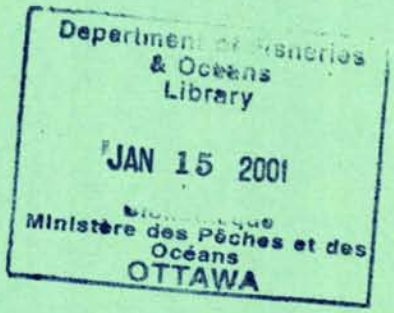
Survey of Red Sea Urchin Populations in the Kelsey Bay Area, Johnstone Strait, British Columbia, 1999

D. Bureau, A. Campbell, and W. C. Hajas



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SURVEY OF RED SEA URCHIN POPULATIONS IN THE KELSEY BAY AREA, JOHNSTONE STRAIT, BRITISH COLUMBIA, 1999

by

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ABSTRACT

Bureau, D., A. Campbell, and W. C. Hajas. 2000. Survey of red sea urchin populations in the Kelsey Bay Area, Johnstone Strait, British Columbia, 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2542: 19 p.

A survey of red sea urchin populations in the portion of Johnstone Strait near Kelsey Bay, parts of Pacific Fishery Management (PFM) Areas 12 and 13, was conducted in August 1999. A total of 74 transects were surveyed by SCUBA divers. Densities and biomass were estimated on a per PFM sub-area basis. In PFM area 12, estimated mean density ranged from 0.43 to 0.81 urchins per m^2, overall mean density was 0.59 urchins per m^2. In PFM area 13, estimated mean density ranged from 0.52 to 2.68 urchins per m^2, overall mean density was 1.79 urchins per m^2. Estimated mean biomass ranged from 226.4 to 320.2 g per m^2 and overall mean biomass was 265.3 g per m^2 in PFM area 12. Biomass ranged from 183.9 to 933.9 g per m^2 and overall biomass was 718.5 g per m^2 in PFM area 13. Overall, 8.1% of the total urchins measured were ≤50mm test diameter (TD) whereas 65.3% of urchins 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 in the Kelsey Bay Area, Johnstone Strait, British Columbia, 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2542: 19 p.

Sont présentés les résultats d'un relevé des populations d'oursin rouge effectué en août 1999 dans la partie du détroit de Johnstone, près de Kelsey Bay, qui est incluse dans les zones de gestion des pêches du Pacifique 12 et 13. Au total, 74 transects ont été réalisés en plongée autonome; les données recueillies ont servi à l'estimation des densités et de la biomasse dans chaque sous-zone des deux zones de gestion. La densité moyenne estimative variait entre 0,43 et 0,81 oursins par m^2 et 0,52 et 2,68 oursins par m^2 dans les zones 12 et 13, respectivement, tandis que la densité moyenne générale s'élevait à 0,59 oursins par m^2 et 1,79 oursins par m^2. La biomasse moyenne estimative dans chacune de ces zones variait entre 226,4 et 320,2 g par m^2 et entre 183,9 et 933,9 g par m^2, respectivement, tandis que la biomasse moyenne générale s'élevait à 265,3 g par m^2 et 718,5 g par m^2. En général, le diamètre du test chez 8,1 % du nombre total d'oursins mesurés s'élevait à ≤50 mm, tandis que 65,3 % des oursins étaient de taille marchande légale (diamètre du test ≥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 100 mm 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 in the North Coast 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 in the South Coast, were reported by Adkins et al. (1981), Breen et al. (1976; 1978) and Sloan et al. (1987).

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 of Johnstone Strait around Kelsey Bay [parts of Pacific Fishery Management (PFM) Areas 12 and 13] was selected for survey (Figure 1) through discussion between DFO and PUHA. 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 here were presented in Campbell et al. (1999b).

METHODS

SURVEY AREA AND TRANSECT LAYOUT

Survey efforts were concentrated evenly throughout all PFM sub-areas surveyed. The survey was in part explorative since this was the first survey of red sea urchin populations in this region. Harvest of red sea urchins in the Johnstone Strait region has been concentrated near

Kelsey Bay, the point of landing of red sea urchins for the region. Urchin bed locations are determined from charts submitted by the harvesters where they indicate areas fished. The lack of bed area information farther from Kelsey Bay might therefore reflect the harvesters' preference to fishing close to the harbour, as opposed to a shortage of urchins in areas farther from Kelsey Bay. Transects were assigned throughout the entire PFM sub-areas so as to obtain representative estimates. In some past surveys only portions of certain sub-areas were surveyed which may cause problems when extrapolating densities to a whole sub-area. Transects locations were selected and transects were plotted on a marine chart prior to the survey to avoid biases in the field. The survey was divided in two sections: shoreline and islands. The number of transects assigned to each section was proportional to the ratio of the surface area of water between 0 and 10m below chart datum of each section over the total surface area of water between 0 and 10m below chart datum. Surface area of water between 0 and 10m below chart datum was estimated using the Compugrid GIS system after digitising the survey areas.

