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Quota Options for the Red Sea Urchin Fishery in British Columbia for Fishing Season 2002/2003

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ABSTRACT

Annual landings of red sea urchin (*Strongylocentrotus franciscanus*) increased rapidly in the early 1980s for the south coast of British Columbia (B.C.) and in the late 1980s for the north coast, but subsequently were reduced and stabilised by quotas. Coastwide landings were 4,815.4 t valued at approximately $8.4 M (Cdn.), with 110 licenses issued during the 2000/2001 fishing season. Bed areas were obtained by digitising locations on charts indicated in harvest logbooks during 1997-2000. Analyses of surveys, during 1994-2001, provided estimates of mean density and weights of red sea urchin biomass within beds. Natural mortality rates of red sea urchins were assumed, for fishery management purposes, to be between 0.075 and 0.15. The minimum size limit was reduced from 100 mm to 90 mm test diameter (TD) for the 2000-2001 fishing season. Of the total (N = 22,739) measured in a survey of red sea urchins in processing plants, harvested throughout the 2000-2001 fishing season, the majority (95.0 %) was in the 95-140 mm TD size group and only a few (4.3 %) were < 95 mm TD. Biomass and quota options were estimated for a variety of size limits (e.g., $\geq$ 90, $\geq$ 95, $\geq$ 100, 95-140 mm TD) for red sea urchins in B.C. Further surveys for red sea urchin density are required in areas of B.C. where surveys are > 5 years old, and that have been heavily fished and or invaded by sea otters. Reliable biomass estimates and accurate estimates of bed areas, natural mortality and recruitment rates for red sea urchins in most areas of B.C. are required to manage this fishery effectively.

RÉSUMÉ

En Colombie-Britannique, les débarquements annuels d'oursin rouge (*Strongylocentrotus franciscanus*) ont rapidement augmenté au début des années 1980 sur la côte sud et à la fin de cette décennie sur la côte nord, mais ont par la suite été réduits et stabilisés par le biais de quotas. Les 110 permis délivrés pour la saison de pêche 2000-2001 ont donné des débarquements à l'échelle du littoral de 4 815,4 t, d'une valeur d'environ 8,4 M$CAN. La superficie des gisements a été établie par numérisation sur des cartes des endroits indiqués dans les journaux debord couvrant la période 1997-2000. Les analyses des données de relevés effectués de 1994 à 2001 ont permis d'obtenir des estimations de la densité et du poids moyens des oursins pour chaque gisement. Pour fins de gestion des pêches, on a supposé que le taux de mortalité naturelle de l'espèce se situait entre 0,075 et 0,15. Le dimaètre minimum du test des prises a été réduit pour la saison de pêche 2000-2001, pour passer de 100 mm à 90 mm. La plupart des 22 739 oursins, soit 95,0 %, mesurés lors d'un relevé des usines de transformation de l'oursin rouge récolté tout au long de cette saison de pêche étaient dans la tranche de taille 95-140 mm, seuls quelques-uns (4,3 %) ayant un diamètre du test inférieur à 95 mm. Les options de biomasse et de quotas ont été estimés d'après une gamme de diamètres du test (p. ex. µ 90 mm, $\geq$ 95 mm, $\geq$ 100 mm, 95-140 mm). D'autres relevés visant à établir la densité sont requis dans les secteurs de la province où des relevés n'ont pas effectués depuis plus de cinq ans et qui ont été soit fortement exploités ou envahis par la loutre de mer. Des estimations fiables de la biomasse et des estimations précises de la superficie des gisements, de la mortalité naturelle et des taux de recrutement de l'oursin rouge sont requises pour la plupart des secteurs de la province afin de gérer cette pêche de façon efficace.

INTRODUCTION

A commercial dive fishery for the red sea urchin (*Strongylocentrotus franciscanus*) started during the 1970s in British Columbia (B.C.) (Table 1). Annual landings started to increase rapidly in the early 1980s for the south coast and the late 1980s for the north coast of B.C., but subsequently were reduced and stabilised by quotas (Table 1). Coastwide landings were 4,815.4 t valued at approximately $8.4 million (Cdn.) with 110 licenses issued during the 2000-2001 fishing season. The history of the management of this fishery is summarised in Campbell and Harbo (1991), Heizer *et al*. (1997), Rogers and Neifer (1999), Campbell *et al*. (1999a), and Rogers and Parker (2000). A number of papers review various aspects of red sea urchin biology (Bernard and Miller 1973; Mottet 1976; Breen 1980; Sloan *et al*. 1987; Tegner 1989; Campbell and Harbo 1991; Botsford *et al*. 1993, 1994; Lai and Bradbury 1998; Ebert 1998). Surveys to estimate standing stock of red sea urchins in B.C. during 1976-99 have been published (Breen *et al*. 1976, 1978; Adkins *et al*. 1981; Sloan *et al.* 1987; Jamieson *et al*. 1998a, b, c, d; Bureau *et al.* 2000 a, b, c, d). Based on the results of some of these surveys Campbell (1998), and Campbell *et al*. (1999 a, b, 2000) provided quota estimates for the red sea urchin fishery in recent years. The density estimated from unpublished surveys conducted during 2000 and 2001 also are included in the present paper.

In this paper, the B.C. coast was divided into two main regions, the 'North Coast' and the 'South Coast'. In addition, fishery statistics in B.C. were subdivided into Pacific Fishery Management (PFM) areas and PFM subareas for management and economic purposes (detailed charts are not shown in this paper).

Managers have requested biomass estimates based on the most recent surveys and that quotas, where possible, be estimated by PFM subarea so they can be applied to the 2002/2003 red sea urchin fishery in B.C. Managers have also requested an evaluation of the size range of urchins harvested in the commercial fishery, since the legal minimum size was reduced to $\geq$ 90 mm test diameter (TD), during the 2000-2001 fishing season, from that of $\geq$ 100 mm TD in previous years. Improvements in Global Positioning Systems (GPS), the careful recording of fishing locations in log books, digitising data, GIS software and computer capacity have provided opportunities to accurately determine bed areas that were fished during 1997-2000. Consequently, more detailed density data have been required for the last two years in an attempt to match the fished bed areas for estimating red sea urchin biomass. Since previous surveys included transects randomly placed along a coastline, the implications of using only transect samples that occurred in fished bed areas needed to be determined.

The purpose of this paper was to: (1) summarize historical catch trends from the sales slips and harvest logbooks; (2) examine the size range of red sea urchins harvested in the 2000-2001 commercial fishery; (3) compare bed areas determined prior to 1997 with those determined during 1997-2000; (4) determine the effect of using only density data from transects matching the bed areas; (5) summarize the density surveys conducted to date and estimate biomass of red sea urchins; (6) determine annual quotas based on several size limit options for the red sea urchin fishery in B.C.

METHODS

CATCH AND EFFORT

Catch and effort data were summarised from sales slips and from harvest logbooks that fishers completed during each day of fishing. Information from sales slips included total weight (pounds) and value (dollars) landed, vessel registration number (VRN), date and days fished. Information from the harvest logbooks included location of bed (with diagram), date, landed weight and minutes of diving. Prior to 1997, the harvest logbooks were not completed by all vessels so the data were used as a sample (CPUE, kilograms per hour) only where both total catch (kg) and effort (minutes) per region were reported per diver for each area per day. During 1997 and thereafter, validation was combined with the harvest logbook program so the harvest logbooks were completed by all vessels; subsequently the sales slips were not completed by all vessels. Total average annual CPUE were calculated from mean daily vessel CPUE values.

COMMERCIAL SIZE FREQUENCY

A survey to determine the sizes of commercially fished red sea urchins was conducted each month from 4 November, 2000, to 27 April, 2001, when most of the landings of red sea urchins occurred during the 2000-2001 fishery. The test diameters of red sea urchins were measured from 7 processing plants and 3 ports. A total of 50 urchins were randomly collected and measured from each tote or bag that was randomly chosen at the location (processing plant or port). A minimum number of 150 to a maximum number of 2000 urchins were measured from a plant or port per month, which would represent as diverse a number of fishing vessels and PFM areas as possible throughout B.C.

BED AREAS

In the past, historic commercial bed areas of red sea urchins were indicated on charts or diagrams provided by fishers with their harvest logbooks throughout B.C. during 1982-1996. An inefficient two-step method was used to transcribe the data from the harvesters' charts to a master set of nautical charts from 0 - 9.1m (0-5 fm) below chart datum, and subsequently digitised and areas estimated (based on sea surface area) using proprietary, raster-based software (Compugrid). Prior to 1997, the logbook program was independent from the validation program; compliance with requirements for timely submission of harvest logs and charts was less enforceable and consequently not all fished locations may have been recorded.

Based on the above concerns and those of Campbell *et al*. (1999 a, b) suggesting that the use of historic cumulative estimates of fishable red sea urchin bed areas may have included locations that no longer were fished, we devised new procedures in an attempt to improve accuracy and efficiency of estimating bed areas on an annual basis.

The new methods used in this paper to estimate fished red sea urchin bed areas are as follows. Starting with the 1997 fishing season, harvest log data were more reliable, with harvest weights provided through the dockside validation program and submission of chart information facilitated by the third party service provider, hired by the Pacific Urchin Harvesters Association (PUHA), to administer the validation/harvest log program. Harvest location information was digitised, in the form of polygons, directly from the chart record, provided by the harvester to the electronic spatial file. Area measurements were generated using a Universal Transverse Mercator projection, zone 9, which was also consistent with previous analyses. The analysis utilised vector-based software Arcview 3.2. A "fishing event" approach was applied to location information provided for the 1997 through 1999-2000 fishing seasons. A fishing event was defined as a single record as reported in the harvest logbook, representing one dive by one commercial harvester in a single location. The fishing events were digitised in reference to the same land basemap as used in previous urchin bed area analyses. Subsequently, this fishing event record could be linked via a one-to-one relationship to an entry in the GIS spatial data set. The ability to make the one-to-one linkage of location information to harvest logbook information was a result of the combined validation/harvest log program.

A separate spatial file was developed for each fishing season to allow (a) isolation and review of harvest locations from within a single season, (b) comparison of fishing locations from one season to the next or (c) combination of several seasons of harvest locations to review trends over a longer time period. Procedures were implemented to ensure that, where fishing event polygons were wholly or partially coincident, the events were combined to eliminate double counting the area of the coincident portions. In this paper we calculated the total bed areas, restricted to a depth range of 0 - 9.1m (0-5 fm) below chart datum, based on three fishing seasons (1997-2000) for each PFM subarea. Any fishing events falling in areas officially closed to the fishery were excluded from the bed area totals.

Data for bed areas fished in 2000-2001 were not complete so a full analysis was not included in this paper. However, we calculated and included bed areas from new PFM subareas where landings had been reported in logbooks for 2000-2001, but which had not reported landings during 1997-2000. Bed areas from most of PFM area 14, which had been closed to fishing for several years and reopened for the 2000-2001 fishing season, were estimated from a recent population survey (Bureau *et al*. 2000 b) using only transects that had $\geq$1 urchin per m^2 (all sizes) to indicate fishable locations. Bed areas from PFM subareas 7.001N, 7.002N, 7.031S were estimated from a red sea urchin survey conducted during 2001 (unpublished data) using only transects that had $\geq$1 urchin per m^2 (all sizes) to indicate fishable locations.

Estimation of these red urchin bed areas must be treated with caution since the beds were not measured empirically in the field, and the proportion of the suitable substrate types (e.g., boulders or flat bedrock area more suitable than sand or mud) are unknown and may differ from one area to another.

DENSITY AND BIOMASS

Densities of red sea urchins were generally estimated within 1 m^2 quadrats along randomly chosen transects. Details of survey methodology varied between surveys (Breen *et al*. 1976, 1978; Adkins *et al*. 1981; Sloan *et al.* 1987; Jamieson *et al*. 1998a, 1998b, 1998c, 1998d; Bureau *et al.* 2000 a, b, c, d). Test diameters (TD, in mm) of urchins were measured on all the surveys except that by Adkins *et al*. (1981). Density estimates from Adkins *et al*. (1981) could be biased since counts were made only at sites where there were more than 1 red sea urchin /m^2. Surveys of sea urchin density were also conducted during 1995 to 2001, using the methodology described by Jamieson and Schwarz (1998). The survey data prior to 1994 had a different survey methodology and could not be used in the analyses in this paper. We analysed the data from the 1994-2001 surveys using only those transects that occurred within the bed boundaries fished during 1997-2001.

We used similar methods of Campbell *et al*. (1999b) for estimating mean densities. The methods consider the numbers, sizes, weights and biomass of red sea urchins within each transect length and weights this according to the total transect lengths sampled within the urchin beds of each PFM subarea or area. N.B. (a) the number of quadrats sampled for urchin density was usually half the potential number of quadrats (i.e., alternate quadrats were sampled) along a transect, and (b) the number of quadrats sampled for urchin sizes could be lower or equal to the quadrats sampled for density along a transect. In some areas high urchin abundance made measuring each urchin logistically unfeasible.

The estimated mean density, $\bar{d}$ (number / m^2) or biomass density (g / m^2), of urchins across a number of transects surveyed in a PFM area or subarea was calculated as

$$\bar{d} = \frac{\sum_t (d_t * L_t)}{\sum_t L_t} \qquad (1)$$

The standard error of the mean density, s_d , was calculated as

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

where n is the number of transects, $d_t = N_t / S_t$ is the density at transect t, S_t is the number of quadrats surveyed for density estimates in transect t, N_t is the number of red sea urchins counted for density estimates in transect t, L_t is the length of transect t (or area in square metres since each transect was one metre wide), $\bar{L} = \frac{\sum_t L_t}{n}$ is the mean transect length (or mean area in square metres), and T is the total potential number of transects that could possibly be sampled in the beds. The expression $\sqrt{(1-n/T)}$ was assumed to be approximately one, because the sample size n was substantially smaller than T, as only a small fraction of the potential number of transects in the beds were surveyed.

To estimate the mean densities (number / m^2) or biomass density (g / m^2) for a specific size group (J) the value d_t was substituted with densities ($P_{t,J}$) or biomass ($B_{t,J}$), in equations 1 and 2.

The mean density $P_{t,J}$ (number/ m^2)of red sea urchins of size group J in transect t was calculated as

$$P_{t,J} = \frac{\left(N_t * \frac{\sum_{i \in J} m_{t,i}}{M_t} \right)}{S_t} \qquad (3)$$

The mean biomass density $B_{t,J}$ (g / m^2) of red sea urchins of size group J in transect t was calculated as

$$B_{t,J} = \frac{\left(\frac{N_t}{M_t} * \sum_{i \in J} \left(m_{t,i} * w_i \right) \right)}{S_t} \qquad (4)$$

where J is a subset of possible i values representing a range of test diameters (TD_i) (e.g. $\geq$ 90, $\geq$ 95, $\geq$ 100, 90-130, 90-140, 95-130, 90-140 or 100-140, mm TD), $M_t = \sum_i m_{t,i}$ the total number of red sea urchins measured for size in transect t, $m_{t,i}$ is the number of red sea urchins in size range J of transect t, and $w_i = 0.0012659 * TD_i^{2.7068}$ is a relationship between mean wet weight (g) and size i (TD in mm) for red sea urchins (Campbell 1998).

Where there were no mean density estimates for a PFM subarea, an overall mean density for all years surveyed within the whole PFMA was used. Where there were no density data for a whole PFMA then mean values of data from the nearest or adjacent PFMA were used. The accuracy of these extrapolations is unknown and will require further comparative field surveys.

Standard errors were not calculated for densities that had < 5 transects. However, because an approximate lower 90% confidence interval of mean biomass density (L90CIB) was required for each PFM subarea, the following method was used. The standard errors were assumed to be proportional to the means and sample size. Thus, a linear regression, $s_d = b^*\bar{d}/\sqrt{s}$, was used to describe the relation between the standard error (s_d) and the mean biomass density ($\bar{d}$) divided by the square root of the total transect length (s) used for the biomass estimates, with b being a constant estimated using the least squares method. Data analysed from each red sea urchin size limit class group in all PFM subareas and years (N = 25) resulted in b values of 6.56 (R^2 = 0.89) for $\geq$90 mm TD; 6.65 (R^2 = 0.89) for $\geq$95 mm TD; 6.92 (R^2 = 0.90) for $\geq$100 mm TD; 5.88 (R^2 = 0.87) for 90 - 130 mm TD; 6.48 (R^2 = 0.87) for 90 - 140 mm TD; 5.90 (R^2 = 0.88) for 95 - 130 mm TD; 6.46 (R^2 = 0.87) for 95 - 140 mm TD; 6.74 (R^2=0.87) for 100-140 mm TD. To calculate the approximate lower 90% confidence interval (L90CIB) of the mean biomass density (g/m^2) for each size limit class of red sea urchin and PFM subarea, we assumed $L90CIB=\bar{d} - 1.64^* s_d$, and by substituting s_d (with the formula above), the equation $L90CIB=\bar{d}^*(1.0 - 1.64^*b/\sqrt{s})$ was used to calculate the approximate lower 90% confidence interval, where 1.64 is the z-value corresponding to the 0.05 quantile. Negative values of L90CIB for PFM subareas were assigned zeros.

