Survey of Red Sea Urchin Populations Near Comox, Denman Island and Hornby Island, British Columbia, 1999

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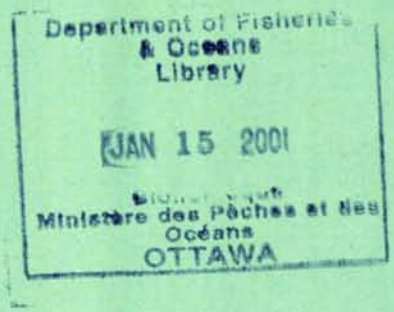

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ABSTRACT

Bureau, D., A. Campbell, and W. C. Hajas. 2000. Survey of red sea urchin populations near Comox, Denman Island and Hornby Island, British Columbia, 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2546: 17 p.

A survey of red sea urchin populations in parts of Pacific Fishery Management (PFM) Area 14 (Comox, Denman Island and Hornby Island), was conducted in June 1999. A total of 61 randomly placed transects were surveyed by SCUBA divers. Densities and biomass were estimated on a per PFM sub-area basis. Density ranged from 0.20 to 0.79 urchins per m^2; overall mean density was 0.59 urchins per m^2. Biomass ranged from 60.2 to 281.5 g per m^2; overall mean biomass was 165.4 g per m^2. Size frequency distributions showed relatively strong recruitment in some PFM sub-areas. Overall, 22.2% of the total urchins measured were ≤50mm test diameter (TD) whereas 38.6% were of legal size (≥100mm TD) for the commercial fishery.

RÉSUMÉ

Bureau, D., A. Campbell, and W. C. Hajas. 2000. Survey of red sea urchin populations near Comox, Denman Island and Hornby Island, British Columbia, 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2546: 17 p.

Une étude des populations d'oursins rouges a été effectuée, en juin 1999, dans certaines parties du Secteur de gestion des pêches du Pacifique numéro 14 (Comox, île Denman et île Hornby). Les plongeurs ont exploré un total de 61 transects aléatoires et les densités et la biomasse ont pu être estimées pour chaque sous-secteur. Les densités variaient entre 0,20 et 0,79 oursin par m^2 avec une moyenne de 0,59 oursin par m^2 pour l'ensemble du secteur. La biomasse variait entre 60,2 et 281,5 g par m^2 avec une moyenne pour l'ensemble de 165,4 g par m^2. La distribution des tailles révèle un fort recrutement dans certains sous-secteurs. Sur l'ensemble du secteur, 22,2 % des oursins avaient un diamètre inférieur ou égal à 50 mm tandis que 38,6 % dépassaient la taille légale pour la pêche commerciale, soit un diamètre supérieur ou égal à 100 mm.

INTRODUCTION

Red sea urchin (*Strongylocentrotus franciscanus*) distribution in North America ranges from the southern tip of Baja California to Alaska (Kato and Schroeter 1985). In British Columbia (BC) the red sea urchin is found in shallow rocky subtidal habitats throughout the coast (Bernard 1977). Red sea urchins are commercially harvested for their roe, which is sold in Japan. Coastal First Nations communities harvest sea urchins as a food fishery. The commercial red sea urchin fishery started in the early 1970's and total landed value in 1997/98 was $ 14 million (Campbell et al. 1999a), making the red sea urchin fishery one of the most valuable shellfish fisheries in BC.

The commercial red sea urchin fishery history and management are described in Campbell and Harbo (1991) and Campbell et al. (1999a). Current management approaches include a minimum harvest size of 100mm test diameter (TD), a coast-wide quota, individual vessel quotas and limited licence entry. Quota calculations are based on estimates of urchin density from field surveys, and estimates of urchin bed areas. Density estimates are therefore essential to the assessment and management of the red sea urchin fishery.

Red sea urchin population surveys are part of a joint effort between the Pacific Urchin Harvesters Association (PUHA), First Nations and Fisheries and Oceans Canada (DFO). They have been conducted in BC since 1993 in an effort to better understand urchin abundance, distribution and biology along the BC coast. The results of 1993 and 1994 surveys have been published (Jamieson et al. 1998a; 1998b; 1998c; 1998d). Results from earlier red sea urchin population surveys, conducted during the 1970's and 1980's, were reported by Adkins et al. (1981) and Breen et al. (1976; 1978). Sloan et al. (1987) conducted a survey in the vicinity of the current one.

Fishery managers requested that surveys be conducted in the South Coast of BC to update density and biomass estimates to help determine quotas. The area around Comox, Denman Island and Hornby Island [parts of Pacific Fishery Management (PFM) Area 14] (Figure 1) was selected for survey through discussion between DFO and PUHA. These areas have been fished in the past but have been closed to fishing since 1990 (Guy Parker, DFO Operations Branch, Nanaimo, personal communication). Harvesters have requested for the area to be opened to fishing again. The objective of this survey was to estimate current red sea urchin biomass in the area to help determine fishery quotas. Since biomass estimates, used for quota determination, are calculated on a PFM sub-area basis for management purposes (Campbell et al. 1999b), the results are presented on a PFM sub-area basis. Detailed survey results are presented here. Biomass estimates and quota recommendations for each PFM sub-area surveyed were presented in Campbell et al. (1999b).

METHODS

SURVEY AREA AND TRANSECT LAYOUT

Survey efforts were concentrated in areas where urchins were reported to be present by harvesters and harvest records. Transects locations were randomly selected prior to the survey and transects were plotted on marine charts to avoid biases in the field. The survey was divided into four sections: Cape Lazo, Comox Bar, the shores of Denman Island and the shores of Hornby Island (Figure 1). The number of transects assigned to each section was proportional to the surface area of water between 0 and 10m below chart datum of each section. Surface area of water between 0 and 10m below chart datum was estimated using the Compugrid GIS system after digitising the survey areas.

