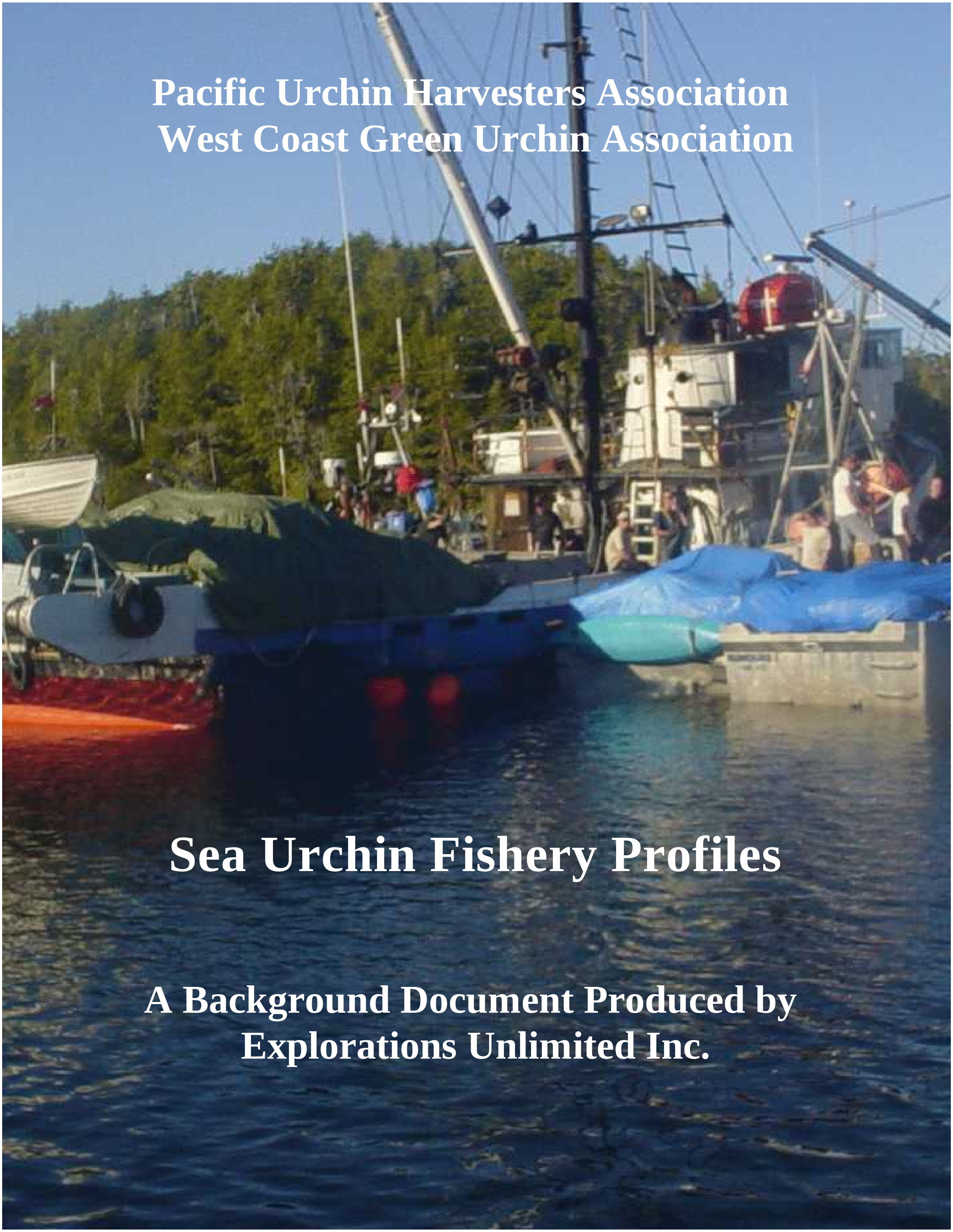
Pacific Urchin Harvesters Association
West Coast Green Urchin Association



Sea Urchin Fishery Profiles

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Abstract

This document comprises a review of the available literature on various sea urchin fisheries around the world. The jurisdictions examined include British Columbia and the Maritimes in Canada, Northern and Southern California, Maine and Alaska in the USA, Chile, Japan, Russia, China and Mexico. The subjects include a look at the market issues, the biology behind the product development, quality criteria and product types. The resources available in each area are profiled and the fisheries in each area are described. This document was produced as a back-grounder for a Benchmarked Competitiveness Study of BC's Sea Urchin products Industry.

Sea Urchin Fishery Profiles

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Acknowledgements

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Sea Urchin Fishery Profiles

1.0 Introduction

Sea urchins are esteemed for their highly nutritious roe, considered one of the one of the most valuable seafoods in the Japanese market. Red sea urchins (*Strongylocentrotus franciscanus*) and Green sea urchins (*Strongylocentrotus droebachiensis*) are handpicked by divers in the coastal waters of British Columbia and either shipped live or locally processed to the standards of the traditional Japanese market and then shipped to Japan. Canada exports approximately 460 MT of sea urchin products to Japan each year, accounting for approximately 75% of all the Canada's production of sea urchin products. The export value was about $25 million in 2002 but this had declined to about $21.6 M by 2004.

Buyers and consumers form around the world are increasingly demanding consistency, innovation, sustainability, and traceability at competitive prices. The BC Seafood Alliance, the Pacific Urchin Harvesters Association (PUHA) and the West Coast Green Urchin Association (WCGUA), are examining market issues to further define the requirements of the market and develop a range of options so BC players can operate profitably in this challenging business environment. The Associations have worked with Fisheries and Oceans Canada for some years to ensure the sustainable management and utilization of the fisheries. The effective realization of this goal in the fisheries management sense was acknowledged at the International Sea Urchin Forum held in Chile in 2003.

The main objective of this document is to profile the industry on a global basis. This document reviews the factors affecting sea urchin fisheries and provides an in-depth profile and comparison of the wild sea urchin products production sectors and standards in BC and in other jurisdictions including the US, Mexico, Chile, Russia and Japan. China is also examined in its role as a supplier of labour intensive primary processing as well as a potential, or perhaps eventual, developer of sea urchin culture capacity .

The performance of the BC urchin products production industry will be compared against suppliers in the dominant urchin market in a separate study. Benchmarking the current and potential performance of the BC industry should provide some guidance as to what sorts of changes make economic and/or business sense. The realized balance is also examined in general terms to get an estimate of the impacts that product quality sacrifices may be having on the market's perceptions of BC production.

2.0 Market Issues

Japan continues to predominate as the world's single largest sea urchin products market and sales to Japan currently absorb about 80% of BC's annual production. Traditionally the product, uni, was strictly considered a luxury product but an increase in the relative value of the yen to other currencies in the 1970's allowed foreign sources to compete, increasing the supply and allowing more economically-minded markets to develop allowing more popular use of the product. As a result, the average unit (whole weight) prices of *S. intermedius* and *S. nudus* of $US 23.10

(¥2,772) and $US 13.30 (¥1,596) per kg in 1991 had, based on a steady exchange rate of 120¥ per USD, dropped to $US13.70 (¥1,644) and $US 8.60 (¥1,032) respectively by 2000 (Sakai et al 2004). The acceleration of the Russian IUU urchin fishery (*S. intermedius*) fishery in the Kuriles since then has rendered the Japanese production increasingly uneconomic because that production is coming in at between ¥150 - 600 /kg.

This being said, Japanese consumers are renowned for their willingness to pay premium prices for high quality products but they also have very high quality standards when it comes to assigning a “good value” label on the product. This has allowed the Tsukiji auction price for some special California production to reach ¥12,000 per tray vs a more standard price of ¥ 3,000 - 4,000 per tray. This example illustrates the upside potential for higher quality production if the Japanese are convinced the product represents good value. The non-cynical meaning of this is that the market is telling us that we are not there consistently enough to build that reputation.

The high, mid and low end markets are quite different with respect to the revenues and growth potential. The use of uni as a flavour additive market is dependent upon low cost supplies. These industries may be in some jeopardy because of the trajectories of the Chilean and Russian fisheries which may be limited because of declining abundance in the not too far future. This may provide a window to supply lower grade material until cultured product comes up to speed but the interval cannot be assumed to extend beyond a couple of seasons at this point. It does suggest that moving to re-balance the production profile towards higher value uses even as the lower value demand for off colour product strengthens may support continuing economic sustainability. In the retail supermarket segment, assumed here to be the mid-grade market, BC holds a significant market share in part because of the product’s reputation with regard to taste. BC’s market share in the high-end sushi restaurant segment is low because these outlets get their supplies through the central markets.

The major competing suppliers for the extracted uni market in Japan in 2004-05 were Chile (3,012 MT or 51.7% of the imports), US (1,254 MT or 21.5%) and Canada (467 MT or 8%). The volume and average price rankings for fresh chilled roe, the highest quality product form, are listed in Tables 1 and 2 respectively. Significant supplies of live animals were also brought in from Russia (10,597 MT or 88.9% of live imports), North Korea (735 MT or 6.1%), US (431 MT or 3.6%) and Canada (157 MT or 1.3%). The live production from Russia is particularly problematical in that it is reducing prices throughout the Japanese uni market and impacting all legitimate producers.

Table 1: Fresh, chilled sea urchin roe imports into Japan (kg) (Canadian Trade Commissioner- Tokyo).

	2002	2003	2004	Vol Chge 04/03	%change 04/03
World	3,033,310	2,636,830	2,466,385	-170,445	-6.46%
USA	1,185,405	946,557	933,602	-12,955	-1.37%
Chile	693,354	638,486	559,258	-79,228	-12.41%
Canada	401,726	380,129	380,189	60	0.02%
China	260,674	288,719	239,921	-48,798	-16.90%
North Korea	182,324	112,328	136,165	23,837	21.22%
Mexico	101,037	109,267	113,148	3,881	3.55%
Peru	63,801	54,493	51,855	-2,638	-4.84%
South Korea	100,340	82,183	49,241	-32,942	-40.08%

Table 2: Average price of chilled sea urchin roe imports into Japan ($C /kg) (Canadian Trade Commissioner- Tokyo)

	2002	2003	2004	$ Chge 04/03	%change 04/03
World	$63.02	$58.31	$54.22	-$4.09	-7.02%
USA	$73.35	$71.56	$63.02	-$8.53	-11.92%
Chile	$50.40	$45.94	$45.24	-$0.70	-1.53%
Canada	$61.73	$58.46	$56.82	-$1.65	-2.81%
China	$44.55	$41.58	$38.57	-$3.01	-7.24%
North Korea	$63.35	$49.55	$45.20	-$4.35	-8.78%
Mexico	$86.90	$79.49	$62.78	-$16.72	-21.03%
Peru	$52.13	$47.67	$45.87	-$1.80	-3.78%
South Korea	$65.20	$58.39	$59.06	$0.66	1.13%

The unit value, gross value and export volumes of sea urchin products sold to Japan declined in 2004-05 primarily in response to the saturated supply situation in Japan caused by an Illegal, Unregulated and Unreported (IUU) Kurile Island fishery conducted by Russian interests, and the Canadian suppliers to this market continue to underperform. As a measure of the problem faced by Canadian producers, some 20 - 25% of the BC sea urchin Total Allowable Catch (TAC) was not be harvested last year. Overall, only about 45% of the GSU TAC from BC was taken over the 2004-05 while in 2005-06 less than 20% of the TAC was taken as of January 15, 2006, at a point where about 60-80% of the TAC should have been harvested, making this the worst season on record since the Total Allowable Catch (TAC) was established for the 1994-95 season.. Only 12 of the 49 green Sea Urchin and 90 of 110 Red Sea Urchin licences have been activated this year.

The 2004- 05 season started better than the 2001-02 and 2002-03 seasons which had previously been the most affected by the market collapse in Japan. In these and previous years demand had remained somewhat robust through January. In contrast, it almost totally collapsed last year in January primarily because Russian landings in Hokkaido flooded the market with the equivalent of a full-year Canadian GSU TAC each week.. The Russians generally fish at the same time as Canada through the fall and up to Christmas, so starting fishing a bit earlier in the season to beat the Russian product to the market is not likely to prove an effective counter-strategy.

The market situation in Japan has deteriorated for all suppliers, including Japanese and California producers. The saturated supply situation is however, widely projected to change over the next couple of years as Russian and Chilean production falls off, although as is discussed in this document, this is not necessarily a given. Japanese production levels are not expected to increase and while aquaculture of sea urchins will likely advance quite quickly once the wild harvests decline, success in this field is likely some distance off in the future as yet.

2.1 Discussing the Biology Underlying Product Development

The market for edible sea urchin products is based solely on the animal's gonads (Figure 1). The increase in gonad size in urchins is related to feeding and the storage of glycogen and the seasonality in the product is generally explained by patterns of food availability. The nutritional state of the urchin is also important and areas devoid of preferred algae produce sea urchins with

Figure 1: Uni in the sea urchin (*S. intermedius*)

poor yield or poor colour. Studies on cultured RSU in Northern California has provided a couple of interesting insights. There is no significant difference in gonad production over a temperature range of 12.9 - 16.1° C and while gonad production increases in animals fed supplemental feed over animals fending for themselves, the gametogenic states of the gonads remained in synch (Tegner 2001).

Only three types of cells occur in the urchin gonads: nutritive phagocytes which store nutrients in the urchin and are the actual focus of the gonad as a human food product, gametogenic cells from which gametes a formed, and gametes (Olivarez 2004). The relative abundance of these three cell types varies according to the state of maturity and the value of the gonad as an economic product is directly proportional to the abundance of the nutritive phagocytes.

Gametogenesis and intra-gonadal nutrient storage and utilization are linked processes in sea urchin reproduction. Sea urchin gonads grow as somatic cells in the organ and store extensive nutrient reserves before the gametes develop. Once the gametogenesis process commences, as indicated by the initiation of the genial cell mitosis, these nutrient reserves are used in the production of the gametes. At this point the gametogenic cells proliferate and basically suck the nutrients out of the nutritive phagocytes to produce gametes, even as the nutrient cells will continue to accumulate nutrients for some time after this. The gametes are biologically the ultimate product of the organ but their increasing presence actually diminishes the economic value of the gonad.

This process continues over a period of some 2-4 months by which point the majority of the local urchin population is ready for spawning, a process which is triggered by a number of natural factors including an abrupt change in water (or holding) temperature which can be generally correlated with improving feeding conditions for the developing and feeding echinopluteus larvae. The males spawn first in each event and the spermatozoa are activated and start to swim as soon as they contact the seawater. The fully mature ova are then expelled into a cloud of actively swimming spermatozoa (Lawrence et al 2001).

After the urchins spawn, the phagocytes again proliferate and accumulate nutrients for some months until gametogenesis is again initiated. The immediate cue for the commencement of mitosis is the availability of nutrients in the nutritive cells, as evidenced by the presence of gametes in the tissue in out of season periods. The maturation of gametes is continuous throughout the gametogenesis process (Walker et al 2001) and there appears to be some kind of feedback mechanism at work here as well as some of the ova and sperm are reabsorbed by the phagocytes during the gametogenic process so there is a kind of equilibrium established. It seems that all parts of the process are sort of revved up and running, particularly in the presence of β-carotene, which might allow faster response if environmental conditions quickly change to favour better survival of the larvae (Olivarez 2004).

The factors that initiate spawning are relatively unknown but a low molecular weight protein released by phytoplankton blooms has been implicated in the GSU (*S. droebachiensis*) while lunar influences have been suggested for some others. Whatever the particular trigger, a key scheduling factor would logically revolve around the seasonal presence of conditions, including an abundance of appropriate feed resources, which favour the survival, growth, speedy development and successful settlement of the larvae. Where food is available from mid-spring through the fall, as in Northern California northwards, the spawning season for RSU is reported from late spring to early summer whereas in areas where food is abundant all year, as in the Point Loma kelp forest in Southern California, RSU spawn throughout the year although there is a peak in the winter (Tegner 2001).

