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Science Advisory Report 2009/080

SUMMARY OF THE STOCK ASSESSMENT AND QUOTA OPTIONS FOR THE GREEN SEA URCHIN, *Strongylocentrotus droebachiensis,* FISHERY IN BRITISH COLUMBIA, 2010-2013

*Figure 1. Juvenile to adult stages of the green sea urchin (*Strongylocentrotus droebachiensis*) from British Columbia. Wolf Carolsfeld, photo.*

Figure 2. Map of south coastal British Columbia showing areas open to fishing in 2009-2010 for the green sea urchin Strongylocentrotus droebachiensis*. Areas 12-13 are Northeast Vancouver Island; Areas 18-19 are Southeast Vancouver Island.*

Context

*The green sea urchin (*Strongylocentrotus droebachiensis*) fishery is a small but important component of British Columbia's dive fisheries. Integrated Fishery Management Plans (IFMP) for this fishery are prepared for three year periods. Stock assessments which analyse fishery-dependent and fishery-independent data are required to provide the scientific advice for these management plans. A new three year IFMP (2010-2013) will be developed following advice from this paper. DFO Fisheries Management has requested advice on: 1. the ranges of sustainable harvest quotas for the major commercial harvest areas on the coast (Areas 12-13, and 18-19); 2. the risks or uncertainties associated with the range of quota options; 3. the recent trends in the local populations of green urchins in areas where data exist; 4. the trends in population structure; 5. whether the current annual surveys at the index locations need to be continued to provide reliable data on a longer time series, and whether additional sites should be initiated; and 6. recommendations for additional research needed in the program. Note that since the last green sea urchin assessment (Perry* et al*. 2006), PFMA's 11 and 20 have been closed, and this assessment is for PFMA's 12, 13, 18 and 19 only (see Fig. 2).*

SUMMARY

- Green sea urchins remain a small but important part of the British Columbia dive fisheries.
- Overall, green urchin populations in their two major fishing regions of British Columbia (Northeast Vancouver Island and Southeast Vancouver Island) appear to be under low fishing pressure. The catch per unit of effort has been steadily increasing since 1993-94 and is now at its highest level in the 22 year history of the fishery.
- Total landings and landed value decreased by approximately 50% each fishing season from 2003-04 (167 t, worth Cdn$0.725 million) to the lowest values in 2006-07 (22 t, worth Cdn$0.073 million; preliminary data). Although there was a 3-fold increase in landings and landed value from 2006-07 to 2007-08, and another slight increase in 2008-09, the last five fishing seasons were historically the lowest on record. This was a result of poor market prices in Japan, due to competition from Russia.
- A series of quota options [target reference points expressed as reductions from the Maximum Sustainable Yield (MSY) limit reference point] are provided for each fishery management area, along with the associated levels of probability that they may be equal to or greater than the true MSY.
- Quotas established at their current (2009-10) levels (177.3 t in Northeast Vancouver Island; 25.5 t in Southeast Vancouver Island) would represent low probabilities of being equal to or greater than the true MSY (4.0% in Northeast Vancouver Island; 0.4% in Southeast Vancouver Island).

BACKGROUND

Commercial harvesting for green sea urchins, *Strongylocentrotus droebachiensis*, in British Columbia began in 1987. The fishery was managed with few restrictions until 1991, when licence limitation was introduced to control record high effort and catches, followed by quota limitations in 1994 and an individual quota system with dockside validation in 1995. Waddell *et al*. (2010) provide information on previous assessments and greater detail on this present assessment. The purpose of this Advisory Report is to summarize the stock assessment results and fisheries management advice presented in Waddell *et al*. (2010).

Biology

Green sea urchins occur in cool temperate waters in both the Pacific and Atlantic Oceans. They are circumpolar in the Pacific, occurring from northern Washington State through the Aleutian Islands and west to Hokkaido (Japan) and Korea. Green urchins occur inter-tidally and to depths of >140 m, generally on rocky, gravel or shell substrates. Sexes are separate, with sizes at maturity of about 25 mm in southern B.C. In B.C., the spawning period generally occurs during February and March. Larvae are pelagic for 9-10 weeks depending on temperature. In Alaska, it takes about 4 years for a green urchin to reach a test diameter of 55 mm (the minimum legal size in B.C.).