The slope of the seabed on Comox Bar and off Cape Lazo is very gentle therefore transect layout for these two sections was determined using a similar method to that used by Jamieson et al. (1998b) for Virago Sound. Transects (100m long) were randomly placed along parallel rows laid over the proposed survey area on marine charts. Rows were spaced 100m and transects ran perpendicular to the rows. Rows at Cape Lazo ran parallel to shore (Bearing 165° True), whereas rows at Comox Bar ran parallel to the shallow reef present on the bar (Bearing 130° True).

Transects off Denman and Hornby Islands were systematically placed along the shores with a random starting point (Figure 1). Areas of sandy substrate and the marine park located on the southern part of Hornby Island (from Shingle Spit south and then east to Cape Gurney), were excluded from the survey. Total shoreline length of the survey areas was measured on marine charts using a digital curvimeter. Position of the first transect was determined randomly, subsequent transects were then spaced evenly along the shoreline. Since fluctuations in urchin density are unlikely to match the spacing of the transects, the systematic sample may therefore be treated as a random sample of transects (Jamieson and Schwarz 1998).

SURVEY LOGISTICS

The survey was conducted between June 19 and June 29, 1999, on the "McLaughlin Bay", a commercial red sea urchin fishing vessel. A crew of four people: three divers and a boat tender, was used for the survey. The boat was first based out of Comox harbour to survey the Comox Bar and Cape Lazo areas. The boat was subsequently moved to Deep Bay to survey Denman and Hornby Islands.

DIVE SURVEY METHODS

Leadline transects were laid perpendicular to shore from the boat. At Denman and Hornby Islands, transects were laid out from shallow water to a depth of 15 m and thus transect length was dependent on the slope of the substrate. At Comox Bar and Cape Lazo, the boat was positioned at the pre-determined latitude and longitude of the shallow end of each transect, and 100m of leadline was laid out along the transect bearing. A float was attached to the deep

end of each transect. A 2-diver team surveyed each transect from deep to shallow, one diver measuring urchins while the other recorded data. A one meter squared ($1m^2$) quadrat was placed on the bottom beside the transect and the test diameter (TD) of each urchin present was measured to the nearest mm with callipers. The depth, substrate type, types of algae and number of green sea urchins (*Strongylocentrotus droebachiensis*) present in the quadrat were also recorded. The quadrat was then moved 2m forward along the transect and the process repeated, so that every second meter on the transect was surveyed. In cases where the substrate was sand or mud and no urchins were present at the deep end of transects, observations of depth, substrate and algae were recorded every 20m to minimize dive time. Skipped quadrats were assigned zero values for urchin counts before data were analysed. Once urchins were encountered, sampling was conducted every 2m until the intertidal zone or the surface was reached. On long transects with large numbers of urchins, measurements of test diameters were recorded in only a portion of the quadrats surveyed (usually half). The number of urchins measured on a transect could therefore be smaller than the number of urchins counted.

ESTIMATION OF DENSITY AND BIOMASS

Density and biomass were estimated for urchins of 2 size groups, a) all sizes and, b) for urchins of legal size for the commercial fishery (≥100mm TD). Estimates of mean density and biomass were calculated for each PFM sub-area in the survey using the following equations.

Density estimates (d_{ts}), in number of urchins/m^2, for each transect (t) and size group (s) were calculated as:

$$d_{ts} = \frac{N_{ct}}{a_t} * \frac{N_{mts}}{N_{mt}}$$

where N_{ct} is the total number of urchins counted on transect t, N_{mts} is the number of urchins measured in size group s on transect t, N_{mt} is the total number of urchins measured on transect t, and a_t is the surface area of all quadrats surveyed on the transect t. Here a_t is equal to the number of all quadrats surveyed on the transect, since each quadrat had a surface area of $1m^2$.

Overall mean density ($\overline{d_s}$) for a PFM sub-area for urchins of size group s was estimated as:

$$\overline{d_s} = \frac{\sum_t (d_{ts} * L_t)}{\sum_t L_t}$$

where L_t is the length of transect t (Campbell et al. 1999b).

The standard error (s_d) of estimated mean density was calculated as:

$$s_d = \sqrt{1-\frac{n}{T}} * \sqrt{\frac{\sum_t (d_{ts} * L_t - \bar{d}_s * L_t)^2}{n*(n-1)*\bar{L}^2}}$$

where n is the number of transects surveyed, T is the total possible number of transects that can be sampled in a surveyed PFM sub-area and mean transect length ($\bar{L}$) was calculated as:

$$\bar{L} = \frac{\sum_t L_t}{n}$$

from Campbell et al. (1999b). The expression $\sqrt{(1-(n/T))}$ was approximately equal to 1 since n was much smaller than T.

To calculate biomass, the weight of all urchins measured was calculated using the relationship between urchin weight (W) in grams and test diameter (TD) (Campbell et al. 1999b; 2000).

$$W = 0.0012659 * TD^{2.7068} \quad n= 167, r^2=0.960$$

Biomass density (b_{ts} in g/m^2) of urchins of size group s, on a transect t, was estimated using a simplified form of the formula used in previous papers (Campbell et al. 2000). The formula was modified by Campbell et al. (1999b) to simplify computations:

$$b_{ts} = \frac{N_{ct}}{N_{mt}} * \frac{\sum W_{ts}}{a_t}$$

where ΣW_{ts} is the sum of the weights (in g) of urchins measured in size group s on transect t and a_t is the surface area of quadrats surveyed on the transect t.