Transect layout along the shoreline was done by systematically placing transects along shore with a random starting point. Areas of sandy substrate were excluded from the survey area. Total shoreline length (TSL) 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. Distance between transects was TSL/n where n is the number of transects 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).

Transects around islands were assigned by randomly choosing islands and then randomly assigning a transect compass bearing to determine the position and direction of the transects off an island.

Density and biomass estimates were obtained from transects randomly placed through entire PFM sub-areas, excluding sandy areas. Therefore, the total number of urchins and total biomass could be extrapolated to the surface area (of water between 0 to 10m below chart datum) of each whole PFM sub-area (minus the excluded sandy areas), as opposed to using only the urchin bed areas for extrapolation.

SURVEY LOGISTICS

The survey was conducted between August 3 and 12, 1999, on the "Karohshi", a commercial red sea urchin fishing skiff. The vessel "Suncrest" was used as a live-aboard and remained docked at Kelsey Bay for most of the survey. The "Suncrest" was moved to Port Harvey when surveying the western-most portion of the survey area (PFM sub-area 12-2). A crew of four people: three divers and a boat tender, was used for the survey.

DIVE SURVEY METHODS

Leadline transects were laid perpendicular to shore from the boat. Transects were laid out from shallow water to a depth of 15m and thus transect length was dependent on the slope of the substrate. 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 was repeated, so that every second meter on the transect was surveyed. In cases where the substrate was sand and no urchins were found at the deep end of transects, observations of depth, substrate and algae were recorded only 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, per PFM sub-area, were calculated using the following equations.

Density estimates (d_{ts}) in numbers/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) in millimetres (Campbell et al. 1999b; 2000).

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

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 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 ($\bar{b}_s$) per surface area (g/m^2) was calculated for each PFM sub-area 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 74 transects were surveyed (Table 1 and Figure 1) in 10 days. After the first 64 scheduled transects were surveyed, time permitted the addition of 10 transects. Additional transects were randomly added in areas 13-32 and 13-33. A few of the scheduled transects could not be surveyed due to high current conditions, which are common in the portion of Johnstone Strait that was surveyed. A total of 2322 red sea urchins were counted and measured in 1332 quadrats on the 74 transects. Total transect length surveyed was 3570m. The slope of the substrate in the survey area was generally steep so that average transect length was relatively short (48m).

SIZE FREQUENCY DISTRIBUTIONS

The overall mean size of red sea urchins measured was 102.3mm TD (n=2322) for all red sea urchins measured in all PFM sub-areas surveyed (Table 2, Figure 2). On a PFM sub-area basis, mean size ranged from 93.2 to 125.6mm TD, the smallest urchin measured ranged between 10 and 24mm TD whereas the largest urchin measured ranged from 141 to 165mm TD.

The overall percent of legal sized urchins (≥100mm TD) was 65.3% whereas the overall percent of urchins ≤50mm TD was 8.1%. On a PFM sub-area basis, the percent of urchins ≤50mm TD ranged from 2.5% to 15.9% and the percent of legal sized urchins ranged from 55.7% to 89.2% (Table 2, Figure 3).

DENSITY AND BIOMASS ESTIMATES

The estimated mean density of urchins of all sizes was 0.59 urchins per m^2 in PFM area 12 and 1.79 urchins per m^2 in PFM area 13 (Table 3). The estimated mean density of legal sized urchins was 0.41 urchins per m^2 in PFM area 12 and 1.15 urchins per m^2 in PFM area 13. The estimated mean biomass of red sea urchins of all sizes was 265.3 g per m^2 in PFM area 12 and 718.5 g per m^2 in PFM area 13 (Table 4). The estimated mean biomass of legal sized urchins was 239.8 g per m^2 in PFM area 12 and 613.4 g per m^2 in PFM area 13.