Fisheries

The green sea urchin fishery in B.C. developed rapidly in the late 1980s, with landings reaching a peak of 1042 t and a landed value of Cdn $4.4 million dollars in 1992, followed by a sharp decline, in part induced by management regulations. The fishery is conducted by hand-picking by SCUBA divers using small vessels due to the patchy distribution of the resource. It is principally a roe fishery

with product shipped live to the Japanese market. The fishing season currently opens in the fall and runs through the winter to the early spring (September to March), with the highest market prices usually occurring around Christmas. The fishery is managed with a 55 mm test diameter size limit, licence limitation, area quotas, individual quotas, and area closures. The areas now open to harvesting green sea urchins are Northeast Vancouver Island (NEVI) [Pacific Fishery Management Areas (PFMA) 12 and13] and Southeast Vancouver Island (SEVI; PFMA 18 and19) (Fig. 2). Since the last assessment in 2005-06, PFMA 11 and 20 have been closed due to low fishing activity. Therefore, the data presented for the NEVI and SEVI regions will look slightly different than in the last assessment (Perry *et al.* 2006), as they now represent data for fewer areas. The licence year is defined from 1 June to 31 May of the next year; accordingly the analyses presented in this report are conducted on a "fishing season" basis, i.e. from the fall of one year to the spring of the following year.

Over the last several years, British Columbia's green and red sea urchin fisheries have been drastically affected by the Russian sea urchin fishery in the Kurile Islands off the east coast of Hokkaido, Japan (which is largely illegal, unregulated, and unreported: IUU). This fishery has been flooding the Japanese market with low cost product, and therefore lowering the demand (and value) for urchins from B.C. As a result, dive fishers in B.C. have been experiencing great difficulties over the past five years trying to compete; to the extent that only 11% of the quota was landed in the 2006-07 fishing season. Other confounding factors for the green urchin fishery are the rise of the Canadian dollar, which is putting the B.C. "uni" (urchin roe) in a higher price bracket, and weakness in the Japanese economy, which is reducing the consumption of mid-range luxury goods.

ASSESSMENT

The Fishery

This analysis updates information from the green sea urchin fishery and fishery-independent surveys in the 2005-06 to 2008-09 fishing seasons. It should be noted that PFMA 11 and 20 have been closed since the 2006-07 fishing season. As a result, the calculations performed in this assessment include only PFMA's 12, 13, 18 and 19. Landings from PFMA 11 represented less than 1% of the total landings from the NEVI from 1987-88 to 2008-09, and landings from PFMA 20 represented less than 10% of the total landings from the SEVI during the same time period. Since 2007-08, the fishery opened as early as September in some PFMA's, as compared to November in the earlier years of the fishery.

Landings, since the 1994 fishing season, have been limited by quotas. In 2004-05 and onwards, landings have been the lowest since the inception of the fishery (Fig. 3a). However, this is due to the market conditions in Japan, and is not indicative of low stock abundance in B.C. Total effort has followed the same trend as the total landings (Fig. 3a). However, the overall Catch per Unit of Effort (CPUE) has increased each year since 2004-05 to reach its highest value in 2008-09 (Fig. 3a). The landed values (Fig. 3b) followed the same trend as the total landings and effort. They fell to their lowest level since the start of the fishery in 2006-07 (Cdn$0.073 million). Unit price has remained low over the last 4 years (Cdn$3.15/kg to Cdn$3.55/kg), and is similar to values seen in 1991-92 (Cdn$3.24/kg).

The median catch per unit of effort declined each fishing season until 1992-93 in the SEVI region (PFMA 18 and 19) and until 1993-94 in the NEVI region (PFMA 12 and 13)(Fig. 4). Since then the median CPUE has increased, so that by 2008-09 it reached the highest values over the history of the fishery in both regions (Fig. 4). Trajectories of median CPUE versus effort for both the NEVI (PFMA

12 and 13) and SEVI (PFMA 18 and 19) regions indicate that by about 2003-04, the median CPUE's had returned to the high levels seen during the early days of the fishery.

