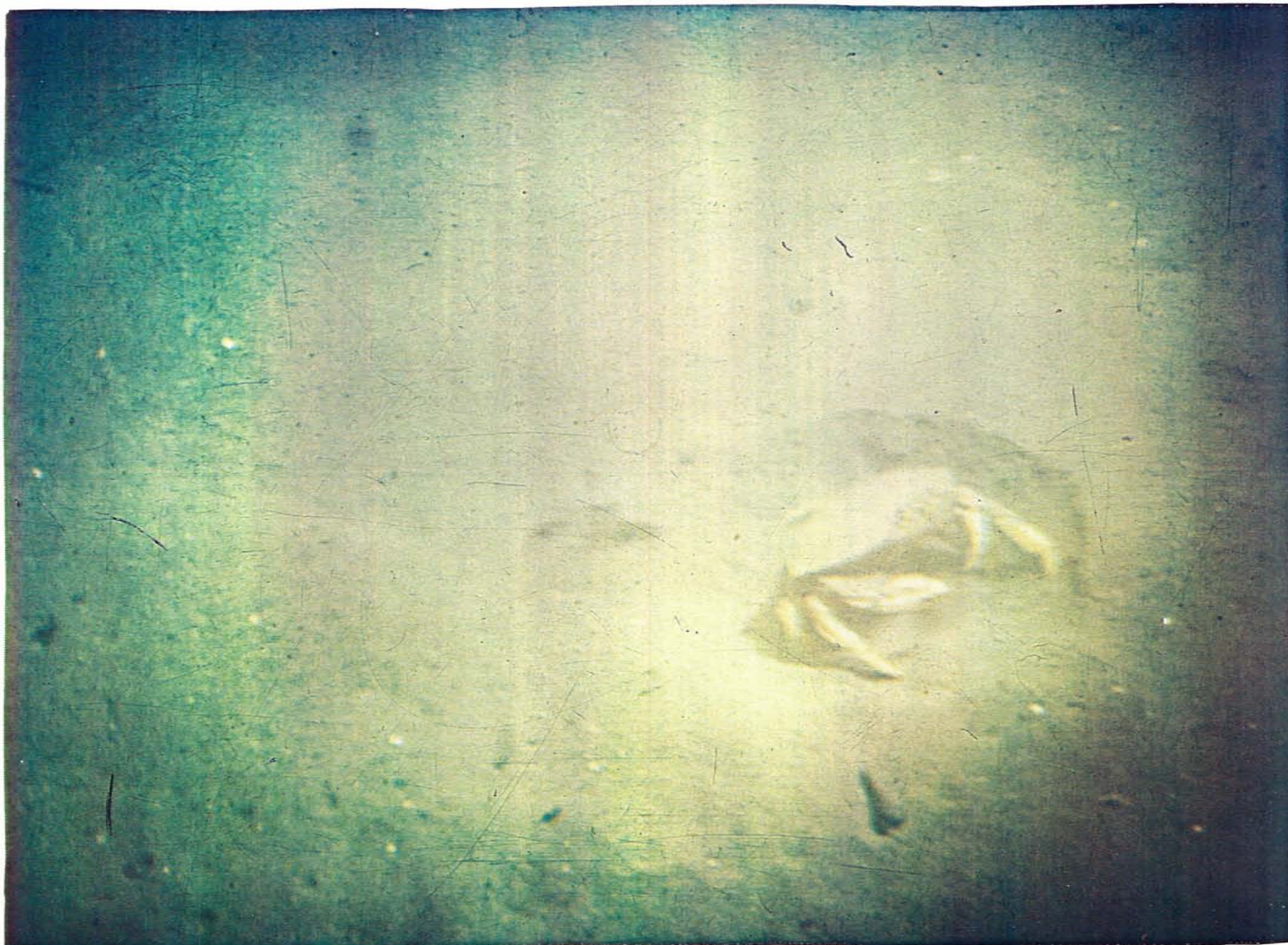


Fig. **4**. Photograph of a Dungeness crab in the process of extracting itself from a buried condition Note the obvious "burial pit" left behind. Photograph taken from the **Pisces IV** at a depth of approximately 40 m in Port Gardner.