Overall estimated mean biomass per surface area ($\bar{b}_s$ in g/m^2) for a PFM sub-area was calculated as (Campbell et al. 1999b):

$$\bar{b}_s = \frac{\sum_t (b_{ts} * L_t)}{\sum_t L_t}$$

The standard error of estimated mean biomass was calculated using the same formula used for standard errors of density but where d_{ts} and $\bar{d}_s$ were substituted for b_{ts} and $\bar{b}_s$, respectively.

Recruitment estimates for the red sea urchin in BC have generally been expressed as the proportion of total red sea urchins measured that were ≤50mm TD (Adkins et al. 1981; Breen et al. 1976; 1978; Jamieson et al. 1998b; 1998c; 1998d, Sloan et al. 1987). We used the same size for comparison purposes.

RESULTS

SURVEY LOGISTICS

A total of 61 transects were surveyed (Figure 1 and Table 1). Sixteen transects were surveyed on Cape Lazo (transects 1 to 16). Seventeen transects were surveyed on Comox Bar (transects 17 to 35). Sixteen transects were surveyed off Denman Island (transects 36 to 51). Twelve transects were surveyed off Hornby Island (transects 52 to 64). Three of the scheduled transects could not be surveyed due to time or weather constraints. The survey was conducted over an 11 day period, one day was lost due to rough weather. A total of 2508 red sea urchins were counted and measured in 2640 quadrats on the 61 transects. Total length of transects surveyed was 8391m for an average transect length of 138m per transect.

SIZE FREQUENCY DISTRIBUTIONS

The mean size of all red sea urchins measured in all PFM sub-areas of the survey was 82.0mm TD (Figure 2 and Table 2). Mean size, on a PFM sub-area basis, ranged from 74.1 to 100.7mm. On a PFM sub-area basis the minimum size ranged between 7 and 10mm whereas maximum size ranged from 142 to 172mm.

The overall percent of legal sized urchins (≥100mm TD) was 38.6% whereas 22.2% of urchins were ≤50mm TD. On a PFM sub-area basis, the percent of urchins ≤50mm TD ranged from 6.6% to 40.1% and the percent of legal sized urchins ranged from 24.7% to 58.9% (Table 2). Strong recruitment peaks were visible for three of the six PFM sub-areas where transects were surveyed (Figure 3).

DENSITY AND BIOMASS ESTIMATES

The estimated mean density of urchins of all sizes, for all PFM sub-areas, was 0.59 urchins per m^2 and 0.23 urchins per m^2 for legal sized urchins (Table 3). The estimated mean biomass of red sea urchins of all sizes, for all PFM sub-areas pooled, was 165.4 g per m^2 and 120.6 g per m^2 for legal sized urchins (Table 4).

Only 2 transects were surveyed in PFM sub-area 14-5, however, both transects were surveyed off Chrome Island, which is small and is the only area of suitable red urchin habitat open to fishing in that PFM sub-area. Other areas of suitable red sea urchin habitat in PFM sub-area 14-5 are within the marine park located on the southern shores of Hornby Island. The two transects surveyed should therefore provide suitable estimates of density and biomass in PFM sub-area 14-5.

DISCUSSION

Recruitment was defined as the percent of the total red sea urchin population that was ≤50mm TD. Recruitment of red sea urchins in the surveyed area was relatively high (22.2%) (Figure 2, Table 2). The present survey showed a higher recruitment than that for other areas surveyed in 1998 and 1999 on the East Coast of Vancouver Island (Bureau et al. 2000a; 2000b). The proportion of urchins ≤50mm TD was 8.1% in Johnstone Strait (Bureau et al. 2000a) and 3.1% in the Gulf Islands (Bureau et al. 2000b). More detailed analysis on a per PFM sub-area basis showed recruitment to be variable on a small spatial scale (Figure 3). Recruitment was highest in PFM sub-areas 14-7, east side of Denman Island, the portion of PFM sub-area 14-9 on the east side of Hornby Island, and 14-11, Comox Bar.

A previous survey, conducted in 1985, found 19.9% of urchins ≤50mm TD at Comox and Hornby Island but overall only 9.5% urchins ≤50mm TD at four locations on the east coast of Vancouver Island (Sloan et al. 1987). A second, finer scale survey, at Hornby Island only, then found 26.8% urchins ≤50mm TD in 1985 (Sloan et al. 1987). The relatively high recruitment observed on the current survey (22.2%) was consistent with that observed in 1985 for the same area. The reasons why recruitment would be higher in the Comox and Hornby Island area than in other areas of the east coast of Vancouver Island are unknown.

Red sea urchins often have low recruitment (Bernard 1977; Sloan et al. 1987). Recruitment (proportion of urchins ≤50mm TD) reported for red sea urchins for southern BC was variable and ranged from 0 to 26.8% (Adkins et al. 1981; Breen et al. 1976; 1978, Sloan et al. 1987). Recruitment for surveys conducted on red sea urchins in 1994 were 12.8% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b), 8.5% south of Bella Bella, central coast (Jamieson et al. 1998c) and 10.0% for Queen Charlotte Strait and Broughton Strait, north-east Vancouver Island (Jamieson et al. 1998d).

Sloan et al. (1987) reported 57.7% of urchins were of legal size at Comox and Hornby Island in 1985 and 76.0% overall for four areas in the Strait of Georgia. The percentage of legal sized urchins was lower in the present survey (38.6%) than in 1985. This decrease may have resulted from removal by the fishery. The percent of legal sized urchins per PFM sub-area, found on the current survey, ranged from 24.7% to 58.9% and the overall percent of legal sized urchins (38.6%) remained higher than in some areas of the coast.