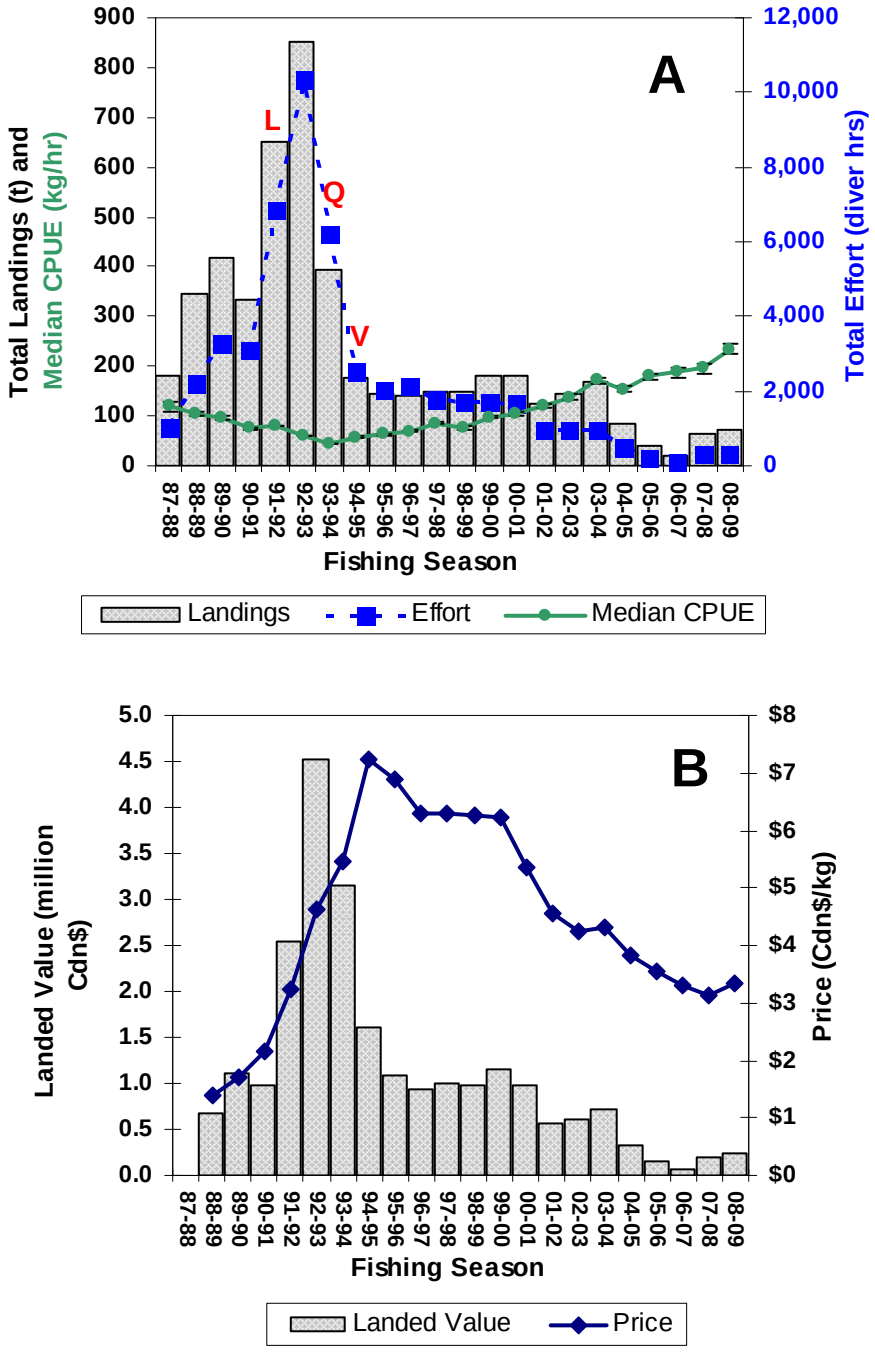

Figure 3. (A) Landings (from sales slip data up to 1995, then from harvest and validation logs), effort, and catch per unit of effort (CPUE) for PFMAs 12, 13, 18, and 19 (combined); and (B) landed value and unit price for the green sea urchin fishery in B.C.(for all open PFMAs combined). Data are presented on the basis of a fishing season (Fall of year i to Spring of year i+1). "L" = Licence Limitation, "Q" = quotas introduced; and "V" = dockside validation program initiated and Individual Vessel Quotas (IVQ's) introduced.