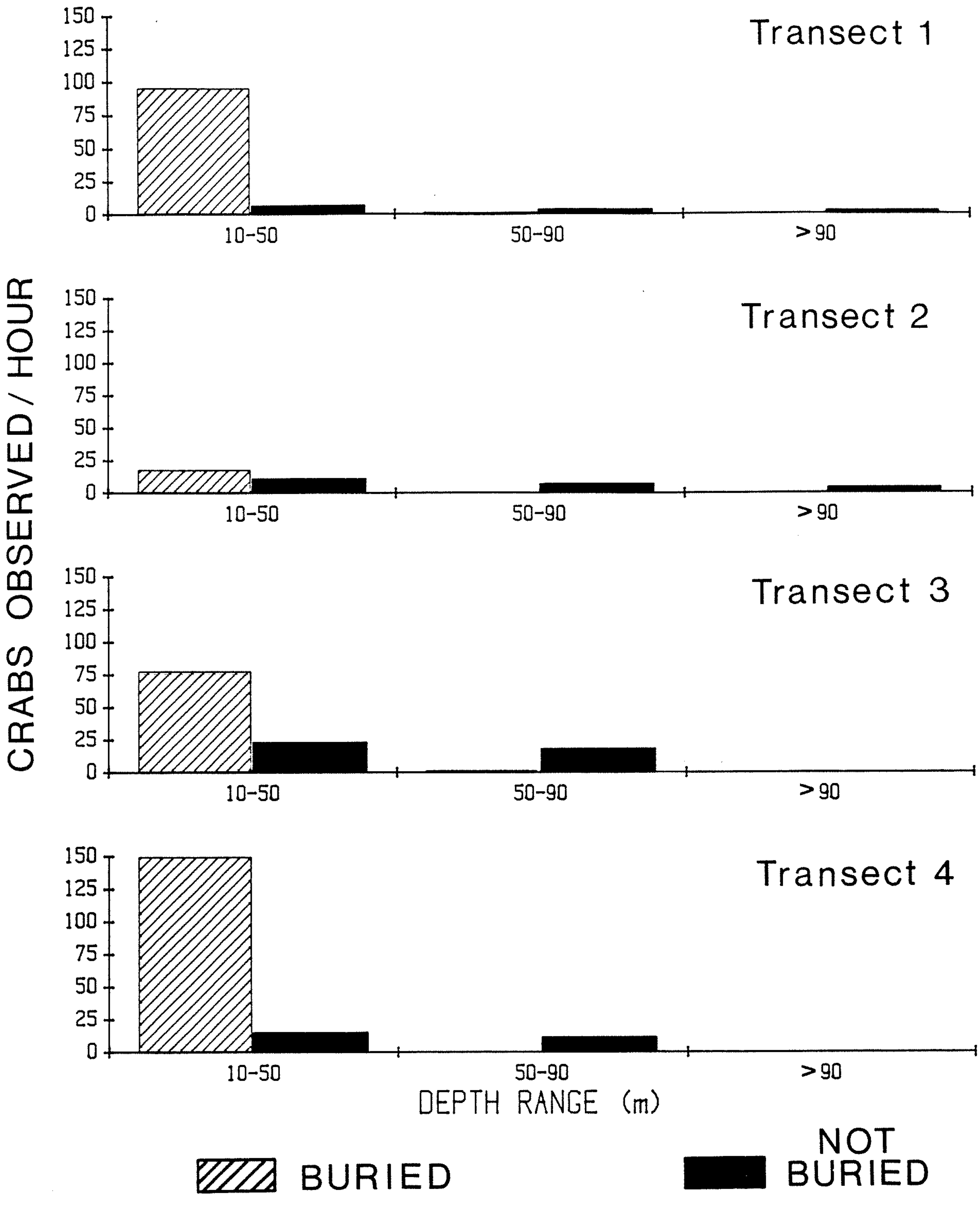


Fig. 5. Number of Dungeness crab observed from the **Pisces IV** along four transects in Port Gardner during January 1987. See Figure 2 for the transect locations.