Total current biomass of red sea urchins, for each size group, for each PFM subarea was calculated as

$$B_c = A^*\bar{d} \tag{5}$$

where B_c is the current total biomass (g); *A* is the commercial urchin bed areas (presented as hectares, but converted to m^2 for biomass calculations) estimated from digitised charts and summed for each PFM subarea; $\bar{d}$ is the estimated mean biomass density (g / m^2) of red sea urchins in a size group (e.g., $\geq$ 90 mm or 95-130 mm TD). The values for B_c were subsequently converted to tonnes for presentation. Since many of the surveys were conducted >4 years ago and there could be considerable uncertainty in the mean biomass density estimates in some areas we have adopted the Woodby (1992) method by also including the approximate lower 90 % confidence interval (L90CIB) as a reasonable alternative for the $\bar{d}$ values in the B_c calculations.

NATURAL MORTALITY

There are no published estimates of instantaneous natural mortality rate (M) for red sea urchins from northern B.C. Breen (1984) estimated that M ranged from 0.016 to 0.22 for red urchins from 3 sites in southern B.C. and considered a value between 0.1-0.2 to be acceptable. Woodby (1992) estimated M = 0.16 for red sea urchins from the Sitka, Alaska area. Botsford *et al*. (1993) estimated M = 0.14 for a population of red sea urchins in

California. Lai and Bradbury (1998) estimated M to be about 0.16 for red sea urchins from Washington. Based on published values Campbell (1998) assumed M to be 0.15 in calculating quotas for the 1995 red sea urchin fishery in B.C. However, all these authors considered growth rates of red sea urchins to be faster (e.g., 4 - 6 years to reach 100 mm TD) than that reported by Ebert (1998) who found tagged sea urchins from Washington and Oregon to take about 10 years to reach 100 mm TD and 50 years to reach 140 mm TD. Ebert (1998) calculated the mean instantaneous total mortality rate (Z $year^{-1}$) of red sea urchins, from a total of twelve samples collected from six locations in Oregon and Washington, to be 0.052 (min. 0.016, max 0.133, lower 95% confidence interval (CI) 0.028, upper CI 0.076); equivalent to a mean annual survival rate of 0.949 (e^{-Z}). The average mortality values reported by Ebert (1998) were generally below those previously reported in the literature. Clearly M will vary between areas and between size classes for red sea urchins in B.C. Although a similar tagging program on red sea urchins in some areas of B.C. has been conducted, further experimental work is required to estimate growth of urchins < 2years (5-30 mm TD). Initial analyses of the growth and mortality data indicated Z (instantaneous natural mortality rate) varied between sites from 0.03 to 0.16 (Campbell et al. unpublished data). For the purposes of the present paper, a range of M values from 0.075 to 0.150 (with an approximate mean M of 0.10) was considered for red sea urchins in B.C.

RECRUITMENT

Sloan *et al*. (1987) estimated recruitment to be highly variable between areas and to average about 9.5% of the total number of sea urchins in the size frequencies per area. Little is known about the stock and recruitment relations of red sea urchins in B.C. (Campbell et al. 1999a).

QUOTA ESTIMATION

A conservative management approach is used to estimate quotas (Q) for the red sea urchin fishery in B.C. A modified surplus production model is used to estimate a maximum sustainable yield (MSY) from a stock that is in the early stages of fishing (Schaefer 1954; Gulland 1971). The model assumes that the MSY occurs when the maximum sustainable fishing mortality is equal to M.

$$Q = X*M*B_c \tag{6}$$

where B_c is the current biomass, M is the instantaneous natural mortality rate and X = a correction factor to insure that a sustainable fishing mortality rate is well below the calculated MSY. We chose the value of X = 0.20 in this paper as a reasonably conservative safeguard to account for errors in estimating the lower current biomass values (Caddy 1986; Garcia *et al*. 1989). The correction factor should provide for a conservative harvest per year in a developing fishery where little is known about the productivity of the population. Since equation 6 is derived from a Graham-Schaefer production model, recruitment is assumed to be unaltered by these low fishing levels.

Although this approximation was developed for an unexploited virgin stock (B_o) we assumed that $B_c = B_o$.

Caution is required in the interpretation of these calculations for the quota because there are so many assumptions in the parameters used in the oversimplified model. Since many of the surveys were conducted >4 years ago and there could be uncertainty in the mean biomass density estimates in some areas, we have adopted the Woodby (1992) method by also including the approximate lower 90% confidence intervals as an alternative for the mean B_c calculations.

RESULTS AND DISCUSSION

CATCH AND EFFORT

The number of licences issued peaked at 240 in 1989 and subsequently declined and stabilised at 110 during 1997-2001 (Table 1). The number of fishing vessels reporting landings peaked at 102 in 1992 and subsequently declined to 52 during 2000-2001 (Table 1). This recent decline is due to more licences being used (stacked) by fewer vessels. Coastwide landings peaked in 1992 (Tables 1, 2). Seasonal changes in landings for different PFM areas in B.C. are shown in Table 3. Quotas have generally restricted landings in the South Coast since 1985 and in the North Coast since 1993 (Table 1). There was no overall general trend in annual CPUE (kilograms per diver hour) for the red sea urchin fishery in B.C. between 1983-96 (Table 1). The general lack in CPUE trends suggests that either the fishery is at an early stage of development or CPUE data for red sea urchins may not be used to indicate fishery trends in B.C. Fishermen have increased search time for high quality urchins in response to recent changes in market demands and the implementation of an individual quota scheme. Also, fishermen may be maintaining high CPUE values, through serial depletion, by moving to unexploited sea urchin beds within a PFM area suggesting that CPUE would not decline until most legal-sized sea urchins were removed from most of the areas in the PFM area. There is a need to re-examine the distribution of effort and variability of CPUE data on a smaller spatial scale (*e.g.*, by bed) than the PFM subarea level to determine whether CPUE is an appropriate index of red sea urchin abundance. Although updating the data base on matching bed locations and landings for the fishery during 1997-2000 has been completed, additional years of data probably are required to examine spatial changes in CPUE over many years.

COMMERCIAL SIZE FREQUENCIES

The summary statistics of test diameters (in mm TD) of commercially fished red sea urchins (N = 22,739), measured during the 2000-2001 fishery, were mean = 111.4, median = 110, minimum = 40, maximum = 196 (Fig 1A). A small percentage (0.85 %) of urchins was <90 mm TD, 3.49 % in the 90-94 mm TD size group, whereas most urchins (94.14%) occurred for the size groups 90-130 mm TD, 98.52% for 90-140 mm

TD, 96.48 % for ≥ 95 mm TD, 90.62 % for 95-130 mm TD, 95.00 % for 95-140 mm TD, 87.38 % for ≥ 100 mm TD, 85.90 % for 100-140 mm TD, 1.70 % for ≥ 140 mm TD.

In contrast, the summary statistics, in mm TD, of red sea urchins (N = 66,951) measured in all population surveys during 1994-2001, were mean = 85.6, median = 90.0, minimum = 2, maximum = 195 (Fig 1B). Examining only legal-sized urchins, ≥ 90 mm TD (N = 34,098), 12.23 % was in the 90-94 mm TD size group, 84.84% for 90-130 mm TD, 93.51% for 90-140 mm TD, 87.77 % for ≥ 95 mm TD, 72.61 % for 95-130 mm TD, 81.28 % for 95-140 mm TD, 75.21 % for ≥ 100 mm TD, 68.72 % for 100-140 mm TD, 7.61 % for ≥ 140 mm TD.

Clearly, fishermen targeted the majority (95.00%) of red sea urchins within the 95-140 mm TD group during 2000-2001 compared to 81.28% of this size group measured in the total wild legal urchins ≥ 90 mm TD (Fig. 1, 2). Although median size was about 110 mm TD for both sampling methods of legal urchins ≥ 90 mm TD (Fig. 2), fishers tended to select urchins > 95 mm TD and < 130 mm TD compared to what was probably available in the wild. Fishermen were optimising the quality and quantity of urchin gonads within the quota available. Also many fishermen tended to avoid urchins < 100 mm TD (only 12.62% of commercial samples) to deliberately reduce the chances of being involved with a lower than minimum legal size enforcement problem.

Caution is advised in interpreting these size frequencies in several respects. The size frequencies were grouped together from many areas in B.C. without weighting them according to total wild population abundance or total landings in a fishing season. An initial examination of weighting by landings indicated there was little difference between weighted and unweighted size frequencies of the commercial samples. The size frequencies of wild populations were obtained over a seven year period and some samples obtained > 3 years ago may not reflect accurately the relative abundance of sizes > 90 mm TD in some fished areas.

Future annual surveys to monitor the sizes of commercially fished red sea urchins should be continued so that a time series of size frequencies can be maintained and examined for changes in sizes within PFM areas and between years.

BED AREAS

The total estimated bed area was 29,161.8 ha for the North Coast and 6,459.1 ha for the South Coast as of 1997-2000, which are 58.08% and 66.80%, respectively, of the 1982-1996 cumulative estimates (Table 4). No consistent changes in estimating bed areas between the new and old methods were observed; there were major increases, decreases, totally new beds identified or no beds fished in some PFM subareas.

The exact reasons for these changes are unknown, but may be due to reduced and or increased fishing events between the two periods. Many of the beds identified in the early days of the fishery may not have been actual beds but areas where fishermen erroneously suspected sustainable urchin numbers could have been present. Some beds may have been abandoned over the course of the fishery due to the possibility of serial depletion. There have been several PFM sub areas that were closed based on fishermen's requests for closure to allow local red sea urchin populations to recover. Some areas may be avoided by fishermen due to the presence of sea otters (major predators of red sea urchins) which have expanded their range in recent years, especially on the west coast of Vancouver Island (PFM areas 25, 26, 27) and some locations in the North Coast (PFM area 7). Some beds may no longer be commercially viable because sea otters have depleted the red sea urchin stocks.

Bed area estimates probably provide the most uncertainty of all the estimates used to calculate red sea urchin biomass. Estimating bed areas was crude, especially as each location may have different substrate surface areas. In the past, the harvest logbooks provided an historical cumulative estimate of fishable sea urchin areas, but may have included areas that no longer had viable red sea urchin populations. Recent logbook entries on locations fished are becoming accurate, due to GPS and the validation process. However, fishing activity in one season may not indicate the extent of some beds. The most recent bed area estimates for the 2000-2001 fishing season have yet to be analysed; there also are a few harvest logs showing fished beds that have to be received from some fishermen and digitised. Another uncertainty is the number of most recent years (e.g., rolling accumulation of the last 3 - 5 years) that are required to be grouped together to provide a reasonable indication of currently fished beds.

In some areas there may be large numbers of red sea urchins deeper than 9.1 m (D. Bureau, unpublished data; W. Bradbury, Washington State Fisheries and Wildlife, personal communication). Estimating bed areas in the reasonably shallow depth range (0 – 9.1m) probably provides conservative bed area values to the estimation of red sea urchin biomass. There may be areas still unexplored, especially in the North Coast, that may contain unfished "virgin" populations that have not been included in the bed area estimates.

The new method will continue to be improved. The most recent complete season of data were captured in a conservative manner using the depth range information described in the harvest log records and available bathymetric contour data. To address the often small scale and crude nature of the charts provided by commercial harvesters, we recommend that the range of fishing depths reported in the harvest logs continue to be used as a guide when digitizing fishing locations. This has been facilitated through the recent availability of more detailed bathymetric base data, first used for fishing location data capture of the 2000-2001 fishing season data. For future analyses it may be beneficial to reference the older seasons of data to the newer, more detailed land and bathymetric base data. This may remove the need to clip the fishing location data using a restrictive depth strata or allow for analysis of fishing events at varying depths.

The records of log book bed area entries should continue to be made on an annual basis. Clear identification of beds in relation to the amount of red sea urchins removed from each bed needs to be recorded carefully by fishers and on-ground monitor to allow detailed stock analyses on a bed by bed and/or PFM subarea basis in both the North and South Coasts. Although there has been an on-ground monitor in the North Coast, to date there have not been any on-ground monitor for the South Coast.

DENSITY AND BIOMASS

In general, there was considerable variation in the size structure and densities of local red sea urchin populations. Estimated mean densities (number / m^2) and mean biomass density (g / m^2) for each size group of red sea urchins varied between PFM subareas and years (Tables 5, 6). Generally, mean density and biomass density were highest for the widest size limit, $\geq$ 90 mm TD, and density lowest for 100-140 mm TD, biomass density lowest for the narrowest size limit 95-130 mm TD of the size groups examined for each PFM areas (Tables 7).

We examined the implications of using only the "clipped" (including only transects lying within bed boundaries) compared to the unclipped (all transects included inside and outside beds) data to determine red sea urchin densities for each PFM subarea. Means, standard errors and 90 % confidence intervals for biomass densities were calculated for both the clipped and unclipped data. A t-test comparing clipped and unclipped mean densities indicated that there were no significant ($p < 0.05$) differences for each PFM subarea where there was survey data. The results were similar between each size group examined separately. There were more PFM areas (64.52%) that had higher or the same mean densities for the clipped data compared to the unclipped data (e.g., Fig. 3A). Clipping had the result of generally increasing the mean densities, reducing the number of sample sizes or transects, therefore generally increasing the standard error of the mean densities (Fig. 3B), and consequently generally lowering the lower 90% confidence bound intervals (Fig. 3C).

As the fishery progresses, the average density and mean weight of the size group of urchins being exploited may decrease. Further surveys for red sea urchin density are required in areas of B.C. where surveys are > 5 years old, that have been heavily fished and or invaded by sea otters.

BIOMASS AND QUOTA

Red sea urchin biomass (B_c) differed considerably between PFM subareas (Table 8). Total biomass of red sea urchins in the 90-140 mm TD size group was estimated at 203,221 t for the North Coast and 29,026 t for the South Coast (Table 8). These biomass and quota estimates must be treated with caution, especially when considering how inaccurate the bed estimates of viable red sea urchin populations may be.

If the size limit of $\geq$ 90 mm TD is to remain the same as the 2000-2001 fishing season, and considering fishermen tend to select for better gonad quality, the more appropriate quota estimate should be made from B_c calculated from the 90-140 mm TD size group

(Table 8, 9). Choice of a conservative quota probably should be based on M values $\leq$ 0.10 (fishing rates of $\leq$ 2%) which would suggest that the overall B.C. coastwide 2002/2003 quota could be 4,679.4 t, based on the mean densities, or 2,876.5 t, based on the approximate lower 90% confidence interval estimate (Table 9). Alternatively, if fishermen wish to increase the minimum size to $\geq$ 95 mm TD, a conservative quota of 4350.6 t could be based on the 95-140 mm TD size group or the approximate lower 90% confidence interval estimate of 2262.3 t (Table9).

Although we examined two alternative formulations, proposed by Garcia *et al* (1989) (i.e., equations 7a and 8a, based on the Schaefer (1954) and Fox (1970) production models), to estimate Q and MSY by including current yield (Y_c) in an exploited population, both formulae were unstable when attempting to obtain MSY estimates below Y_c. Garcia *et al* (1989) also indicated that these formulae are unstable under other conditions. Die and Caddy (1997) question whether any simple approximation method alone, in obtaining sustainable yield indicators from biomass estimates, can provide a safe yield target. They advocated use of low conservative targets for fishing mortality and several biological reference points (BRPs) as a precautionary approach. Lai and Bradbury (1998), through simulation of red sea urchin populations in Washington, suggested that target harvest rates should be well below biological references points such as $F_{max} = 0.48$ (fishing mortality at which Y/R is maximised) and $F_{0.1} = 0.19$ (at which slope of Y/R curve is 10% of the slope at origin) calculated from a yield per recruit model. Campbell et al. 1999b (Table 3 in appendix B), using a yield per recruit analysis, found $F_{0.1} = 0.11$ and 0.16 for a size limit of $\geq$ 90 mm TD and 90-140 mm TD, respectively.

If stock assessment and management is needed on a bed by bed and up to date basis, landings and bed areas will be required in a timely way (within one year). A two (or longer) year periodic rotation of fishing grounds would provide for easier monitoring of the fishing fleet and landings and allow timely analysis of up to date landings data. Three or six year rotation of fishing grounds would also allow recovery of the harvestable stock through recruitment and growth. Botsford *et al*. (1993) and Lai and Bradbury (1998) consider periodic harvest schedules (rotation), although not increasing cumulative yield, to be biologically beneficial, reduce variability of yield, risk, and probably management and enforcement costs.