Caution must be used when comparing percentages since high recruitment could decrease the percent of larger sized animals even in the absence of harvest. However, the proportion of juveniles found in 1999 was between the two values estimated in 1985 (Sloan et al. 1987) which suggested that the decrease in the proportion of legal sized urchins may not be an artefact associated to high recruitment. Conversely a decrease in the proportion of legal size urchins may lead to an over-estimate of recruitment rate. However, a definite recruitment peak occurred overall (Figure 2) and for PFM sub-areas 14-7 and 14-9 (Figure 3), which suggested that the high proportion of juveniles observed in 1999 was due to recruitment.

Proportions of urchins ≥100mm TD for surveys conducted in 1994 were 49.6% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b), 27.3% south of Bella Bella, central coast (Jamieson et al. 1998c) and 52.7% for Queen Charlotte Strait and Broughton Strait, north-east Vancouver Island (Jamieson et al. 1998d). Proportions of urchins ≥100mm TD for surveys conducted in 1993 were 19.0% on the west side and 48.9% on the east side of the Queen

Charlotte Islands, 26.3% in the southern portion of the central coast, 39.9% in the northern portion of the central coast and 50.4% for the Dundas Island and Stephens Island region in the north coast (Jamieson et al. 1998a). Surveys conducted in 1998 and 1999 reported proportions of legal sized urchins of 65.3% in Johnstone Strait (Bureau et al. 2000a) and 87.1% in the Gulf Islands (Bureau et al. 2000b).

Overall few urchins were encountered on transects at Comox Bar (14-11, Table 1). The substrate was rocky in shallow water and then switched to sand/mud bottom in deeper water. Most of the rocky substrate seemed to be located too shallow to support urchin populations. Red sea urchins were present at Cape Lazo (14-12 and part of 14-9) where the rocky substrate extended deeper than at Comox Bar, however, most urchins were found at the deep end of the survey grid. Similarly to Comox Bar few urchins were found in shallow water at Cape Lazo. The survey grid, placed where harvest records and harvesters suggested urchins were, did not extend as deep as the urchin distribution extended so that part of the urchin population present at Cape Lazo was not surveyed. The fact that few urchins were found in shallow water was consistent with observations that urchins in the Strait of Georgia have been generally found deeper than in other areas of the BC coast (D. Bureau personal observation).

Urchin densities were higher on the southern shores of Denman Island and off Hornby Island (14-5, 14-7, 14-8, and part of 14-9). A large population was present at the north end of Hornby Island where the gently sloping smooth bedrock substrate, provided for a large surface area of suitable urchin habitat.

The only published density estimates for the Hornby Island area were those of Sloan et al. (1987) where the average density on five transects surveyed in 1985 was 3.9 urchins per m^2. The sampling was confined, however, to the shallow edge of the urchin distribution to the depth where urchin density declined below 0.5 urchins per m^2. The average density for six transects, sampled within the confines of urchin beds, at Hornby Island in 1993 was 1.17 urchins per m^2 (A. Campbell unpublished data). The sampling techniques used by Sloan et al. (1987) and Campbell (unpublished data) were different than ours. The technique used in 1993 was also different than that used in 1985. Comparisons of the various density estimates are therefore difficult. The method presently used would underestimate density compared to that used in the previous surveys since the early surveys were confined to urchin beds whereas in the present survey the whole depth range from 0 to 10m below chart datum was sampled whether urchins were present or absent. The lower densities obtained in the present survey therefore do not necessarily reflect a decrease in urchin densities. Sampling in earlier surveys was biased so that densities would be over-inflated. The present survey protocol was not biased and therefore more suitable to use in estimates of biomass for the purpose of quota determination for the fishery.

Density estimates from the current survey (0.59 urchins per m^2) were in the mid-range of densities reported from surveys conducted between 1998 and 1999 on the east coast of Vancouver Island. Surveys conducted in 1998 and 1999, using the same survey and analysis methods, showed red sea urchin densities (overall mean per survey) of 1.27 urchins per m^2 in Johnstone Strait (Bureau et al. 2000a) and 0.30 urchins per m^2 in the Gulf Islands region (Bureau et al. 2000b).

The overall mean biomass estimate from the current survey, 165.4g per m^2, was lower than in the Gulf Islands (Bureau et al. 2000b) despite the fact that urchin density was higher in the current survey. Surveys conducted in 1998 and 1999, using the same survey and analysis

methods, showed red sea urchin biomass (overall mean per survey) of 524.4g per m^2 in Johnstone Strait (Bureau et al. 2000a) and of 199.1g per m^2 in the Gulf Islands (Bureau et al. 2000b). Comparison of the size frequency distributions from the current survey and the Gulf survey (Bureau et al. 2000b) explained why biomass was lower in the present survey than in the Gulf despite higher densities. The Gulf Islands survey showed little recruitment and the size frequency distribution was dominated by large urchins. Such a pattern in size frequency distribution would produce a relatively high biomass estimate for the observed density. Instead, the current survey showed high recruitment, so that a large number of small urchins were present but their contribution to population biomass was small.