There is evidence that the spawning season for at least some species of sea urchins is embedded genetically in different stocks. The spawning season for *S. intermedius* urchins from the Sea of Japan is restricted to a period between September and November in the autumn even if they are transplanted to Pacific coastal waters whereas *S. intermedius* native to the Pacific waters spawn in the Spring from April through May in addition to the Fall spawn or, alternatively, can spawn anytime between the end of May to about the end of October (Agatsuma 2001). This would appear to be a practical example of natural selection at work as those urchins with the appropriate schedule encoded in their DNA spawn at an appropriate time and have better survival than those with poorer timing.

Interestingly, gametogenesis and maturation are faster in males than in females thought to be due in large measure to the vitellogenesis process in the females production of nutritive stores (a ‘yolk’) to see the developing embryo through the two-arm and into the four-arm pluteus larval stage (~2 days) just prior to the commencement of feeding. This is likely the reason behind often mentioned apparent quality differences between male and female uni.

The concentration of carotenoids is lower in the testes than in the ovaries, another feature thought to be related with the additional costs imposed on the female so she can leave a nutrient store in each ova to ensure more viable larvae. Increasing the carotenoid concentration can substantially improve the gonad colour in both sexes however they are not necessary for gonadal growth in either sex (Walker et al 2001). Experiments with artificial feeds (regular diet and AlGro) have demonstrated a rapid gametogenesis where maturity and spawning is achieved in under 12 days. In contrast, the use of another feed with the pigment Hi Zea slowed the process so the gonads remain in the earlier stages and do not seem to advance (Olivarez 2004).

2.2 Quality criteria

The quantity and quality of roe contained in sea urchins is vital to the market and is considered critical to the profitability of the processing operation. Quantity is by and large a seasonal phenomenon, as the amount of roe depends in part on the reproductive state of the sea urchin. The Japanese standard which they consider commercially viable is a roe size equal to 18% of the total (wet) weight (Sakai et al 2004) although the guarantee threshold required of BC GSU producers from Japanese buyers is a bit lower at 16%. Urchins found to have low recoveries are sometimes ponded and fed over a period of some months to increase the recoveries although this usually requires the harvest of wild kelp to finish them off to ensure they have a good taste profile.

Japan seeks the world's best and highest quality food products but Japanese consumers are increasingly value-conscious, demanding high quality at ever lower prices. Many imports are cheap in comparison to the Japanese products but there is still a remnant attitude that Japanese products are inherently superior in terms of quality to those produced elsewhere. This complicates things and it remains a very tough market if you're just trying to break in because existing Japanese manufacturers ensure zero-defect service and can provide portion-controlled supply. In Japan and the US, most of the roe is bought by sushi shops which openly display their mostly raw seafood offerings in refrigerated showcases. Sea urchin roe is displayed in traditional wooden trays and to maintain good appearance only whole, firm roe is placed on the top layers while broken pieces of roe are placed on the bottom.

Roe colour is exceedingly important in marketing. Clear, bright yellow or orange roe is best for the fresh market. Up to eight colour grades are used and when packing higher quality trays the various hues and shades are all separated from each other so the colour on any given tray is consistent. Any dark or discoloured roe is best discarded as it will otherwise downgrade the buyers opinion of the supplier. Bright yellow roe was considered the highest quality in Tokyo, but consumers in other areas of Japan often prefer bright orange roe and since the late 1970's the Tokyo prices for the two colours have been the same. In addition to having good colour and appearance, best quality roe is firm, small (less than 5 cm), and free of leaking fluids (Figure 2). Some authorities feel that poor quality roe tends to occur in greater frequency in large (old) urchins, and for this reason the harvest of the very large red sea urchins is discouraged.

It is important to remember that significant quality deterioration is not generally thought to commence until the animals actually expire as their natural metabolic recovery systems remain active protecting the integrity of their proteins and therefore their fats until that point. This though has never been examined in any detail and while the impact of drying out a bit in the winter are probably not very significant, if fishing extends further in to the spring or even gets restarted in the summer, this will likely not be the case.

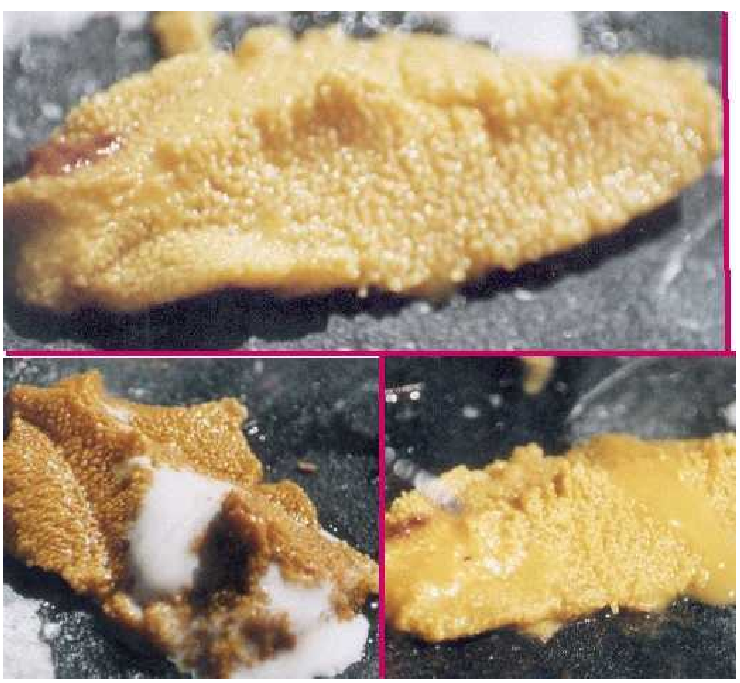

Figure 2: Fresh uni (top), melting male (l) and female (r)

At any rate, once they die their enzyme systems start running amok and the internal structures, including the gonads, become targets for the urchins digestive enzymes. As these break down, the component fats and oils are exposed to oxidation and the result of all this is the release of taste components which impart a bitter and/or off taste to the product. The details in urchins are not known at this time but the enzyme activity levels in most animals vary directly in proportion to temperature up to a certain critical level at which point the enzymes denature and become inactive. Simply allowing the fats to warm will make them less viscous and increase the ‘runniness’ of the uni, decreasing its quality and value.

The oxidation of fats is also directly proportional to temperature as well as exposure to oxygen. One of the other initiatives being pursued in Canada at the request of the processors is to let the urchins drain as much possible before they validated so they are not actually buying the water. The differential rates of discolouration of the uni when immersed and when exposed to air has never been examined but given the importance of the colour to the product’s quality, it should be. The processors may well be shooting themselves in the foot on this one.

2.3 Product Types

The best quality roe is reserved for trays of fresh product which brings the best prices. Secondary products are made from broken roe, or roe that is off-colour, too large, or pieces that are leaking fluids excessively. A 40-50 mm sized skein is best for use in the sushi market but RSU roe is usually larger. Very large pieces are often used in other products, or broken up into smaller pieces and packed on the bottom of trays.

Exports of sea urchin from Canada includes trays ready for final sale while bulk trade at this point includes fresh and frozen processed roe destined for re-packing houses where it is re-graded by the Japanese firms for final distribution to retailers and final consumers, and live animals which are generally processed in full by Japanese processors. It is estimated that approximately 70% of the imported fresh sea urchin roe is consumed at sushi restaurants with the rest retailed at supermarket stores, department stores and fish retailers. Lessor quality sea urchin roe, such as frozen, salted or preserved with alcohol, is used as material for "neri-uni" (kneaded sea urchin roe) products, such as fermented sea urchin roe, and as an ingredient for adding sea urchin roe flavor to various products

2.3.1 Live

Live animals are sometimes shipped to the destination market where they are processed by domestic firms. Buyers in Japan know and trust these firms and their quality control measures and are, or perhaps were, willing to pay a premium for their uni that they just will not match for the Canadian equivalent. These higher final prices though did work their back through the supply chain so the fishermen were getting much higher prices than they could for product processed in Canada. Processors in Canada likewise enjoyed handling the product because the prices and margins were attractive and their expenses low because the processing requirements were minimal. Processing basically revolved around simply chilling and packing them in styrofoam and sending them along to the airline ASAP.

Shipments of live product to Japan have been the basis of the Green Sea Urchins fishery in BC and processors have not voiced much interest in building a processing capacity in BC. In part this is because the greens are smaller and a bit more tedious to process but the relatively small size of the fishery likely limits the upside for them as well.

2.3.2 Fresh

This is considered the highest use for the product and the best grades are generally directed this way. The roe, or uni, is very delicate and must be treated very tenderly to retain its quality. It's shelf life is generally measured in terms of days so delays in the processing, shipping or distribution at any point along the supply chain must be avoided.

Processing urchins is generally pretty straight forward, although knowledge and skill are required for brining, for grading and packing to ensure things turn out acceptably. Different brine concentrations and temperature combinations are used to control the firmness of the product and the experience and skill of the person in charge of this can make or break a processing operation. The grading and packing are considered critical skills for the trays and considerable training and experience is generally required before workers can consistently meet the standards required by the Japanese market.

The processing generally proceeds from the urchins being cracked so the uni can be extracted. From here, it is washed and soaked in a light brine to condition the product so the texture remains acceptable. Once the brine procedure is complete the uni is then graded and can be either packed onto the traditional trays which will then display the product at the retail outlet, generally a sushi restaurant, or into more of a bulk format where the grading is not as precise.

2.3.2.1 Trays

The trays (Figure 3) are traditionally the final display used for the product in sushi restaurants etc and trays are generally distributed to the outlets without further processing. Appearance in this case is important to the Japanese and the uni must be separated by colour and size so that each tray comprises as identical looking as possible pieces. They must also be placed in a manner that imparts a certain symmetry to the appearance and this style is often considered a bit of a signature of different producers. The trays are packed and sold in a variety of sizes, generally starting at less than 100 g. for high grade product to trays with upwards of 350- 400 g.

Figure 3: Packed tray of uni.

2.3.2.2 Bulk

So important is the quality of grading and the packing that a considerable proportion of the product imported into Japan is bulk packed (Figure 4) with less intensive grading. These are then taken apart and re-packed onto the traditional trays by Japanese firms which are then able to profitably market a more meticulously graded and packed product. These products are also packed onto styrofoam trays and sold in supermarkets etc. for home use.

Figure 4: Bulk pack of Red Sea Urchin.

2.3.3 Frozen

Freezing is an acceptable option for holding the processed uni over if it can not be sent along to the final retail outlet in a timely enough manner. The freezing of course lengthens the shelf life, as it will not deteriorate as long as it is properly held in frozen storage, but it also compromises the quality because the ice crystals can actually pierce the cell walls and allow the contents to leak out once it thaws. Freezing generally lowers the value of the uni by about 25 - 50% meaning it should only be used in the absence of other options. However, this is balanced by the increased flexibility provided the processor, allowing more efficient production runs when the green product is abundant during the fishery and continuing sales throughout the year from inventory.

Figure 5: Frozen & vacuum packed uni from Chile.

Uni and other caviars are particularly delicate and the freezing process must achieve at least the Individual Quick Freeze (IQF) standard whereby the product transits the 0°C to -5°C, an interval within which 95% of the free water freezes, in less than 2 hours as the size of the crystals is directly proportional to the time through this interval. In this regard, faster is better. The product is also susceptible to moisture loss through sublimation and should also be vacuum packed as a further measure to preserve its quality (Figure 5).

Freezing the product is common in Chile where the flights to Tokyo involve a couple of legs because of the distances involved. It is also used as an option in Canada when production exceeds sales orders and there is just no alternative. This generally makes everybody real keen so production goes through the roof for a couple of days and the whole supply chain is completely glutted. The impact of this on the top and bottom lines of all the harvesters and processors involved can be severe and while some might enjoy the high-balling, everybody is essentially hurt. A shift to focus more on quality maintenance also supports claims that logistics and continuity of supply, including perhaps a live inventory system to hold product that can be accessed when weather has closed other harvest options, remain a critical issue for the BC industry.

3.0 Urchin Resources

Sea urchin stocks represent very valuable fishery resources in jurisdictions where this is fully recognized and they can profitably managed and utilized as evidenced by these products being the most valuable marine export in California, the second most valuable fishery product in Maine after lobster until recently and the twelfth most valuable fishery product in Canada as recently as 2003. Despite the acknowledged potential for economic benefit, the scientific understanding underlying effective and sustainable management of the wild urchin fisheries is still very weak. The number of peer reviewed papers looking at aspects of urchin biology have more than doubled, to about 200/year, since the early 1970's but the majority of these are concerned with subjects like genetics, marine ecology and culture and do not offer many insights into the wild population dynamics or urchin fishery management (Robinson 2004).

3.1 Japanese species

Japan harvests five species of sea urchins in its waters. *Strongylocentrotus nudus*,. *S. intermedius*, *Hemicentrotus pulcherrimus*, *Pseudocentrotus depressus* and *Anthocidaris crassispina.*

Figure 6: *Strongylocentrotus nudus*

Strongylocentrotus nudus (Figure 6), listed on Tsukiji as Japanese (w), is the most commonly harvested edible sea urchin in Japan and accounts for ~ 44% of the total commercial harvest (Agatsuma 2001a). It is found on inter- and sub-tidal rocky bottoms extending from Dalian, China northwards to Primorskyi Kray, Russia and in Japan where it is found in the Pacific from Sagami Bay to Cape Erimo on Hokkaido and in the Sea of Japan from Omi Island in Yamaguchi to Soya Cape northern Hokkaido. Growth rates are determined primarily by type of food and ration size. The urchins generally reach the legal size (40 mm) in 2 to 4 years when feeding on perennial Laminarians whereas they may take 7 to 8 years on coralline flats. Sub-tidal coralline flats in the Japan Sea off the SW coast of Hokkaido have expanded from the 1960's, a development thought to be due to urchin densities greater than 7 individuals/ m^2 (~200 g/m^2).

In the northern parts of its range, food intake decreases markedly at temperatures below 5° C and by increasing water velocity, as might be associated with greater wave action, when the water temperatures are higher than 7° C. In some northern areas urchins larger than 20 mm TD migrate into the intertidal areas from July to October to take advantage of the higher food (algal) density and then back to the subtidal areas between November to March to find refuge from storm action. In contrast, around Kyoto the urchins move deeper in the summer to avoid the higher water temperatures and move into shallower water from autumn to spring.

S. nudus spawns in the fall from September to October at all locations in Japan from Kyoto in southwestern Honshu to Northern Hokkaido and the actual event is cued a fall in the water temperature of about 5° C, from 25 to 20°C in the south and from about 20 to 15° C in the north. The larval period is optimal at about 15 days at 20 - 22° C being slightly higher at water temperatures of 25 and 19° C (Agatsuma 2001a). The upper lethal temperature limits would appear to rest somewhere around 26 - 28° C.

S. nudus is parasitised and killed by the snail *Pelseneeria castanea*. Areas with up to 43% parasitism rates have been documented off Irate but the snail's range has been expanding northwards and rates up to 5% are now found in SW Hokkaido (Agatsuma 2001a).

The Japanese Green Sea Urchin, *Strongylocentrotus intermedius,* (Figure 7) is the next most commercially important urchin Japan. It is common on rocky bottoms in shallow waters around Hokkaido and is harvested commercially in Irate, Aomori and Hokkaido (Agatsuma 2001). The minimum legal size for *S. intermedium* is 40 mm., a size generally attained at between 2 to 4 years (post-settlement). It has small reddish-yellow gonads which have a nice sweet taste and is listed on Tsukiji as Japanese (r). Unit biomass estimates for beds comprising densities of 65 urchins/m^2 come in at 1.6 kg/m^2 (Agatsuma 2001). Urchin beds with densities up to 100 urchins/m^2 (~1.2 kg/m^2) have been found in the Okhotsk Sea around Oumu where even 8 year old urchins do not reach the legal harvest size. This species is adapted cold water though and the growth restriction does not appear to be a temperature related limit (Agatsuma 2001) suggesting that it is linked to either a genetic cause or food limitation.