Overall mean density for the survey (PFM Area 12 and 13 combined) was 1.27 and 0.83 urchins per m^2 for urchins of all sizes and legal sized urchins, respectively. Overall mean biomass for the survey (PFM Area 12 and 13 combined) was 524.4 and 453.4g per m^2 for urchins of all sizes and legal sized urchins, respectively.

Although only two transects were surveyed in PFM sub-area 12-24, the transects surveyed should provide acceptable estimates of density and biomass because this PFM sub-area is very small.

DISCUSSION

Recruitment was defined as the percent of the total red sea urchin population that was ≤50mm TD. Red sea urchins populations often have low recruitment (Bernard 1977; Sloan et al. 1987). The size frequency distribution of red sea urchins from the current survey indicated low recruitment (Figure 2), 8.1% of urchins found were ≤50mm TD. The present survey showed recruitment levels similar to those observed in other parts of the BC coast. Surveys conducted in 1998 and 1999 showed that recruitment was higher in the Comox region (22.2%) (Bureau et al. 2000a) and lower in the Gulf Islands (3.1%) (Bureau et al. 2000b) than in Johnstone Strait. No previous recruitment figures are available for Johnstone Strait. However, in a survey conducted in 1985 in the Campbell River area, 24.0% of urchins found were ≤50mm TD (Sloan et al. 1987). Overall, 9.5% urchins were ≤50mm TD at four locations on the East Coast of Vancouver Island in 1985 (Sloan et al. 1987). A survey conducted in Queen Charlotte Strait and Broughton Strait, north-east Vancouver Island, in 1994 found 10.0% of urchins to be ≤50mm TD (Jamieson et al. 1998d).

Recruitment reported for southern BC was variable and ranged from 0 to 27% (Adkins et al. 1981; Breen et al. 1976; 1978; Sloan et al. 1987). In Northern BC, proportions of urchins ≤50mm TD for surveys conducted in 1994 were 12.8% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b) and 8.5% south of Bella Bella, central coast (Jamieson et al. 1998c).

The percentage of legal sized urchins (≥100mm TD) in the present survey ranged from 55.7% to 89.2%, on a PFM sub-area basis, and averaged 65.3% overall making the region covered in this survey one of the regions with the highest proportions of legal sized urchins on the BC coast. Surveys conducted on the east coast of Vancouver Island, in 1998 and 1999, reported proportions of legal sized urchins of 38.6% in the Comox region (Bureau et al. 2000a) and 87.1% in the Gulf Islands region (Bureau et al. 2000b). Sloan et al. (1987) reported 48.0% of urchins were of legal size at Campbell River in 1985 and 76.0% overall for four areas in the Strait of Georgia. In 1994, the percent of urchins ≥100mm TD was 52.7% for Queen Charlotte Strait and Broughton Strait, north-east Vancouver Island (Jamieson et al. 1998d).

In the North Coast of BC, the percent of urchins ≥100mm TD for surveys conducted in 1994 was 49.6% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b) and 27.3% south of Bella Bella, central coast (Jamieson et al. 1998c). On surveys conducted in 1993, the percent of urchins ≥100mm TD was 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 region in the north coast (Jamieson et al. 1998a).

Estimated densities were highest in PFM sub-areas close to Kelsey Bay, i.e., 13-31, 13-32 and 13-33 (Figure 1). These PFM sub-areas appeared to have the highest current; Johnstone Strait is narrower and generally shallower east of Kelsey Bay, causing higher currents, than west of Kelsey Bay (Thomson 1981). The harvesters' preference to fishing close to Kelsey Bay when working in Johnstone Strait may therefore be related to the higher red sea urchin densities closer to Kelsey Bay combined with reduced travel time and costs.

The overall density observed on the current survey (1.27 urchins per m^2) was the highest reported for the east coast of Vancouver Island for surveys conducted in 1998 and 1999. Other surveys on the east coast of Vancouver Island showed red sea urchin densities (overall mean per survey) of 0.59 urchins per m^2 in the Comox region (Bureau et al. 2000a) and of 0.30 urchins per m^2 in the Gulf Islands region (Bureau et al. 2000b).

The current survey provided the highest red sea urchin biomass estimate (524.4g per m^2 overall) of all areas surveyed on the east coast of Vancouver Island in 1998 and 1999. Estimates from other areas on the east coast of Vancouver Island were 165.4g per m^2 in the Comox region (Bureau et al. 2000a) and 199.1g per m^2 in the Gulf Islands (Bureau et al. 2000b).