The influence of different size limits and fishing mortality rates were reported by Campbell et al. (1999 see Appendices A & B) for a red sea urchin population in B.C. The general results of these analyses are summarised as follows. Minimum size limits of $\geq$70 and $\geq$90 mm TD are clearly less precautionary than that of $\geq$100 mm TD. Adding a lower maximum size to a minimum size reduces yield but increases the reproductive potential and consequently reduces the potential for collapse of red sea urchin populations. Low fishing mortality rates (e.g., $\leq$ 0.02) are precautionary and may reduce the influence of size limits. However, having both minimum and maximum size limits and a low fishing mortality provide for a precautionary approach to exploiting red sea urchin populations when determining quotas from uncertain natural mortality and biomass estimations for particular PFM areas.

The commercial quality of red sea urchin roe is based on a combination of criteria such as color, texture, size and taste. Generally, good quality roe from red sea urchins is considered to have a yellow/gold consistent color, firm texture (growing or premature gonads), sweet taste and of medium size which is mainly found in the approximately 90 – 120 mm TD size range. Poor quality roe is generally considered to have variable yellow/brown color, soft texture and or oozing gametes (from mature, post spawn or spent gonads). Red sea urchins >130 mm TD generally have large gonads and inconsistent color quality which are less desirable by the industry than smaller mature individuals. There is an annual reproductive cycle with the timing of the spawning season varying within the period from February to September depending on local environmental conditions such as food availability and temperature (Bernard 1977). Gonads increase in size usually from September to January (Kramer and Nordin 1975). The effect of food quality and availability to support growth and reproduction are important limiting factors on urchin stocks. Although red sea urchins are omnivorous grazers, kelps, such as *Nereocystis leutkeana*, provide optimal growth and gonad quality (Vadas 1977; Bureau et al. 1997; Morris and Campbell 1996). In areas of low supply or quality of food, individuals may relocate nutrients causing poor quality gonads thereby reducing reproduction potential of local red sea urchin populations. The influence of adult age, especially in large old red sea urchins, on low egg production, senescence or of poor quality and low survival of larval offspring is unknown.

Breen (1984) argued that a size limit could be used to protect sufficient reproductive potential in attempt to insure that recruitment did not fall below replacement. A special argument for a maximum size limit can be made for red sea urchins as adult urchins may provide a spine cover for juveniles that is necessary for good survival (Tegner and Dayton 1977). Minimum and maximum size limits would leave enough large adults to protect the settlement of juveniles, such as used in Washington State (Lai and Bradbury 1998). Breen (1984) suggested that using a size limit as the only control mechanism to prevent recruitment overfishing would not be achieved with the ≥100 mm TD size limit. A larger size limit would be required to prevent recruitment overfishing but would be larger than the industry's upper limit for market quality. Breen (1983) recommended that a better way of preventing recruitment overfishing was "controlling effort or catch in such a way as to protect local stocks from over harvesting".

The influence of market demand for high quality gonads may cause fishermen to concentrate fishing in a small size range (e.g., 95 –130 mm TD) of red sea urchins even though the quota may be based on a legal size limit of ≥ 90 mm TD or 95 – 140 mm TD. This would result in a higher fishing mortality on the small size range than was originally intended by the managers. Clearly, setting a quota on the appropriate size range that will be harvested in an area will ensure less deviation from the intended fishing mortality on local red sea urchin populations. Continued monitoring of harvested red sea urchins at ports and or at commercial processing plants will provide the means to track temporal changes and area differences in size frequency and provide a tool to assess the appropriate size range to set quotas.

There are a number of complex density dependent compensatory and depensatory mechanisms that red sea urchins may elicit in growth, mortality, increased survival of juveniles due to protection by adult spine canopies, spawning success, roe quality and egg viability. A stock at low density levels may impact on the population negatively, e.g. "the Allee affect" (Allee 1931), reducing the reproductive success of the animals. This is particularly important in organisms that are broadcast spawners. Levitan et al. (1992) found that fertilization success was a function of the number of red sea urchins, distance apart, position in the cluster, flow direction and velocity of the current, etc. For animals that show this type of fertilization, this is a factor that should be considered in the management system in providing various forms of harvest refugia (e.g. size restrictions, catch limits through quotas or rotating spatial harvests and spatial closures) (Botsford et al. 1993; Quinn et al. 1993; Pfister and Bradbury 1996; Levitan and Sewell 1998). Ebert (1998) found potentially little Allee effects on growth of red sea urchins in Oregon and Washington using simulation techniques. He recommended not to automatically assume Allee effects are important in local areas without some evaluation, such as incorporating sensitivity analyses in dynamic modelling methods.

In addition to resource monitoring through fishery independent surveys, additional biological information is clearly required on age estimation and on the variation of growth, mortality and recruitment rates for production modelling of red sea urchin populations in different areas of B.C.

RECOMMENDATIONS

1. If the size limit of $\geq$90 mm TD is to be maintained, we recommend that a precautionary approach could include the inclusion of a maximum size of 140mm TD and a low fishing mortality of $\leq$ 0.02 ($M \leq 0.10$) when calculating quotas.

2. Continue improving the process of estimating bed areas holding viable populations of red sea urchins. Bed areas fished on an annual basis need to be recorded, validated, digitized and updated.

3. Continue monitoring harvested red sea urchins at ports and or at commercial processing plants which will provide temporal changes and area differences in size frequency, mean weights, and gonad quality of commercial-sized individuals, and provide a tool to assess the appropriate size range to set quotas in the future.

4. Surveys for the abundance estimates of red sea urchins in alternative areas in B.C. should be conducted on an annual basis. Areas with no surveys for over 5 years and areas that have been heavily fished should be considered a priority.

5. Further research is required to understand age, and growth, mortality and recruitment rates of red sea urchins in B.C. to assist with production modeling.

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FIGURE LEGENDS

Fig. 1. Size frequencies of red sea urchins measured (A) at processing plants during the 2000-2001 fishing season, and (B) on population surveys during 1994-2001 throughout B.C.

Fig. 2. Cumulative size frequencies, expressed as a proportion of the total red sea urchins ($\geq$ 90 mm TD) sampled from the processing plants (N = 22,546) during the 2000-2001 fishing season, and from population surveys during (N = 34,098) during 1994-2001 throughout B.C.

Fig. 3. Comparison of (A) means, (B) standard error of mean, and (C) lower 90 % confidence bounds of 95-130mm TD red sea urchin density (biomass, g/m^2) from unclipped (all transects) and clipped (only transects lying within bed boundaries) survey data by PFM subarea in B.C.

Table 1. Annual red sea urchin landings (tonnes), value and effort throughout British Columbia, during 1978-2001, as reported on fish slips and harvest logs. N.B. Annual landings and effort during 1978-96 are on a calendar basis (January to December), but thereafter are based on a fishing season (July to June).

Year	Licences Issued	Vessels with Landings	South Coast Quota[a] (t)	North Coast Quota (t)	HARVEST LOG DATA: Coastwide Landings (t)	Total Diver Hours	Mean CPUE (kg/diver hr)[c]	FISH SLIP DATA[d]: Coastwide Landings (t)	Landed Value ($000)	$/ Kg	Total Vessel Fishing Days	Mean CPUE (t/vessel day)
1978	C	4			-	-	-	75.0	16.0	0.21	54	1.4
1979	C	29			-	-	-	317.0	76.0	0.24	298	1.1
1980	C	18			-	-	-	333.0	84.0	0.25	331	1.0
1981	C	18	136		-	-	-	116.0	34.0	0.29	127	0.9
1982	C	21			45.4	75.6	-	160.0	56.0	0.35	195	0.8
1983	Z 64	36			720.2	1,428.4	504	982.0	357.8	0.36	757	1.3
1984	Z 85	47			1,377.0	3,781.6	364	1,764.4	712.2	0.40	1,058	1.7
1985	Z 86	46	1,803		1,204.4	2,881.6	418	1,815.4	763.5	0.42	1,126	1.6
1986	Z 103	67	1,500		1,582.0	3,397.0	466	2,066.6	1,010.8	0.49	1,534	1.3
1987	Z 184	97	1,633		1,435.6	3,429.4	419	2,223.4	1,275.6	0.57	1,737	1.3
1988	Z 184	84	1,678		1,763.8	5,056.7	349	2,115.4	1,238.2	0.59	1,239	1.7
1989	Z 240	98	1,644		2,004.8	5,409.4	371	2,658.1	1,631.5	0.61	1,542	1.7
1990	Z 188	88	1,668		2,439.7	7,478.7	326	3,158.1	1,953.0	0.62	2,651	1.2
1991	Z 102	76	1,531		6,427.4	16,356.0	393	6,945.2	4,187.1	0.60	3,862	1.8
1992	Z 108	102	1,554		12,479.9	31,170.0	400	12,981.8	8,661.5	0.67	6,222	2.1
1993	Z 107	95	1,401	5,443	6,106.4	17,201.5	355	6,388.0	5,372.7	0.84	3,364	1.9
1994	Z 110	95	1,543	5,897	5,959.8	18,942.0	315	5,828.7	8,066.4	1.38	3,978	1.5
1995	Z 108	88	1,387	5,455	6,806.9	21,397.7	318	6,584.7	11,349.8	1.72	4,167	1.6
1996	Z 109	77	1,265	5,360	6,466.4	18,180.3	356	5,282.5	10,045.8	1.90	3,536	1.5
1997/98 [b]	Z 110	90	1,702	8,150	8,738.2	30,227.4	289	8,450.8 [d]	14,477.1 [e]	1.66	5,161	1.6
1998/99	Z 110	68	968	4,635	5,182.9	16,554.4	313	5,076.7 [d]	8,029.5 [e]	1.55	3,239	1.6
1999/00	Z 110	61	967.5	4,634	5,282.6	16,664.8	317	4,896.1 [d]	8,450.4 [e]	1.60	3,027	1.6
2000/01	Z 110	52	843.9	4,042	4,815.4	14,041.0	343	3,781.8 [d]	8,361.0 [e]	1.74	2,113	1.8

[a] South coast quota includes exploratory areas; North Coast quota new in 1993.
[b] Change in licencing from calender year to market-driven year. 1997/98 season ran January 1/97 to June 30/98.
After 1997 licencing year continued to be July to June
[c] CPUE from harvest log data.
[d] Fish Slip Data preliminary for 1996-2001, landings data not validated since 1997.
[e] Approximate landed value estimated by multiplying Fish Slip $/kg by landings from the harvest log data.

Table 2a. Red sea urchin annual landings (tonnes) by Pacific Fishery Management areas in the North Coast, during 1984-2001, as reported on fish slips and harvest logs. 1994-2001 catch data corrected to use validation & harvest logs only.

	North Coast PFM Areas											
Year	1[a]	2E	2W[b]	3	4	5[c]	6[d]	7	8	9	10	Total Landings
1984	2.2											2.2
1986											12.0	12.0
1987					23.0			179.0	91.0			293.0
1988					73.0	11.0	7.3	314.0	32.0			437.3
1989	0.2	223.0		1.6	116.0	1.3	168.0	217.0	65.0		180.0	972.1
1990		26.6	10.7	24.5	156.8	265.3	67.1	1,040.1				1,591.1
1991		333.1	2.7	143.3	1,026.7	2,577.3	77.7	774.7	114.6	24.5	304.9	5,379.5
1992		1,111.0		1.0		3,294.0	4,063.0	2,763.0	140.0	114.0	38.0	11,524.0
1993	97.0	189.0	88.9	127.2	1,008.0	463.0	2,103.0	1,012.0	43.4		215.3	5,346.8
1994	221.0	402.2	167.4	173.0	687.0	1,056.0	1,244.0	861.0	57.0	46.0	164.0	5,078.6
1995	258.0	440.2	256.3	48.0	940.0	1,280.0	1,053.0	1,076.0	111.0	49.0	224.0	5,735.5
1996	259.0	365.0	241.8	66.0	851.0	1,156.0	1,213.0	833.0	122.0	10.0	248.0	5,364.8
1997/1998[e]	582.0	718.7	311.1	62.0	1,076.0	1,107.0	2,175.0	870.0	112.0	41.0	152.0	7,206.8
1998/1999	276.2	294.0	144.1	38.8	595.1	741.8	1,373.6	526.2	87.6	36.8	191.4	4,305.6
1999/2000	296.1	288.9	222.3	32.4	602.6	746.8	1430.3	462.6	88.1	38.6	189.5	4,398.2
2000/2001	269.5	273.8	197.3	136.8	400.8	690.4	1385.6	361.9	78.3	44.2	155.2	3,993.7
1984 to June 2001	2,261.2	4,665.5	1,642.6	854.5	7,556.0	13,390.0	16,360.5	11,290.5	1,141.9	404.0	2,074.3	61,641.2

[a] Includes landings from Area 101
[b] Includes landings from Area 142
[c] Includes landings from Area 105
[d] Includes landings from Area 106
[e] Change in licencing from calender year to market-driven year. 1997/98 season ran January 1/97 to June 30/98.
After 1997 licencing year continued to be July to June

Table 2b. Red sea urchin annual landings (tonnes) by Pacific Fishery Management areas in the South Coast, during 1971-2001, as reported on fish slips and harvest logs. 1994 to 2001 catch data corrected to use Validation & Harvest logs only.

	South Coast PFM Areas																		
	East Coast Vancouver Island										West Coast Vancouver Island								
Year	11[d]	12	13	14	15	16	17	18	19	28	29	20	21	23[e]	24[f]	25	26	27	Total Annual Landings
1971 to 1973[a]									110.0						254.0				364.0
1974 to 1977[a]		1.4		*	*	1.4			66.0			*		1.3					70.1
1978			*						46.0			29.0							75.0
1979			*	78.0			57.0	133.0	45.0			1.8	0.9	2.5					318.2
1980				18.0			162.0	54.0	97.0			1.8							332.8
1981			20.0	4.0	*		5.3	47.0	22.0						17.0				115.3
1982		2.5		46.0			0.8	11.0	94.0						5.0				158.5
1983[b]	7.8	99.0	264.0	260.0	*	*	59.0	38.0	112.0			24.0		22.0	38.0		62.0		985.8
1984	0.3	437.0	777.3	172.0			33.0	67.4	76.3		5.7	69.1		17.3	103.0		3.9		1,762.3
1985		354.0	492.0	167.0	106.0	5.9	29.0	48.0	77.0		47.0	30.0		96.0	158.0	145.0	15.0	45.0	1,814.9
1986	27.0	548.0	376.0	178.0	56.0	4.4	57.0	129.0	105.0		2.0	40.0		154.0	285.0		2.5	91.0	2,054.9
1987[c]	6.9	420.0	491.0	193.0	32.4		71.0	71.0	123.0	17.0	7.8	17.0		63.0	199.0	95.0	8.3	12.0	1,827.4
1988	2.6	534.0	480.0	78.0	21.0	2.3	*	22.0	78.0			74.0		13.0	250.0	66.0		58.0	1,678.9
1989		569.0	493.0	122.0	6.7		9.0	64.0	57.0		1.6	15.0			223.0	39.0		86.0	1,685.3
1990	84.8	437.6	428.4	56.6	1.2	0.6	43.0	46.5	58.6	0.3	1.8	7.9		59.7	215.1	56.8		68.1	1,567.0
1991	36.4	358.7	370.7		8.6		26.6	94.8	27.2		14.1	31.2	2.7	58.4	185.1	115.8		121.1	1,451.4
1992	8.0	531.0	320.0				103.0	36.0	86.0		4.0	56.0	9.0	31.0	200.0	10.0		65.0	1,459.0
1993	55.5	329.0	184.0				21.0	104.7	17.3			14.5		40.4	92.0	7.0	2.0	50.0	917.4
1994	17.0	348.0	168.0				4.0	59.0	14.0		1.0	3.0		54.0	111.0	50.0		49.0	878.0
1995	34.0	364.0	175.0				28.0	69.0	15.0		9.0	20.0		57.0	199.0			98.0	1,068.0
1996	38.0	344.0	238.0				25.0	112.0	7.0		10.0	33.0		46.0	122.0			70.0	1,045.0
1997/1998[g]	61.0	594.0	426.0		2.3		26.0	67.0	40.0		16.0	32.0		54.0	132.0			85.0	1,535.3
1998/1999	49.7	285.2	196.4				26.9	85.3	21.1		2.9	22.5		31.5	107.6			48.2	877.3
1999/2000	81.1	270.4	204.3				26.6	63.0	42.7		4.3	22.6		29.1	113.1			27.3	884.4
2000/2001	57.3	287.3	178.7	23.0			22.7	22.4	32.1		3.3	22.0		39.3	99.1			34.6	821.7
1971 to June 2001	567.4	7,114.1	6,282.8	1,395.6	234.2	14.6	835.1	1,444.1	1,469.3	17.3	130.5	566.3	12.6	869.5	3,108.0	584.6	93.7	1,008.3	25,747.9

* Less than 500 kg.

[a] Data for each year cannot be published separately.

[b] Mandatory log book under Z licence came into effect in 1983.

[c] Sales slips were combined for red and green sea urchins in 1987, were later separated by price criteria, but 320 t remains missing in area table.