Figure 7: *Strongylocentrotus intermedius*

This is the same species fished by the Russians in the Illegal, Unregulated and Unreported (IUU) fishery in the Kuriles. The minimum 40 mm TD size for the urchins is defined in the delivery contracts between the Russians and their Japanese buyers. The product quality for these urchins generally peaks in April-May at about 15% vs around 5-6% in November.

Recruitment of juvenile urchins into *S. intermedius* populations has been generally poor in all areas around Hokkaido except the Okhotsk Sea since the 1960's. Commercial harvests remove up to between 75 - 100% of the legal sized urchins in some fishing beds each year (Agatsuma 2001) and hatchery raised juveniles are used to replenish the fishery each year.

Hemicentrotus pulcherrimus, *Pseudocentrotus depressus* and *Anthocidaris crassispina* co-occur in the temperate waters of southern Japan. Insufficient information is available to characterize the latter two species but they are nonetheless harvested commercially around Kyoto and Chiba and around Kyoto in the Sea of Japan and Wakayama in the Pacific respectively. *Hemicentrotus pulcherrimus* is found inter- and sub-tidally from Kyushu to Shikari Bay in Hokkaido and in Korea and China and is harvested commercially from northern Kyushu to Fukui in the Sea of Japan.. The warm Tsushima warm Current has been extending further north over the past while and this species has consequently spread further north in Hokkaido (Agatsuma 2001 b). This urchin has a bitter taste and is generally preserved in small bottles of brine or alcohol as opposed to being eaten raw.

3.2 Chilean Red Sea Urchins

The Chilean Red Sea Urchin, *Loxechinus albus,* (Figure 8) is a relatively slow growing urchin found along the Pacific coast of South America from Isla Lobos de Afuera in Peru (~7°S) to the Southern tip of South America (~57°S) at depths ranging from intertidal to as deep as 340 m. (Vasquez 2001). These urchins can live to as old as 20 years and reach sizes up to TD 130 mm (Andrew et al 2002). This urchin is one of the most economically important species along the SW coast of South America where it has been used as a food source since pre-Columbian times. These urchins have a strong preference for exposed habitats and are rare in protected environments, apparently for reasons related to differential availability of larvae (Vasquez 2001).

Figure 8: *Loxechinus albus* (juvenile?)

These urchins are closely associated with Macrocystis beds, and are therefore most abundant below about 40° S where these beds occur. The first commercial landings for this species were reported at 4,000 MT in 1957 and the fishery has since expanded to some tens of thousands metric tonnes per year, largely supported by landings from more southern areas between 42° S and 56° S (Vasquez 2001).

L. albus are generally rare in Tierra del Fuego at the southern extent of South America. These habitats are influenced by the circumpolar West Wind Drift Current where the only upstream source of larvae would be from Cape Horn Archipelago. Given a pretty much standard four to five week larval period, this current will remove the vast majority of the larvae and only those trapped within an eddy or some such other trap would remain.

The reproductive period of the urchin varies with latitude and appears to be triggered by seasonal water temperature increase to about 14° C in the north and 11° C in the south. The more northern (tropical) populations tend to spawn towards June- August (fall-winter) with a secondary capacity around the peak spawning period for the more southerly populations, extending down to about

35°S, in September - October (spring). The fall maturation is sometimes resorbed to serve as a nutrient store for the autumn-winter fast prior to a single spring spawn. At the southern end of the region affected by the Humboldt Current, at about 40 - 45° S, the peak spawning period occurs during November- December (late spring- early winter). The main bulk of the fishery is supplied from areas further south of this, lying between about 48° S through to about 57°S, where the urchins spawn primarily between about August through October 9 (spring). These more southerly stocks are influenced by the Cape Horn Current, which is an important bio-geographical boundary in the region (Vasquez 2001).

Juvenile *L. albus* urchins settle in the rocky intertidal areas until they grow to about 20 mm TD and migrate to depths between 5 - 8 m to feed primarily on drift algae. Urchins up to 45 mm TD often face significant extraction pressure by shore-based shore divers but urchins larger than this again migrate to deeper areas between about 9 to 15 m dominated by *Macrocystis* and *Lessonia* spp. kelps, where they then comprise the main commercial stocks. It apparently takes about 3 years for these urchins to reach sexual maturity at about 45 mm and a further 2 years before they reach the legal size limit of 70 mm TD (Vasquez 2001).

Extensive observations of inter and sub-tidal populations over the whole range of this species in Chile have never recorded a mass mortality of any sea urchin species (Vasquez 2001). Urchin populations north of about 30° S are occasionally affected by El Nino- Southern Oscillation events but the magnitude of these effects has not been documented.

The abundance of sea urchins is often influenced by efficient predators such as sea otters, fish, lobsters or asteroids. Southeastern Pacific kelp communities do not have keystone species regulating the herbivore (urchin) densities as happens in the Northern hemisphere although in this area there are a number of sea stars and fish forming a “guild” which accomplishes some degree of control (Vasquez 2001). A major predator of the urchins in areas characterized by lots of crevices, is the Rock Shrimp, *Rhynchocinetes typus*. This shrimp feeds on juveniles and adult sized urchins and restricts the establishment of urchins from shallow, less exposed sub-tidal areas. This leads to the formation of dense aggregations of urchins in shallow exposed areas where the shrimp are less abundant (Stotz 2004).

Similarly the density of these urchins does not control the density or diversity of kelps, up to and including the development of urchin barrens, to the same degree as is seen in the Northern Hemisphere. This is thought to be related to a higher abundance of drift algae along the South American coast and to some anatomical modifications in the species that helps them better capture and feed on drift algae thereby decreasing the pressure on marine algae in this system (Vasquez 2001). Urchin barrens tend to appear in areas which are more exposed to wave action where drift algae is not available. In contrast, drift material has a better chance to accumulate in wave protected areas where it provides the primary feed resource for resident urchins, reducing their feeding pressure on young emerging annual algae each year and allowing the development of more dense kelp forests. Commercial exploitation of urchin populations also reduces these pressures and the kelp forests in Southern Chile were much scarcer and patchier prior to the establishment of the urchin fishery in the area.

A great deal of biological information remains to be collected to understand the biology and ecology of *L. albus* along the Chilean coast. Much of the information gathered on the animals thus far has been obtained for populations in the far north of the country (Vasquez 2001) and, given the range of differences between these areas and more southern locales where the majority of the landings are derived, key factors and mechanisms underlying the ongoing productivity, and ultimately the sustainability, of the fishery remain unexplained.

3.3 North American Sea Urchins

The Red Sea Urchin *Strongylocentrotus fransiscanus* (Figure 9) is the largest sea urchin in the world and is common along the West Coast of North America from Baha California to the Aleutian Archipelago. They have been reported from as far south as the tip of Baja California, Mexico (23°N) but their abundance declines at sites south of the Vizcaino Peninsula (27° N). Their range extend northwards up the west coast to Sitka and Kodiak AK at 58° N (Tegner 2001).

Figure 9: *Strongylocentrotus fransiscanus*

The total catch of *S. fransicanus* has declined by about one half from its peak of about 35,000 tons per year in 1989 (Andrew et al 2002). California has heavily dominated the cumulative take of RSU over its range but fisheries also target these urchins in all jurisdictions along the west coast. There has been minimal fishing in Central California because of sea otter predation and landings from the Northern California stocks continue to decline because they have been largely fished down but the Southern California harvest remains stable at between about 8 - 10 million pounds (2,625 - 4,535 MT) per year.

The probability of survival in RSU increases from about 0.77 yr^{-1} in Southern California to about 0.93 yr^{-1} in Alaska. This has been attributed to additional stresses, including greater challenges from disease, involved with warmer water and/or increased role of predation in Southern California (Tegner 2001). RSU generally grow to a market size of 90 mm in 5 to 7 years in Northern California (Tegner 2001). The oceanographic conditions north of Point Conception, the dividing point between the Northern and Southern California oceanographic regimes, are fairly consistent right up into Alaska and the same growout range is likely applicable to RSU in BC as well. While there is a certain logic in suggesting that RSU from Southern California, where the water is warmer, grow more quickly, sea urchin growth rates are generally reported as being independent of the rearing temperature.

The Green Sea Urchin, *Strongylocentrotus droebachiensis*, (Figure 10) is a circumpolar species that occurs throughout Arctic seas with a bathymetric range extending from the intertidal to about 1150 m. The urchins are found all around Greenland and extend down to Chesapeake Bay along the East coast of North America. In the NE Atlantic, they extend down to Iceland, the Faroes and Northern Scotland while in the North Sea they are found in Scotland but not through the English Channel. In the Pacific they are found throughout the Bering Sea and the North Pacific islands extending as far south as Puget Sound along the west coast of North America and to Petropavlovsk on the Kamchatka Peninsula in the Northwestern Pacific.

Figure 10: *Strongylocentrotus droebachiensis*

Fisheries for *S. droebachiensis* are concentrated in Maine and the Canadian Maritimes but smaller fisheries are prosecuted in Alaska, BC, Washington and Iceland. The minimum legal size in BC is 55 mm TD and the time required to grow to this size in the wild is thought to range between 4 and 8 years in most cases (Taylor 2004), again depending the feed and habitat resources. Worldwide catches peaked in 1993 at about 22,454 tons but the catch soon declined reaching 39% of the maximum by 1999 with further declines since. Significant resources are also located in Newfoundland and Labrador (Andrew et al 2002) and in Norway although the development of fisheries has thus far not proceeded (Andrew et al 2002, Schei 2004), in Norway's case because of the generally low recoveries, @ <10%, found in most areas (Aas 2004). A developmental fishery on GSU in Iceland wound down in 1997 after a five year run that saw a peak harvest in 1994 at 1,500 tons because of limited demand for the product in Japan (Andrew et al 2002).

4.0 Stock Production Issues

World production of sea urchins is difficult to determine because the data passed to the Food and Agriculture Organization (FAO) from producing nations almost certainly underestimates landings, especially prior to the 1980's. The accuracy is further compromised because the production of other echinoderms is sometimes aggregated with the sea urchin data and the FAO cannot readily filter the differences. World production of sea urchins, including contributions not included in FAO totals in Figure 11, peaked in 1998 at around 120,000 tons and has been declining ever since (Andrew et al 2002). Chilean production first jumped in the mid-1970s's and now accounts for more than 50% of the world total and if Chile is excluded, world production of sea urchins has been declining since about 1992 (Andrew et al 2002). Serious declines have thus far been observed in many important fisheries in those in California, Maine, Japan, South Korea, Ireland, France and Chile (Andrew et al 2004) and significant continuing risks in many producers, including Chile and Japan, cannot be discounted.

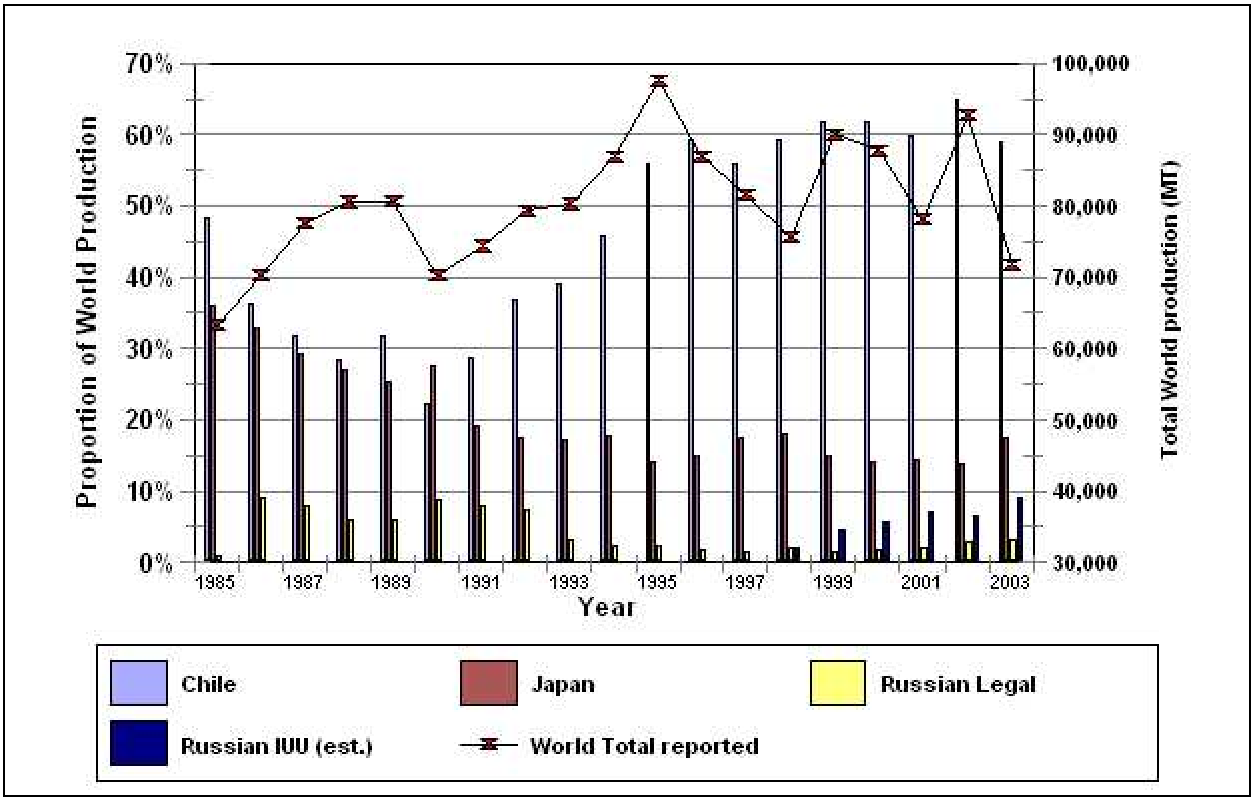

Figure 11: Total Sea Urchin production and the proportions held by select countries.

The general pattern in sea urchin fisheries is one of serial depletion of the species in different areas of the fishery followed by a decline, or perhaps a total collapse, over a period some years or decades (Andrew et al 2002). One exception to this appears to be Japan which is suffering a much longer-term decline despite large efforts to enhance the populations with releases of juveniles, the imposition of closures size limits and exclusive access rights held by the FCA's. It can be assumed that the populations are more vulnerable at very low densities but the actual definition of a critical limit remains elusive because of all the possible confounding factors.

Sea urchins are susceptible to catastrophic collapse at high harvest rates (Tegner 2001) but one major shortcoming identified in many fisheries is a complete absence of any pre-fishery biomass assessment which can be used to actually evaluate the harvest rate. Assessments of the fisheries are, having been reported for only Alaska, BC, Washington and California, rare but what evidence there is suggests that fisheries such as Northern and perhaps Southern California, France, Maine, Ireland, Japan, South Korea and Washington are over fished. The evidence is equivocal on Mexico while that for British Columbia indicates it is relatively stable. In the case of Chile, it is just impossible to know.

4.1 Management

Classical fisheries science was developed in consideration of offshore, open access and industrial fishing situations and the resulting management systems are not well adapted, or particularly robust, when applied to more complex spatial structure of small scale, inshore fishery resources

(Orensanz and Jamieson 1998). The social significance of small scale inshore fisheries is much greater, given the numbers of fishermen and other players involved, than the sometimes more productive offshore fisheries, which generally involve larger enterprises, higher capital investment and limited numbers of fishermen. As a result, much of the challenge in ensuring the sustainability of shellfish fisheries lies in developing and applying appropriate utilization, assessment and management models.

The weakness of the traditional fisheries stock assessment process on spatially structured invertebrate stocks, including sea urchins, clams, crabs and the like, has been acknowledged since at least 1984 but, as with any situation where change is involved, there is a certain conservatism associated with the political realities of any variety of established interests which slows any transition away from the established order. People who are doing well by one system do not generally like to see it change.