The present survey was the first red sea urchin survey of the Johnstone Strait area, consequently, no earlier estimates of density and biomass were available for direct comparison.

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Table 1. Position of transects surveyed during the 1999 red sea urchin (RSU) population survey in the Kelsey Bay and Johnstone Strait areas. Transect lengths in m, density in number/m^2 and biomass in g/m^2. Num = Number, PFM = Pacific Fishery Management.

Transect	PFM Sub-area	Latitude	Longitude	Transect Length	Number Quadrats	Num RSU Counted	RSU Density	RSU Biomass
1	13-30	50 22.984	125 40.695	31	16	32	2.00	776.54
2	13-30	50 22.713	125 42.609	19	10	12	1.20	300.85
3	13-31	50 22.603	125 44.437	37	19	36	1.89	783.89
4	13-31	50 22.859	125 46.222	37	19	53	2.79	643.44
5	13-30	50 21.614	125 41.463	81	5	0	0.00	0.00
6	13-30	50 21.406	125 43.000	31	3	0	0.00	0.00
7	13-31	50 21.693	125 44.802	71	36	99	2.75	893.19
8	13-31	50 21.845	125 46.595	43	22	100	4.55	1826.08
9	13-31	50 22.596	125 48.127	41	21	26	1.24	466.40
10	13-32	50 23.401	125 46.286	101	6	0	0.00	0.00
11	13-32	50 24.506	125 49.114	27	14	32	2.29	677.68
12	13-32	50 24.807	125 51.011	37	19	23	1.21	457.94
13	13-32	50 25.183	125 52.774	67	34	42	1.24	655.32
14	13-32	50 24.871	125 54.602	145	73	95	1.30	649.92
15	13-32	50 24.188	125 52.182	17	9	21	2.33	1016.00
16	13-32	50 24.188	125 52.182	39	20	23	1.15	563.49
19	13-32	50 23.059	125 49.801	73	37	140	3.78	1377.46
20	13-32	50 22.845	125 51.615	23	12	42	3.50	622.01
21	13-32	50 23.141	125 53.470	21	11	28	2.55	642.11
22	13-33	50 25.189	125 56.520	35	18	72	4.00	1184.54
23	13-33	50 26.060	125 57.803	43	22	8	0.36	91.52
24	13-33	50 23.254	125 55.293	159	80	256	3.20	1262.75
25	13-33	50 24.134	125 58.104	47	24	75	3.13	1209.96
26	13-33	50 24.876	125 59.481	81	41	90	2.20	867.25
27	13-35	50 27.236	125 59.579	39	20	35	1.75	837.16
28	13-35	50 26.844	125 58.914	33	17	14	0.82	565.43
29	13-35	50 26.644	125 57.619	17	9	7	0.78	481.87
30	13-35	50 26.896	125 55.456	25	13	0	0.00	0.00
31	13-35	50 27.383	125 54.716	19	10	8	0.80	460.30
32	13-35	50 28.279	125 56.468	21	11	5	0.45	382.12
33	13-35	50 28.164	125 58.133	37	19	15	0.79	746.84
34	13-35	50 28.249	125 59.562	27	14	36	2.57	1885.69
35	13-35	50 28.548	125 59.519	101	6	0	0.00	0.00
36	12-1	50 25.707	126 01.313	31	16	29	1.81	791.95
37	12-1	50 26.148	126 02.806	47	24	30	1.25	446.55
38	12-1	50 26.682	126 04.603	39	20	3	0.15	121.00
39	12-1	50 27.185	126 06.431	43	22	81	3.68	1070.50
40	12-1	50 27.508	126 08.302	17	9	39	4.33	1644.39
41	12-1	50 27.399	126 10.155	101	6	0	0.00	0.00
42	12-1	50 27.781	126 11.700	25	13	21	1.62	735.54
43	12-1	50 28.798	126 01.473	101	6	0	0.00	0.00

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Table 1. (cont'd)