[d] Includes landings from Area 111.

[e] Includes landings from Area 123.

[f] Includes landings from Area 124.

[g] Change in licencing from calender year to market-driven year. 1997/98 season ran January 1/97 to June 30/98.
After 1997 licencing year continued to be July to June

Table 3a. Monthly landings (tonnes) by Pacific Fishery Management areas in the North Coast, during 2000-2001, as reported on validation and harvest logs.

Month-Year	North Coast PFM Areas: Queen Charlotte Islands 1[a]	2E	2W[b]	North Coast Mainland 3	4	5[c]	6[d]	7	8	9	10	Monthly Totals
Jul-00												0.0
Aug-00										17.0	20.0	37.0
Sep-00						80.2	138.3				9.7	228.2
Oct-00				16.2	252.4	297.9						566.5
Nov-00				34.5	90.7	267.9	365.1					758.2
Dec-00							656.8	220.4				877.2
Jan-01							141.7	77.4	*	27.1	82.6	328.8
Feb-01		273.8	37.9	86.1	57.6	23.5						478.9
Mar-01	269.5		39.9									309.4
Apr-01			119.5			20.9	83.7	51.1			37.9	313.1
May-01								13.0	*		5.1	18.1
Jun-01												0.0
Total:	269.5	273.8	197.3	136.8	400.8	690.4	1385.6	361.9	78.3	44.2	155.2	3993.7

* Data not provided for reasons of confidentiality where less than 3 vessels report landings. PFM area totals not affected. Monthly totals reflect only reported values.

[a] Includes landings from Area 101.

[b] Includes landings from Area 142.

[c] Includes landings from Area 105.

[d] Includes landings from Area 106.

Table 3b. Monthly landings (tonnes) by Pacific Fishery Management areas in the South Coast, during 2000-2001, as reported on validation and harvest logs.

Month-Year	South Coast PFM Areas												Monthly Totals
	East Coast Vancouver Island								West Coast Vancouver Island				
	11[a]	12	13	14	17	18	19	29	20	23[b]	24[c]	27	
Jul-00													0.0
Aug-00													0.0
Sep-00										39.3	99.1		138.4
Oct-00		22.2	72.6	23.0	11.9							12.5	142.1
Nov-00		106.3			*			3.3				*	109.6
Dec-00	*	72.5	106.1			22.4	32.1		22.0				255.0
Jan-01	20.4	43.3			*								63.7
Feb-01	9.7	*											9.7
Mar-01	14.2	*											14.2
Apr-01	7.7	*											7.7
May-01	*	*										*	0.0
Jun-01													0.0
Total:	57.3	287.3	178.7	23.0	22.7	22.4	32.1	3.3	22.0	39.3	99.1	34.6	821.7

* Data not provided for reasons of confidentiality where less than 3 vessels report landings. PFM area totals not affected. Monthly totals reflect only reported values.

[a] Includes landings from Area 111.

[b] Includes landings from Area 123.

[c] Includes landings from Area 124.

Table 4. Bed areas (ha) for fished red sea urchins by PFM subarea according to digitized data from fishery logs for period 1982-96 and 1997-2000. NB : a = estimated from 2000/2001 harvest logbooks; s = estimated from recent population surveys (Bureau et al. 2000a, b); t = new beds areas estimated from a population survey conducted in 2001 (unpublished data).

PFM	Bed Areas (ha) during		
Subarea	1982-96	1997-2000	NB
North Coast of BC			
1.001	4837.56	967.75	
1.002	405.00	721.82	
1.003	2024.16	1103.96	
1.005	454.68	31.06	
1.007	1360.44	1093.93	
2.003	339.28		
2.006	298.00		
2.007	469.36		
2.008	331.88	329.77	
2.009		3.62	
2.010	2.24	57.93	
2.011	973.44	612.58	
2.012	212.84	249.58	
2.013	26.24	0.79	
2.014	284.48	562.55	
2.015	128.68	283.88	
2.017	341.80	299.85	
2.018	291.12	698.26	
2.019	34.36	92.27	
2.031	419.60	357.48	
2.036	95.16		
2.037	28.96		
2.049	193.36	20.15	
2.050	146.24	18.87	
2.051	27.20		
2.055		1.54	
2.059			
2.064	29.36		
2.065	27.04	2.26	
2.066	5.80		
2.067	61.84		
2.068	561.88	387.95	
2.069		24.75	
2.070		2.10	a
2.071		76.72	
2.073		0.05	
2.074		1.40	a
2.075		133.84	
2.078		11.93	
2.079		4.91	
2.080		9.61	
2.082		28.84	
2.086		1.83	
2.087	32.60	118.84	
2.088	61.88	36.58	
2.089		0.40	
2.092		18.89	
2.093		26.91	
2.094	47.60		
2.095	68.84	0.56	
2.096	96.56	17.51	
2.097		35.88	
2.098	98.84	23.97	
2.099		24.19	
2.100	11.80	13.36	
3.001	724.16	458.91	
3.002	33.00	72.13	
3.003	73.68	18.54	
3.004	24.36		
4.001	1074.00	1155.21	
4.002	848.80	697.24	
4.003	875.16	336.32	
4.004	55.04	96.71	
4.005	85.48	155.61	
4.009	659.36	422.41	
4.012		201.82	
4.013	738.16	903.50	
5.004		1.40	
5.009	342.48	227.78	
5.010	1506.36	481.23	
5.011	556.96	420.01	
5.012	395.32	338.27	
5.013	835.60	276.32	
5.014	114.56	72.97	
5.016	525.84	6.02	
5.017	996.16	450.53	
5.018		8.36	
5.019	3.72		
5.020	2174.24	1865.76	
5.021	667.08	191.63	
5.022	2169.88	1132.48	
6.005	65.72	4.08	
6.006		2.72	
6.009	3230.72	1970.07	
6.010	1671.72	1175.59	
6.011	99.68	91.14	
6.012	203.48	24.25	
6.013	2545.40	1442.52	
6.014	299.88	251.46	
6.015	520.08	202.22	
6.016	903.76	330.83	
6.017	510.28	202.35	
6.018	115.40		
6.019	109.32	109.20	
6.020	29.80		
6.025	28.80		
6.026		4.31	
7.001	55.16	32.47	
7.001N		33.80	t
7.002		3.10	a
7.002N		53.50	t
7.003	439.20	311.73	
7.004	208.72	87.57	
7.005	56.52	7.54	
7.006	142.40		
7.008		26.01	
7.009	713.12	388.32	
7.012	148.84	167.84	
7.015		0.40	a
7.017	3.48		
7.018	1294.32	231.16	
7.019	94.60	71.70	
7.020	51.76	35.17	
7.021	40.08	27.57	
7.023	51.56	31.29	
7.024	2.64	0.00	
7.025	796.04	167.56	
7.026	52.16	2.68	
7.027	204.08	297.20	
7.028	19.44	52.24	
7.031	1107.12	0.39	
7.031S		60.00	t
7.032	308.24	126.38	
8.001	27.08	126.83	
8.002	87.48	122.39	
8.003	5.48	7.06	
8.004	156.20	143.39	
8.016	64.64	51.42	
9.001	138.60	104.83	
9.002	232.20	62.44	
9.003		0.40	a
9.010	26.28	6.22	
9.011	5.56	9.35	
9.012	103.08	33.15	
10.001	266.12	107.11	
10.002	485.80	238.41	
10.003	214.84	185.97	
10.004	74.04	134.37	
10.005		3.60	a
10.006		0.88	
10.008		0.72	
10.011		2.71	
10.012		12.40	
101.001		33.46	
101.002		91.14	
101.006		41.77	
101.007		41.96	
102.002		0.36	
105.001	50.32	215.36	
105.002	6.56	18.24	
106.001		10.21	
106.002	1827.88	870.92	
142.001		10.06	
142.002		93.04	
North Coast Total	50205.20	29308.63	

Table 4. (continued)

PFM Subarea	Bed Areas (ha) during 1982-96	Bed Areas (ha) during 1997-2000	NB
South Coast of BC			
11.001	135.88	29.92	
11.002	142.64	135.83	
12.001	61.60	20.71	
12.002	96.52	4.09	
12.003	180.60	91.58	
12.004	2.28	0.37	
12.005	143.20	56.68	
12.006	146.12	20.16	
12.007	73.48	35.38	
12.008	93.00	401.45	
12.009		5.23	
12.010		0.34	
12.011	239.40	134.33	
12.012	172.60	89.27	
12.013	117.32	31.57	
12.014	425.30	121.14	
12.015	27.56	36.29	
12.016	303.72	112.00	
12.017	39.08	45.93	
12.018	350.04	282.29	
12.019	65.72	57.51	
12.020	1.40	3.58	
12.021	17.64	15.08	
12.026	3.96		
12.039	59.84	15.36	
12.041	86.76	29.86	
12.042	18.00		
13.001	170.24	117.16	
13.002	74.68	169.52	
13.003	40.72	6.48	
13.006	60.84	5.06	
13.007	51.08	10.98	
13.008	8.44	3.78	
13.009	19.32	31.62	
13.010	72.32	10.56	
13.011	28.84	1.64	
13.012	142.12	30.82	
13.014		15.04	
13.016	14.88		
13.017	8.92		
13.018		3.84	
13.023	66.12	3.09	
13.025	107.60	106.18	
13.026	30.48	10.24	
13.027	31.04		
13.028	152.08	123.58	
13.029	17.56	4.34	
13.030	84.12	1.59	s
13.031	29.12	26.48	
13.032	164.96	35.95	

PFM Subarea	Bed Areas (ha) during 1982-96	Bed Areas (ha) during 1997-2000	NB
13.033	53.20	45.76	
13.035	71.92	6.91	
13.036	46.08		
13.039	62.60	24.36	
13.040	23.32		
13.041	18.68	2.10	a
14.005		16.03	s
14.007	79.92	20.70	s
14.008	22.00	23.80	s
14.009	205.36	123.04	s
14.010	226.00		
14.011	75.92	59.31	s
14.012	55.80	56.46	s
14.013	182.28	12.73	a
15.001	6.68		
15.002	25.80		
15.004	4.44		
17.001	1.16		
17.002	65.76	21.47	
17.003	69.72	95.33	
17.008	30.08	15.10	
17.010	40.04	43.40	
17.012	4.04		
17.017	8.12	7.86	
18.001	89.84	20.72	
18.002	131.60	77.66	
18.003	53.84	31.76	
18.004	66.84	78.47	
18.005	67.52	356.49	
18.006	181.28	344.58	
18.007	19.36		
18.009	4.20		
18.011	54.92	96.75	
19.003		111.51	
19.004	29.48	284.75	
19.005	215.92	90.49	
20.003	294.16		
20.005	172.52	411.57	
20.006	32.52	50.22	
23.005	52.88	31.44	
23.007	64.24	48.35	
23.009	6.92		
23.011	132.60	39.43	
24.002	88.40	92.95	
24.006	452.48	528.90	
24.007	97.52		
24.008	153.88	266.57	
24.009	7.00		

PFM Subarea	Bed Areas (ha) during 1982-96	Bed Areas (ha) during 1997-2000	NB
25.006	70.32		
25.007	193.44		
25.013	297.40		
25.015	41.44		
26.001	12.12		
26.006	25.68		
27.001	29.44	63.84	
27.002	268.44	1.64	
27.003	42.12		
27.005	21.76		
27.007	46.16		
27.009	59.08	43.85	
28.001	6.48		
29.002	1.12		
29.003	3.84		
29.004	23.80	23.20	
29.005	35.48	89.40	
111.000	205.40	100.44	
123.003		15.28	
124.003	2.76	45.16	
125.001	54.92		
127.003		45.45	
South Coast Total	9669.18	6459.09	
BC Total	59874.38	35767.72	

Table 5. Estimated mean density (number/m^2) of red sea urchins in British Columbia by PFM subarea, obtained from population surveys during 1994-2001. Only those transects which intersect within the beds fished during 1997-2000 are included. SE = standard error not included if fewer than 5 transects were used.

PFM Subarea	Survey	Year	Total Transect		Urchin density (number/m^2) for each size group (mm TD)															
					≥90		≥95		≥100		90-130		90-140		95-130		95-140		100-140	
			Number	Length (m)	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
North Coast of BC																				
1.002	Langara	1994	10	1267	3.62	0.85	3.29	0.74	2.95	0.68	3.27	0.81	3.49	0.82	2.94	0.70	3.16	0.72	2.81	0.66
1.003	Langara	1994	8	1046	1.86	0.56	1.78	0.54	1.76	0.53	1.16	0.42	1.58	0.58	1.08	0.40	1.50	0.56	1.48	0.55
1.007	Langara	1994	8	2209	0.77	0.25	0.75	0.24	0.70	0.21	0.55	0.19	0.68	0.23	0.52	0.18	0.66	0.22	0.61	0.19
2.018	Rennell Sound	1995	8	678	1.06	0.33	0.92	0.28	0.79	0.25	0.97	0.29	1.02	0.31	0.84	0.25	0.88	0.26	0.75	0.23
2.031	Rennell Sound	1995	6	541	1.89	0.82	1.66	0.77	1.57	0.77	1.13	0.36	1.57	0.68	0.89	0.27	1.34	0.62	1.24	0.62
2.068	Rennell Sound	1995	2	216	2.20		1.55		1.14		2.20		2.20		1.55		1.55		1.14	
2.071	Rennell Sound	1995	1	53	3.50		2.62		1.89		3.50		3.50		2.62		2.62		1.89	
2.074	Rennell Sound	1995	1	201	1.81		1.44		1.15		1.81		1.81		1.44		1.44		1.15	
2.075	Rennell Sound	1995	1	138	4.44		4.22		4.00		4.22		4.44		4.00		4.22		4.00	
2.078	Rennell Sound	1995	1	30	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
4.002	Stephens Is.	1995	16	1041	2.14	0.55	1.87	0.50	1.54	0.40	1.66	0.43	1.85	0.48	1.39	0.36	1.58	0.41	1.26	0.32
4.004	Stephens Is.	1995	2	155	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
4.009	Stephens Is.	1995	3	326	1.39		1.22		1.04		1.30		1.36		1.14		1.20		1.02	
5.011	Banks Is.	1997	3	466	0.53		0.48		0.45		0.45		0.49		0.39		0.44		0.41	
5.013	Banks Is.	1997	3	396	0.41		0.36		0.34		0.28		0.33		0.24		0.29		0.26	
5.020	Banks Is.	1997	14	1586	1.53	0.33	1.36	0.29	1.23	0.26	1.22	0.29	1.40	0.32	1.05	0.26	1.23	0.28	1.10	0.25
5.021	Banks Is.	1997	8	1274	1.17	0.31	1.03	0.27	0.88	0.24	0.96	0.26	1.05	0.28	0.82	0.22	0.90	0.24	0.76	0.20
6.010	Campania	1994	22	4186	1.67	0.22	1.57	0.21	1.40	0.18	1.37	0.18	1.56	0.20	1.27	0.16	1.45	0.18	1.28	0.15
6.012	Campania	1994	1	105	0.16		0.16		0.16		0.08		0.08		0.08		0.08		0.08	
6.014	Laredo	2000	26	1649	0.50	0.17	0.43	0.14	0.36	0.12	0.45	0.15	0.48	0.16	0.37	0.12	0.41	0.13	0.34	0.11
6.015	Laredo	2000	28	1298	0.75	0.22	0.64	0.19	0.57	0.17	0.67	0.20	0.72	0.21	0.57	0.17	0.62	0.18	0.54	0.16
6.016	Price Is.	1995	7	409	1.26	0.14	1.12	0.13	0.89	0.13	1.24	0.14	1.24	0.14	1.10	0.14	1.11	0.14	0.88	0.13
6.017	Price Is.	1995	3	216	1.82		1.70		1.34		1.62		1.79		1.49		1.67		1.31	
7.001N[a]	Price Is.	2001	5	119	2.77	0.28	2.07	0.24	1.40	0.26	2.65	0.27	2.70	0.29	1.96	0.21	2.01	0.24	1.33	0.24
7.002N[a]	Price Is.	2001	9	247	4.36	0.66	3.54	0.52	2.54	0.52	4.25	0.59	4.33	0.64	3.44	0.46	3.51	0.50	2.52	0.50
7.003	Price Is.	2001	8	224	3.31	0.85	2.83	0.71	2.40	0.62	3.15	0.81	3.28	0.84	2.67	0.67	2.81	0.70	2.37	0.62
7.018	Heiltsuk	1994	4	187	2.89		2.24		1.84		2.76		2.89		2.11		2.24		1.84	
7.018	Heiltsuk	1995	5	305	1.47	0.59	1.24	0.46	0.97	0.35	1.33	0.57	1.45	0.60	1.10	0.44	1.22	0.47	0.95	0.35
7.018	Heiltsuk	1996	8	587	1.60	0.22	1.52	0.23	1.20	0.29	1.55	0.19	1.60	0.22	1.46	0.20	1.52	0.23	1.20	0.29
7.018	Heiltsuk	1997	4	263	2.21		1.91		1.59		2.09		2.20		1.78		1.90		1.58	
7.031S[a]	Price Is.	2001	10	306	2.58	0.48	2.05	0.40	1.33	0.29	2.56	0.49	2.58	0.48	2.03	0.41	2.05	0.40	1.33	0.29
8.004	FitzHugh	2001	1	21	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
8.016	FitzHugh	2001	3	115	1.37		1.33		1.18		1.32		1.37		1.28		1.33		1.18	
106.002	Campania	1994	7	544	3.18	0.73	2.78	0.69	2.45	0.64	2.89	0.64	3.12	0.70	2.49	0.60	2.72	0.67	2.38	0.61