On the fisheries management measures side, minimum legal sizes are used in all major urchin fisheries but in this case, the conservation objective is often compromised because, unlike many other fisheries, it is the intermediate-sized animals which are the most valuable. Poor compliance, particularly in Chile, reflects this conflict (Andrew et al 2002). Another of the most widely applied management measures, using Catch Per Unit Effort (CPUE) as an index of stock abundance, is likewise not a reliable because of the interaction between the distribution patterns of the target stock and the harvester's behaviour (Orensanz and Jamieson 1998) and the influence of, for example, economic, market and technology factors. Changes in these can effectively mask any CPUE trend as a sign of overfishing so sequential depletion of the more localized concentrations that make up the meta-population goes undetected until such time that the urchins are gone. This has been well documented and widely acknowledged as a serious concern in fisheries with spatially structured stocks. Despite these problems, CPUE data is still widely used because the fact remains that it is cheap and easy to monitor landings and fishing effort (Orensanz and Jamieson 1998).

There are any number of differences between the offshore and inshore situations but at least some revolve around the identification of meaningful scales and the respective processes which are affecting changes in the population or community dynamics. The mesoscale is the domain of traditional fisheries models and the emphasis here is on changes in the population size over time with no real differentiation of the small scale variability of the processes affecting the population size. However, the spatial distribution of abundance is at least as important as total abundance and is certainly more important at low abundance levels (Orensanz and Jamieson 1998). This means more detailed models are needed to meaningfully address the varied processes contributing to the overall change as part of an effective management regime. Even with all the dynamic complexity involved though, it is also apparent that the spatial arrangement of the population centres comprising the meta-population are often remarkably persistent as concentrations (fishing beds) tend to occur in the same places as in the past (Orensanz and Jamieson 1998).

For example, with regard to the large (meta) scale, source-sink dynamics relate to the release, dispersal and accumulation of larvae and must consider such things as oceanographic features (currents, temperature, salinity, up-welling etc), weather, length of larval stage, etc. Within this there are also a number of compensatory and depensatory density dependant processes controlling recruitment to benthic stocks operating at a small ('neighbourhood') scale although, perhaps just to confuse the issue, the effects may be seen at various scales depending on when the density dependant effect is active (ie. before or after dispersal)(Orensanz and Jamieson 1998).

Many urchin fisheries suffer from ad hoc and reactionary management because they are constrained by poorly defined property rights, inappropriate scales of management and stock assessment and/or poor data (Andrew et al 2004). Management regimes are as different as the cultures they hail from, with probably the most fundamental difference being the nature of the property right held by the fisher, and it should be possible to compare their performance. For example, in Japan, cooperatives own areas of the seabed and have near-exclusive domain over them. In Chile, property rights in a small subset of the fishing area are analogous to those in Japan but most of the harvest is taken by a fishers with very few rights in the fishery and the government's ability to constrain their effort is quite limited (Andrew et al 2004).

The management measures that explicitly acknowledge spatial structure of fishery resources, and are therefore the most suitable for these sorts of fisheries, include (Orensanz and Jamieson 1998):

i. territorial property & use rights including lease, traditional tenure systems etc.;
ii. harvest rotation coupled with pulse fishing and/or thinning;
iii. reproductive refugia and Marine Protected Areas;
iv. experimental management with spatial controls, contrasting treatments and replication; and
v. localized enhancement including habitat manipulation, seeding and predator control.

Territorial user rights systems are identified as an effective management solution for spatially structured fisheries resources. Such systems have developed over centuries in places like Japan and more recently in smaller scale artisanal urchin fisheries in (north) Chile. Territorial user rights create greater incentives for investment in the sustainable use of the fisheries resources under their control through effective conservation and/or enhancement because there is direct economic accountability to success or failure. Unfortunately, the precepts and strategies used in the West for the management of open access fisheries are inconsistent with tenure systems and considerable resistance to change remains in the fishing and wider community.

Rotation has been practised for centuries as a common sense strategy for the sustainable exploitation of sedentary resources but has attracted little attention from western shellfish managers. Bed rotation is currently practised in BC's geoduck and RSU fisheries (Orensanz and Jamieson 1998). Rotational strategies benefit from experimental application because the recovery rates of harvested plots depends on a number of subtle and unpredictable ecological responses to harvesting as well as on the local dynamics of the target population.

Marine Protected Areas (MPA's) or similar harvest refugia provide better protection from extinction than rotating closures (Tegner 2001) and have been proposed as a major component in the precautionary management of fisheries in general. This is encouraging but, while their development is termed urgent for a number of fisheries (Orensanz and Jamieson 1998), information relevant to designing an effective network is often scarce. Large scale examination of the meta-population characteristics, including identification of the predominant larval sources and sinks, should provide some guidance for the initial design. This sort of approach is being advocated for southern Chile where populations enjoying some protection from fishing because of their exposure to the open South Pacific, their depth or their off-colour roe, may act as source populations in more sheltered waters (Andrew et al 2002). At this point however, it appears that the required data has not been collected and the argument remains hypothetical.

4.2 Sustainability

Translating a better understanding of sea urchin biology and ecology into improved management is difficult because highly variable interactions complicate the elucidation of critical pieces of information. These include details on the oceanographic conditions (temperature, nutrients, chemistry, feed particle size, predators etc) and currents and weather and how these are affecting the larvae and determining the degree of interconnectedness amongst the sub-populations (Andrew et al 2002). Sea urchin larvae generally spend between 14 - 40 days in floating about as part of the plankton and can therefore be dispersed over considerable distances by whatever ocean currents they encounter. This, in turn, allows mixing among the various sub-populations within a fishery which gives rise to the concept of a metapopulation as the functional ecological unit of the stock.

Overlie this complexity with the variable impacts from, and changing dynamics of, commercial fishing activity and the results at larger scales quickly become unpredictable. The common use of management scales on the order of 100's to 1,000's of kilometres is arguably inappropriate because of this unpredictability. Innappropriate scales may be an underlying element behind the serial depletion so often seen in spatially structured fisheries. For sea urchin fisheries to maximize their harvest and their prospects of sustainability over the long-term (ie. scales looking at decades if not centuries), they may have to move from large scale capture fisheries to some form of more intensive management. To date, small scale management has only been practised in Japan, Mexico and South Korea as well as parts of Chile and Nova Scotia (Andrew et al 2002).

Centralized fisheries management systems have been categorized by some as primitive and various forms of co-management more advanced, although wholesale adoption of the latter is not necessarily a guarantee of sustainability in and of itself (Orensanz and Jamieson 1998). Co-management is attractive, and continues to receive considerable attention, as a means to increase the effectiveness of management process. The main issues being looked at include participation of fishermen in the management process, the definition of community-based management and the special fishing rights of aboriginal peoples in western societies. The participation of fishermen is increasingly being recognized as being crucial to the process, not just for paying for the assessment and management measures, but also because they bring a lot to the table in terms of their on-site field activities, knowledge and understanding of the situation at hand. Industry players continue to earn a place at the table and the changeover to an individual vessel quota system, as has happened in BC’s urchin fisheries, provides a direct economic incentive for fishermen to act as stewards for the resource. The levels of trust in the process are likewise increasing with the degree of participation. With regard to aboriginal access, co-management arrangements between government and aboriginal groups is likely to remain a major factor in fisheries at least in Canada, the US, Australia, New Zealand and South Africa (Orensanz and Jamieson 1998).

4.2.1 Ecological Considerations

Implicit in the realization of sustainable utilization and management is an understanding of the processes affecting the populations but unfortunately this understanding is not, as yet, well developed. Sea urchins are possibly one of the best candidates for multi-species or ecosystem management because they are so instrumental in the formation of their associated community structure. However, despite the advantages of an ecosystem approach, sea urchin fisheries are, with the possible exception of the fisheries in Japan and South Korea where they are managed as part of a suite of species and habitat manipulation is used to increase productivity, managed strictly on a single species basis (Andrew et al 2002). In western countries, the prevailing systems of governance, and the embedded fishing rights that have been consequently established as part of the legal framework, complicate a transition to a more ecologically-minded management approach that will by necessity require yield considerations for more than a single species at a time. The 1997 Oceans Act in Canada, the 1996 Sustainable Fisheries Act in the US and a number of state statutes in Alaska, Washington, Oregon, California and Maine encourage the development of criteria and guidelines to protect ecosystem health but development of these remains preliminary. The laws governing the wild fisheries in Chile, Japan, the Phillipines and South Korea make no reference to ecosystem effects or ecosystem-based management (Andrew et al 2002).

4.2.1.1 Dispersal

Improved understanding of the hydrographic influences on larval supply, settlement and growth can improve fisheries management because they are so fundamental to the processes affecting the recruitment variability. The effects can be dramatic as demonstrated for example, by the 40+ years of observations on sea urchin populations in Ireland which have seen population densities naturally varying by four orders of magnitude in the absence of commercial fishing pressures.

Recruitment of Red Sea Urchins is episodic in Northern California, Oregon, Washington and British Columbia but is less so in Southern California and Mexico (Andrew et al 2002). The larvae drift on the currents for periods varying between about 30 - 50 days at temperatures ranging from about 15° C and 12° C respectively and so their dispersal is strongly affected by the currents they encounter. The Southern California Bight has the highest known rates of RSU recruitment throughout its range, a phenomenon that is related to not just the warmer water temperatures, which reduces larval mortality simply because they develop faster, but also because of its being an area of minimal upwelling with a closed gyral circulation near the coast which acts to retain the larvae (Tegner 2001). Recruitment is generally more infrequent and episodic along other parts of the coast because the larvae are generally found in the top 5-10 m of the water column and are generally carried offshore in areas where and/or when conditions favour upwelling. This includes most of the coast north of Point Conception, including Northern California , Oregon, Washington, BC and Alaska. The settlement events are correlated with a change in the winds can see the development of down-welling conditions and the larvae may also be concentrated on the lee side of headlands and/or within other eddy current systems.

4.2.1.2 Habitat effects

Sea urchins are well known to play important roles in the ecology of subtidal reefs and as having complex effects on ecosystems in cases where their abundance either increases or decreases substantially. In the case of large scale sea urchin fisheries, the most dramatic impact of removing tons of these herbivores off a patch of ground will be the rapid development of stands of large brown algae (kelps) and subsequent changes in the relative abundance of various fish and invertebrates this engenders (Andrew et al 2002). As the habitat in effect becomes more complex, the abundance of animals which prey on (especially) juvenile urchins often increases. This, in turn, leads to higher juvenile urchin mortality, lower urchin recruitment and lower productivity for the any subsequent urchin fishery.

This effect does not necessarily require removal of the urchins, whether by harvesting or say disease. Sea urchins are, at least in part, opportunistic feeders and Red Sea Urchins at least have been observed feeding on salps in Alaska during an anomalous oceanographic event which brought them to the urchins during a period when they would have been normally feeding on small growing kelps. This break from the feeding pressure allowed the kelps to grow sufficiently that a kelp forest was established (Tegner 2001). This may suggest that a temporary artificial feeding regime on an urchin barrens in the spring when the sporophytes (young kelps) are just beginning to take off might have a similar effect.

On the other hand, removal of such predators, perhaps through a fishery, reduces mortality of smaller urchins leading to abundance increases in urchin stocks and , in some cases, the development of urchin barrens. This effect has been extended include the effects of commercial fisheries targeting species which feed on the juveniles and it is thought that the large populations of GSU in the Gulf of Maine are the result of overfishing for cod, wolffish and haddock (Andrew et al 2002). Urchin density reductions in the Gulf of Maine have likewise seen habitat changes which favour urchin predators, further inhibiting urchin population recovery (Taylor 2004).

4.2.1.3 Sea Otters

The sea otter presents a significant threat to the commercial urchin fisheries in Russia, Alaska, British Columbia, Washington, Oregon and California. In Russia the otters have effectively removed all the large urchins in their range which moved northwards at about 25 km per year between 1985 to 1988 so it was just south of Asatcha Inlet. The expansion in Alaska was equally dramatic with the population expanding from just over 400 otters in 1968 to over 10,000 in 2002, an expansion which has diminished the prognosis for the future of RSU fishery in Alaska (Andrew et al 2002) although some hope may be engendered by the increasing predation on otters by Killer Whales up in the Aleutians. the sea otter population is also on the increase in British Columbia, particularly on the West Coast of Vancouver Island, and the Central and North Coast. The Sea Otter remains on the protected species list and there is still no plan to either manage this species or co-manage these interacting species (Andrew et al 2002).

4.2.1.4 Disease

The magnitude and major ecological consequences of the catastrophic mass mortalities of *Diadema antillarum* and *Strongylocentrotus droebachiensis* in the Carribean and up the east coast of North America respectively in the early 1980's and wiped out more than 270,000 t of sea urchins (Andrew et al 2002) really grabbed biologist’s attention. The outbreaks of bald sea-urchin disease on the Green Sea Urchins were attributed to an amoeba, *Paramoeba invadens*, have recurred since 1994 and have been attributed with the death of an additional 100,000 t since then, knocking down population densities to levels below economically viable levels inb a number of counties around Nova Scotia. The time to death in infected urchins is directly related to the water temperature with a lower threshold lying between 8 - 12°C. The disease has not been found in British Columbia but 100% and 25% of *S. droebachiensis* and *S. purpuratus* respectively are susceptible (Kajima and Lawrence 2001). GSU in Norway have been infected with a parasitic nematode which apparently affects the condition of the urchins, decreasing gonad production, but not causing direct mortality.

Disease outbreaks have also been persistent at a number of the urchin hatcheries set up in Japan as part of their enhancement program. These outbreaks have included mass mortalities of *Pseudocentrotus depressus* in Northern Kyushu in 1992 and of *S. intermedius* in SE Hokkaido in 1993. This latter outbreak was caused by spotting disease which has shown up every year since at a smaller scale at several hatcheries around Hokkaido. This disease generally shows up between May and July when the seawater temperatures range between 11 - 13°C and is caused by a *Vibrio* sp. bacterium. These infections can be controlled by treatment with a 500 ppm chlorine dioxide for 30 minutes at 15°C without injury to the urchins (Kajima and Lawrence 2001).

Seeded juveniles can be lost through a number of mechanisms including burial by sand or by disease especially when water temperatures exceed 23° C in the shallows during the summer. Mass mortalities at about 20°C reported prior to removal of the juveniles from the culture tanks have been attributed to a *Flexibacter* sp while a *Vibrio* sp has been implicated in other in-tank mortalities in May- June periods when water temperatures range between 11 - 13 °C (Agatsuma 2001). The experience with disease in Japanese hatcheries will very likely be repeated in any other hatcheries that might be developed for an aquaculture industry., These disease effects will at some point probably extend to the adult rearing operations (Kajima and Lawrence 2001).

4.3 Enhancement

Overfishing and a decline in world production have prompted increasing in enhancement as a means of at least maintaining production but it has moved beyond the research phase only in Japan, South Korea and the Phillippines. It is most developed in Japan where the 1974 Coastal Fishing Ground Improvement and Development Law provides the basis for stock enhancement (Agatsuma 2004). The goal of this program is to “develop and improve coastal fishing grounds systematically by the construction of artificial reefs and the release of seedlings”. Enhancement is considered one of the most important tools in the management of Japan’s urchin fisheries but can actually be broken up into three components: reseeding, habitat improvements and roe enhancement.

Enhancement can comprise a number of different activities including direct stock enhancement through seeding of hatchery-raised juveniles, habitat improvement or restoration, creation of artificial reefs, predator control, thinning and/or roe enhancement through supplemental feeding to increase the product recoveries etc. These sorts of actions can be considered as part of a continuum leading ultimately to aquaculture. They are generally considered feasible at least at intermediate to small scales, particularly when some sort of exclusive territorial use rights are involved and can all be viewed as steps leading in the direction from a gamblers philosophy to that of an investor (Orensanz and Jamieson 1998).