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Table 1. Summary of transects surveyed during the 1999 red sea urchin (RSU) population survey at Cape Lazo, Comox Bar, Denman Is. and Hornby Is.
Compass bearings are magnetic taken from deep (D) or shallow (S) end of transects. Transect lengths in m, density in number/m^2 and biomass in g/m^2. Num = Number, PFM = Pacific Fishery Management

Location	Transect	PFM Sub-area	Latitude	Longitude	Bearing Bearing	Bearing From	Transect Length	Num Quadrats	Num RSU Counted	RSU Density	RSU Biomass
Cape Lazo	1	14-12	49 42.34	124 51.32	240	D	101	51	60	1.18	365.71
Cape Lazo	2	14-12	49 42.47	124 51.31	220	D	101	5	0	0.00	0.00
Cape Lazo	3	14-12	49 42.33	124 51.32	260	D	101	5	0	0.00	0.00
Cape Lazo	4	14-12	49 42.17	124 51.21	280	D	101	6	0	0.00	0.00
Cape Lazo	5	14-12	49 42.07	124 51.11	230	D	99	50	16	0.32	248.22
Cape Lazo	6	14-9	49 42.00	124 51.26	280	D	101	6	0	0.00	0.00
Cape Lazo	7	14-9	49 41.96	124 51.26	220	D	101	6	0	0.00	0.00
Cape Lazo	8	14-9	49 41.99	124 51.16	265	D	101	6	0	0.00	0.00
Cape Lazo	9	14-9	49 41.53	124 51.20	280	D	101	6	0	0.00	0.00
Cape Lazo	10	14-9	49 41.65	124 50.95	240	D	101	6	0	0.00	0.00
Cape Lazo	11	14-9	49 41.70	124 50.70	80	S	99	50	27	0.54	262.95
Cape Lazo	12	14-9	49 41.62	129 50.78	20	S	101	51	22	0.43	211.97
Cape Lazo	13	14-9	49 41.57	124 50.76	50	S	101	6	0	0.00	0.00
Cape Lazo	14	14-9	49 42.19	124 50.73	30	S	99	50	46	0.92	353.19
Cape Lazo	15	14-9	49 41.86	124 50.63	50	S	101	51	30	0.59	228.68
Cape Lazo	16	14-9	49 41.55	124 50.50	20	S	101	51	10	0.20	119.43
Comox Bar	17	14-11	49 40.03	124 53.10	60	S	101	6	0	0.00	0.00
Comox Bar	18	14-11	49 39.75	124 53.41	100	S	101	6	0	0.00	0.00
Comox Bar	19	14-11	49 39.68	124 52.80	60	S	101	6	0	0.00	0.00
Comox Bar	20	14-11	49 39.51	124 53.22	40	S	101	6	0	0.00	0.00
Comox Bar	21	14-11	49 39.47	124 52.80	25	S	101	6	0	0.00	0.00
Comox Bar	22	14-11	49 39.58	124 20.48	60	S	101	6	0	0.00	0.00
Comox Bar	23	14-11	49 39.55	124 52.27	25	S	101	6	0	0.00	0.00
Comox Bar	25	14-11	49 39.44	124 20.35	40	S	101	6	0	0.00	0.00
Comox Bar	26	14-11	49 39.31	124 52.29	340	D	101	6	0	0.00	0.00
Comox Bar	28	14-11	49 39.22	124 52.56	70	S	101	6	0	0.00	0.00
Comox Bar	29	14-11	49 39.16	124 52.42	80	S	99	50	109	2.18	510.39
Comox Bar	30	14-11	49 39.35	124 53.35	70	D	101	6	0	0.00	0.00
Comox Bar	31	14-11	49 39.28	124 53.38	60	D	101	6	0	0.00	0.00
Comox Bar	32	14-11	49 39.36	124 53.69	40	D	101	6	0	0.00	0.00
Comox Bar	33	14-11	49 39.42	124 53.76	60	D	101	6	0	0.00	0.00
Comox Bar	34	14-11	49 39.50	124 53.96	65	D	101	6	0	0.00	0.00
Comox Bar	35	14-11	49 39.97	124 52.52	60	D	101	51	67	1.31	521.99
Denman Is.	36	14-8	49 28.77	124 43.86	200	S	201	101	21	0.21	86.05
Denman Is.	37	14-8	49 28.78	124 43.54	167	S	147	74	61	0.82	263.13
Denman Is.	38	14-8	49 28.81	124 43.17	267	S	161	81	85	1.05	345.63
Denman Is.	39	14-8	49 28.75	124 42.60	180	S	101	6	0	0.00	0.00
Denman Is.	40	14-8	49 28.56	124 41.95	186	S	81	41	61	1.49	616.78
Denman Is.	41	14-8	49 28.39	124 41.45	200	S	121	61	76	1.25	553.55
Denman Is.	42	14-5	49 28.27	124 41.02	200	S	81	41	49	1.20	333.36
Denman Is.	43	14-5	49 28.31	124 40.86	109	S	121	61	48	0.79	156.93
Denman Is.	44	14-7	49 28.94	124 40.70	70	S	85	43	116	2.70	421.79
Denman Is.	45	14-7	49 28.93	124 41.16	60	S	95	48	53	1.10	364.10
Denman Is.	46	14-7	49 29.34	124 41.43	20	S	99	50	139	2.78	758.58
Denman Is.	47	14-7	49 29.49	124 41.94	355	S	321	17	0	0.00	0.00
Denman Is.	48	14-7	49 29.83	124 42.86	35	S	121	7	0	0.00	0.00
Denman Is.	49	14-7	49 29.97	124 43.21	70	S	161	81	44	0.54	81.34
Denman Is.	50	14-7	41 30.25	124 43.51	70	S	201	101	3	0.03	23.55
Denman Is.	51	14-7	49 30.40	124 43.55	40	S	159	80	149	1.86	509.23
Hornby Is.	52	14-7	49 32.28	124 43.09	307	S	141	71	45	0.63	226.16
Hornby Is.	53	14-9	49 32.45	124 43.05	267	S	281	141	126	0.89	282.79
Hornby Is.	54	14-9	49 32.75	124 42.64	170	D	199	100	110	1.10	519.73
Hornby Is.	56	14-9	49 35.44	124 42.54	300	S	381	191	151	0.79	217.05
Hornby Is.	57	14-9	49 33.43	124 41.65	30	S	305	153	184	1.20	231.81
Hornby Is.	58	14-9	49 33.34	124 41.23	10	S	101	51	82	1.61	211.57
Hornby Is.	59	14-9	49 33.26	124 40.52	180	D	167	84	161	1.92	440.47
Hornby Is.	60	14-9	49 33.12	124 40.12	355	S	321	17	0	0.00	0.00
Hornby Is.	61	14-9	49 33.07	124 39.82	85	S	195	98	240	2.45	369.86
Hornby Is.	62	14-9	49 32.55	124 38.42	350	S	197	99	94	0.95	235.15
Hornby Is.	63	14-9	49 32.37	124 37.88	15	S	261	131	23	0.18	20.42
Hornby Is.	64	14-9	49 32.19	124 37.23	45	S	261	14	0	0.00	0.00