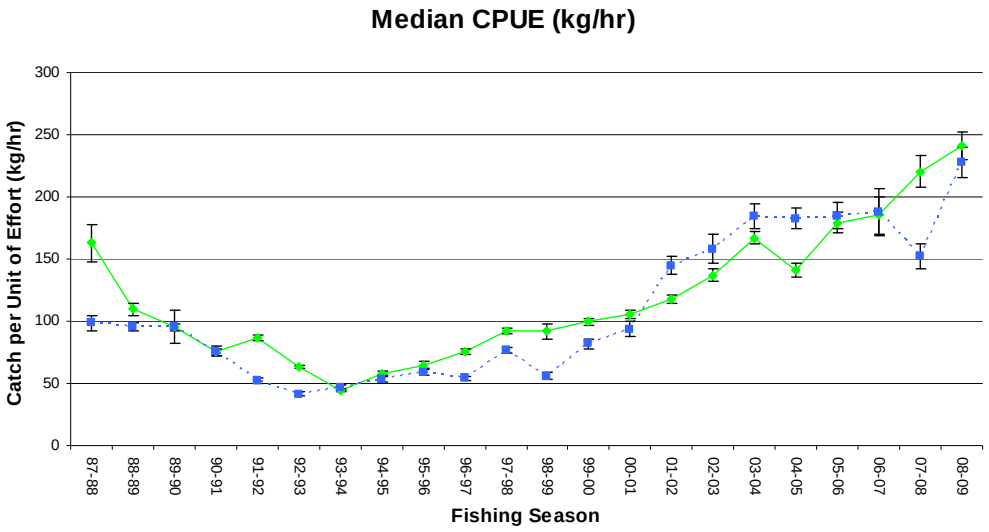

Figure 4. Median catch per unit of effort ± 1 standard error (kg/diver hour) on a fishing season basis for the green urchin fishery in B.C.. Solid line: Northeast Vancouver Island region (PFMA 12 and 13); dashed line: Southeast Vancouver Island region (PFMA 18 and 19).

Biomass Dynamic Model

The present analysis used a Bayesian assessment model, described in Waddell *et al.* (2010). The data used for the analysis included the median catch per unit of effort (CPUE: kilograms per diver hour) for each season of the commercial fishery from 1987-88 to 2008-09 (including standard errors), and the biomass estimates and standard errors of legal-sized and sublegal-sized green urchins from twelve fall surveys at the index site in PFMA 12 (Stephenson Islets, Stubbs Island and Plumper Islands). The model was run separately for the Northeast Vancouver Island (NEVI) and Southeast Vancouver Island (SEVI) regions (Table 1). The Bayesian model includes uncertainties in observations and model structure (see below regarding Sources of Uncertainty).

Table 1. Summary of median maximum sustainable yield (median MSY) estimates and 2 standard deviations of the mean MSY (to approximate the 95% confidence interval) from the Bayesian model for all currently open PFMAs (bold) and for historic PFMAs (i.e. PFMA 11 and 20 are currently closed).

AREA	***PFMAs***	***Median MSY (t)***	***2 Standard Deviations***
Northeast Vancouver Island	**12-13**	298	176
Southeast Vancouver Island	**18-19**	78	67

Fishery-independent Surveys

Beginning in October 1995, twelve fall (Oct./Nov.) surveys have been conducted at an index site at Stephenson Islets (PFMA 12, in the NEVI region), just prior to the opening of each fishing season. The biomass estimates for both legal (≥55 mm test diameter) and sublegal-sized (<55 mm test diameter) urchins at the Stephenson Islets have increased so that by October 2008 they were at their highest levels observed (Fig. 5). This represents a 252% increase in biomass for legal-sized

urchins and a 136% increase for sublegal-sized urchins since November 2004. Published reports on all surveys in PFMA 12 are referenced in Waddell *et al*. (2010).