Re-seeding has been especially applied in Japan since the late 1980's. The numbers have been fairly stable since 1997 with about 70 - 85 million juveniles reared to about 5-10 mm TD and released each year primarily in the areas with the largest historical harvests. *S. intermedius* accounts for about 85% of the urchins released by the Japanese in Hokkaido (Andrew et al 2002). Predator removal is required as excess predation by sea stars etc has been implicated in the few cases where the re-seeding did not have any benefit on the subsequent urchin production and crabs and sea stars are removed from the grounds using baited traps prior to the release of the urchins to control mortality in the immediate period after release.

Government has considerable involvement in the management of coastal fisheries , particularly in the provision of subsidies for enhancement and infrastructure development as well as management coordination amongst the FCA’s. A couple of studies have looked at the contribution of re-seeding or habitat enhancement to the actual abundance of urchins in harvest areas in a sort of round-about way at localized sites around Hokkaido and estimated that re-seeded urchins comprised 62%, 66% and 80% of the catch in 1994, 1995 and 1996 respectively. They also estimated that 45% of the catch in 1996 comprised urchins re-seeded in the area two years previously in 1994 (Agatsuma 2004) supporting claims that seeded urchins grow to harvestable size in two years, as opposed to the 5-7 years required for RSU in north-eastern Pacific waters.

None of the data however supports national or prefectural scale assessments, because data on other confounding variables is missing or incomplete, and the effectiveness of the re-seeding programme in Japan has not been evaluated on either a national or prefectural scale. The missing variables include changes/differences in fishing effort, natural recruitment trends, other enhancement contributions and management of the wild fishery.

In 2000 more than 84 million seed were produced at 57 hatcheries in Japan. The unit price of the seed ranges from about ¥5 - 10 ($C 0.05 - 0.10) with the major component costs comprising pumping (20%), heating of the hatchery water (30%) and wages (50%) (Sakai et al 2004). Work in California has demonstrated that an RSU enhancement programme comprising re-seeding *S. fransiscanus* is not likely to be economically feasible because of the high early mortality, slow growth and high expenses of culturing the animals to an effective seeding size of 15 mm (Andrew et al 2002).

The aim of habitat enhancement programmes is to expand areas of good habitat for sea urchins and promote colonisation of algae as a feed resource and the measures used include the construction of artificial reefs (Figure 12) and/or stone plains and/or breakwaters. Creation of such


Figure 12: Concrete block design examples for artificial reefs (picture compliments of Dave McRae)

reefs in Japan is concentrated in Hokkaido, Tohoku, Yamaguchi and Kyushu which collectively have about 50 sites being enhanced this way each year, including some 122 sites in Hokkaido between 1976- 1992. In South Korea, 7.6 cu. km of artificial reef was established in 151,649 between 1971 and 2002. Despite the 30 year history of this activity the effects on coastal fisheries and ecosystems have not been analysed in any detail (Andrew et al 2002).

Sea urchin gonads can readily increase over a 3-4 month period at any time of the year but are most effectively enhanced just as the nutrients are being mobilized for gametogenesis (Andrew et al 2002). At times, Japanese FCA's also enhance the quality of the roe to raise its value prior to harvest. The roe is most valuable just prior to and in the early stages of gametogenesis when the roe are large but still firm. The roe size can be increased at any time during the year but it is most readily manipulated when the nutrients are being mobilized for the actual production of the gametes at the commencement of gametogenesis. The most common method used in Japan is by transplanting the urchins from barrens or areas which lie a bit deeper, where roe development is slowed because of a lack of available feed, to kelp forests where the uni development can quickly proceed. The Japanese practice is to give the urchins 3 months in the enhanced feed area to develop prior to harvest (Agatsuma 2004).

In Japan, translocation of the urchins is used for a number of related reasons. In areas where kelp forest development is held back by excessive urchin densities, urchins are sometimes removed and replaced with adult kelps to permit rapid development of complex kelp forests (Agatsuma 2004). The urchins may then be placed into intensive sea ranching pens where they are fed ad libitum and prepared for harvest some months down the road. Experiments have shown that GSU at densities up to 35 kg/m^2 have recorded recovery increases from 6% to over 18% in 11 weeks on an artificial diet (Aas 2004), although further finishing for about 6 weeks on a natural kelp diet is still required to get an acceptable taste profile at this point.

The sea urchin *Evechinus chloroticus*. is widely distributed around New Zealand but attempts to establish a commercial fishery have, like Norway, not succeeded because of the poor product quality and low recoveries. Experiments with ponding over 2 month periods have seen recoveries increase to near 20% and produced other quality improvements that bode well for the future but further research is still needed to reach an economic breakeven. There are a number of aquaculture sites around New Zealand which are currently considered marginal for mussel farming which would be suitable for urchin ponding or culture (Barker 2004).

The effectiveness of transplantation of RSU from an urchin barrens as a means to enhance the product was examined in California. Survival and growth were both high and the method is considered a viable alternative to the more costly hatchery-based reseeding option (Andrew et al 2002). Delivering prepared food in abundance following spawning and before the out-of-season photo period cue results in substantial growth of the nutritive cells in the gonads in both males and females, leading to an increase in the recoveries (Walker et al 2001) even as the gametogenic states of the gonads remain in synch with their seasonal norms (Tegner 2001).

Japanese re-seeding efforts have been largely successful as landings form re-seeded areas have at least remained stable. and the economic returns have been estimated at 2 dollars for every dollar spent (Robinson 2004a), although it appears that the commercial fisheries are now almost completely dependent on the seeded urchins. Several countries, including Japan, the US (in Maine) and Chile, have or are working towards enhancement fisheries where juveniles are re-seeded to previously harvested grounds to increase the productivity of their fisheries.

Enhancement of marine species is a large and growing business but evidence is accumulating that density dependant processes in the ocean pose difficult obstacles for marine stocking program success. Notwithstanding the claims of proponents, stocking programs should be subject to peer review by scientists without a vested interest in the success of the program and the economics of stocking should be compared with that of alternatives such as habitat protection, fishery regulation, and stricter enforcement (Hilborn 1998). There are a number of issues to consider aside from the strictly economic ones. This includes the observation that production from within a hatchery system is well known to decrease the genetic diversity because of the relatively low number of individuals making up the broodstock. This problem is being faced by all hatchery operations around the world and there is no easy resolution in sight (Robinson 2004a). This is not such a problem when the animals being produced are strictly for culture as these are often artificially selected for characteristics that are not advantageous or widespread in the wild populations.

Multi-disciplinary approaches are needed for stock enhancement and both scientific and user group advisors should be involved (Masuda and Tsukamoto 1998). Some authorities claim that the responsibility for maintaining the genetic diversity should lie with government organisations but this sort of responsibility as well should be subject to open and peer review because we all know how effective centralized bureaucracies are in matters like this.

One method of enhancement that apparently works very well with Green Sea Urchins simply requires the presence of a salmon net pen. The urchins can apparently settle out quite abundantly on such structures and grow quite nicely by feeding on the fouling organisms on the mesh. The farmers don’t mind the urchins as they help clean the nets but they must eventually be removed as the nets require a major cleaning on occasion. This has provided some opportunities for Canadian fishermen in BC for some easy harvests.

This sort of colonization response might also lead to similar developments in Chile, a country with a very high number of salmon farms. If urchin fishermen, or the companies they work for, have noticed this opportunity, they, being fishermen or businessmen, are most likely trying to take advantage of it. There are thus far no literature reports substantiating this.

4.4 Aquaculture

Aquaculture operations for marine species do not typically start until such time as the wild stocks are depleted. As supplies drop, continuing demand generally drive prices up to the point where the investments required to establish a culture capability can be justified. That the global production trends of sea urchins are in decline around the world suggest that the time to initiate culture operations may soon be at hand. Detailed analysis of the landing records reveal that the wild production has been driven by a succession of countries over-fishing their resources with new suppliers coming on stream to bolster production just as existing majors fade out (Robinson 2004), a typical serial depletion scenario where the problem can be lie in disguise until the fishery simply collapses. One index of the rising interest in echinoculture can be found in the treatment of the subject by the academic community. The topic of sea urchin culture was addressed only on the periphery of scientific conferences less than 10 years ago but it has now progressed to the point where directed conferences on the subject are regularly held because of the continuing depletion of wild stocks and the relatively high value of the product (Robinson 2004a).

Land-based sea urchin culture has seen spectacular rise in recent years (Andrew et al 2003) - at least on the technology side although continuing abundance of urchins from new areas has limited the commercial culture production from any source. Research into full-cycle culture of urchins has been undertaken but, while all aspects are biologically feasible, several logistic and economic issues due to the feeding behaviours and impacts of the urchins require resolution. Some cage culture operations, as used for abalone, have found growth rates double those found in the wild, but again additional system trials are needed. The element(s) affecting the taste of the gonad remains the most elusive subject of study (Robinson 2004). Wild algae as a last-stage feed is still required for about the final six months to finish off the product so it has an acceptable taste, although this aspect of the feed is now drawing considerably more research effort.

Research into prepared diets for culture operations has led to a greater understanding of the component factors affecting various aspects of the animal's growth and development cycle and the foods produced for the urchins will be different for different objectives. For example, pigments in artificial diets affect the fecundity of the urchins eating them with beta-carotene and xanthophylls producing the most gametes even as they affect the colour of the roe. The primary pigment in the gonad is echininone, an oxidized form of the pre-cursor β-carotene, and the rule of thumb is that increasing levels of this pigment are correlated with a brighter orange colouration and increasing value to the market (Robinson 2004).

The Norwegian Institute of Fisheries and Aquaculture Research has developed an artificial feed with a high protein: carbohydrate ratio which promotes fast gonad growth. It has a positive effect on the gonad size (recovery), colour and texture but also seems to impart a bitter aftertaste. In an experiment to determine what might be causing this, a professional taste panel assessed gonad quality using 12 different sensory characteristics and found that the urchins feed with the highest protein: carbohydrate ratios were the most bitter (Dale et al 2004).

In land-based aquaculture facilities, it is possible to maintain urchins in optimum gonad condition by simply holding them under invariant long-day photo period that they normally experience during the inter-gametogenic phase (Lawrence et al 2001). This allows the provision of a consistent, high quality product on demand when it is needed by the market no matter what the weather or season. The unit costs are subject to modification by simply applying economies of scale and ramping up production to bring down unit costs. Once the taste issues are worked out, and the low cost suppliers have eliminated themselves, these producers will benchmark the majority of the market and wild product suppliers will have to be differentiated as a niche product for a luxury market.

Developments in urchin culture are being structured in part by the development history in precedent culture species, namely salmon, shrimp, oysters and mussels (Robinson 2004a). With reference to shrimp culture, that industry has evolved over the past couple of decades to highly intensive systems profitably producing 3-5 kg of product for every square metre of pond area every 3-4 months. This was not always the case, lots of money was lost and many mistakes were made in the process but now the global market has been completely transformed as uniformly high quality cultured prawns and shrimp are available throughout virtually the whole world.

The current market system used for the urchin trade developed in tandem with the wild fishery but this will no doubt change dramatically once cultured product is available in substantial quantities. cultured production is more tightly controlled than from the wild fishery so that, as with the cultured salmon, the consistent availability of an invariably high quality product throughout the year will have a tremendous impact on the urchin markets throughout the world. Traditional harvesters of sea urchins do not generally know much about the potential of aquaculture (Robinson 2004) and will likely tend towards obstructing its development as opposed to recognizing the available advantages and applying them to their own benefit.

This will be unfortunate because if the wild and cultured urchin fisheries could be more closely integrated, both would stand to benefit. For example, the gonad size and quality are quite easy to manipulate and the economic yield of the roe can be dramatically and fairly easily increased. This knowledge is probably directly applicable to the wild fishery and could contribute to an increase in quality, value and profitability. Already, fisheries and aquaculture are blurring together with respect to product (gonad) enhancement and re-seeding of juveniles are coming to the fore in a number of countries (Robinson 2004a).

4.5 Quality Management

Quality management thus far seems to revolve around scheduling the harvest so the gonads are reasonably large and targeting areas where the algal feed resources are appropriate for good taste and colour and recoveries. Sea urchins which are part of the same metapopulation, but are in different areas, spawn at about the same time but the growth of the gonads will be different depending upon the feed resources for the urchins. There are of course other measures applied at the processing stage which impact the eventual quality of the product but these are generally considered proprietary buy the processors and will not be further addressed in this document.

One other area of interest though revolves around the care taken of the urchins between harvest and their arrival at the plant. The urchins are delivered live so additional care measures have not been a priority. Obvious problems, such as breakage due to excessively rough handling, exposure to wind, rain and direct sun, are at least partly resolved by common sense solutions, but impacts which are not so readily apparent, such as possible changes caused by temperature abuse, are not considered. This may be significant oversight compromising the eventual quality of the product but unfortunately no research on the possible impacts has been found. With regard to quality, it is important to remember the mishandling and other abuses cumulatively impact quality and that once the quality declines, that increment cannot be recovered once the animal dies.

4.6 Productivity Optimization

Additional costs are imposed with the application of additional protective measures, so there has to be a trade off. For example, forcing a packer to run every day without fail without regard to how much product it has on board will raise the unit costs of the transport when volume is low. Another example might involve the choice of areas to harvest when some of the TAC is not going to be picked. The most obvious rational alternative is to leave the product which is the most expensive to extract so the net returns can at least be maximized. This is not always the way things go though, whether it's because of rigid observance of a previously established harvest schedule or some other motivation to see one area harvested over another.

Fishermen are a generally pretty flexible lot when it comes to adapting to new production requirements. This includes the skills and knowledge to adapt their boats to use new gear as well as well as the openness to readily take up working with different groups in cooperative relationships in an open manner that encourages the innovation, mobilization of resources and the spread of knowledge necessary to build a new fishery (Lauer 2001). This implies a certain degree of mutual respect and trust held between fishermen for others they know and perhaps work with in various fisheries is required. This is often an underappreciated element of an efficient operation and once morale deteriorates to a certain degree, the ensuing lack of cooperation reduces the chances that things will run as smoothly as expected. This can lead to damaged product, damaged equipment, high staff turnover, loss of critical skills and abilities to the industry and a general decline in capacity. Also, once the fishers feel disenfranchised and over-ruled too often by the guys on shore, their care and attention to produce the best product possible will flag.

There are a number of market and cost issues which are putting additional pressure on the bottom lines of all seafood suppliers. This is especially so for products which are marketed primarily in Japan in part because of the deflationary environment mind-set there as well as because seafood sold in that country is generally priced in US dollars. The recent decline of the US dollar against the Japanese Yen is increasing the buying power of buyers in that country. Unfortunately, the Canadian dollar is also appreciating against the US dollar. The increase over the past few years is about 30%, meaning returns to Canadian suppliers have decreased by the same amount.

The resulting pressure on suppliers is squeezing margins to the point where continuing profitability is not assured and all companies must look for cost savings wherever they can. One of the obvious places to look is product loss due to excessive quality deterioration. This happens directly, as for instance when product is held for too long before arriving at the processors, and indirectly as when larger than anticipated loads arrive at a plant which is not prepared to process the urchins in a timely manner. Costs are often further elevated in the latter instance as crews sometimes end up working at overtime rates, compounding the problem.

This just reinforces the notion that the need to optimize productivity and efficiency is part and parcel of today's competitive marketplace. The need to reduce costs wherever they occur extends to such matters as waste management as well. The primary option of dealing with the urchin processing waste remains disposal in landfill. This does not make a lot of sense as the urchin test contains a lot of calcium carbonate meaning the processing remains of the urchins likewise hold some value and should be recycled and used for compost, soil conditioners or fertilizers.