Transect	PFM Sub-area	Latitude	Longitude	Transect Length	Number Quadrats	um RS Counted	RSU Density	RSU Biomass
44	12-1	50 28.543	126 03.150	43	22	30	1.36	841.02
45	12-1	50 29.068	126 05.665	61	4	0	0.00	0.00
46	12-1	50 28.984	126 05.969	35	18	3	0.17	96.27
47	12-1	50 29.129	126 07.457	43	22	10	0.45	290.12
48	12-1	50 29.132	126 09.349	41	3	0	0.00	0.00
49	12-24	50 29.684	126 11.026	41	3	0	0.00	0.00
50	12-24	50 29.941	126 12.803	31	16	30	1.88	743.62
51	12-2	50 30.417	126 14.447	91	46	0	0.00	0.00
52	12-2	50 30.489	126 16.338	101	6	0	0.00	0.00
53	12-2	50 30.854	126 17.338	73	37	52	1.41	781.83
54	12-2	50 30.928	126 17.936	51	4	0	0.00	0.00
55	12-2	50 31.184	126 17.864	31	3	0	0.00	0.00
56	12-2	50 31.196	126 17.660	45	4	0	0.00	0.00
57	12-2	50 31.260	126 17.447	51	26	0	0.00	0.00
58	12-2	50 32.809	126 17.123	17	9	0	0.00	0.00
59	12-2	50 31.849	126 18.428	19	10	0	0.00	0.00
60	12-2	50 31.324	126 20.200	37	19	4	0.21	162.26
61	12-2	50 28.771	126 20.401	41	3	0	0.00	0.00
62	12-2	50 28.648	126 18.548	41	21	21	1.00	320.93
63	12-2	50 28.298	126 14.897	21	11	11	1.00	450.63
64	12-2	50 28.104	126 13.210	27	14	35	2.50	923.18
65	12-2	50 32.278	126 16.248	121	7	0	0.00	0.00
66	12-2	50 30.917	126 17.106	63	32	61	1.91	1227.06
68	13-33	50 23.420	125 56.310	19	10	9	0.90	342.48
70	13-33	50 24.872	125 55.716	79	40	70	1.75	613.78
71	13-32	50 25.082	125 53.744	61	4	0	0.00	0.00
72	13-32	50 25.023	125 51.903	81	41	178	4.34	1997.45
73	13-32	50 24.657	125 50.086	17	9	8	0.89	225.76
74	13-32	50 23.744	125 47.089	39	20	65	3.25	1339.92
76	13-32	50 22.961	125 52.558	19	10	3	0.30	140.65
77	13-32	50 23.306	125 54.341	29	15	22	1.47	760.31
78	13-32	50 24.317	125 53.126	21	11	5	0.45	140.95
79	13-32	50 23.621	125 52.253	51	26	77	2.96	1043.70

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 in the Kelsey Bay and Johnstone Strait area.

PFM	Size Measured (mm)			Numbers Measured		
Sub-area	Minimum	Maximum	Mean	Total	≤50mm TD	≥100mm TD
12-1	14	159	100.6	246	27 (11.0)	156 (63.4)
12-2	19	165	113.5	184	9 (4.9)	145 (78.8)
12-24	24	159	97.8	30	4 (13.3)	18 (60.0)
12 Total	14	165	105.6	460	40 (8.7)	319 (69.3)
13-30	17	141	93.2	44	7 (15.9)	25 (56.8)
13-31	10	149	95.6	314	28 (8.9)	175 (55.7)
13-32	10	165	102.2	804	65 (8.1)	543 (67.5)
13-33	14	162	99.2	580	44 (7.6)	347 (59.8)
13-35	14	161	125.6	120	3 (2.5)	107 (89.2)
13 Total	10	165	101.5	1862	147 (7.9)	1197 (64.3)
12 & 13 Total	10	165	102.3	2322	187 (8.1)	1516 (65.3)

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 Kelsey Bay and Johnstone Strait areas.

PFM	Number	Sum of	Est. Number of RSU		Mean Density		Standard Error	
Sub-	of	Transect	on Transects		RSU/m^2		of Mean Density	
Area	Transects	Lengths (m)	All Sizes	≥100 mm	All Sizes	≥100 mm	All Sizes	≥100 mm
12-1	13	627	477	302	0.76	0.48	0.325	0.187
12-2	16	830	360	284	0.43	0.34	0.200	0.163
12-24	2	72	58	35	0.81	0.48	-	-
12 Total	31	1529	895	621	0.59	0.41	0.171	0.116
13-30	4	162	85	48	0.52	0.30	-	-
13-31	5	229	615	343	2.68	1.50	0.508	0.411
13-32	18	868	1575	1066	1.81	1.23	0.423	0.295
13-33	7	463	1144	685	2.47	1.48	0.405	0.270
13-35	9	319	232	207	0.73	0.65	0.330	0.298
13 Total	43	2041	3651	2349	1.79	1.15	0.260	0.173

Table 4. Estimates of biomass per m^2 of red sea urchins (RSU), by Pacific Fishery Management (PFM) sub-area, for the 1999 survey in the Kelsey Bay and Johnstone Strait areas.