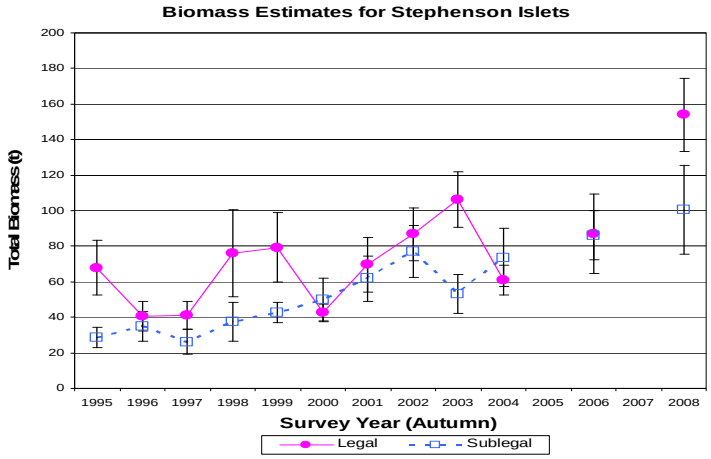

Figure 5. Biomass estimated from fishery-independent surveys conducted annually in the autumn (October or November) at Stephenson Islets off Northeast Vancouver Island (PFMA 12). Solid line: legal-sized biomass (≥55 mm test diameter); dashed line: sublegal-sized biomass. Error bars represent standard errors about the mean.

Fishery-independent surveys have also been conducted at Fulford Reef (PFMA 19, in the Southeast Vancouver Island region) in March 2008 and 2009, and in August 2009. Results showed that the estimated biomass of legal-sized urchins at Fulford Reef decreased between March 2008 and March 2009, by approximately the same amount as the quota taken from PFMA 19 during that time period (Fig. 6), and remained unchanged when surveyed again in August 2009 (no fishing occurred between March and August 2009). In contrast, biomass estimates for sublegal-sized urchins increased slightly over the three surveys.

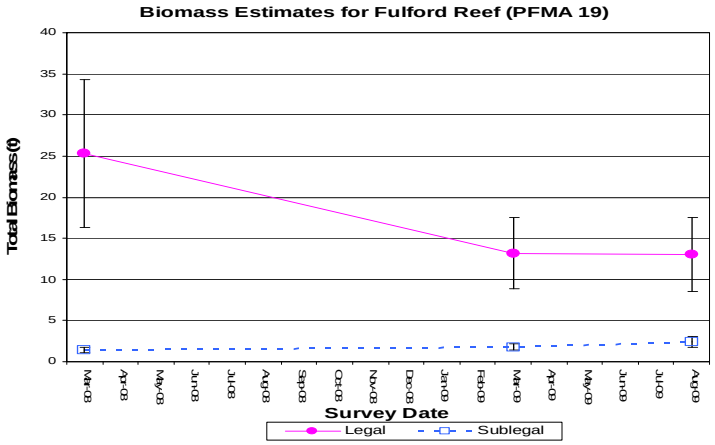

Figure 6. Biomass estimated from fishery-independent surveys conducted at Fulford Reef in Southeast Vancouver Island (PFMA 19), a heavily commercially fished location. Solid line: legal-sized biomass (≥55 mm test diameter); dashed line: sublegal-sized biomass. Error bars represent standard errors about the mean.

Regular surveys at index sites are useful in providing fishery-independent assessments of trends in green urchin abundance, and should be carried out in all PFMA's open to fishing green sea urchins. Fishery-independent surveys are the only method to obtain information about the sublegal-sized portion of the population. In addition, the data obtained from surveys are used to calculate density and biomass for both legal and sublegal-sized urchins.

Quota Options

Traditionally, MSY values have been considered as targets which management actions should try to achieve. However, many of the assumptions of surplus production models, such as no change in gear efficiency, constant catchability (in time, space, and across ages), a linear relationship between CPUE and effort, and equal availability of the fish to the fishery may not be true in a fishery such as for green sea urchins. The present approach defines values such as MSY to be limit reference points (LRPs) which management actions should ensure are not exceeded. The target reference points (TRPs), to which management actions should aim, should be set sufficiently far from the LRP so that there is a low probability that the TRP is equal to or larger than the true LRP (median MSY in this assessment).

The LRPs for the NEVI (calculated for PFMA 12-13; Table 2a) and for the SEVI (calculated for PFMA 18-19; Table 2b) regions are represented by the medians of the posterior probability distributions of MSY's, as determined by the Bayesian model. Table 2 provides the MSY LRPs for each region, and the TRPs that are equivalent to various reductions from the MSY values. For each of these TRPs, the probabilities that the TRPs may be equal to or larger than the true MSY are also provided, based on the Bayesian model results. For each TRP, the allocations of quota to each of the PFMA's are also provided based on the proportion that area contributed to aggregate landings from the 1995-96 to 2008-09 fishing seasons. This dependence on using the pattern of previous landings to set the current quotas carries a risk that some PFMA's may become more exploited than intended, if the conditions that determine green urchin distributions and abundance change among areas over time. Fishery-independent surveys are being used to guard against this possibility. Quotas assigned during previous years have had a very low probability (low risk) that they were equal to or greater than the true MSY. Quotas similar to the previous three years (177.3 t in NEVI, PFMA 12-13; 25.5 t in SEVI, PFMA 18-19) have a 3.96% probability in NEVI and a 0.36% probability in the SEVI of being equal to or greater than the true MSY.