4.6.1 Continuity of Supply and Capacity coordination

This refers in large part to the difficulties in matching the production from the fishery to not just the demand from the market but also to the capacity capacities of the downstream processes involved in the supply chain. This is simpler in situations where the fishery is conducted as a day fishery but rapidly gets more complex in more remote settings where packers take the product to the dock where it is loaded onto a truck for transport to the processing facilities. Interruptions due to poor weather in winter are not uncommon and packers are sometimes laden with 2 - 3 day loads which overwhelm the capacity of the system when they finally land the product.

This sort of problem is reported in Hokkaido when the packers with IUU product from the Kuriles unload too much product and the whole downstream supply chain, up to and including the retail outlets, is glutted. When this happens in Japan, the market effects are often dramatic and price collapses have been disrupting, and even bankrupting, production from other domestic and import suppliers. The same drought and glut situation is common in British Columbia, particularly when production is focussed on the North and Central coast area. It has not been reported as a problem in Chile but the geographical setting for the majority of the fishery strongly indicates that it is likely an issue.

From the marketing perspective, it is also important to maintain a constant presence in the market at all times to maintain interest in the product. If it is only intermittently available, even the best customers will be forced to turn to other suppliers. It is then incumbent on the supplier to win back that customer instead of being able to build on an already existing relationship. The sea urchin fishery in California understands this and continues to supply product throughout the year simply to maintain their customer loyalties.

5.0 Supplier Profiles

5.1 Canada

Sea Urchins are harvested on the Pacific and Atlantic coasts of Canada with the majority of the country's production coming from the Pacific coast off BC. The fisheries generally saw a striking rise soon after they were initiated followed by a retreat to a more sustainable level as the accumulated biomass was fished down (Figure 13).

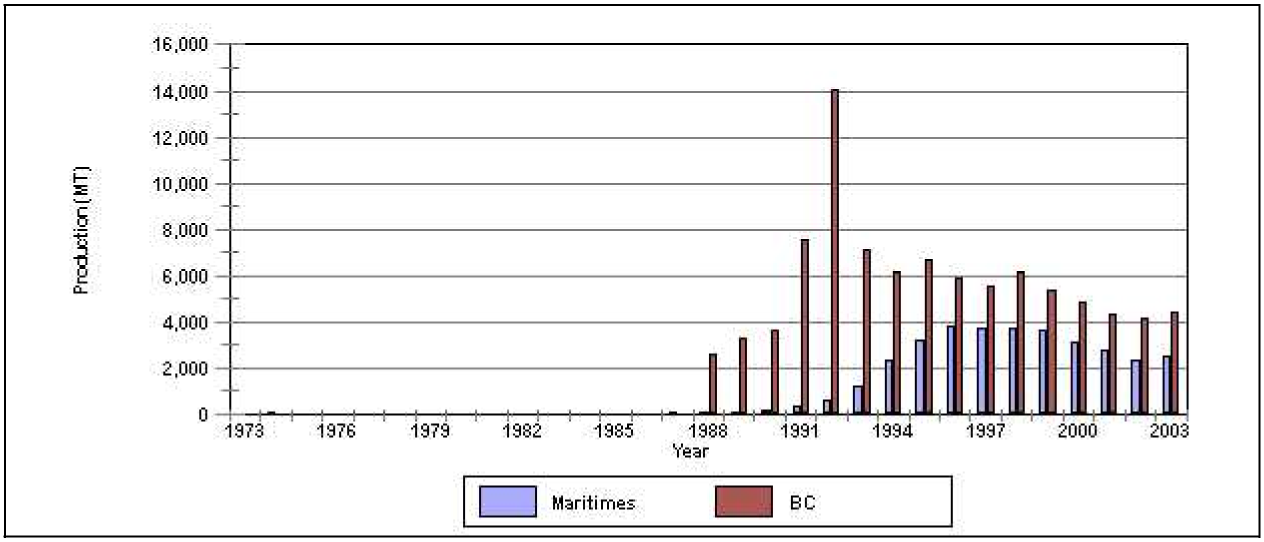

Figure 13: Sea Urchin Production history in Canada

5.1.1 British Columbia

Two species of sea urchins, the Red Sea Urchin (RSU), (*Strongylocentrotus fransiscanus*) and the Green Sea Urchin (GSU), (*Strongylocentrotus droebachiensis*) are harvested in British Columbia. Both of these fisheries have established industry associations, The Pacific Urchin Harvesters Association (PUHA) and the West Coast Green Urchin Association (WCGUA), both founded in 1994, to represent all of the harvesters and exporters of Canadian west coast Red and Green sea urchins respectively. The commercial dive fishery for RSU in BC began in the 1970's and the Association represents all 110 licences that have been issued for the fishery. A similar structure holds for the GSU fishery which is, with 49 licences issued, significantly smaller. The fishermen and their Associations carry all of the direct costs associated with regular harvest monitoring programs as well as stock assessment and research programs in their respective fisheries. These are designed to ensure the sustainability of the fishery and are carried out in close collaboration with DFO Science.

5.1.1.1 Fisheries Management and Research

Both associations co-operate in the management of their respective fisheries with the Government of Canada to ensure the stocks are managed sustainably to provide Canadian sea urchin products to the markets of the world. A strong emphasis is placed on improving the scientific information and research programs to support the development and implementation of the best fishery and environmental quality management practices. DFO and industry have Joint Project Agreements (JPA) in place which mandate and ensure the delivery of the biological and catch monitoring data collection programs for both fisheries each year.

A critical component of this collaboration is the industry-provided funding for all the incremental costs of science and management associated with their respective fishery including catch validation, biomass surveys and stock assessment programs. The Associations also hire contract biologists to work with DFO on these projects and over $750,000 is contributed annually by them to fund these activities. They are also actively participating in a number of ecological research projects and biological productivity studies in collaboration with DFO aimed at maximizing the benefits of the fishery and optimizing the net economic and environmental returns to Canada. The WCGUA has been supporting research into a novel surface-operated, video-based survey technology (V-quad or KVQ) and the development of appropriate protocols for its use.

Current fishery regulations in BC include limited licence entry, a minimum size limit , a quota system for 77 North Coast and 32 South Coast areas to provide a conservative target reference point of about a 2% exploitation rate for the estimated current biomass. Fishery independent assessments are used as the basis for these estimates. DFO recognizes that the use of index survey sites as a method is not sensitive to low local densities which appear periodically in most areas because of the sporadic and patchy nature of urchin recruitment and rely on fishermen to identify problem areas. Industry has come through on this on a number of occasions and requested the closure of localized areas so the populations can recover. The biomass is estimated as the product of the product of the density (# RSU/m^2), the mean weight of the urchins and the area fished for each bed. An increase in the accuracy of the GPS equipment used to define the urchin bed areas by the fishermen over the past few years is confounding the biomass estimates and DFO is changing over to shoreline length as a more appropriate geographic reference system.

The BC sea urchin associations, PUHA and the WCGUA, strongly supported and were in fact instrumental in the implementation of their respective individual quota programs. They have each signed a Joint Project Agreement (JPA) with Fisheries and Oceans Canada mandating a third party catch monitoring and validation program and other responsible fishing measures. This including, in the case of the RSU fishery and PUHA's JPA, provisions for an On-grounds monitor (OGM) for the North Coast. The associations also participate in annual biological sampling and research programs since their inception in recognition of the precautionary approach which requires ongoing stock assessment, the development of management objectives, the recognition of uncertainty in biological and fishery information.

Under the IQ program, 2% of the coast-wide TAC is reserved for First Nations and each of the 110 commercial RSU and 49 GSU licences are allocated 1/110 and 1/49 of the remainder respectively. In the RSU fishery, the number of licences has remained constant since 1991 but the number of participating vessels has declined to from 102 in 1992 to 48 in 2001. Up to five licences can be stacked on each vessel.

A TAC is set for each fishery based primarily on fishery independent survey results and on-going stock assessments. The RSU fishery is distributed along the North, Central and South coast while the GSU fishery is restricted to the South Coast. The seasonal timing and movement of the fishing fleets is dependent on the weather and product quality and is decided by the fishery manager in consultation with stake holders. The commercial fishing seasons have been changed to reflect a market-driven year and extend from July 1 of one calendar year to June 30 of the next.

One of the larger concerns for the fishermen is the growing sea otter (*Enhydra lutris*) population along the BC coast. These animals are listed as endangered and are therefore not being managed for any aim other than increasing their population. The success of this program is causing considerable concern amongst the whole of the invertebrate seafood industry in BC, including the sea urchin fisheries, because of their voracious appetites. They have totally cleaned up any urchins, crabs, clams (including geoducks) and abalone within one year in all areas where they have become established. These areas are then lost to the industry because there are no commercially interesting invertebrate fishery stocks remaining.

5.1.1.2 Operations

Canadian harvesters and processors work closely with Japanese importers to extend the reputation of the Canadian industry as a consistent and dependable source of high quality and good value seafood, produced in an environmentally sound and sustainable manner. The fisheries are strictly diver based, providing very good selectivity and negligible impacts from gear (eg. trawl) damage. The vast majority of operations use SCUBA because of the greater mobility and flexibility it offers over surface supply. In most cases, each boat has two divers and a tender who delivers bags, recovers product and takes care of the divers equipment needs etc as necessary throughout the day.

A typical day's fishing starts at close to first light and continues on until enough product has been picked to at least fill the day's order, generally somewhere in the neighbourhood of 4,000 - 5,000 lbs per diver per day. The divers collect the urchins they pick in a bag which is either left on the bottom with a float line for collection towards the end of the day or alternatively immediately hooked up by the tender for storage on board. Delaying the recovery and then covering the urchins would seem to make sense as a quality conservation measure but there have been no directed studies to develop empirical data on the relative merits of each option and there remains some debate on which is better. From the perspective of the boat tender, immediately picking up the bags spreads the work out better over the day and allows more immediate departure when the day's diving is done. Attention to the quality requirements is apparently spotty with some boats reportedly not even covering the product to protect it from the elements. Rain and sun both bleach the urchins and undoubtedly lead to increased and earlier mortalities. All of these can be expected to accelerate product deterioration, but the economic incentives to take the extra measures are, because prices paid by processors are not directly referenced to the quality of the load, indirect and somewhat erratically applied.

Figure 14: Dive boat delivery (~9 k-lbs)

At the end of the day, the dive boats deliver their catch (Figure 14) to either the dock, in which case a validator will be in attendance to verify the catch weight and area(s) fished etc, or to a packer which then delivers the product to the dock, again with validation. The weight and number of bags, each of which is marked to identify the owner or source boat, delivered from each of the dive boats is recorded on delivery to the packer but the validated weight is used as the basis for payment and calculating remaining quota.

Once a threshold weight of about 25,000 - 30,000 pounds is on the packer, the packer is theoretically free to run for port but this is not always what happens. In fact, the packers will sometimes wait for another day, or two, and load up with perhaps 100,000 lbs or more, filling their holds and covering all of their deck space (Figure 15). The reasons behind this vary but it continues to happen on a regular basis even though the effect on quality of hold the product on the packer for an day or two extra is entirely predictable. Accumulating extra product on the packer provides an immediate benefit to the packer, because they are paid on a per pound basis, but, as often as not it, it seems that it is one or another processor who calls for the boat to hold and take on another day's harvest. The reasons for avoiding this are manifold: the holds on the packers are not chilled or iced so the urchins are basically held in an uncontrolled environment and allowed to heat up for an extra period. processing is delayed, the transport and/or processing system is glutted and the hurry-up processing lowers the output quality and fishermen and other crew become increasingly become increasingly dispirited and jaded because nobody bothers to tell them why or to seemingly care for their sacrifices to produce the best quality product they can.

Figure 15: Filled deck on packer (~100 k-lbs)

Holding the product on deck is not, in and of itself, necessarily a bad thing as long as the urchins are properly covered. A series of temperature readings taken on precut held on deck and in the hold produced temperature profiles that were better for the on-deck option even though a warm spring sun was out heating the product. The average temperature for the product stored on the deck was 11.4° C, about 2° C warmer than it was when it came out of the water but significantly cooler than the 13.3°, 12.6° and 12.7° C recorded for the hold products respectively. This suggests that there is a source of heat getting into the product in the holds, a source that logically is going to be related to the engine room and which is going to require some remedial action.

One of the choke points in the delivery process appears to be the unloading at the dock. When the product is being pulled from the deck and the dock crew is up to it, things proceed fairly quickly with perhaps upwards of 500 - 750 lbs/minute transferred. However when the product in being pulled from a hold, or the dock crew is too small or otherwise not up speed on the task, this rate can slow to perhaps 100 - 200 lbs per minute. There are a number of factors contributing to this slowdown, but at its base seems to rest the low limit to the number of bags which can be simultaneously pulled from the hold at one time.

The product bags used for this fishery have not been standardized as yet, as can be seen in Figure 16, despite the advantages this might offer. There seems to be any number of shapes and sizes in use, capacities ranging from about 150 lbs to upwards of apparently 1,500 lbs, with designs ranging from 3' diameter spheres to 6' long by 1.5' diameter tubes. While they each have their advantages and disadvantages, the very diversity in design complicates the handling of the product off the harvest vessels and packers, and precludes the consideration and adoption of productivity, and/or perhaps quality, enhancement measures that could be applied equally to the product from all vessels.

Other problems causing inefficiencies that have been reported include a shortage of returned totes for refilling so the product cannot be properly packed and protected for the trip south in the truck, overloaded totes with excessive crushing which may or may not be related to the preceding, product which has been exposed to freshwater or which has been partially frozen because of inappropriate exposure which leads very quickly to accelerated spoilage. Some processors report losses of up to 50% on some loads, a cost which comes directly off the bottom line. A single 'bad' load counteracts 10 days of normal profitable operations when everything goes just right.

Figure 16: RSU product bags.

5.1.1.3 Harbour Facilities

By world standards, BC is a small producer with high costs, a largely small boat fleet and, perhaps most importantly, weak infrastructure (BCSA 2005). This is a function of the general lack of development and low population densities along the vast majority of the coast throughout most of the interior and is, of course, most apparent along the Central and North Coast (Figure 17) where about 75% of the RSU quota is located. Road transportation links to the Lower Mainland where all of BC's urchin processors are located, for the Central and North Coast areas are limited to Prince Rupert and Port Hardy. It can take upwards of 16 -18 hours travel time for a packer to make it to either of these locations from many spots along the North and Central Coast and from the Queen Charlottes. From Port Hardy the road trip is generally 7 - 9 hours while from Prince Rupert it takes about 20 hours. The lack of a processing capacity in Prince Rupert especially adds to the cost of transport because something in excess of 85 - 90% of the RSU weight is discarded. Attempts to establish processing capacity in Prince Rupert have thus far not found sufficient staff with the required skills to efficiently crack and pack the urchins in the area.