Table 5. (continued)

PFM Subarea	Survey	Year	Total Transect		Urchin density (number/m²) for each size group (mm TD)															
					≥90		≥95		≥100		90-130		90-140		95-130		95-140		100-140	
			Number	Length (m)	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
South Coast of BC																				
11.002	Cape Sutil	1996	2	123	0.77		0.67		0.67		0.21		0.44		0.11		0.34		0.34	
12.001	Kelsey Bay	1999	3	91	2.04		1.89		1.78		1.80		1.97		1.65		1.82		1.72	
12.003	Queen Charl. Strait	1994	2	42	1.12		1.12		1.05		0.98		0.98		0.98		0.98		0.91	
12.003	Robson Bight	2001	9	315	0.92	0.25	0.89	0.24	0.85	0.23	0.55	0.19	0.70	0.20	0.52	0.17	0.67	0.19	0.64	0.18
12.005	Queen Charl. Strait	1994	2	106	0.32		0.32		0.29		0.11		0.22		0.11		0.22		0.18	
12.006	Queen Charl. Strait	1994	1	35	0.96		0.84		0.84		0.72		0.84		0.60		0.72		0.72	
12.008	Queen Charl. Strait	1994	1	53	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
12.009	Queen Charl. Strait	1994	2	170	2.92		2.62		2.09		2.57		2.75		2.26		2.44		1.91	
12.011	Queen Charl. Strait	1994	4	150	3.96		3.72		3.34		3.16		3.66		2.92		3.42		3.04	
12.013	Deserters	2000	9	381	1.52	0.35	1.38	0.33	1.15	0.30	1.32	0.29	1.45	0.32	1.17	0.26	1.30	0.30	1.07	0.27
12.015	Queen Charl. Strait	1994	1	34	1.35		1.35		1.35		1.35		1.35		1.35		1.35		1.35	
12.016	Queen Charl. Strait	1994	5	205	2.20	1.19	1.99	1.00	1.78	0.96	1.37	0.82	1.76	1.06	1.16	0.64	1.55	0.88	1.34	0.82
12.018	Queen Charl. Strait	1994	5	362	0.72	0.41	0.71	0.40	0.67	0.39	0.46	0.26	0.64	0.37	0.45	0.25	0.63	0.36	0.59	0.35
12.019	Queen Charl. Strait	1994	1	79	1.06		0.92		0.87		0.63		0.92		0.48		0.77		0.72	
12.020	Queen Charl. Strait	1994	1	59	2.80		2.80		2.80		0.89		1.77		0.89		1.77		1.77	
12.021	Queen Charl. Strait	1994	1	28	2.13		2.02		1.68		1.79		2.13		1.68		2.02		1.68	
12.021	Robson Bight	2001	3	93	1.34		1.32		1.25		0.66		0.92		0.64		0.89		0.83	
12.039	Queen Charl. Strait	1995	1	31	0.90		0.83		0.83		0.14		0.51		0.07		0.43		0.43	
13.030[a]	Kelsey Bay	1999	2	50	1.08		1.04		0.96		0.89		1.00		0.85		0.96		0.89	
13.031	Kelsey Bay	1999	1	41	0.95		0.81		0.67		0.86		0.95		0.71		0.81		0.67	
13.032	Kelsey Bay	1999	1	145	1.16		1.12		1.08		0.99		1.11		0.95		1.07		1.03	
13.033	Kelsey Bay	1999	5	363	1.96	0.40	1.77	0.38	1.55	0.34	1.78	0.34	1.94	0.40	1.59	0.32	1.75	0.37	1.52	0.33
14.005[a]	Comox, Denman Is.	1999	2	202	0.40		0.31		0.23		0.39		0.39		0.30		0.30		0.23	
14.007[a]	Comox, Denman Is.	1999	2	244	0.82		0.74		0.58		0.75		0.81		0.67		0.73		0.57	
14.008[a]	Comox, Denman Is.	1999	2	202	0.98		0.95		0.89		0.74		0.92		0.71		0.89		0.83	
14.009[a]	Comox, Denman Is.	1999	4	866	0.69		0.61		0.49		0.63		0.68		0.55		0.60		0.48	
14.011[a]	Comox, Denman Is.	1999	5	503	0.30	0.19	0.30	0.18	0.28	0.17	0.20	0.13	0.27	0.17	0.20	0.13	0.26	0.17	0.24	0.16
14.012[a]	Comox, Denman Is.	1999	1	101	0.69		0.65		0.57		0.65		0.69		0.61		0.65		0.57	
18.001	Gulf Is.	1998	1	105	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
18.002	Gulf Is.	1998	3	165	0.20		0.20		0.20		0.11		0.13		0.11		0.13		0.13	
18.003	Gulf Is.	1998	1	45	0.22		0.22		0.22		0.04		0.13		0.04		0.13		0.13	
18.004	Gulf Is., Cowichan	1999	4	392	0.15		0.15		0.15		0.02		0.06		0.02		0.06		0.06	
18.005	Gulf Is., Cowichan	1999	2	142	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
18.006	Gulf Is., Cowichan	1999	9	1081	0.38	0.13	0.37	0.12	0.36	0.12	0.15	0.07	0.22	0.08	0.15	0.06	0.22	0.08	0.20	0.07
18.011	Gulf Is.	1998	1	53	0.86		0.86		0.80		0.68		0.80		0.68		0.80		0.74	
24.002	Tofino	2000	1	55	0.46		0.25		0.21		0.46		0.46		0.25		0.25		0.21	
24.006	Tofino	2000	14	1574	0.82	0.27	0.72	0.22	0.53	0.17	0.78	0.26	0.80	0.26	0.67	0.22	0.70	0.22	0.51	0.16
24.008	Tofino	2000	5	523	2.05	0.84	1.62	0.63	1.35	0.51	1.85	0.79	1.95	0.81	1.41	0.57	1.52	0.60	1.24	0.48
27.001	Cape Sutil	1996	1	100	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
111.000	Cape Sutil	1996	2	201	2.67		2.59		2.27		2.45		2.63		2.36		2.54		2.22	
124.003	Tofino	2000	3	149	2.01		1.39		0.97		2.01		2.01		1.39		1.39		0.97	

[a] Survey transects did not fall within clipped 1997-2000 commercial red sea urchin beds. Beds were estimated using survey data.

Table 6. Estimated mean biomass density (g/m^2) of red sea urchins in British Columbia by PFM subarea, obtained from population surveys during 1994-2001. Only those transects which intersect within the beds fished during 1997-2000 are included. SE = standard error not included if fewer than 5 transects were used.

PFM Subarea	Survey	Year	Total Transect		Urchin biomass (g/m^2) for each size group (mm TD)															
					≥90		≥95		≥100		90-130		90-140		95-130		95-140		100-140	
			Number	Length (m)	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
North Coast of BC																				
1.002	Langara	1994	10	1267	1726.4	405.3	1638.5	377.9	1536.1	360.9	1441.3	369.7	1598.7	380.4	1353.4	341.1	1510.8	352.5	1408.4	334.9
1.003	Langara	1994	8	1046	1149.0	306.6	1126.7	303.0	1121.7	301.3	558.7	207.2	871.8	325.5	536.5	202.1	849.5	320.8	844.5	318.7
1.007	Langara	1994	8	2209	440.7	139.8	433.6	137.4	418.5	130.7	256.3	86.6	355.6	114.3	249.2	83.8	348.5	111.5	333.4	103.2
2.018	Rennell Sound	1995	8	678	453.4	148.1	418.4	136.9	379.7	128.6	385.1	117.6	418.0	129.3	350.1	106.6	383.0	118.1	344.3	109.1
2.031	Rennell Sound	1995	6	541	1113.9	563.0	1053.3	554.1	1025.8	556.8	474.3	154.1	805.5	422.9	413.7	136.2	744.9	411.2	717.4	413.0
2.068	Rennell Sound	1995	2	216	779.8		607.0		487.5		779.8		779.8		607.0		607.0		487.5	
2.071	Rennell Sound	1995	1	53	1224.4		998.7		788.2		1224.4		1224.4		998.7		998.7		788.2	
2.074	Rennell Sound	1995	1	201	645.1		548.7		463.9		645.1		645.1		548.7		548.7		463.9	
2.075	Rennell Sound	1995	1	138	1889.6		1833.2		1766.0		1725.4		1889.6		1668.9		1833.2		1766.0	
2.078	Rennell Sound	1995	1	30	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
4.002	Stephens Is.	1995	16	1041	1124.6	310.2	1053.7	304.0	956.2	274.0	678.2	177.2	820.8	208.7	607.4	158.7	749.9	193.2	652.4	165.0
4.004	Stephens Is.	1995	2	155	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
4.009	Stephens Is.	1995	3	326	612.9		571.2		518.3		548.4		593.5		506.7		551.8		498.9	
5.011	Banks Is.	1997	3	466	251.2		236.1		227.3		179.9		216.6		164.8		201.6		192.7	
5.013	Banks Is.	1997	3	396	230.3		219.0		212.1		119.1		152.9		107.8		141.6		134.7	
5.020	Banks Is.	1997	14	1586	772.1	152.0	727.0	142.1	687.8	132.9	512.6	115.0	649.5	138.5	467.6	105.8	604.4	128.4	565.1	118.7
5.021	Banks Is.	1997	8	1274	573.7	150.4	536.0	141.9	492.1	135.0	397.5	106.6	458.3	121.8	359.9	96.8	420.7	111.5	376.8	102.5
6.010	Campania	1994	22	4186	848.0	110.9	820.5	107.7	770.7	100.5	596.7	70.1	738.1	87.4	569.2	66.7	710.6	83.8	660.8	77.8
6.012	Campania	1994	1	105	112.3		112.3		112.3		39.2		39.2		39.2		39.2		39.2	
6.014	Laredo	2000	26	1649	222.2	72.3	202.9	66.1	181.8	60.0	176.3	58.8	204.0	67.6	157.0	52.1	184.7	61.1	163.6	54.9
6.015	Laredo	2000	28	1298	331.0	95.2	304.3	87.9	280.3	82.0	271.3	80.7	305.2	89.4	244.6	73.2	278.5	82.0	254.6	76.2
6.016	Price Is.	1995	7	409	502.9	51.8	466.0	52.3	397.7	52.0	486.6	56.3	491.4	55.7	449.7	56.7	454.5	55.8	386.1	54.1
6.017	Price Is.	1995	3	216	798.8		766.4		658.4		638.8		767.7		606.4		735.3		627.3	
7.001N[a]	Price Is.	2001	5	119	1022.8	132.0	842.0	137.0	637.0	152.8	929.5	101.5	965.8	125.5	748.8	97.1	785.1	123.8	580.0	131.4
7.002N[a]	Price Is.	2001	9	247	1615.9	293.7	1403.4	261.6	1104.7	262.1	1536.7	238.3	1594.4	274.8	1324.2	205.5	1381.8	242.6	1083.2	243.6
7.003	Price Is.	2001	8	224	1349.0	352.9	1224.7	316.0	1094.1	293.4	1224.4	322.3	1325.1	347.9	1100.2	285.1	1200.8	310.8	1070.2	288.2
7.018	Heiltsuk	1994	4	187	1164.7		993.9		871.9		1059.7		1164.7		888.9		993.9		871.9	
7.018	Heiltsuk	1995	5	305	621.5	232.7	559.6	200.2	480.9	165.7	510.9	216.6	602.2	236.9	449.0	181.2	540.3	202.9	461.6	168.2
7.018	Heiltsuk	1996	8	587	675.7	143.2	652.9	146.7	556.3	172.8	635.3	110.1	675.7	143.2	612.5	113.0	652.9	146.7	556.3	172.8
7.018	Heiltsuk	1997	4	263	895.0		814.8		717.2		806.0		888.7		725.8		808.4		710.9	
7.031S[a]	Price Is.	2001	10	306	908.1	175.4	770.1	156.8	555.9	123.6	894.5	177.5	908.1	175.4	756.5	158.3	770.1	156.8	555.9	123.6
8.004	FitzHugh	2001	1	21	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
8.016	FitzHugh	2001	3	115	620.0		611.7		566.5		583.5		620.0		575.2		611.7		566.5	
106.002	Campania	1994	7	544	1402.5	359.3	1298.7	353.6	1195.8	339.3	1149.2	268.3	1324.3	326.1	1045.4	259.1	1220.5	319.6	1117.7	305.1

Table 6. (continued)

PFM Subarea	Survey	Year	Total Transect		Urchin biomass (g/m²) for each size group (mm TD): ≥90		≥95		≥100		90-130		90-140		95-130		95-140		100-140	
			Number	Length (m)	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
South Coast of BC																				
11.002	Cape Sutil	1996	2	123	564.0		539.4		539.4		81.7		259.3		57.2		234.8		234.8	
12.001	Kelsey Bay	1999	3	91	975.4		936.1		904.8		796.2		921.0		756.8		881.6		850.4	
12.003	Queen Charl. Strait	1994	2	42	589.4		589.4		569.5		422.1		422.1		422.1		422.1		402.2	
12.003	Robson Bight	2001	9	315	594.1	179.5	586.1	177.4	576.8	177.0	251.7	84.6	366.6	101.9	243.7	80.7	358.6	98.6	349.3	95.9
12.005	Queen Charl. Strait	1994	2	106	246.3		246.3		235.1		56.1		138.3		56.1		138.3		127.2	
12.006	Queen Charl. Strait	1994	1	35	576.0		545.5		545.5		387.5		476.3		357.0		445.7		445.7	
12.008	Queen Charl. Strait	1994	1	53	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
12.009	Queen Charl. Strait	1994	2	170	1532.2		1453.6		1297.9		1113.7		1253.6		1035.1		1175.0		1019.3	
12.011	Queen Charl. Strait	1994	4	150	2088.4		2027.6		1915.0		1425.6		1796.7		1364.9		1736.0		1623.3	
12.013	Deserters	2000	9	381	726.3	189.2	687.8	186.4	618.4	180.1	559.6	129.0	654.0	158.9	521.1	124.3	615.5	155.1	546.1	147.3
12.015	Queen Charl. Strait	1994	1	34	691.8		691.8		691.8		691.8		691.8		691.8		691.8		691.8	
12.016	Queen Charl. Strait	1994	5	205	1352.0	719.4	1298.1	673.0	1236.9	662.0	604.2	368.0	899.5	548.6	550.3	321.0	845.6	502.1	784.4	485.2
12.018	Queen Charl. Strait	1994	5	362	434.8	253.0	430.7	250.5	419.3	246.8	226.9	130.6	361.1	215.6	222.8	128.2	357.0	213.2	345.6	209.6
12.019	Queen Charl. Strait	1994	1	79	637.6		598.2		584.0		273.9		498.7		234.5		459.4		445.2	
12.020	Queen Charl. Strait	1994	1	59	2021.8		2021.8		2021.8		423.9		1087.4		423.9		1087.4		1087.4	
12.021	Queen Charl. Strait	1994	1	28	1021.6		991.4		888.0		782.9		1021.6		752.7		991.4		888.0	
12.021	Robson Bight	2001	3	93	931.3		926.0		906.5		325.0		512.9		319.7		507.6		488.1	
12.039	Queen Charl. Strait	1995	1	31	729.5		710.6		710.6		57.9		334.5		39.0		315.5		315.5	
13.030[a]	Kelsey Bay	1999	2	50	551.2		541.1		516.7		397.9		486.8		387.8		476.6		452.2	
13.031	Kelsey Bay	1999	1	41	439.0		401.3		358.5		366.4		439.0		328.6		401.3		358.5	
13.032	Kelsey Bay	1999	1	145	624.8		614.3		601.8		485.0		574.6		474.4		564.0		551.6	
13.033	Kelsey Bay	1999	5	363	885.9	198.4	835.4	193.1	765.9	179.6	748.7	148.3	862.6	190.6	698.2	142.3	812.0	185.0	742.5	171.6
14.005[a]	Comox, Denman Is.	1999	2	202	160.5		136.5		112.9		152.2		152.2		128.2		128.2		104.6	
14.007[a]	Comox, Denman Is.	1999	2	244	362.5		341.2		292.8		307.0		354.7		285.8		333.5		285.0	
14.008[a]	Comox, Denman Is.	1999	2	202	545.0		537.1		519.2		348.0		491.0		340.1		483.0		465.2	
14.009[a]	Comox, Denman Is.	1999	4	866	296.1		275.3		240.7		252.0		287.5		231.2		266.7		232.1	
14.011[a]	Comox, Denman Is.	1999	5	503	186.3	114.6	184.2	113.3	178.3	109.7	100.6	66.2	147.6	94.9	98.5	64.4	145.6	93.3	139.6	90.6
14.012[a]	Comox, Denman Is.	1999	1	101	301.4		291.7		268.0		272.7		301.4		263.0		291.7		268.0	
18.001	Gulf Is.	1998	1	105	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
18.002	Gulf Is.	1998	3	165	143.3		143.3		143.3		60.5		78.2		60.5		78.2		78.2	
18.003	Gulf Is.	1998	1	45	190.2		190.2		190.2		22.3		93.3		22.3		93.3		93.3	
18.004	Gulf Is., Cowichan	1999	4	392	131.2		131.2		131.2		9.4		39.3		9.4		39.3		39.3	
18.005	Gulf Is., Cowichan	1999	2	142	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
18.006	Gulf Is., Cowichan	1999	9	1081	279.3	95.5	276.9	94.8	273.1	93.8	74.9	30.9	127.4	42.7	72.5	30.2	125.0	42.0	121.1	39.8
18.011	Gulf Is.	1998	1	53	530.3		530.3		512.2		370.4		462.9		370.4		462.9		444.7	
24.002	Tofino	2000	1	55	151.6		96.3		84.9		151.6		151.6		96.3		96.3		84.9	
24.006	Tofino	2000	14	1574	328.8	102.1	302.3	91.8	247.4	77.4	294.0	96.0	310.0	97.3	267.6	85.2	283.5	86.8	228.6	71.4
24.008	Tofino	2000	5	523	868.0	334.6	756.0	285.3	673.1	254.4	690.7	283.3	767.5	299.9	578.7	229.5	655.6	249.8	572.6	217.0
27.001	Cape Sutil	1996	1	100	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
111.000	Cape Sutil	1996	2	201	1204.1		1180.1		1086.0		1027.6		1163.5		1003.7		1139.6		1045.5	
124.003	Tofino	2000	3	149	669.9		507.2		385.4		669.9		669.9		507.2		507.2		385.4	

[a] Survey transects did not fall within clipped 1997-2000 commercial red sea urchin beds. Beds were estimated using survey data.