Table 1. Number of exposed and buried Dungeness crab observed at three depth ranges from the **Pisces IV** in January 1987 in Port Gardner. See Figure 2 for the transect locations.

Location/depth range	Duration (min)	No. crabs observed/hr Exposed	Buried
Transect 1:			
10-50 m	60	7	96
50-90 m	30	4	2
>90 m	60	3	0
Transect 2:			
10-50 m	26	12	18
50-90 m	56	8	0
>90 m	50	5	0
Transect 3:			
10-50 m	89	24	78
50-90 m	45	19	2
>90 m	Not sampled		
Transect 4:			
10-50 m	46	16	150
50-90 m	15	12	0
>90 m	65	1	0
Transect 5:			
10-50 m	Not sampled		
50-90 m	Not sampled		
>90 m	40	3	0
Transect 6:			
10-50 m	Not sampled		
50-90 m	Not sampled		
>90 m	90	1	0
All transects combined:			
10-50 m	221	16.0	91.0
50-90 m	146	10.7	1.2
>90 m	305	2.4	0.0

These data show that almost all shrimp were observed in the deeper portions of Port Gardner and that "small shrimp" were most abundant at mid-depths while the "large shrimp" were less abundant than small shrimp and most common below 90 m.

Bottomfish

Ratfish (*Hydrolagus colliei*) were the most frequently observed bottomfish below 50 m at Transects 1, 2, and 6, while flatfish (e.g., *Parophrys vetulus* and *Microstomus pacificus*) were most often observed below 50 m at Transects 4 and 5 (Table 2). Sablefish (*Anoplopoma fimbria*) were observed below 90 m and absent at shallow depths. Rockfishes (*Sebastes* spp.) were usually observed in association with sunken logs or other large solid objects in deeper water. Few Pacific hake (*Merluccius productus*) were observed from the submersible and all were seen below 90 m. At depths above 50 m there was a lower abundance of bottomfish and fewer species than at greater depths. Schools of surfperch were generally observed in the 10-80 m depth range.

Fish data obtained from **Pisces IV** dives were generalized because water visibility was poor and the observers for each dive had varying degrees of fish identification expertise. For example, the terms flatfish and rockfish each represent numerous bottomfish species. Some fish species, on the other hand, were unmistakable regardless of water clarity and the experience level of the observer, and hence are mentioned specifically (e.g., ratfish).

Discussion

The **Pisces IV** proved to be a very valuable tool to help define the distribution of gravid female Dungeness crab, allowing confirmation that female crab were not burying in the proposed RADCAD site and allowing observation of the habits of shrimp and bottomfish. Limitations of this type of sampling method were poor visibility at greater depths and the difficulty in defining the area seen by the observers. This latter limitation is presently under consideration by Canadian researchers and may be solved by new technology (e.g., visible laser beams forming sampling boundaries).

Table 2. Number of fishes observed from the submersible **Pisces IV** in Port Gardner. Data are given as the number of observations during the given depth and time interval. NR = not recorded.