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	≥100 mm	All Sizes	≥100 mm	All Sizes	≥100 mm
12-1	13	627	194.6	171.6	310.4	273.7	118.3	102.9
12-2	16	830	187.9	174.2	226.4	209.9	113.0	107.8
12-24	2	72	23.1	20.7	320.2	288.5	-	-
12 Total	31	1529	405.6	366.5	265.3	239.8	77.4	71.4
13-30	4	162	29.8	25.8	183.9	159.5	-	-
13-31	5	229	213.9	171.0	933.9	746.7	218.0	215.7
13-32	18	868	639.8	557.4	737.1	642.1	174.7	158.3
13-33	7	463	428.3	346.7	925.0	748.7	167.9	140.8
13-35	9	319	154.8	151.1	485.3	473.7	217.4	213.9
13 Total	43	2041	1,466.6	1,252.0	718.5	613.40	104.2	91.5

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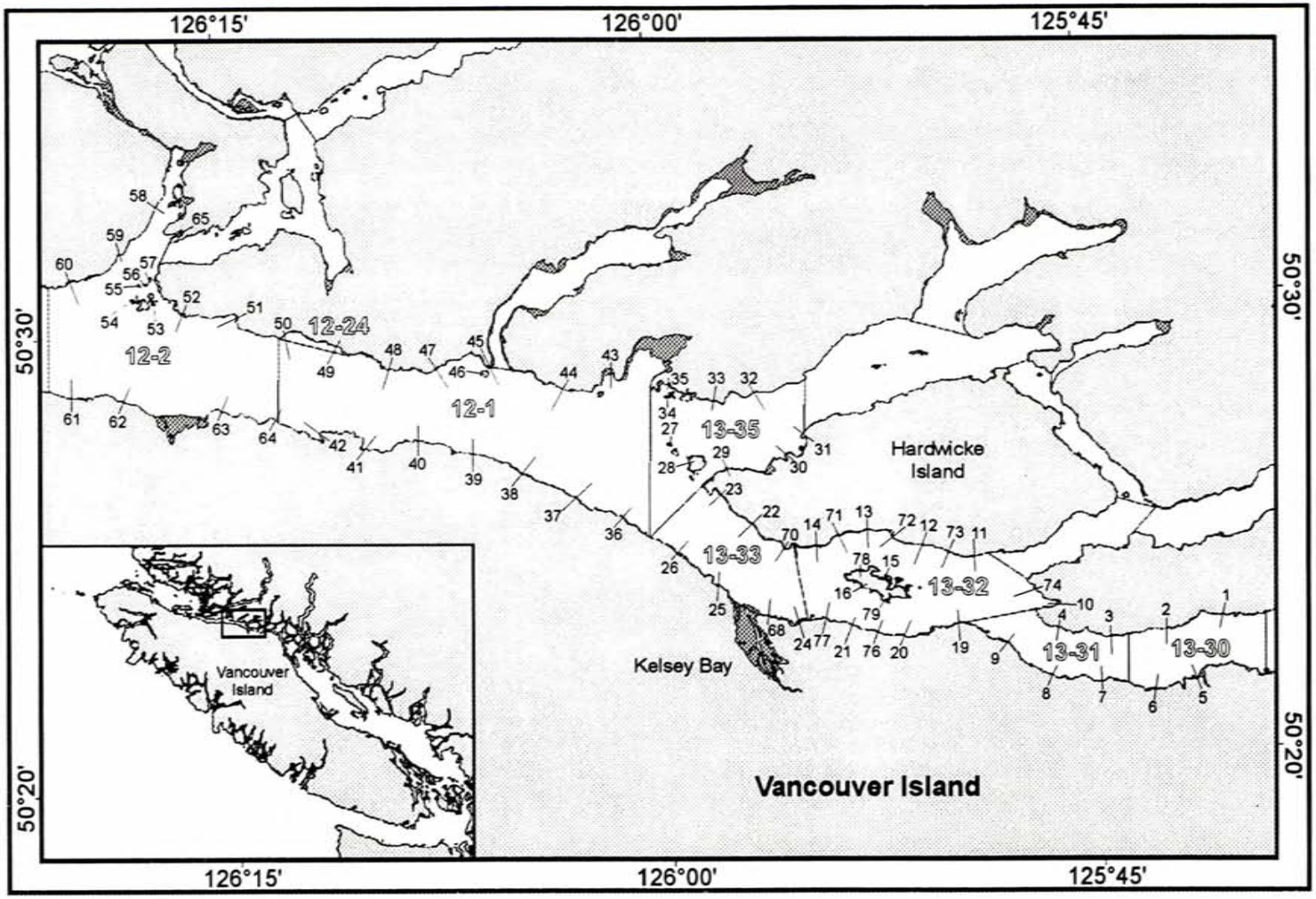