Sources of uncertainties:

The major sources of uncertainties in this assessment relate to the fishery-dependent data, which form the core of the assessment. They are derived principally from fishery logbooks completed by the fishers. Landing data are measured at dockside by Port Validators as part of the Individual Quota System for this fishery. However, effort data, the number of hours spent by each diver underwater to obtain the product that is landed, can have wide uncertainty, due both to the way the logbooks are completed and to the method of fishing underwater (e.g. "surveying" versus harvesting). These uncertainties have been dealt with in this assessment in two ways: (1) by excluding entries with blank or zeros for dive time, then calculating the median CPUE, which is more robust to outliers in effort data than other measures of central tendency such as the mean; and (2) by using a Bayesian model to estimate MSY and its potential range. The Bayesian model structure explicitly includes uncertainties in the fishery logbook data, in the data from the earliest 9 years of the fishery (the "gold-rush" period), and in the fishery-independent survey data. Additional drawbacks of CPUE data, such as hyper-stability (CPUE remaining high as successive aggregations are "mined") also may apply in this benthic fishery.

Fishery-independent surveys are an important source of additional information, and are included directly into the Bayesian assessment model. The approach for this fishery has been to use index sites which are surveyed once or twice a year. The first index site was established in the Stephenson Islets area of PFMA 12 in 1995, and was sampled twice a year (prior to and just after the active fishing season) from October 1995 to March 1998, to determine how commercial fishing was impacting green sea urchins. Since the autumn of 1998, surveys have been

conducted annually or biennially to assess green urchin population variability. Identifying a suitable index site in the SEVI region has been more difficult, due largely to logistical reasons. As a result, there is no time series of fishery-independent data in the SEVI region comparable to that in the NEVI region. The Fulford Reef site in PFMA 19 has been consistently and heavily fished for the last few years, however, there is not a nearby reserve that can be considered the control site to compare results.

Table 2. Target reference points (TRP), as reductions from the median MSY (in tonnes), the probability the TRP may be equal to or greater than the true MSY, and allocation of the total quota to: (a) Northeast Vancouver Island, PFMA's 12-13 and (b) Southeast Vancouver Island, PFMA's 18-19, based on the proportion that the PFMA contributed to aggregate landings from 1995-96 to 2008-09 fishing seasons. Limit reference point (LRP, or median MSY) and probabilities (risk) that the TRP is equal to or greater than the true MSY are derived from the Bayesian model.

(a)	TRP (Total for PFMA 12-13) (t)	Probability TRP => true MSY (%)	TRP for PFMA 12 (t)	TRP for PFMA 13 (t)
Proportion caught			0.633	0.367
LRP (median MSY)	298	50	188	109
0.9*median MSY	268	34.1	170	98
0.8* median MSY	238	20.3	151	87
0.7* median MSY	208	9.87	132	76
0.6* median MSY	179	3.99	113	66
0.5* median MSY	149	1.59	94	55
0.4* median MSY	119	0.59	75	44
0.3* median MSY	89	0.1	57	33
0.2* median MSY	60	<0.1	38	22
0.1* median MSY	30	<<0.1	19	11
(b)	TRP (Total for PFMA 18-19) (t)	Probability TRP => true MSY (%)	TRP for PFMA 18 (t)	TRP for PFMA 19 (t)
Proportion caught			0.437	0.563
LRP (median MSY)	78	50	34	44
0.9*median MSY	70	36	31	39
0.8* median MSY	62	23	27	35
0.7* median MSY	54	13.3	24	31
0.6* median MSY	47	7.53	20	26
0.5* median MSY	39	3.71	17	22
0.4* median MSY	31	1.43	14	18
0.3* median MSY	23	0.33	10	13
0.2* median MSY	16	<0.1	7	9
0.1* median MSY	8	<<0.1	3	4