Table 2. Number of red sea urchins measured and percent (in brackets) of total urchins ≤50mm TD and ≥100mm TD for each Pacific Fishery Management (PFM) sub-area surveyed in the 1999 population survey at Cape Lazo, Comox Bar, Denman Island and Hornby Island.

PFM	Size Measured			Numbers Measured		
Sub-area	Minimum	Maximum	Mean	Total	≤50mm TD	≥100mm TD
14-5	7	142	82.3	97	12 (12.4)	24 (24.7)
14-7	7	161	74.1	549	176 (32.1)	187 (34.1)
14-8	10	162	98.9	304	24 (7.9)	179 (58.9)
14-9	7	165	80.8	1306	267 (20.4)	466 (35.7)
14-11	10	172	78.5	176	72 (40.1)	70 (39.8)
14-12	10	162	100.7	76	5 (6.6)	43 (56.6)
Total	7	172	82.0	2508	556 (22.2)	969 (38.6)

Table 3. Estimates of density (number/m^2) of red sea urchins (RSU), by Pacific Fishery Management (PFM) sub-area, for the 1999 survey in the Cape Lazo, Comox Bar, Denman Is. and Hornby Is. areas. Estimated numbers of red sea urchins were extrapolated to transect length.

PFM	Number	Sum of	Est. Number of		Mean Density		Standard Error	
Sub-	of	Transect	RSU in Transects		RSU/m^2		of Mean Density	
Area	Transects	Lengths (m)	All sizes	≥100mm	All sizes	≥100mm	All sizes	≥100mm
14-5	2	202	192	47	0.95	0.23	-	-
14-7	9	1383	1088	371	0.79	0.27	0.337	0.126
14-8	6	812	603	355	0.74	0.44	0.222	0.140
14-9	22	3776	2598	927	0.69	0.25	0.158	0.057
14-11	17	1715	349	139	0.20	0.08	0.144	0.056
14-12	5	503	151	85	0.30	0.17	0.229	0.114
Total	61	8391	4981	1924	0.59	0.23	0.097	0.038

Table 4. Estimates of biomass (g/m^2) of red sea urchins (RSU), by Pacific Fishery Management (PFM) sub-area, for the 1999 survey in the Cape Lazo, Comox Bar, Denman Is. and Hornby Is. areas. Estimated weights of red sea urchins were extrapolated to transect length.

PFM Sub-Area	Number of Transects	Sum of Transect Lengths (m)	Est. Weight of RSU on Transects (kg)		Mean Biomass of RSU (g/m^2)		Standard Error of Mean Biomass	
			All Sizes	≥100mm	All Sizes	≥100mm	All Sizes	≥100mm
14-5	2	202	46.0	22.8	227.7	112.9	-	-
14-7	9	1383	276.2	205.4	199.7	148.5	85.4	67.7
14-8	6	812	228.6	188.4	281.5	232.1	88.3	78.0
14-9	22	3776	672.6	454.7	178.1	120.4	37.3	30.0
14-11	17	1715	103.2	89.7	60.2	52.3	41.3	35.9
14-12	5	503	61.5	51.0	122.3	101.4	77.6	62.5
Total	61	8391	1,388.1	1,012.0	165.4	120.6	25.2	20.5