Table 7. Summary of estimated mean density (number/m^2) and biomass (g/m^2) of red sea urchins by PFM area in British Columbia, all years combined, obtained from population surveys during 1994-2001. Only those transects which intersect within the beds fished during 1997-2000 are included.

PFM Area	Year	Total Transect		Mean urchin density (per m^2) for each size group (mm TD)								Mean biomass (g/m^2) for each size group (mm TD)							
		Number	Length (m)	≥ 90	≥ 95	≥ 100	90-130	90-140	95-130	95-140	100-140	≥ 90	≥ 95	≥ 100	90-130	90-140	95-130	95-140	100-140
North Coast of BC:																			
1	1994	26	4522	1.82	1.70	1.57	1.45	1.68	1.33	1.55	1.43	964.77	931.55	894.30	658.25	823.28	625.03	790.05	752.80
2	1995	19	1656	1.82	1.56	1.38	1.52	1.70	1.25	1.43	1.26	847.90	779.30	726.53	597.31	732.68	528.71	664.08	611.31
4	1995	21	1522	1.76	1.54	1.28	1.42	1.56	1.19	1.34	1.08	900.45	843.04	765.00	581.35	688.52	523.94	631.11	553.08
5	1997	28	3722	1.16	1.03	0.92	0.94	1.05	0.80	0.92	0.81	581.31	546.15	512.56	389.69	477.00	354.53	441.84	408.24
6	1994-2000	87	7863	1.24	1.14	1.00	1.04	1.16	0.95	1.06	0.93	602.32	576.37	535.00	442.83	533.31	416.88	507.36	465.99
7	1994-2001	37	1819	2.10	1.81	1.48	1.99	2.09	1.71	1.80	1.47	861.93	787.34	685.65	779.89	851.87	705.30	777.28	675.59
8	2001	4	136	1.16	1.13	1.00	1.11	1.16	1.09	1.13	1.00	524.23	517.23	479.06	493.42	524.23	486.41	517.23	479.06
106	1994	7	544	3.18	2.78	2.45	2.89	3.12	2.49	2.72	2.38	1402.48	1298.66	1195.85	1149.20	1324.31	1045.39	1220.50	1117.68
North Coast Totals:		229	21784	1.55	1.39	1.23	1.30	1.45	1.14	1.29	1.13	754.64	714.28	665.11	545.99	656.18	505.63	615.82	566.65
South Coast of BC:																			
11	1996	2	123	0.77	0.67	0.67	0.21	0.44	0.11	0.34	0.34	563.96	539.43	539.43	81.69	259.31	57.16	234.78	234.78
12	1994-2001	51	2234	1.56	1.45	1.30	1.14	1.36	1.03	1.25	1.10	878.67	850.96	806.17	508.27	675.48	480.56	647.77	602.97
13	1999	9	599	1.63	1.49	1.32	1.45	1.59	1.31	1.45	1.29	764.20	727.59	677.46	629.40	732.50	592.79	695.89	645.76
14	1999	16	2118	0.61	0.56	0.47	0.53	0.59	0.47	0.54	0.45	288.70	273.76	247.53	223.00	269.20	208.05	254.26	228.03
18	1998-1999	21	1983	0.28	0.28	0.27	0.12	0.17	0.11	0.16	0.16	208.63	207.32	204.72	58.15	98.23	56.84	96.92	94.32
24	2000	20	2152	1.11	0.92	0.72	1.03	1.07	0.84	0.88	0.68	455.29	407.32	346.72	386.77	417.11	338.80	369.15	308.55
27	1996	1	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
111	1996	2	201	2.67	2.59	2.27	2.45	2.63	2.36	2.54	2.22	1204.07	1180.15	1086.00	1027.61	1163.53	1003.69	1139.61	1045.46
124	2000	3	149	2.01	1.39	0.97	2.01	2.01	1.39	1.39	0.97	669.92	507.19	385.44	669.92	669.92	507.19	507.19	385.44
South Coast Totals:		125	9659	1.00	0.90	0.77	0.81	0.91	0.70	0.81	0.68	500.76	474.53	437.44	336.35	411.63	310.12	385.40	348.31
BC Totals:		354	31443	1.38	1.24	1.09	1.15	1.28	1.01	1.14	0.99	676.65	640.63	595.17	481.59	581.06	445.57	545.04	499.58

Table 8. Quota (tonnes) options for the red sea urchin fishery by PFM subarea, estimated from various natural mortality values applied to current biomass (Bc) calculated from mean and approximate 90% lower confidence bound (CB) of the clipped biomass values (g/m^2) for commercial red sea urchin sizes 90-140 mm TD, and bed areas fished during 1997-2000. NB: blank = mean values directly from survey data within subarea; a = mean values from all surveys (1994-2001) in PFM area (may include several subareas); b = mean values of surveys in PFM area 4 used for subareas of PFM area 3; c = mean values of surveys in PFM area 7 used for subareas of PFM areas 9 and 10; d = mean values of surveys in PFM area 1 used for subareas of PFM area 101; e = mean values of surveys in PFM area 2E used for subareas of PFM area 102; f = mean values of surveys in PFM area 5 used for subareas of PFM area 105; g = mean values of surveys in PFM area 2W used for subareas of PFM area 142; h = mean values of surveys in PFM area 18 used for subareas of PFM areas 17, 19, 29, and PFM subarea 18.005; i = mean values of surveys in PFM area 24 used for subareas of PFM areas 20, 23, 27, and 123; j = mean values of surveys in PFM area 111 used for subareas of PFM area 127; k = bed area estimated using survey data; y = Subareas with only one survey transect and/or low (0) mean biomass updated to reflect mean biomass for entire PFM area.

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
North Coast of BC															
1.001	94	a	26	4522	823.3	695.2	967.7	7967.2	6728.1	119.5	100.9	159.3	134.6	239.0	201.8
1.002	94		10	1267	1598.7	1128.9	721.8	11539.4	6506.6	173.1	97.6	230.8	130.1	346.2	195.2
1.003	94		8	1046	871.8	589.9	1104.0	9624.2	2816.5	144.4	42.2	192.5	56.3	288.7	84.5
1.005	94	a	26	4522	823.3	695.2	31.1	255.7	215.9	3.8	3.2	5.1	4.3	7.7	6.5
1.007	94		8	2209	355.6	276.4	1093.9	3889.7	1521.5	58.3	22.8	77.8	30.4	116.7	45.6
2.008	95	a	19	1656	732.7	544.4	329.8	2416.2	1795.2	36.2	26.9	48.3	35.9	72.5	53.9
2.009	95	a	19	1656	732.7	544.4	3.6	26.5	19.7	0.4	0.3	0.5	0.4	0.8	0.6
2.010	95	a	19	1656	732.7	544.4	57.9	424.4	315.3	6.4	4.7	8.5	6.3	12.7	9.5
2.011	95	a	19	1656	732.7	544.4	612.6	4488.3	3334.8	67.3	50.0	89.8	66.7	134.6	100.0
2.012	95	a	19	1656	732.7	544.4	249.6	1828.6	1358.6	27.4	20.4	36.6	27.2	54.9	40.8
2.013	95	a	19	1656	732.7	544.4	0.8	5.8	4.3	0.1	0.1	0.1	0.1	0.2	0.1
2.014	95	a	19	1656	732.7	544.4	562.6	4121.7	3062.4	61.8	45.9	82.4	61.2	123.7	91.9
2.015	95	a	19	1656	732.7	544.4	283.9	2079.9	1545.4	31.2	23.2	41.6	30.9	62.4	46.4
2.017	95	a	19	1656	732.7	544.4	299.8	2196.9	1632.3	33.0	24.5	43.9	32.6	65.9	49.0
2.018	95		8	678	418.0	250.1	698.3	2919.0	1208.5	43.8	18.1	58.4	24.2	87.6	36.3
2.019	95	a	19	1656	732.7	544.4	92.3	676.0	502.3	10.1	7.5	13.5	10.0	20.3	15.1
2.031	95		6	541	805.5	443.3	357.5	2879.6	-166.6	43.2	-2.5	57.6	-3.3	86.4	-5.0
2.049	95	a	19	1656	732.7	544.4	20.1	147.6	109.7	2.2	1.6	3.0	2.2	4.4	3.3
2.050	95	a	19	1656	732.7	544.4	18.9	138.3	102.7	2.1	1.5	2.8	2.1	4.1	3.1
2.055	95	a	19	1656	732.7	544.4	1.5	11.3	8.4	0.2	0.1	0.2	0.2	0.3	0.3
2.065	95	a	19	1656	732.7	544.4	2.3	16.6	12.3	0.2	0.2	0.3	0.2	0.5	0.4
2.068	95		2	216	779.8	224.9	388.0	3025.1	872.4	45.4	13.1	60.5	17.4	90.8	26.2
2.069	95	a	19	1656	732.7	544.4	24.7	181.3	134.7	2.7	2.0	3.6	2.7	5.4	4.0
2.070	95	a	19	1656	732.7	544.4	2.1	15.4	11.4	0.2	0.2	0.3	0.2	0.5	0.3
2.071	95		1	53	1224.4	0.0	76.7	939.4	0.0	14.1	0.0	18.8	0.0	28.2	0.0

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
2.073	95	a	19	1656	732.7	544.4	0.1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
2.074	95		1	201	645.1	169.2	1.4	9.0	2.4	0.1	0.0	0.2	0.0	0.3	0.1
2.075	95		1	138	1889.6	207.3	133.8	2529.1	277.4	37.9	4.2	50.6	5.5	75.9	8.3
2.078	95	y	19	1656	732.7	544.4	11.9	87.4	65.0	1.3	1.0	1.7	1.3	2.6	1.9
2.079	95	a	19	1656	732.7	544.4	4.9	36.0	26.7	0.5	0.4	0.7	0.5	1.1	0.8
2.080	95	a	19	1656	732.7	544.4	9.6	70.4	52.3	1.1	0.8	1.4	1.0	2.1	1.6
2.082	95	a	19	1656	732.7	544.4	28.8	211.3	157.0	3.2	2.4	4.2	3.1	6.3	4.7
2.086	95	a	19	1656	732.7	544.4	1.8	13.4	10.0	0.2	0.1	0.3	0.2	0.4	0.3
2.087	95	a	19	1656	732.7	544.4	118.8	870.7	646.9	13.1	9.7	17.4	12.9	26.1	19.4
2.088	95	a	19	1656	732.7	544.4	36.6	268.0	199.1	4.0	3.0	5.4	4.0	8.0	6.0
2.089	95	a	19	1656	732.7	544.4	0.8	5.8	4.3	0.1	0.1	0.1	0.1	0.2	0.1
2.092	95	a	19	1656	732.7	544.4	18.9	138.4	102.8	2.1	1.5	2.8	2.1	4.2	3.1
2.093	95	a	19	1656	732.7	544.4	26.9	197.2	146.5	3.0	2.2	3.9	2.9	5.9	4.4
2.095	95	a	19	1656	732.7	544.4	0.6	4.1	3.0	0.1	0.0	0.1	0.1	0.1	0.1
2.096	95	a	19	1656	732.7	544.4	17.5	128.3	95.3	1.9	1.4	2.6	1.9	3.8	2.9
2.097	95	a	19	1656	732.7	544.4	35.9	262.9	195.3	3.9	2.9	5.3	3.9	7.9	5.9
2.098	95	a	19	1656	732.7	544.4	24.0	175.6	130.5	2.6	2.0	3.5	2.6	5.3	3.9
2.099	95	a	19	1656	732.7	544.4	24.2	177.2	131.7	2.7	2.0	3.5	2.6	5.3	4.0
2.100	95	a	19	1656	732.7	544.4	13.4	97.8	72.7	1.5	1.1	2.0	1.5	2.9	2.2
3.001	95	b	21	1522	688.5	503.9	458.9	3159.7	2312.6	47.4	34.7	63.2	46.3	94.8	69.4
3.002	95	b	21	1522	688.5	503.9	72.1	496.6	363.5	7.4	5.5	9.9	7.3	14.9	10.9
3.003	95	b	21	1522	688.5	503.9	18.5	127.7	93.4	1.9	1.4	2.6	1.9	3.8	2.8
4.001	95	a	21	1522	688.5	503.9	1155.2	7953.8	5821.6	119.3	87.3	159.1	116.4	238.6	174.6
4.002	95		16	1041	820.8	554.7	697.2	5723.0	3171.6	85.8	47.6	114.5	63.4	171.7	95.1
4.003	95	a	21	1522	688.5	503.9	336.3	2315.6	1694.8	34.7	25.4	46.3	33.9	69.5	50.8
4.004	95	y	21	1522	688.5	503.9	96.7	665.9	487.4	10.0	7.3	13.3	9.7	20.0	14.6
4.005	95	a	21	1522	688.5	503.9	155.6	1071.4	784.2	16.1	11.8	21.4	15.7	32.1	23.5
4.009	95		3	326	593.5	249.7	422.4	2506.8	1054.7	37.6	15.8	50.1	21.1	75.2	31.6
4.012	95	a	21	1522	688.5	503.9	201.8	1389.6	1017.1	20.8	15.3	27.8	20.3	41.7	30.5
4.013	95	a	21	1522	688.5	503.9	903.5	6220.8	4553.1	93.3	68.3	124.4	91.1	186.6	136.6
5.004	97	a	28	3722	477.0	395.2	1.4	6.7	5.5	0.1	0.1	0.1	0.1	0.2	0.2
5.009	97	a	28	3722	477.0	395.2	227.8	1086.5	900.3	16.3	13.5	21.7	18.0	32.6	27.0
5.010	97	a	28	3722	477.0	395.2	481.2	2295.5	1902.0	34.4	28.5	45.9	38.0	68.9	57.1
5.011	97		3	466	216.6	111.7	420.0	909.8	469.0	13.6	7.0	18.2	9.4	27.3	14.1
5.012	97	a	28	3722	477.0	395.2	338.3	1613.5	1336.9	24.2	20.1	32.3	26.7	48.4	40.1
5.013	97		3	396	152.9	72.5	276.3	422.4	200.4	6.3	3.0	8.4	4.0	12.7	6.0
5.014	97	a	28	3722	477.0	395.2	73.0	348.1	288.4	5.2	4.3	7.0	5.8	10.4	8.7