ADDITIONAL STAKEHOLDER PERSPECTIVES

Low fishing effort and harvest levels, particularly for the last five fishing seasons, reflect low prices in Japan. These low prices are due principally to very large harvests from the Russian Far East and their importation into Japan. As a result, fewer licence holders have been fishing in B.C., and a large portion of the total allowable catch (TAC) has remained unfished because it was not financially viable. Less than 11% of the TAC was landed during the 2006-07 season (22

t), B.C.'s poorest year in this fishery. There has been a slight improvement in landings in 2007-08 and 2008-09 (65 and 73 t, respectively). Visits to Japan have been conducted by members of the West Coast Green Urchin Association to try and increase the market base and to underline the high quality of the product from B.C. Reports from Japan also suggest that more stringent controls on the Russian harvest of sea urchins may be forthcoming, but it is unknown how effective these may be at increasing the market price of green urchins harvested in B.C.

CONCLUSIONS

Green sea urchins remain a small but important part of the B.C. dive fisheries. Overall, green urchin populations in the two major fishing regions of B.C. appear to be healthy, as the catch per unit of effort for NEVI and SEVI were higher in 2008-09 than at the beginning of the fishery in the late 1980s, considering the relatively low fishing pressure in 2008-2009. Landings and landed value over the past five seasons have been the lowest recorded. This has been due to low product unit price resulting from oversupply in the Japanese market with urchins harvested in Russia.

Fisheries-independent surveys in PFMA 12 indicated that biomass estimates for legal and sublegal-sized urchins in October 2008 were the highest observed since surveys began in 1995. However, surveys in PFMA 19 indicated that the biomass estimates of legal-sized urchins decreased between March 2008 and March 2009 by an amount equivalent to the quota taken from PFMA 19, while the biomass estimate for sublegal-sized urchins increased slightly.

Advice

Advice in response to the questions posed by Fishery Managers (and listed in the Context box of this present report) is:

1) Quota options developed using a Bayesian biomass dynamic model and interpreting maximum sustainable yield (MSY) as a limit reference point (LRP), target reference points (TRPs) set as reductions from the median MSY, and their associated probabilities that the TRP is equal to or greater than the true MSY, are provided in Table 2 for both Northeast Vancouver Island (NEVI; PFMA 12-13) and the Southeast Vancouver Island (SEVI; PFMA 18-19) regions.

2) Quotas established at their current (2009-10) levels (177.3 t in NEVI; 25.5 t in SEVI) would represent low probabilities that the TRP is equal to or greater than the true MSY (4.0% in NEVI; 0.4% in SEVI). Considering the lack of a time series of fishery-independent data for the SEVI region, caution should remain.

3) Fishery-independent surveys (currently conducted in PFMA 12 and PFMA 19) should be continued, on a regular basis, to provide a time series independent of the fishery for assessment of green urchin population trends. Surveys should be expanded to include all PFMA's that are open to commercial fishing of green sea urchins because there is no other method of obtaining data for sublegal-sized urchins, density and biomass information, or roe quality. However, this cannot be accomplished with current resources.

4) No further research is recommended at this time. Laboratory experiments are nearing completion regarding the age and growth of green sea urchins in British Columbia, for

development of a reliable ageing technique. Such a technique will be valuable for assessing the actual age of urchins rather than using the present technique of size-mode analysis.

SOURCES OF INFORMATION

Perry, R.I., Z. Zhang and R. Harbo. 2002. Development of the green sea urchin (*Strongylocentrotus droebachiensis*) fishery in British Columbia, Canada – back from the brink using a precautionary framework. Fisheries Research 55: 253-266.

Perry, R.I., Z. Zhang and B. Waddell. 2006. Stock assessment and quota options for the green sea urchin *Strongylocentrotus droebachiensis* fishery in British Columbia, 2006-2009. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2005/064.

Waddell, B.J., Z. Zhang, and R.I. Perry. 2010. Stock assessment and quota options for the green sea urchin, *Strongylocentrotus droebachiensis*, fishery in British Columbia, 2010-2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/027.

Zhang, Z and R.I. Perry. 2005. Use of state-space modeling with a Bayesian approach to estimate target reference points for green sea urchin (*Strongylocentrotus droebachiensis*) stocks in the Queen Charlotte Strait region, British Columbia, Canada. *Fisheries Research* 74: 253-264.

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