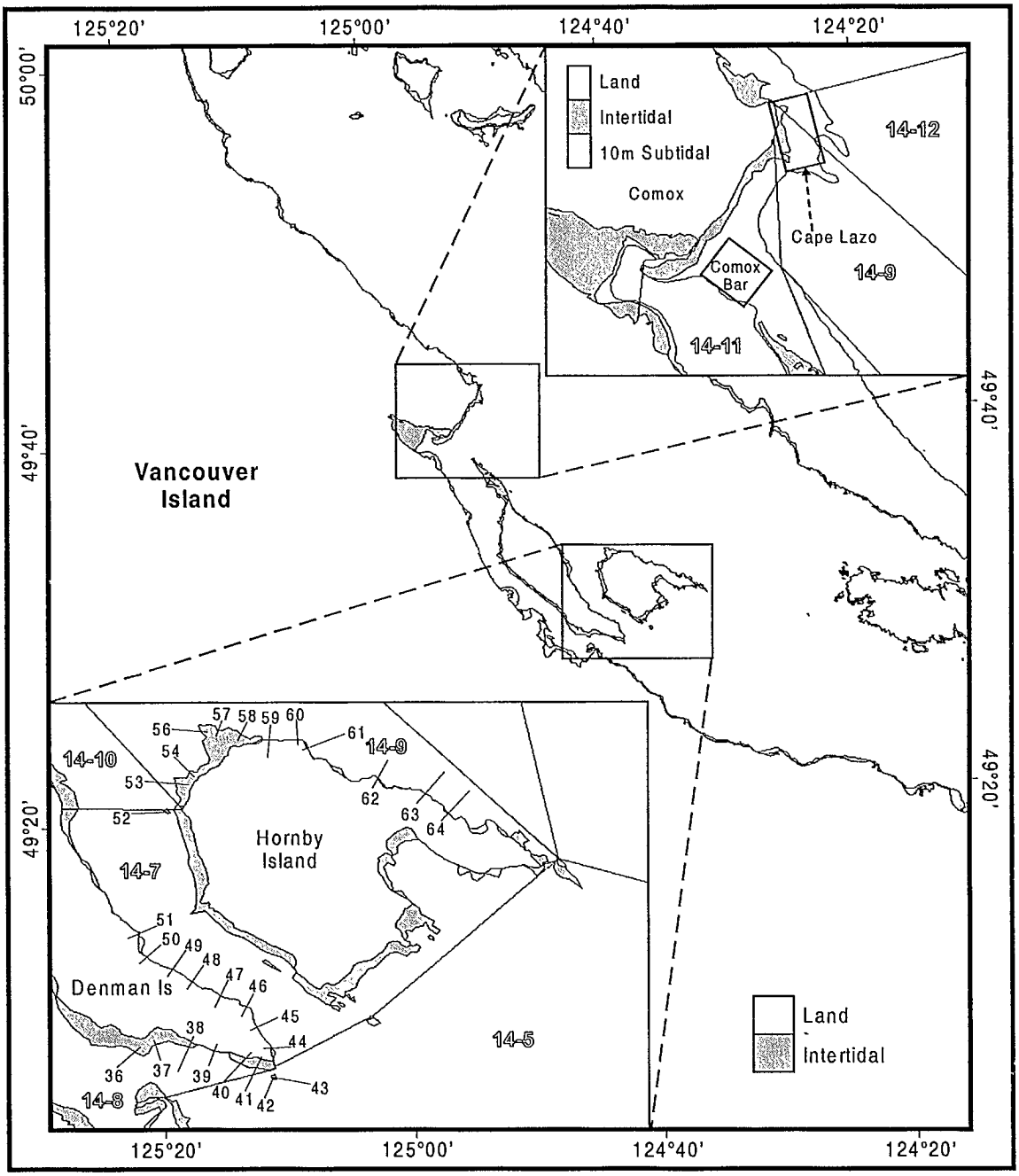

Figure 1. Map of survey area and location of transects surveyed on the 1999 red sea urchin population survey in the Cape Lazo, Comox Bar, Denman Island and Hornby Island area. Outlined numbers indicate Pacific Fishery Management sub-areas and solid numbers identify transect numbers. Position of transect grid only is indicated for Comox Bar and Cape Lazo because transects were too close together to show, see Table 1 for latitudes and longitudes of transect positions.

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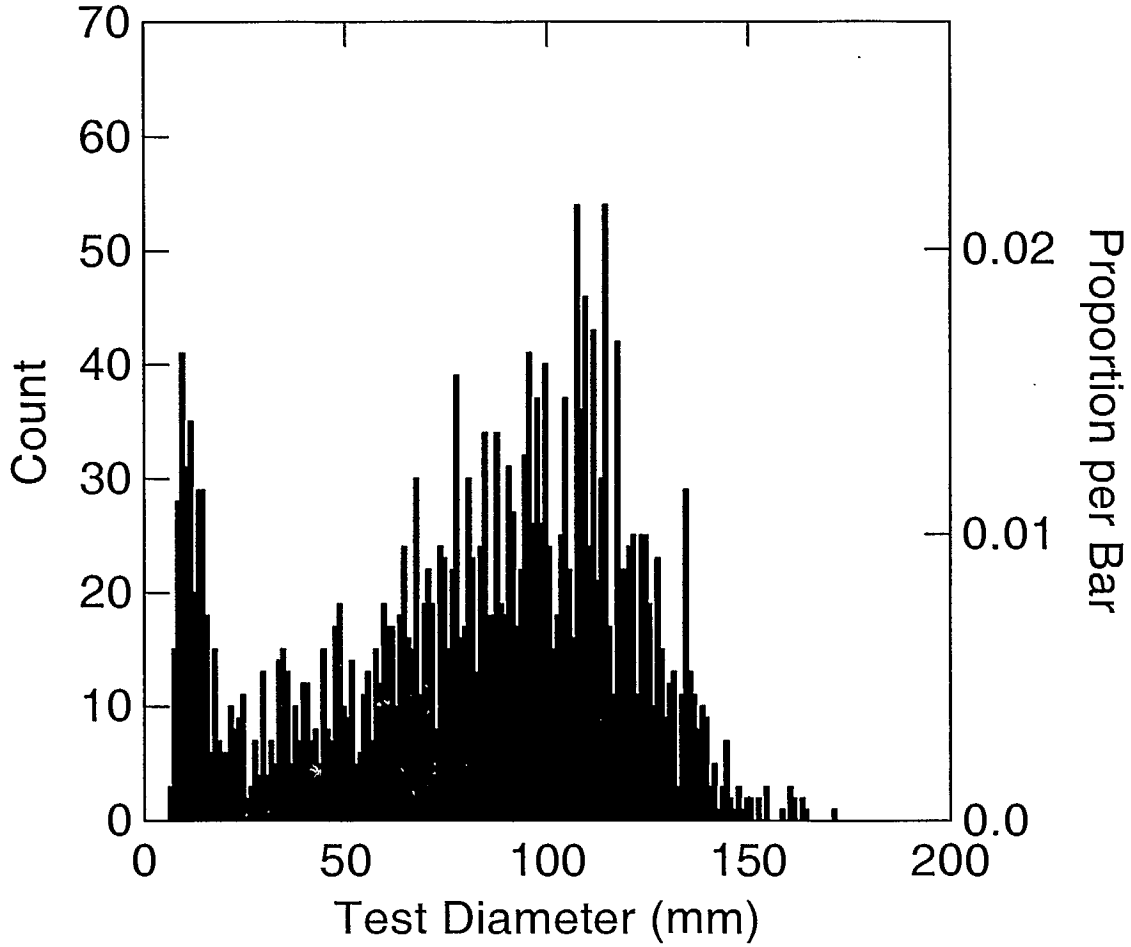