Figure 1. Map of survey area and transect locations for the 1999 red sea urchin population survey in the Kelsey Bay, Johnstone Strait area. Outlined numbers indicate Pacific Fishery Management sub-areas and solid numbers identify transect numbers. Light grey areas represent land and dark grey areas represent the intertidal zone.

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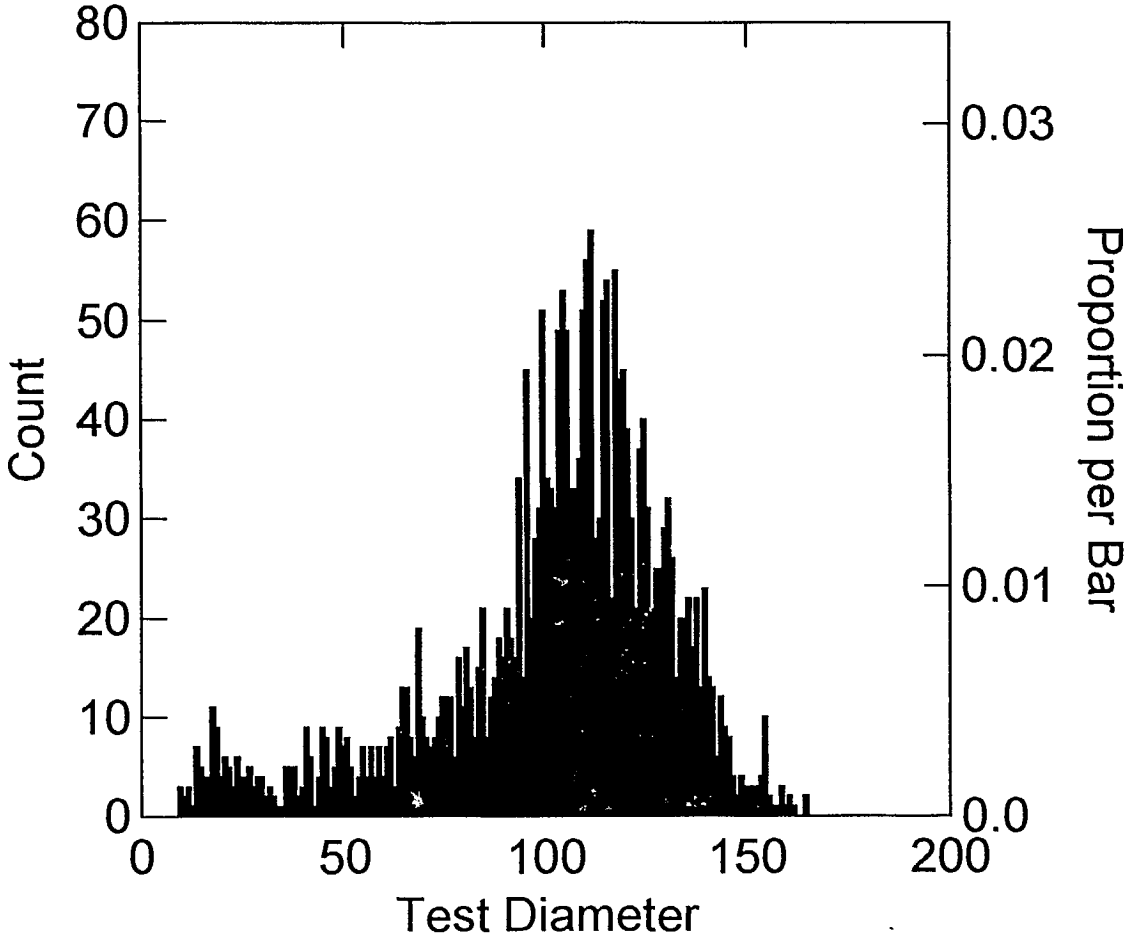

Figure 2. Size frequency distribution of red sea urchins measured on all transects during the 1999 survey in the Kelsey Bay and Johnstone Strait area (n=2322).