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
5.016	97	a	28	3722	477.0	395.2	6.0	28.7	23.8	0.4	0.4	0.6	0.5	0.9	0.7
5.017	97	a	28	3722	477.0	395.2	450.5	2149.0	1780.6	32.2	26.7	43.0	35.6	64.5	53.4
5.018	97	a	28	3722	477.0	395.2	8.4	39.9	33.0	0.6	0.5	0.8	0.7	1.2	1.0
5.020	97		14	1586	649.5	478.9	1865.8	12117.4	7541.2	181.8	113.1	242.3	150.8	363.5	226.2
5.021	97		8	1274	458.3	324.0	191.6	878.2	436.1	13.2	6.5	17.6	8.7	26.3	13.1
5.022	97	a	28	3722	477.0	395.2	1132.5	5401.9	4475.9	81.0	67.1	108.0	89.5	162.1	134.3
6.005	94-00	a	87	7863	533.3	470.4	4.1	21.8	19.2	0.3	0.3	0.4	0.4	0.7	0.6
6.006	94-00	a	87	7863	533.3	470.4	2.7	14.5	12.8	0.2	0.2	0.3	0.3	0.4	0.4
6.009	94-00	a	87	7863	533.3	470.4	1970.1	10506.5	9267.3	157.6	139.0	210.1	185.3	315.2	278.0
6.010	94		22	4186	738.1	618.8	1175.6	8677.6	6909.3	130.2	103.6	173.6	138.2	260.3	207.3
6.011	94-00	a	87	7863	533.3	470.4	91.1	486.1	428.7	7.3	6.4	9.7	8.6	14.6	12.9
6.012	94-00	y	87	7863	533.3	470.4	24.3	129.3	114.1	1.9	1.7	2.6	2.3	3.9	3.4
6.013	94-00	a	87	7863	533.3	470.4	1442.5	7693.1	6785.7	115.4	101.8	153.9	135.7	230.8	203.6
6.014	00		26	1649	204.0	151.5	251.5	513.1	222.8	7.7	3.3	10.3	4.5	15.4	6.7
6.015	00		28	1298	305.2	216.6	202.2	617.2	309.2	9.3	4.6	12.3	6.2	18.5	9.3
6.016	95		7	409	491.4	237.3	330.8	1625.6	1267.7	24.4	19.0	32.5	25.4	48.8	38.0
6.017	95		3	216	767.7	221.4	202.4	1553.5	448.0	23.3	6.7	31.1	9.0	46.6	13.4
6.019	94-00	a	87	7863	533.3	470.4	109.2	582.4	513.7	8.7	7.7	11.6	10.3	17.5	15.4
6.026	94-00	a	87	7863	533.3	470.4	4.3	23.0	20.3	0.3	0.3	0.5	0.4	0.7	0.6
7.001	94-01	a	37	1819	851.9	643.0	32.5	276.6	208.8	4.1	3.1	5.5	4.2	8.3	6.3
7.002	94-01	a	37	1819	851.9	643.0	3.5	30.1	22.7	0.5	0.3	0.6	0.5	0.9	0.7
7.003	01		8	224	1325.1	399.1	311.7	4130.6	2076.1	62.0	31.1	82.6	41.5	123.9	62.3
7.004	94-01	a	37	1819	851.9	643.0	87.6	746.0	563.0	11.2	8.4	14.9	11.3	22.4	16.9
7.005	94-01	a	37	1819	851.9	643.0	7.5	64.2	48.5	1.0	0.7	1.3	1.0	1.9	1.5
7.008	94-01	a	37	1819	851.9	643.0	26.0	221.6	167.2	3.3	2.5	4.4	3.3	6.6	5.0
7.009	94-01	a	37	1819	851.9	643.0	388.3	3308.0	2496.8	49.6	37.5	66.2	49.9	99.2	74.9
7.012	94-01	a	37	1819	851.9	643.0	167.8	1429.8	1079.2	21.4	16.2	28.6	21.6	42.9	32.4
7.015	94-01	a	37	1819	851.9	643.0	0.4	3.4	2.6	0.1	0.0	0.1	0.1	0.1	0.1
7.018	94-97		21	1342	768.9	549.4	231.2	1777.3	1363.3	26.7	20.4	35.5	27.3	53.3	40.9
7.019	97		1	49	1308.2	0.0	71.7	938.0	0.0	14.1	0.0	18.8	0.0	28.1	0.0
7.020	94-01	a	37	1819	851.9	643.0	35.2	299.6	226.2	4.5	3.4	6.0	4.5	9.0	6.8
7.021	94-01	a	37	1819	851.9	643.0	27.6	234.9	177.3	3.5	2.7	4.7	3.5	7.0	5.3
7.023	94-01	a	37	1819	851.9	643.0	31.3	266.6	201.2	4.0	3.0	5.3	4.0	8.0	6.0
7.024	94-01	a	37	1819	851.9	643.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.025	94-95		6	187	816.6	192.1	167.6	1368.3	518.4	20.5	7.8	27.4	10.4	41.0	15.6

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
7.026	94-01	a	37	1819	851.9	643.0	2.7	22.8	17.2	0.3	0.3	0.5	0.3	0.7	0.5
7.027	94-01	a	37	1819	851.9	643.0	297.2	2531.8	1911.0	38.0	28.7	50.6	38.2	76.0	57.3
7.028	94-01	a	37	1819	851.9	643.0	52.2	445.0	335.9	6.7	5.0	8.9	6.7	13.4	10.1
7.031	95		1	17	242.6	0.0	0.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.032	94-01	a	37	1819	851.9	643.0	126.4	1076.6	812.6	16.1	12.2	21.5	16.3	32.3	24.4
8.001	01	a	4	136	524.2	54.1	126.8	664.9	68.6	10.0	1.0	13.3	1.4	19.9	2.1
8.002	01	a	4	136	524.2	54.1	122.4	641.6	66.2	9.6	1.0	12.8	1.3	19.2	2.0
8.003	01	a	4	136	524.2	54.1	7.1	37.0	3.8	0.6	0.1	0.7	0.1	1.1	0.1
8.004	01	y	4	136	524.2	54.1	143.4	751.7	77.6	11.3	1.2	15.0	1.6	22.6	2.3
8.016	01		3	115	620.0	15.3	51.4	318.8	7.9	4.8	0.1	6.4	0.2	9.6	0.2
9.001	94-01	c	37	1819	851.9	643.0	104.8	893.0	674.0	13.4	10.1	17.9	13.5	26.8	20.2
9.002	94-01	c	37	1819	851.9	643.0	62.4	531.9	401.5	8.0	6.0	10.6	8.0	16.0	12.0
9.003	94-01	c	37	1819	851.9	643.0	0.4	3.4	2.6	0.1	0.0	0.1	0.1	0.1	0.1
9.010	94-01	c	37	1819	851.9	643.0	6.2	53.0	40.0	0.8	0.6	1.1	0.8	1.6	1.2
9.011	94-01	c	37	1819	851.9	643.0	9.3	79.6	60.1	1.2	0.9	1.6	1.2	2.4	1.8
9.012	94-01	c	37	1819	851.9	643.0	33.1	282.4	213.1	4.2	3.2	5.6	4.3	8.5	6.4
10.001	94-01	c	37	1819	851.9	643.0	107.1	912.4	688.7	13.7	10.3	18.2	13.8	27.4	20.7
10.002	94-01	c	37	1819	851.9	643.0	238.4	2031.0	1532.9	30.5	23.0	40.6	30.7	60.9	46.0
10.003	94-01	c	37	1819	851.9	643.0	186.0	1584.2	1195.8	23.8	17.9	31.7	23.9	47.5	35.9
10.004	94-01	c	37	1819	851.9	643.0	134.4	1144.6	864.0	17.2	13.0	22.9	17.3	34.3	25.9
10.005	94-01	c	37	1819	851.9	643.0	3.2	27.4	20.7	0.4	0.3	0.5	0.4	0.8	0.6
10.006	94-01	c	37	1819	851.9	643.0	0.9	7.5	5.7	0.1	0.1	0.2	0.1	0.2	0.2
10.008	94-01	c	37	1819	851.9	643.0	0.7	6.2	4.6	0.1	0.1	0.1	0.1	0.2	0.1
10.011	94-01	c	37	1819	851.9	643.0	2.7	23.1	17.4	0.3	0.3	0.5	0.3	0.7	0.5
10.012	94-01	c	37	1819	851.9	643.0	12.4	105.6	79.7	1.6	1.2	2.1	1.6	3.2	2.4
101.001	94	d	26	4522	823.3	695.2	33.5	275.5	232.6	4.1	3.5	5.5	4.7	8.3	7.0
101.002	94	d	26	4522	823.3	695.2	91.1	750.4	633.7	11.3	9.5	15.0	12.7	22.5	19.0
101.006	94	d	26	4522	823.3	695.2	41.8	343.9	290.4	5.2	4.4	6.9	5.8	10.3	8.7
101.007	94	d	26	4522	823.3	695.2	42.0	345.4	291.7	5.2	4.4	6.9	5.8	10.4	8.8
102.002	95	e	8	678	418.0	250.1	0.4	1.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0
105.001	97	f	28	3722	477.0	395.2	215.4	1027.3	851.2	15.4	12.8	20.5	17.0	30.8	25.5
105.002	97	f	28	3722	477.0	395.2	18.2	87.0	72.1	1.3	1.1	1.7	1.4	2.6	2.2
106.001	94-00	a	7	544	1324.3	730.5	10.2	135.2	74.6	2.0	1.1	2.7	1.5	4.1	2.2
106.002	94		7	544	1324.3	730.5	870.9	11533.7	6015.2	173.0	90.2	230.7	120.3	346.0	180.5
142.001	95	g	11	978	950.8	632.8	10.1	95.6	63.6	1.4	1.0	1.9	1.3	2.9	1.9
142.002	95	g	11	978	950.8	632.8	93.0	884.6	588.8	13.3	8.8	17.7	11.8	26.5	17.7
					N. Coast	**Total:**	**29161.8**	**203221.2**	**130405.3**	**3048.3**	**1956.1**	**4064.4**	**2608.1**	**6096.6**	**3912.2**

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
South Coast of BC:															
11.001	96	a	2	123	259.3	14.8	29.9	77.6	4.4	1.2	0.1	1.6	0.1	2.3	0.1
11.002	96		2	123	259.3	14.8	135.8	352.2	20.1	5.3	0.3	7.0	0.4	10.6	0.6
12.001	99		3	91	921.0	0.0	20.7	190.7	0.0	2.9	0.0	3.8	0.0	5.7	0.0
12.002	94-01	a	51	2234	675.5	526.0	4.1	27.6	21.5	0.4	0.3	0.6	0.4	0.8	0.6
12.003	94-01		11	357	373.1	166.6	91.6	341.7	191.7	5.1	2.9	6.8	3.8	10.3	5.8
12.004	94-01	a	51	2234	675.5	526.0	0.4	2.5	1.9	0.0	0.0	0.0	0.0	0.1	0.1
12.005	94		2	106	138.3	0.0	56.7	78.4	0.0	1.2	0.0	1.6	0.0	2.4	0.0
12.006	94		1	35	476.3	0.0	20.2	96.0	0.0	1.4	0.0	1.9	0.0	2.9	0.0
12.007	94-01	a	51	2234	675.5	526.0	35.4	239.0	186.1	3.6	2.8	4.8	3.7	7.2	5.6
12.008	94-01	y	51	2234	675.5	526.0	401.4	2711.7	2111.7	40.7	31.7	54.2	42.2	81.4	63.3
12.009	94		2	170	1253.6	248.0	5.2	65.6	13.0	1.0	0.2	1.3	0.3	2.0	0.4
12.010	94-01	a	51	2234	675.5	526.0	0.3	2.3	1.8	0.0	0.0	0.0	0.0	0.1	0.1
12.011	94		4	150	1796.7	262.4	134.3	2413.5	352.5	36.2	5.3	48.3	7.1	72.4	10.6
12.012	94-01	a	51	2234	675.5	526.0	89.3	603.0	469.6	9.0	7.0	12.1	9.4	18.1	14.1
12.013	00		9	381	654.0	303.6	31.6	206.5	113.2	3.1	1.7	4.1	2.3	6.2	3.4
12.014	94-01	a	51	2234	675.5	526.0	121.1	818.3	637.2	12.3	9.6	16.4	12.7	24.5	19.1
12.015	94		1	34	691.8	0.0	36.3	251.0	0.0	3.8	0.0	5.0	0.0	7.5	0.0
12.016	94		5	205	899.5	242.5	112.0	1007.5	-302.3	15.1	-4.5	20.2	-6.0	30.2	-9.1
12.017	94-01	a	51	2234	675.5	526.0	45.9	310.3	241.6	4.7	3.6	6.2	4.8	9.3	7.2
12.018	94		5	362	361.1	162.6	282.3	1019.2	-278.5	15.3	-4.2	20.4	-5.6	30.6	-8.4
12.019	94		1	79	498.7	0.0	57.5	286.8	0.0	4.3	0.0	5.7	0.0	8.6	0.0
12.020	94		1	59	1087.4	0.0	3.6	38.9	0.0	0.6	0.0	0.8	0.0	1.2	0.0
12.021	94-01		4	121	630.6	31.0	15.1	95.1	4.7	1.4	0.1	1.9	0.1	2.9	0.1
12.039	95		1	31	334.5	0.0	15.4	51.4	0.0	0.8	0.0	1.0	0.0	1.5	0.0
12.041	94-01	a	51	2234	675.5	526.0	29.9	201.7	157.1	3.0	2.4	4.0	3.1	6.1	4.7
13.001	99	a	9	599	732.5	419.5	117.2	858.2	491.5	12.9	7.4	17.2	9.8	25.7	14.7
13.002	99	a	9	599	732.5	419.5	169.5	1241.7	711.1	18.6	10.7	24.8	14.2	37.3	21.3
13.003	99	a	9	599	732.5	419.5	6.5	47.4	27.2	0.7	0.4	0.9	0.5	1.4	0.8
13.006	99	a	9	599	732.5	419.5	5.1	37.0	21.2	0.6	0.3	0.7	0.4	1.1	0.6
13.007	99	a	9	599	732.5	419.5	11.0	80.4	46.1	1.2	0.7	1.6	0.9	2.4	1.4
13.008	99	a	9	599	732.5	419.5	3.8	27.7	15.8	0.4	0.2	0.6	0.3	0.8	0.5
13.009	99	a	9	599	732.5	419.5	31.6	231.6	132.6	3.5	2.0	4.6	2.7	6.9	4.0
13.010	99	a	9	599	732.5	419.5	10.6	77.3	44.3	1.2	0.7	1.5	0.9	2.3	1.3
13.011	99	a	9	599	732.5	419.5	1.6	12.0	6.9	0.2	0.1	0.2	0.1	0.4	0.2