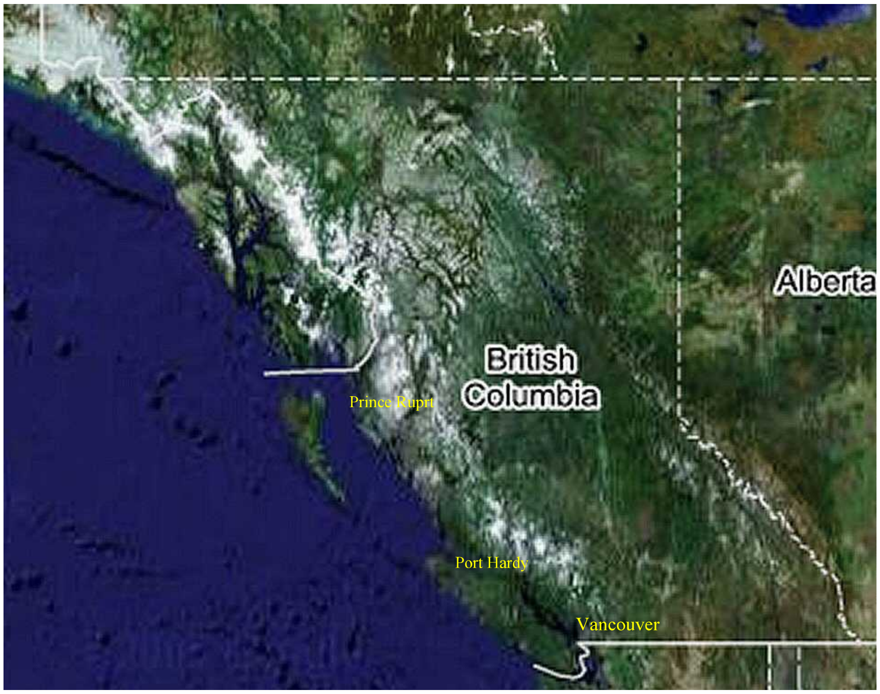

Figure 17: Sat photo of British Columbia showing the locations of Vancouver, Port Hardy and Prince Rupert

5.1.1.4 Processors

There were a total of 9 processors operating in the BC Sea urchin fishery in the 2005-06 season, a total which included two entrants who only entered the fishery in 2004-05. The cumulative sustained processing capacity of the 7 major plants cannot generally keep up with the total harvest capacity of the fishing fleet, so from that perspective, there is room for extra processing capacity. Unfortunately, the market capacity has not been able to build to the same extent, primarily because of market saturation in Japan, and the extra processing capacity led to further oversupply and price undercutting. As a result, processors focussed almost entirely on internal competition this past year and very little progress was made on the marketing initiative or the additional handling tests. Perhaps even more discouragingly, the collaborative spirit among the fishermen has been damaged this year as a result of the processor conflicts.

One of the differences between the BC situation and that found throughout most of the US is that processors are not generally allowed to own harvesting permits in the US because of worries about the undue influence this might give them over pricing. The evidence in the US supporting this is of course contentious but the battle between fishermen and processors over this issue is entirely political and ongoing. The experience of US fishermen in this regard, including in the Alaskan Snow crab fishery which has established Processor Quota Shares, is that a non-competitive environment will ensue. The resulting imbalance allows processors to low ball prices to ridiculous levels even when the market will support higher ex-vessel prices (Holland 2006). Canada has the Competition Act (C-34, 1985) to constrain unfair trading practices but this is reportedly a very complex body of Law and it is very hard to apply effectively.

5.1.2 Canadian Maritimes

The Green Sea Urchin, *S. droebachiensis*, is fished in New Brunswick and Nova Scotia by dragging or divers in the case of New Brunswick and by divers exclusively in Nova Scotia. Landings in both jurisdictions peaked in 1996 at 1,900 t in New Brunswick and at about 1,300 t in Nova Scotia.

The New Brunswick fishery is divided into three areas one of which, the Grand Manan Islands, has fishing restricted to 6 months using drag only while dragging and diving are allowed on the other areas, the mainland and coastal islands, over an 8 month season. TAC’s based on 6.8% and 3.3% of the total harvest able biomass were introduced in the Grand Manan and mainland fisheries respectively in 1996. The stock status is determined annually from the catch rates from mandatory logbooks and there had been no further management intervention despite the considered inadequacy of the assessments as of 2000 (Andrew et al 2002).

The sea urchin fishery in Nova Scotia, on the other hand, has one of the most innovative management strategies anywhere (Andrew et al 2002). This fishery is dive-only, operates to about 15 m, and observes a 50 mm Minimum Size Limit, as it is in New Brunswick but, while there are no fishing seasons or Marine Reserves, management is evolving towards a unique area-based system where individual permit holders, as opposed to groups or communities, have exclusive access to stretches of the coastline. Fishermen may apply for a restricted zone by first demonstrating a history harvesting urchins, providing a map of the kelp and urchin distribution in the zone, promising to increase tothe carrying capacity of the zone for urchins and promising to detail catches and fishing locations. Beyond this, DFO surveys the zone before an appropriate size is negotiated and after four years when the performance is more or less audited. If a significant part of the zone is not being utilized, the borders can again be subject to negotiation. The restricted access offers opportunities to maximize the economic return while satisfying the need for a sustainable harvest. Refuges are provided by areas too deep for the divers and by areas with urchin densities or recoveries too low to support commercial interest (Andrew et al 2002).

The real core of this management strategy is a requirement for the fishermen to maintain a dynamic balance between the sea urchins densities and the kelp. Urchins along the Atlantic coast occur in feeding fronts, dense aggregated bands between 1 and 15 m., while dense kelp forests persist above these bands and urchin barrens are found below. The depth of these bands is then used as an index of exploitation and the length of the band along the shoreline is used as an index of size of the resource in subsequent assessments (Andrew et al 2002).

The fisheries in some counties around Nova Scotia were affected quite dramatically by an outbreak of a parasitic amoeba, first in the early 1980's and intermittently since 1994 which cumulative killed approximately 370,000 t of urchins. Animals below the thermocline are believed to escape the disease and have thus far re-established the shallow water populations over the next decade or so (Andrew et al 2002).

5.2 Japan

Records on Japan’s sea urchin fishery extend back to at least 844 AD with the first commercial fisheries starting up in Hokkaido around 1880. Japan’s urchin harvest peaked in 1969 at 27,528 t and has been in general decline since so that only 13,653 t was harvested in 1998, a level which has been generally been maintained since (Figure 18). Japan consumes more than 80% of the world’s production and is increasingly reliant on imports from around the world to satisfy its huge market for uni.

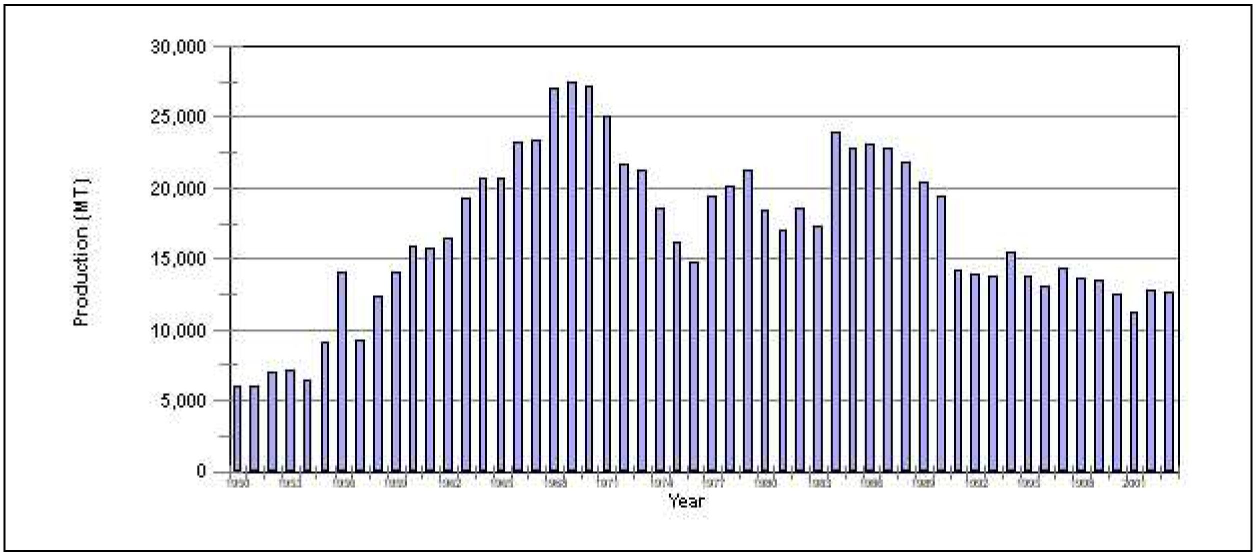

Figure 19: Sea urchin production history in Japan (FAO)

The persistence of the fishery under the same management regime for more than 50 years attests to the efficacy of an exclusive area rights-based management system in which the management of sea urchin fisheries is integrated with other near-shore resources, such as kelp, crabs, abalone and fish. Even in Japan though the deterioration of fishery resources has been noted, a change attributed to increased fishing efficiency through technology as well as natural changes in the oceanographic climate (Anon 2004). A variety of techniques, including SCUBA, breath-hold diving, wading, scoop nets (Figure 19), hooks and spears as well as nets and beam trawls where the bottom allows, are used.

The responsibility for all the fishery resources is vested with Fisheries Cooperative Associations (FCA) in their areas of control which manage the ecological relationships on their grounds in the same sort of way a farmer manages his land with the same aim to maximize production. This approach is very different from that adopted by western agencies but it does have a number of advantages including an inherent property right assignment, limited spatial scale so the data on various areas, components and trends can be effectively catalogued and tracked providing full traceability and full accountability in a practical system which provides integrated consideration of all related conditions (= ecologically-based management) (Agatsuma 2004).

Figure 18: Japanese urchin fishermen at work.

Urchin fisheries in Japan are concentrated in Hokkaido and Honshu, particularly in northern prefectures facing the Pacific Ocean and to a lessor extent in Kyushu in Southern Japan (Figure 20). Hokkaido accounted for about 48% of the nation's total landings in 1997. The catch in Hokkaido began to decline in the mid-1980's and then fell sharply between 1988 and 1991, mainly due to a decline in *S. intermedius* but also to a lessor degree to *S. nudus*, the two most important species in Japan's urchin fisheries. The catch also declined in Miyagi, about half way down the east coast of Honshu Island towards Tokyo, so that now the landings of *S. nudus* are only half of what they were in 1982.

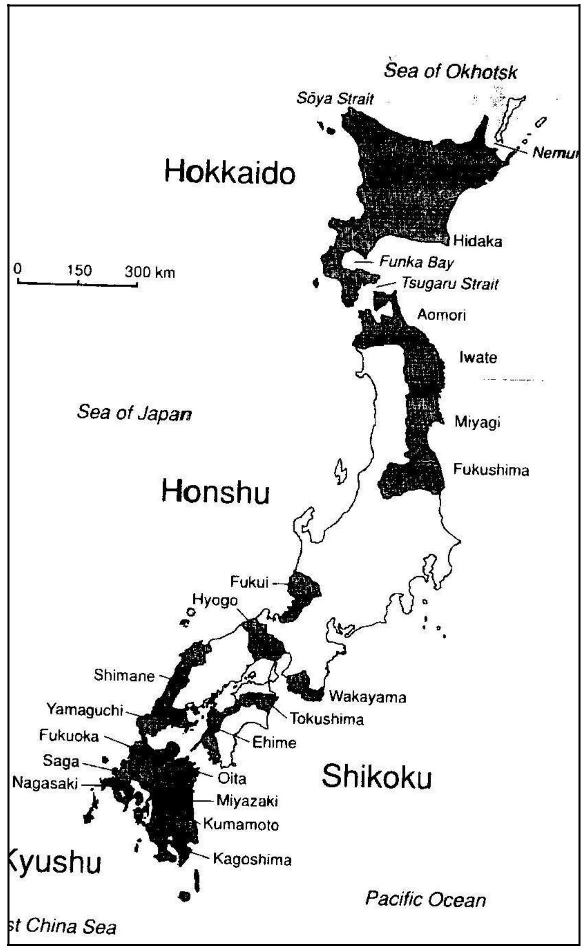

Figure 20: Map of Japan showing the most important urchin producing areas (shaded) (Andrew et al 2002).

5.2.1 Fisheries Management

Japan is one of the great fishing nations of the world and has a long and successful history of community based fisheries management in their territorial waters. Pelagic fisheries are managed by a licensing system similar to that used in Canada and other western jurisdictions, and will not be further discussed in this document. The inshore coastal fisheries of Japan produce nearly 1/3 of the total national catch, or about 4 million MT, each year representing nearly 50% of the total catch value (Pinkerton and Weinstein, 1995). These fisheries are managed through a unique community based system that has its origins in feudal times before the dawn of the 19th Century, but which nonetheless incorporates many progressive attributes.

The management model used for the inshore fisheries in Japan considered by many as the leading example of a system based on fully endowed legal rights for the users of the resource over discrete and legally defined areas. This applies particularly to sedentary resources such as sea urchins, bivalves and seaweed, which are inherently easy to manage on a territorial basis.

Under the Japanese fishery management regime community based cooperatives, termed Fishery Cooperative Associations (FCAs) are at the centre of fisheries management and provide for an unprecedented level of successful self-management. The system advances stewardship among the fishing community and sustainability of the fishery resources and the communities that depend upon it. Independent fisheries cooperatives purchase and release seedlings, maintain the grounds and harvest, process and wholesale their own product (Masuda and Tsukamoto 1998). The primary objective of the system is to ensure the optimal use of the resources and the provision of equal opportunity for member fishers (Pinkerton and Weinstein, 1995).

The inshore fisheries management system is fully linked, democratic and transparent. There are three levels involved in the management regime:

- ✧ Prefectural Fishing Agencies: administrative bodies representing the prefectoral governors which retain the legal authority for inshore resource management. These agencies set the general rules of operation and are obligated to heed the recommendations and plans of the Regulatory Commissions. The respective fishing rights are granted by the prefectoral government through the agency for 10 year terms, again, according to the advice of the Sea Area Regulatory Commission. The Agencies also take the lead in R&D efforts on aquaculture, enhancement and ranching.

- ✧ Sea Area Regulatory Commissions: regional regulatory bodies jointly appointed by government and industry for each of the 65 administrative zones in Japanese inshore waters. These agencies prepare coordinated regional management plans and make recommendations concerning rights and licences to the prefectoral governor. The members of these bodies are elected from the fishing community and are appointed by the government as experts to conduct public hearings and collect pertinent information needed to advise the government.

- ✧ Fishery Cooperative Associations FCAs : FCAs are more than just fishing associations as we know them. They are the sole entities that hold, or can even legally hold, joint fishing rights over prescribed areas. Each FCA holds exclusive rights to the harvest of designated resources, and extensive management responsibilities towards those resources, in a defined territory and is responsible to designate the distribution of those rights to their membership. The transfer of the fishing Rights is under strict legal control and subject to review by the FCA membership to ensure that dominance of the industry by powerful interests is precluded, and that the economic benefits from the fishery accrue largely to the fishing community as opposed to brokers, marketers and/or arbitragers.

In 1990, there were 2,127 FCAs with a collective membership of about 535,000. These numbers had declined to 1,766 and 260,200 respectively by November 1, 2000 reflecting the discontinuance of business by a number of the FCA's caused by aging of the participants and a lack of successors (Anon 2004). At any rate, these FCAs are organized into 43 prefectural associations and represented through a single national association. Each FCA reviews the Agency's general plans and then formulates a detailed fishing plan for each of the Rights that they own. The FCAs have the most in-depth knowledge of local stocks and conditions, and sometimes enact more stringent regulations than those passed down from above. These plans are ratified by the membership and approved by the prefectural government.

All of the generalized indices for the fisheries involved indicate that the management system is very successful. All fishers participating in an inshore fishery must be members of an FCA and all are accountable to themselves and each other as their absolute dependence on the resource(s) means they have to live with their management decisions and have only themselves to blame for bad choices. The production levels appear generally sustainable and the economic value of the fisheries continued trending upwards, despite the continued loss of habitat because of industrial expansion and pollution. The industry has managed to keep pace because of the innovative use of aquaculture, ranching and habitat enhancement techniques (Pinkerton and Weinstein, 1995).

Japan's agriculture and fishing industries have been declining in recent decades, in part because opportunities in financial or more highly technical (electronics, engineering, etc) careers has been increasing attracting young people entering the workforce while fishing and farming were seen as more staid and less exciting. In 1960 fishing employed 1.5% of the working population but this had dropped to 0.43%, or about 280,000 people, by 1994 and to 0.39% , or 260,000 people, by 1997.

Japan has a relatively high wage structure with significant variations by education, age/seniority and position although the occupational wage differentials are much smaller than in most countries. Workers earn an average base wage of about ¥ 30,000/ month, representing approximately 58% of the total wage costs while annual summer and year-end bonuses add about another 34% (Anon 2001.- FY 2001: Country Commercial Guide: Japan. US State Dep't).