Depth/ Time interval	Transect 1			Transect 2			Transect 4			Transect 5	Transect 6	
	>90m NR	50-90m NR	10-50m NR	>90m 37 min	50-90m 68 min	10-50m 8 min	>90m 90 min	50-90m 9 min	10-50m 59 min	>90m 30 min	>90m 75 min	Total
Species												
Ratfish	152	24	0	37	24	0	70	13	0	44	96	460
Flatfish	70	31	16	5	16	numerous	89	54	15	52	25	>373
Sablefish	71	2	0	2	0	0	56	0	0	12	7	150
Rockfish	26	4	0	0	0	0	3	5	0	6	6	50
Dogfish	11	0	0	0	0	0	3	0	0	4	3	21
Eelpouts	3	2	3	1	0	0	3	7	3	1	1	24
Hake	4	0	0	4	0	0	1	0	0	0	2	11
Sculpins	0	0	1	0	0	0	0	1	7	0	0	9
Tomcod	1	5	0	0	0	0	0	0	0	0	0	6
Surfperch	0	2	1	0	0	0	1	schools	schools	1	0	schools
Skate	1	0	0	0	0	0	0	0	0	1	1	3
Salmon	0	0	0	0	0	0	0	0	1	0	0	1
Tubesnout	1	0	0	0	0	0	0	0	0	0	0	1
Poacher	0	0	0	1	0	0	0	0	0	0	0	1
Cod	0	0	0	0	4	0	0	0	0	0	0	4
Herring	0	0	0	0	1	0	0	0	0	0	0	1
Ronquil	0	0	0	0	1	0	0	0	0	0	0	1

Dungeness Crab

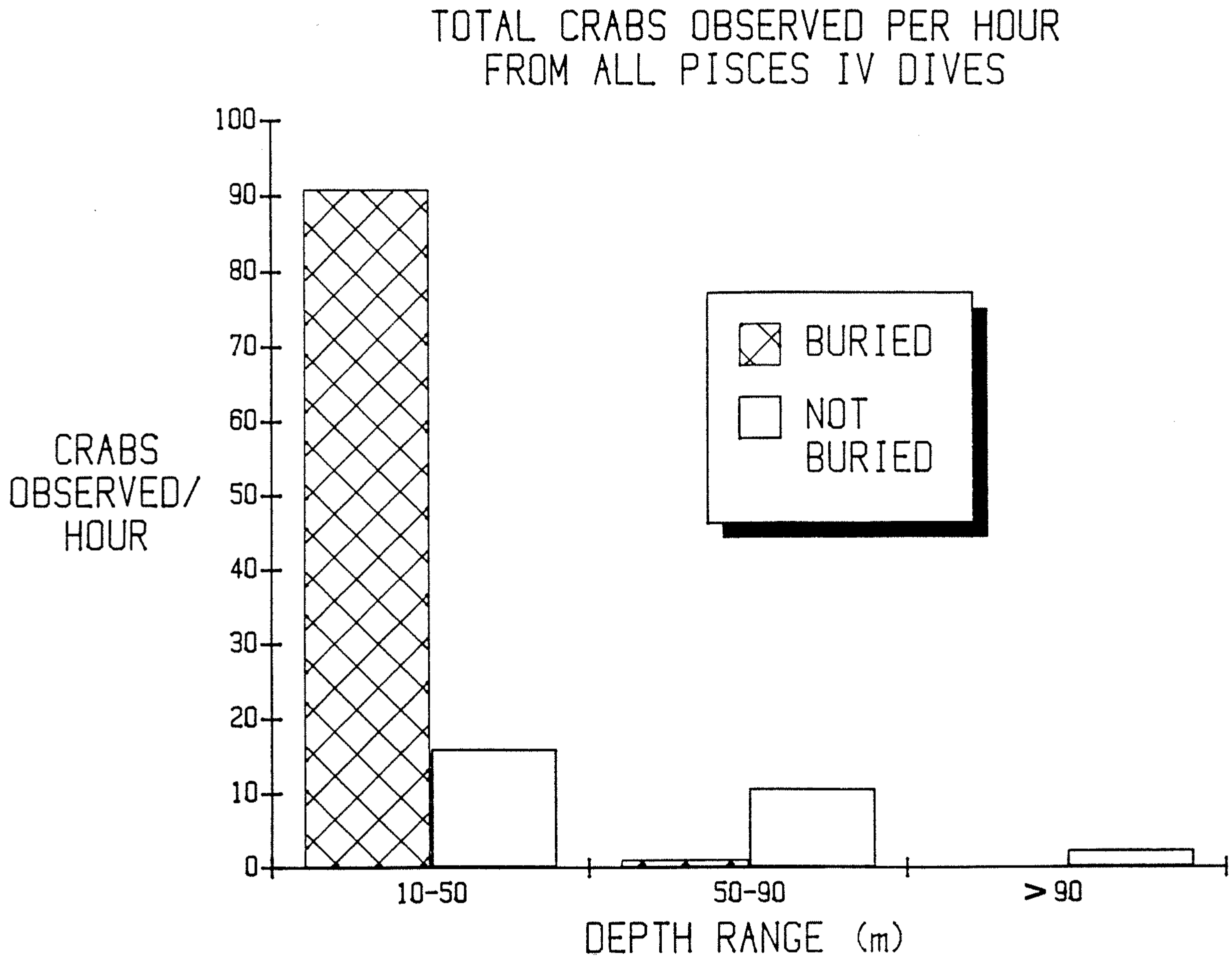
The January **Pisces IV** dive observations showed that the majority (88%) of all crab observed were at depths <50 m and that a distinct depth range existed between 20-40 m where the females (mostly buried) were highly aggregated. These observations confirmed the distribution suggested by a December 1986 trawl survey in Port Gardner (Fig. 6; Dinnel et al. 1987) and also provided valuable insight (i.e., burial behavior) as to why fewer crab were caught by trawl than were thought to be present.