Figure 2. Size frequency distribution of red sea urchins measured on all transects during the 1999 population survey at Cape Lazo, Comox Bar, Denman Island and Hornby Island (n=2508).

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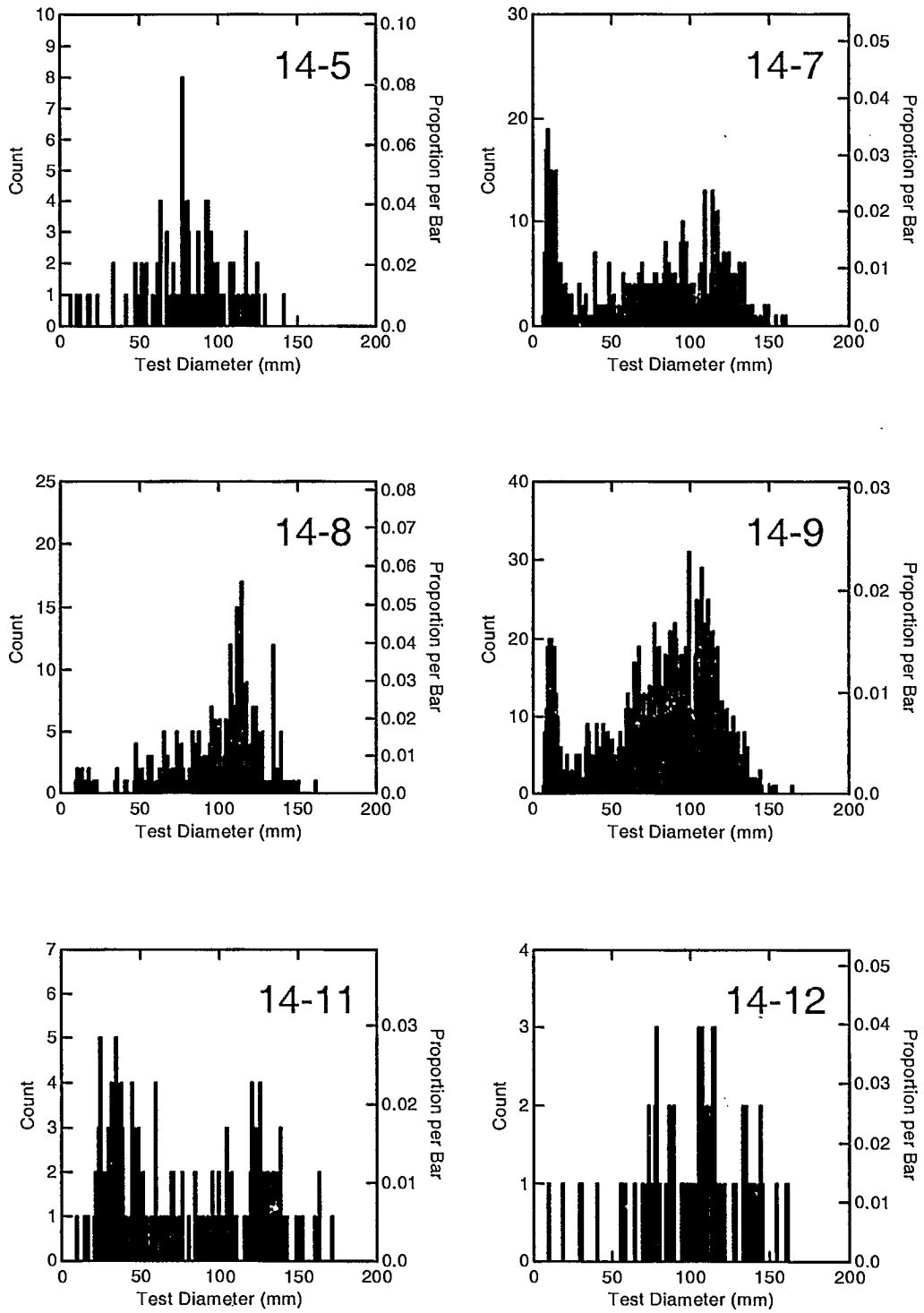

Figure 3. Size frequency distributions, by Pacific Fishery Management (PFM) sub-area, of red sea urchins measured during the 1999 population survey at Cape Lazo, Comox Bar, Denman Island and Hornby Island. The numbers in the upper right hand side of graphs are the PFM sub-area numbers.