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
13.012	99	a	9	599	732.5	419.5	30.8	225.7	129.3	3.4	1.9	4.5	2.6	6.8	3.9
13.014	99	a	9	599	732.5	419.5	15.0	110.1	63.1	1.7	0.9	2.2	1.3	3.3	1.9
13.018	99	a	9	599	732.5	419.5	3.8	28.1	16.1	0.4	0.2	0.6	0.3	0.8	0.5
13.023	99	a	9	599	732.5	419.5	3.1	22.6	13.0	0.3	0.2	0.5	0.3	0.7	0.4
13.025	99	a	9	599	732.5	419.5	106.2	777.8	445.4	11.7	6.7	15.6	8.9	23.3	13.4
13.026	99	a	9	599	732.5	419.5	10.2	75.0	42.9	1.1	0.6	1.5	0.9	2.2	1.3
13.028	99	a	9	599	732.5	419.5	123.6	905.2	518.4	13.6	7.8	18.1	10.4	27.2	15.6
13.029	99	a	9	599	732.5	419.5	4.3	31.8	18.2	0.5	0.3	0.6	0.4	1.0	0.5
13.030	99		2	50	486.8	0.0	1.7	8.4	0.0	0.1	0.0	0.2	0.0	0.3	0.0
13.031	99		1	41	439.0	0.0	26.5	116.3	0.0	1.7	0.0	2.3	0.0	3.5	0.0
13.032	99		1	145	574.6	75.5	35.9	206.5	27.2	3.1	0.4	4.1	0.5	6.2	0.8
13.033	99		5	363	862.6	389.1	45.8	394.7	208.8	5.9	3.1	7.9	4.2	11.8	6.3
13.035	99	a	9	599	732.5	419.5	6.9	50.6	29.0	0.8	0.4	1.0	0.6	1.5	0.9
13.039	99	a	9	599	732.5	419.5	24.4	178.4	102.2	2.7	1.5	3.6	2.0	5.4	3.1
13.041	99	a	9	599	732.5	419.5	2.1	15.4	8.8	0.2	0.1	0.3	0.2	0.5	0.3
14.005	99		2	202	152.2	40.2	16.0	24.4	6.4	0.4	0.1	0.5	0.1	0.7	0.2
14.007	99		2	244	354.7	117.2	20.7	73.4	24.3	1.1	0.4	1.5	0.5	2.2	0.7
14.008	99		2	202	491.0	129.7	23.8	116.8	30.9	1.8	0.5	2.3	0.6	3.5	0.9
14.009	99		4	866	287.5	185.3	123.0	353.8	228.0	5.3	3.4	7.1	4.6	10.6	6.8
14.011	99		5	503	147.6	78.8	59.3	87.6	-32.5	1.3	-0.5	1.8	-0.6	2.6	-1.0
14.012	99		1	101	301.4	0.0	56.5	170.2	0.0	2.6	0.0	3.4	0.0	5.1	0.0
14.013	99	a	16	2118	269.2	208.0	12.7	34.3	26.5	0.5	0.4	0.7	0.5	1.0	0.8
17.002	98-99	h	21	1983	98.2	75.2	21.5	21.1	16.1	0.3	0.2	0.4	0.3	0.6	0.5
17.003	98-99	h	21	1983	98.2	75.2	95.3	93.6	71.7	1.4	1.1	1.9	1.4	2.8	2.1
17.008	98-99	h	21	1983	98.2	75.2	15.1	14.8	11.4	0.2	0.2	0.3	0.2	0.4	0.3
17.010	98-99	h	21	1983	98.2	75.2	43.4	42.6	32.6	0.6	0.5	0.9	0.7	1.3	1.0
17.017	98-99	h	21	1983	98.2	75.2	7.9	7.7	5.9	0.1	0.1	0.2	0.1	0.2	0.2
18.001	98-99	y	21	1983	98.2	75.2	20.7	20.4	15.6	0.3	0.2	0.4	0.3	0.6	0.5
18.002	98		3	165	78.2	14.5	77.7	60.7	11.3	0.9	0.2	1.2	0.2	1.8	0.3
18.003	98		1	45	93.3	0.0	31.8	29.6	0.0	0.4	0.0	0.6	0.0	0.9	0.0
18.004	99		4	392	39.3	18.6	78.5	30.9	14.6	0.5	0.2	0.6	0.3	0.9	0.4
18.005	98-99	y	21	1983	98.2	75.2	356.5	350.2	267.9	5.3	4.0	7.0	5.4	10.5	8.0
18.006	99		9	1081	127.4	86.9	344.6	439.0	165.6	6.6	2.5	8.8	3.3	13.2	5.0
18.011	98		1	53	462.9	0.0	96.8	447.8	0.0	6.7	0.0	9.0	0.0	13.4	0.0
19.003	98-99	h	21	1983	98.2	75.2	111.5	109.5	83.8	1.6	1.3	2.2	1.7	3.3	2.5

Table 8. (continued)

PFM SubArea	Year	NB	Transect Number	Transect Length (m)	Biomass (g/m^2) Mean	Biomass (g/m^2) Lower 90% CB	Bed Area (ha)	Bc Biomass (t) Mean	Bc Biomass (t) Lower 90% CB	Quota 0.2 M Bc (of urchins 90-140 mm TD) M = 0.075 Mean	M = 0.075 Lower 90% CB	M = 0.10 Mean	M = 0.10 Lower 90% CB	M = 0.15 Mean	M = 0.15 Lower 90% CB
19.004	98-99	h	21	1983	98.2	75.2	284.7	279.7	214.0	4.2	3.2	5.6	4.3	8.4	6.4
19.005	98-99	h	21	1983	98.2	75.2	90.5	88.9	68.0	1.3	1.0	1.8	1.4	2.7	2.0
20.005	00	i	20	2152	417.1	323.1	411.6	1716.7	1329.7	25.8	19.9	34.3	26.6	51.5	39.9
20.006	00	i	20	2152	417.1	323.1	50.2	209.5	162.2	3.1	2.4	4.2	3.2	6.3	4.9
23.005	00	i	20	2152	417.1	323.1	31.4	131.1	101.6	2.0	1.5	2.6	2.0	3.9	3.0
23.007	00	i	20	2152	417.1	323.1	48.4	201.7	156.2	3.0	2.3	4.0	3.1	6.1	4.7
23.011	00	i	20	2152	417.1	323.1	39.4	164.5	127.4	2.5	1.9	3.3	2.5	4.9	3.8
24.002	00		1	55	151.6	0.0	93.0	141.0	0.0	2.1	0.0	2.8	0.0	4.2	0.0
24.006	00		14	1574	310.0	228.2	528.9	1639.3	727.8	24.6	10.9	32.8	14.6	49.2	21.8
24.008	00		5	523	767.5	416.5	266.6	2046.0	341.5	30.7	5.1	40.9	6.8	61.4	10.2
27.001	00	i	20	2152	417.1	323.1	63.8	266.3	206.2	4.0	3.1	5.3	4.1	8.0	6.2
27.002	00	i	20	2152	417.1	323.1	1.6	6.8	5.3	0.1	0.1	0.1	0.1	0.2	0.2
27.009	00	i	20	2152	417.1	323.1	43.9	182.9	141.7	2.7	2.1	3.7	2.8	5.5	4.3
29.004	98-99	h	21	1983	98.2	75.2	23.2	22.8	17.4	0.3	0.3	0.5	0.3	0.7	0.5
29.005	98-99	h	21	1983	98.2	75.2	89.4	87.8	67.2	1.3	1.0	1.8	1.3	2.6	2.0
111.000	96		2	201	1163.5	305.2	100.4	1168.7	306.6	17.5	4.6	23.4	6.1	35.1	9.2
123.003	00	i	20	2152	417.1	323.1	15.3	63.7	49.4	1.0	0.7	1.3	1.0	1.9	1.5
124.003	00		3	149	669.9	95.9	45.2	302.5	43.3	4.5	0.6	6.1	0.9	9.1	1.3
127.003	96	j	2	201	1163.5	305.2	45.4	528.8	138.7	7.9	2.1	10.6	2.8	15.9	4.2
					S. Coast	**Total:**	**6459.2**	**29026.0**	**12250.5**	**435.4**	**183.8**	**580.5**	**245.0**	**870.8**	**367.5**
					BC	**Total:**	**35621.0**	**232247.2**	**142655.8**	**3483.7**	**2139.8**	**4644.9**	**2853.1**	**6967.4**	**4279.7**
New bed areas estimated from 2001 Price Island Broadbrush Survey:															
7.001N	01	k	5	119	965.8	698.3	33.8	326.4	236.0	4.9	3.5	6.5	4.7	9.8	7.1
7.002N	01	k	9	247	1594.4	1083.4	53.5	853.0	579.6	12.8	8.7	17.1	11.6	25.6	17.4
7.031S	01	k	10	306	908.1	586.7	60.0	544.9	352.0	8.2	5.3	10.9	7.0	16.3	10.6
					New Area	**Total:**	**147.3**	**1724.3**	**1167.6**	**25.9**	**17.5**	**34.5**	**23.4**	**51.7**	**35.0**
					BC	**Total:**	**35768.3**	**233971.5**	**143823.4**	**3509.6**	**2157.4**	**4679.4**	**2876.5**	**7019.1**	**4314.7**

Table 9. Total quota (tonnes) options for the red sea urchin fishery by north and south BC, estimated from various natural mortality values applied to current biomass (Bc) calculated from mean and approximate 90% lower confidence bound (CB) of the clipped biomass values for eight size limits of commercial red sea urchin, and bed areas fished from 1997-2000.

Size Limit (mm TD)	Region	Quota 0.2 M Bc					
		M = 0.075		M = 0.10		M = 0.15	
		Mean	Lower 90% CB	Mean	Lower 90% CB	Mean	Lower 90% CB
≥90	North Coast	3553.9	2303.4	4738.5	3071.2	7107.7	4606.9
	South Coast	535.3	226.0	713.8	301.3	1070.7	451.9
	BC	4089.2	2529.4	5452.2	3372.5	8178.4	5058.8
≥95	North Coast	3333.5	2145.4	4444.6	2860.6	6666.9	4290.9
	South Coast	509.0	213.9	678.7	285.2	1018.1	427.8
	BC	3842.5	2359.3	5123.3	3145.7	7685.0	4718.6
≥100	North Coast	3082.1	1953.9	4109.5	2605.2	6164.2	3907.9
	South Coast	474.2	190.4	632.3	253.9	948.4	380.8
	BC	3556.3	2144.3	4741.8	2859.1	7112.7	4288.7
90-130	North Coast	2577.0	1699.7	3436.0	2266.3	5154.0	3399.5
	South Coast	351.2	158.9	468.3	211.9	702.4	317.9
	BC	2928.2	1858.7	3904.3	2478.2	5856.4	3717.3
90-140	North Coast	3074.2	1973.6	4098.9	2631.5	6148.4	3947.2
	South Coast	435.4	183.8	580.5	245.0	870.8	367.5
	BC	3509.6	2157.4	4679.4	2876.5	7019.1	4314.7
95-130	North Coast	2356.6	1548.3	3142.1	2064.4	4713.2	3096.6
	South Coast	324.9	148.4	433.2	197.9	649.8	296.9
	BC	2681.5	1696.8	3575.3	2262.3	5363.0	3393.5
95-140	North Coast	2853.8	1818.9	3805.1	2425.1	5707.6	3637.7
	South Coast	409.1	172.1	545.5	229.5	818.2	344.2
	BC	3262.9	1991.0	4350.5	2654.6	6525.8	3981.9
100-140	North Coast	2602.4	1629.1	3469.9	2172.2	5204.9	3258.3
	South Coast	374.3	149.7	499.0	199.5	748.6	299.3
	BC	2976.7	1778.8	3969.0	2371.7	5953.4	3557.6

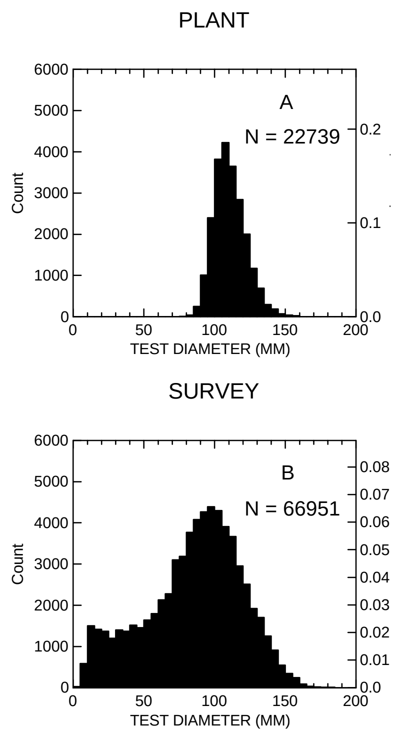

Fig. 1. Size frequencies of red sea urchins measured (A) at processing plants during the 2000-2001 fishing season, and (B) on population surveys during 1994-2001 throughout B.C.

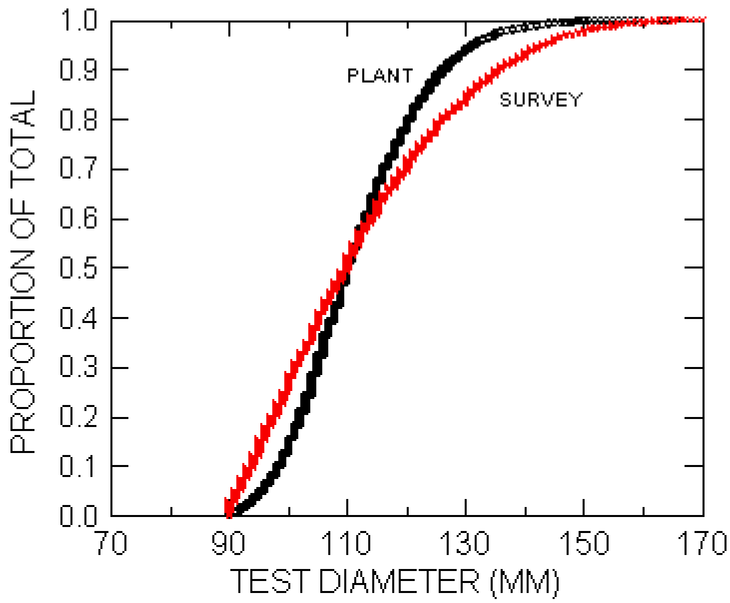

Fig. 2. Cumulative size frequencies, expressed as a proportion of the total red sea urchins ($\geq$ 90 mm TD) sampled from the processing plants (N = 22,546) during the 2000-2001 fishing season, and from population surveys during (N = 34,098) during 1994-2001 throughout B.C.

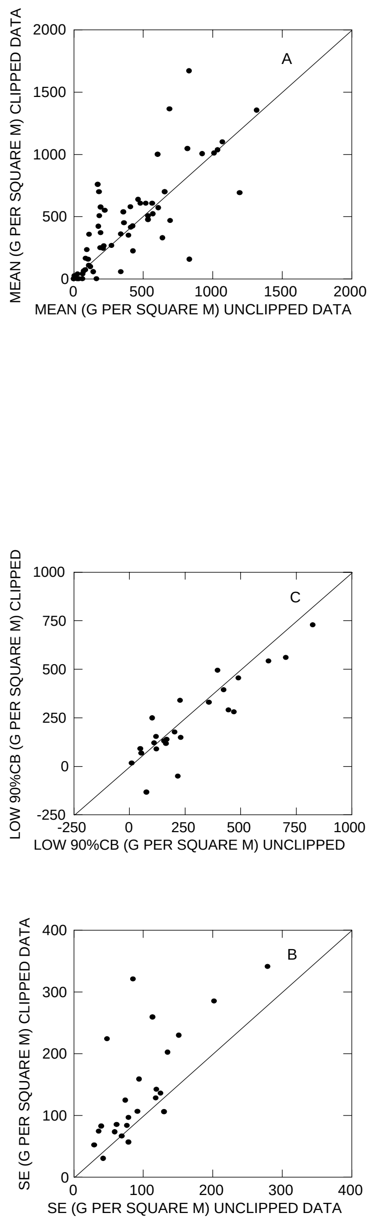

Fig. 3. Comparison of (A) means, (B) standard error of mean, and (C) lower 90 % confidence bounds of 95-130mm TD red sea urchin density (biomass, g/m^2) from unclipped (all transects) and clipped (only transects lying within bed boundaries) survey data by PFM subarea in B.C.

APPENDIX

PSARC INVERTEBRATE SUBCOMMITTEE
Request for Working Paper

Red Urchin Size Implications

Date Submitted:

Individual or group requesting advice: Resource Management/PUHA
(Fisheries Manager/Biologist, Science, SWG, PSARC, Industry, Other stakeholder etc.)

Proposed PSARC Presentation Date: December 2001

Subject of Paper (title if developed): Size frequency of commercially harvested red urchins and potential implications on quota assessments; a summary of the red urchin sampling program

Stock Assessment Lead Author: Alan Campbell, Dimitri Tzotzos

Fisheries Management Author/Reviewer: Juanita Rogers, Laurie Convey, Rick Harbo

Rationale for request:
(What is the issue, what will it address, importance, etc.)

Quotas in the red urchin fishery are currently presented to managers for a size range of animals from 100 to 140 mm test diameter. Stock Assessment has had some concerns that this full range of sizes is not fished in the commercial fishery and that the fishery focuses on animals closer to 100 mm (best market value). In this event, the concern would be that the true exploitation rate could equate to something much higher than the recommended rate of 2-3%.

A port sampling program was initiated in 1999 in the North Coast, in order to start gathering data with which to compare the size classes of urchins from the commercial fishery (“actual”) to the size range on which quota calculations (“theoretical”) are based.

When the minimum size limit was changed from 100 mm to 90 mm for the 2000/2001 management plan, a more extensive, and plant-based, sampling program was initiated to assess the size and quality of urchins harvested, with the objective to compare the theoretical versus actual harvest sizes and implications for exploitation rates.

Question(s) to be addressed in the Working Paper:
(To be developed by initiator)

Present a summary of all port and plant sampling data undertaken to date.

Is there a significant difference between the theoretical size range of urchins (100 to 140 mm test diameter) and the actual size range fished?

If so, does this difference have an impact on the quotas presented to managers in CSAS 99/201?

What are the future recommendations for this sampling program (e.g. sampling protocols, objectives)?

What are the quota recommendations for upcoming annual management planning process?

Objective of Working Paper:
(To be developed by FM & StAD for internal papers)

To compare the size range of urchins harvested in the commercial fishery to the size range on which quotas are based (100 – 140 mm) and to determine the implications for management of the fishery and the setting of quotas.

If the comparison indicates significant discrepancy between the actual and theoretical size range of harvest, to calculate quotas for the red urchin fishery based on the actual size range fished.

Stakeholders Affected:

PUHA, First Nations (2% of TAC designated for food use)

How Advice May Impact the Development of a Fishing Plan:

If StAD feels that the actual range of animals being fished is significantly different from the theoretical, it is likely that a reduction in quota will be required. Impacts on the commercial industry could be significant.

Timing Issues Related to When Advice is Necessary

If advice is to be incorporated into an upcoming annual fishing plan, it must be presented in the winter PSARC session, in order to be used in the spring management planning process.