This is the second time that the burial behavior of gravid female crabs has been described from Puget Sound. A study conducted by Armstrong et al. (1987) in the Anacortes area showed that gravid females had a distinct preference for burying in very shallow (2-5 m below MLLW) eelgrass (*Zostera marina*) areas and that these females seemed to prefer a specific region (the south shore of Guemes Channel between the city of Anacortes and Shannon Point). Hence, a pattern is beginning to emerge that suggests that mature females seek out relatively shallow areas of Puget Sound during the egg-carrying stage, but that depth is not the main characteristic of a habitat preferred by gravid females.

The burial habits of females during the ovigerous stage are poorly understood. Anecdotal information from divers, together with observations that carapaces of buried crab are often blackened by anaerobic conditions under the sediment surface, suggest that female crab may remain buried in one place for days or weeks at a time. The effects that burial may have on egg development and subsequent survival of larvae, especially in areas of anaerobic or contaminated sediments, is presently unknown. The reason(s) or adaptive significance of burial are also unknown, although this behavior would minimize predation on the eggs (and more vulnerable females), especially by larger fish that would be more common at deeper depths. Burial activity would also minimize the metabolic requirements of the females during a time (winter) when food is relatively scarce and foraging movements by the females would be more awkward due to the large ventral egg masses.

Bottomfish

Observations from a submersible can substantially improve our understanding of the abundance and distribution of fishes (Ralston et al. 1986;