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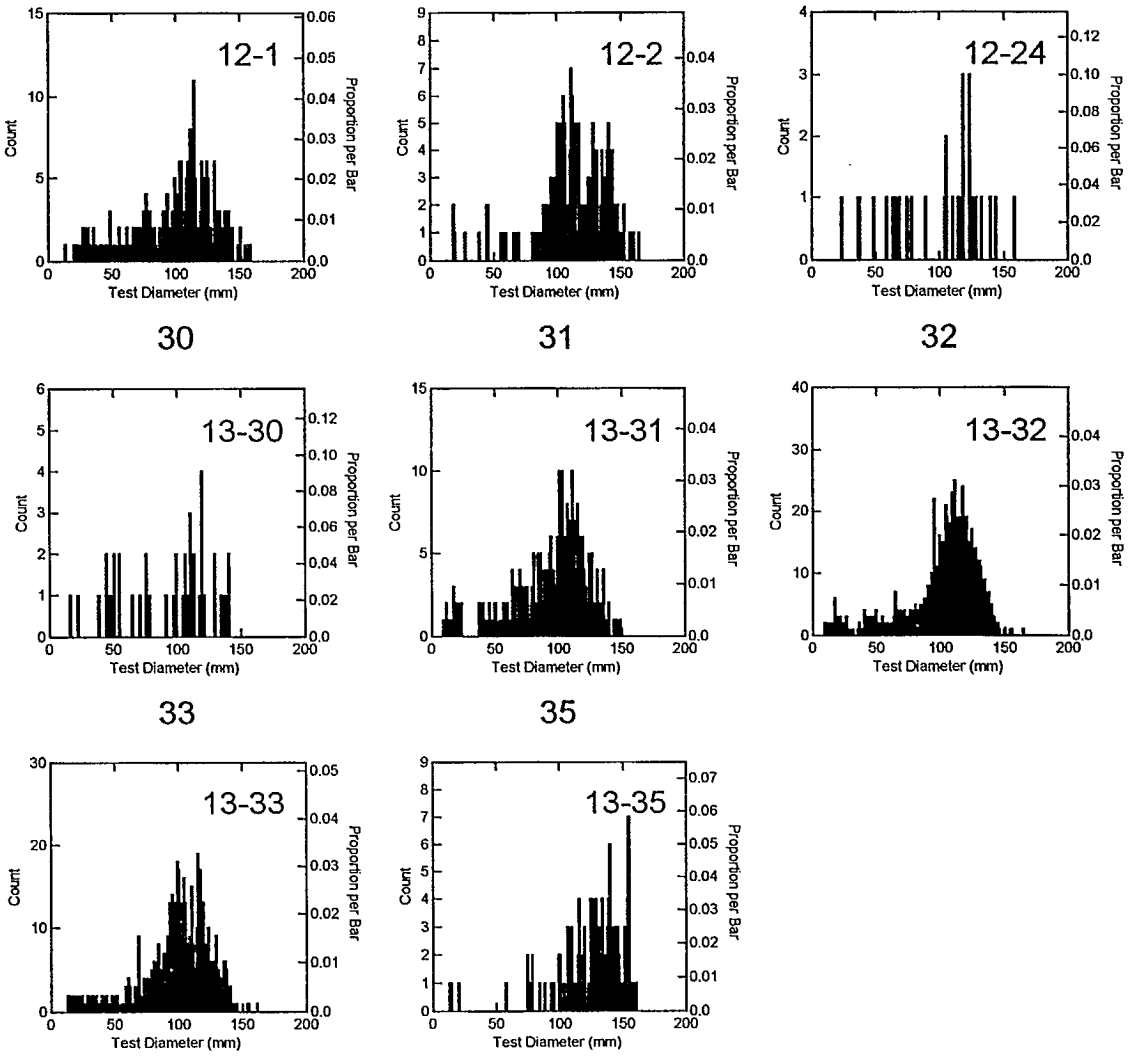

Figure 3. Size frequency distributions, by Pacific Fishery Management (PFM) sub-area, of red sea urchins measured during the 1999 survey in the Kelsey Bay and Johnstone Strait area. The numbers in the upper right hand side of graphs are the PFM sub-area numbers.