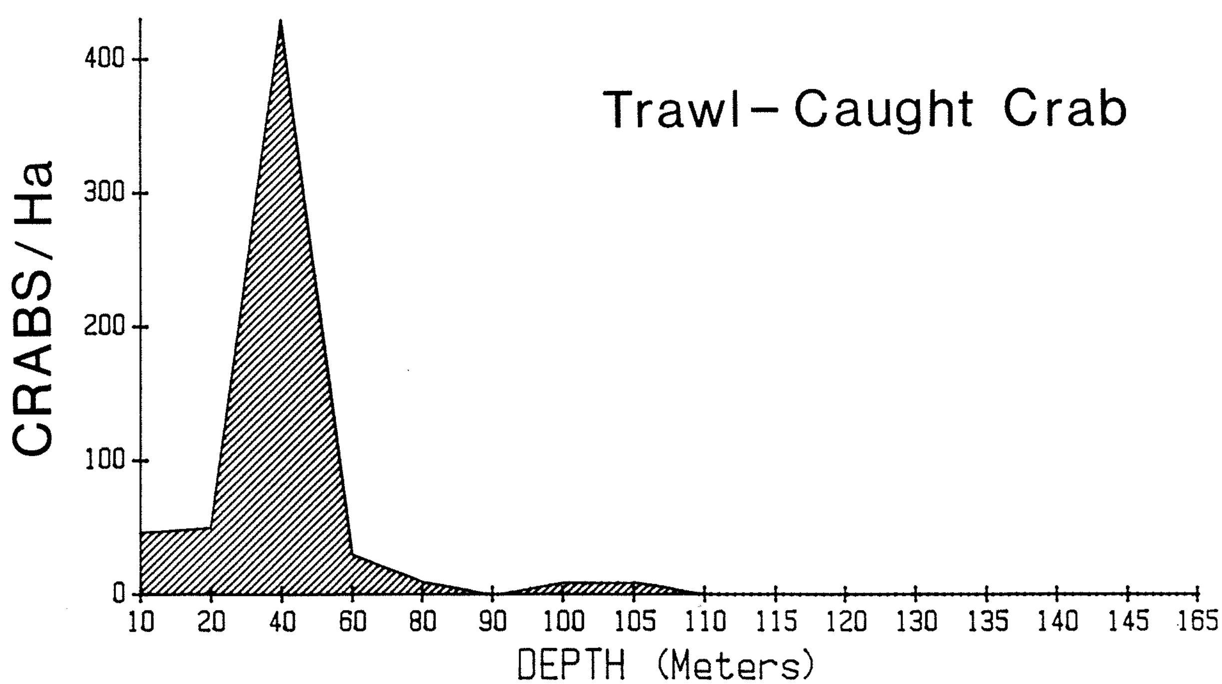


Fig. 6. Comparison of the distribution of Dungeness crab in Port Gardner in January 1987 as observed from the **Pisces IV** and in December 1986 as estimated by beam trawl sampling at 73 stations.

Richards 1986), especially when used as a complementary research tool with other indirect sampling methods such as an otter trawl (Uzmann et al. 1977). On the basis of otter trawl studies in Port Gardner during the winter of 1986 and 1987, we observed that flatfish were in greatest abundance at depths <50 m, while flatfish, ratfish, or both were in highest abundance at depths >50 m (Donnelly et al. 1986). This was in general agreement with the **Pisces IV** data from this study and with prior work done in Puget Sound (Donnelly et al. 1984; English 1979; Quinn et al. 1980; Washington Department of Ecology 1976). Sablefish, on the other hand, were rarely caught during the otter trawl surveys (Donnelly et al. 1986) but were frequently observed from the **Pisces IV**, which suggests that they may be more prevalent within Port Gardner than was previously suspected. The opposite was true for Pacific hake, which were numerous in the otter trawl surveys but were rarely observed from **Pisces IV**. The observed differences between this study and others that used the otter trawl may be attributable to random events, to seasonal variation, or to the limitations of each sampling method. A comparison between a series of otter trawls and submersible observations was done by Uzmann et al. (1977), and significant differences were shown in density estimates for several fish species between the two sampling methods. Other studies have demonstrated that some fishes are sensitive to bright lights and noise of submersibles and have employed special lights and time-lapse photography to minimize the disturbance to fishes (Clark et al. 1986).

Without the use of a submersible, it would also be difficult to determine the depth and habitat distributions of some fishes (e.g., rockfishes; Richards 1986). During this study, rockfishes were observed below 50 m in association with large objects and debris, which may be the preferred habitat-type for this species in the Port Gardner area.

Based on a paper written by Brock (1954), in which a SCUBA visual census technique was used to assess fish populations, several things could be done to improve the quality of fish data obtained during future **Pisces IV** dives: (1) make accurate and consistent fish identification during each transect dive; (2) quantify time intervals and area covered so that fish data can be evaluated in relation to the whole population or to an area covered; and (3) quantify schools of fish, as well as individual fish, and notation of their respective life history stage (i.e., juvenile or adult).

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