Japan is also leading the world with regard to its demographic ageing and the number of deaths is expected to exceed the number of births in Japan this year (2005) meaning Japan's population is set to begin falling two years earlier than previously forecast (Anon 2005). Given the decreasing number and rapid ageing of workers, particularly in the agricultural and fisheries sectors (including processing) and faced with some of the world's highest operating costs domestically, many firms in the first half of the 1990's established new factories which produce products specifically for the wants and needs of the Japanese market in countries with lower labour and material costs such as China, Thailand and Indonesia. This trend weakened somewhat in the late 1990's because of the troubles being encountered by many Asian economies, but has since started picking up again. Despite the problems in the late 1990's, Asia remains fastest-growing regional economy in the world (J. Payne Pers comm 2003).

Manufacturers in Japan are at a minimum designing production to minimize labour inputs ensuring increased demand for capital-intensive, high value-added manufacturing even as the offshore migration of production capacity is continuing in the food and seafood processing sector. Japanese research and development expenditures are the highest in the world but are being increasingly invested in overseas facilities. Japan has currently invested more than US$140 million invested in the Chinese food industry, a figure which has increased by more than US$130 million since 1990.

5.2.2 Fisheries research

Each prefecture in Japan has at least one fisheries research station. Fisheries are more important in Hokkaido though and there is a total 8 such stations, such as the one from Otaru, Hokkaido (Figure 21) located on the island. This station is similar in scale to the Pacific Biological Station in Nanaimo. The scientific staff undertake applied and basic research which is related to the fisheries production in the area, including aquaculture technology development, artificial habitat design, testing and deployment for stock enhancement (abalone condominiums, squid egg laying lairs etc.), artificial reefs (for kelp, urchins, pinto abalone and finfish etc), hatchery services for a variety of species, oceanographic instrumentation etc.

Figure 21: The Hokkaido fisheries research station just outside of Otaru north of Sapporo, Hokkaido.

The economic value of these institutions is undeniable, not just because of the intrinsic value of the scientific operations undertaken but also because of the resulting increase in the fisheries production *vis a vis* that found in other jurisdictions. Contrast, for example, the total fisheries production from wild and cultured fisheries in Hokkaido and British Columbia. Hokkaido produced about 1.7 million MT of seafood in 2000 worth an estimated ¥ 297.5 billion, or about $C 3.72 billion using an exchange rate of 80 ¥/$C over 3,036 km of coastline. This works out to an average production volume of about 559.95 MT of seafood worth about $C 1,225,295 for each kilometre of coastline each year. BC on the other hand produced 304,000 MT of seafood worth about $C 1 billion over its 27,200 km coastline. The average BC production volume and value of 11.18 MT/km and $36,765/km correspond to about 1.9% and 3% of Hokkaido's production volume and value respectively, suggesting there is considerable unrealized production capacity in BC unless one is willing to concede immense differences in the inherent marine productivity capacities in the two areas.

The East Coast of Japan is affected by the Kuroshio Current, a so-called western boundary current system the likes of which are also seen along the east coast of Canada and the NE United States with the Gulf Stream and in the Southern areas of the Chilean coast. The steady and intense current flows make these areas amongst the most productive fishing areas in the world. In Japan, the Kuroshio current runs northwards all year up the East coast of Japan, bringing a whole variety of conditions through the year. The average temperature of the waters around Hokkaido changes from around 0° C in January to as high as 15 - 20° C in July (Anon 1983). Further south off Tokyo, the seasonal averages are 10 - 15°C in the summer and 20 - 25° C in the summer.

5.2.3 Operations

The Japanese coastline is intensively developed with ports or boat basins spaced at very short intervals meaning that the product can be on the dock and loaded into a controlled temperature environment within a very few hours of harvest, meaning the product quality is near pristine. The

Figure 22: mid-size inshore fishing vessel in Japan.

vessels used in the fishery cover a range of designs from open 6 - 8 m. skiffs powered by outboard engines (Figure 19) to 14 -17 m vessels (Figure 22) which can be used for a variety of tasks and fisheries under the purview of the FCA. The vessel to the left looked to be travelling (planing) at something between 20 and 25 knots and was leaving only a very small wake, suggesting a highly efficient hull design. This seems to be very common vessel in eastern Hokkaido. and was observed, along with a variety of other work boat designs, at a number of boat basins seen around Hokkaido.

5.2.3.1 Harbour facilities: Hanosaki Harbour

Just as impressive as the vessels are the fishing port facilities. A delegation representing PUHA and the WCGUA viewed the unloading facilities and the tail end of an urchin packer unloading operation in Hanosaki Harbour just outside of Nemuro on the east coast of Hokkaido (Figure 23). The port is a major fishing harbour and services a number of domestic and foreign fishing vessels, landing sea urchins, crab, salmon, pollock, cod, scallops, clams etc. This port is on the southern coast of the Nemuro Peninsula and, because it is only about 30 miles from the Southwestern end of the Kurile Islands, is the main landing port for the IUU urchin fishery conducted in these islands by Russian fishermen.

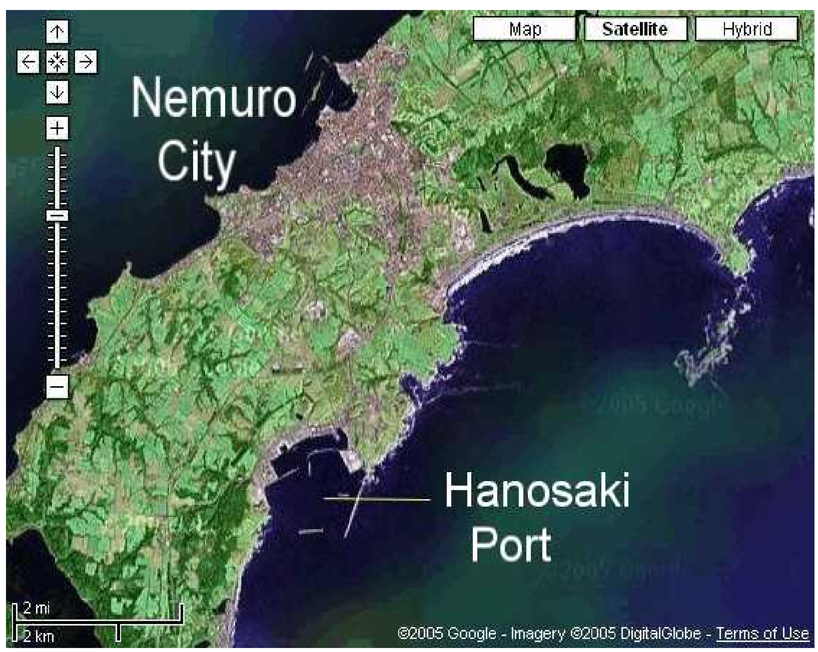

Figure 23: Mid-scale satellite shot of Nemuro and Hanosaki.

The harbour itself comprises a well developed basin approximately 2.5 km^2 surrounded on many sides by concrete jetties where the vessels are unloaded and the fishermen's equipment serviced (Figure 24). The author has visited perhaps a dozen

Figure 24: Smaller scale satellite view of Hanosaki Port.

fishing harbours in Japan and the design and materials used seem to be pretty consistent throughout. The tidal range in the area is apparently less than 2 metres (NOAA Tide predictor) so there is less of a need for floats as would be required in BC where the range is two to three times greater. As a bit of a side note, this harbour is apparently dedicated to commercial fishing traffic, including Coast Guard vessels, and no recreational vessels were seen in the harbour, a situation which is increasingly rare in Canada.

The approaches to the harbour are protected by a series of breakwaters and construction of harbour infrastructure is ongoing. There are six main jetty areas including an outer jetty for unloading large trap and trawl vessels (250 to 450'), a ~0.5 km^2 sub-basin on the NE part of the harbour for smaller fishing vessels (~ 35 - 80'), the main unloading basin with a number of warehouse facilities etc and a vessel storage area in the central part of the harbour. There is another jetty along the western edge of the harbour where foreign vessels were tied up and re-supplied during their stay.

There were probably several hundred vessels in the harbour including perhaps 75 Japanese vessels, including squid boats (length ~ 80') and other vessels ranging in size from about 40 -150', which were run up on rails onshore for winter storage. There appeared to be number of buildings where the vessels could be worked on around the perimeter of these areas. There are also a number of fuel depots (Figure 25) and chandlery businesses in the area, supporting the claim that fishing harbours in Japan are unfailingly impressive in the extent and calibre of the facilities they provide to the commercial fleets.

Figure 25: Fuel storage silos along eastern shore of Hanosaki Harbour. Note also the Japanese inshore fishing vessels (~40 - 50') used by local FCA's.

The main unloading area in Hanosaki Harbour is at the back of the main sub-basin in behind an inner (secondary?) breakwater, which can be seen in Figure 24, and which is just now being extended. This jetty is backed by a number of fairly large buildings (Figure 26) where the products

Figure 26: Main unloading jetty backed by the Hanosaki Fisheries Cooperative warehouse and with the winter storage rails to the left.

are warehoused prior to being loaded on trucks and shipped out for processing and distribution. All of the imported product landed at Hanosaki, including the IUU Russian product brought in from the Kuriles, is loaded into warehouses where it is held until all of the import taxes are paid.

Because fishing, delivery, wholesale marketing and sometimes the processing are all coordinated by the FCA, one can anticipate that the Just in Time logistics and inventory guidelines developed and perfected by Japanese industry are consistently applied so the only as much product as can be reasonably and dependably processed and sold in a timely fashion is actually harvested.

Figure 27: Nested urchin cages ready for loading and stowage on a Russian packer.

The urchins are packed in cages, in some cases supplied by the Japanese processors but likely in other cases actually owned by the FCA The same totes are used in the domestic and the Russian fishermen. Each tote holds about 35 kg of urchins and is designed so that when empty, the cages nest so they take up less space (Figure 27). They each have a pair of rotatable handles which are moved to cover the top of the cages once they are filled with urchins (Figure 28) so the weight of overlying cages is supported by the cage as opposed to pressuring and crushing the urchins.

Figure 28: Stacked cages with handles in filled configuration.

Trucks equipped with reefers pick the product up from the dockside warehouse when product is landed at Hanosaki, although the situation is likely somewhat different at other smaller ports where only domestic product is landed and which do not accept any imports. The totes are moved out of the warehouse using a forklift which then lifts it up to the truck bed where they are hand-packed into the truck. The vehicles we witnessed were taking product to a variety of processors and seemed to be each packing somewhere in the neighbourhood of 3 - 5 MT , suggesting the processing plants are small, but numerous.

5.3 Chile

Chile's sea urchin fisheries are the largest in the world and have been contributing more than 50% of the world's production since the mid-1990's. The fishery grew from an average of just under 20, 000 MT/yr during the 1980's to 30,000 MT/yr ib 1993 and 40,000 MT in 1994. Production since has stayed in a range between about 40,000 - 60,000 MT yr. (Figure 29).
Establishing a sustainable fishery at this level might seem a bit much for a Less Developed Country such as Chile but the country is quite advanced in a number of ways. Chile prides itself on applying the Rule of Law more rigorously than its neighbours (Anon 2006). Michelle Bache let is poised to become Chile's first woman president and is a symbol of the healing the country has undergone as it recovers from he Pinochet dictatorship. The economy grew by 6% last year, primarily because of the soaring price for copper, its main export, and "Chile Inc." is run with an efficiency only rarely seen in this part of the world, impressing with new highways and supermarkets carrying just about everything springing up everywhere. Poverty has fallen to 18% currently from 39% in 1990 and the rule of law has been largely re-established in the country (Jimenez 2006).

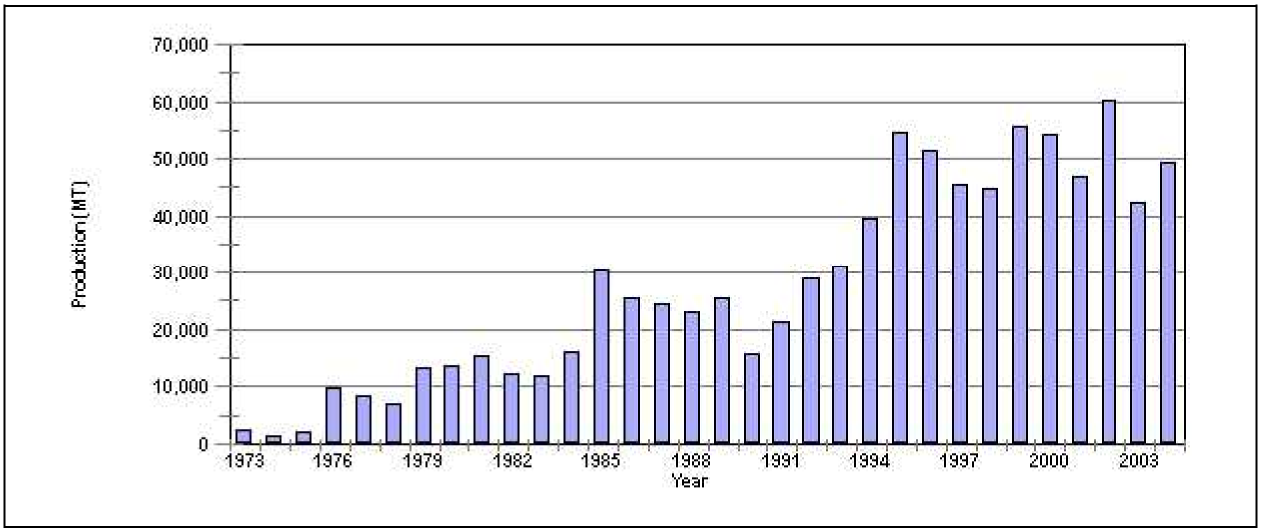

Figure 29: Recent production history for sea urchins in Chile (FAO and Senepesca (2004))

The Chilean sea urchin (*Loxechinus albus*) is distributed along the west coast of South America from Peru in the north to Tierra del Fuego in the south and is considered highly exploited in Chile. Genetic studies have found no significant genetic differences in populations sampled from 23° S, 37° S and 53° S leading to the conclusion that these populations comprise a single stock and supporting the contention that there are no gene flow interruptions along the coast despite the zone restricting the larvae transport where the West Wind Drift Current hits the coast and splits into a northerly and southerly components between about 40° and 45° S. This provides support for the stepping stones distribution model which depends on incremental advances further from the source as a species becomes better established in an area.

Urchin fisheries are present all along the length of Chile's coast but about 95% of the landings come from the three most southern areas of the country (Figure 30) (Stotz 2004). The fisheries in

Areas I through III (Northern third of the country), IV through IX (central) and X through XII (the Patagonian Archipelago etc) have averaged between about 1,500 to 2,000 tons, about 500 tons and about 50,000 tons per year respectively since the early 1990's (Stotz 2004). This compares with about 4,885 MT/yr for the entire BC RSU fishery and 200 t/yr for the BC GSU fishery.

Chilean urchin landings have remained relatively stable since 1999. According to Sernapesca, the Chilean National Fisheries Service, landings for urchins was estimated at 49,228 tonnes in 2004, mainly from the southern part of Chile, the XII Region, (22,514 MT), X Region (13,368 MT) and the XI Region (6085 MT). Other urchin landings were concentrated in northern Chile, mainly in the II Region (4600 MT) and I Region (1738 MT) (R. Pouffe. Pers. Comm. Dec. 2005). According to one urchin producer from Chile, approximately 60% of their production is sold fresh (locally?) while the rest is sold frozen. The fresh uni is valued at US$28/kg while frozen product is valued at US$22/kg.

According to figures in the 2004 Fishing and Aquaculture Consolidated Sectorial Report from Subpesca , the Chilean Fisheries Sub-secretariat, 98% of the Chilean urchin catch is exported to Japan. In 2004, total earnings from urchin exports totalled FOB US$67M. Urchin exports in the September 2005 quarter were valued at FOB US$42M.

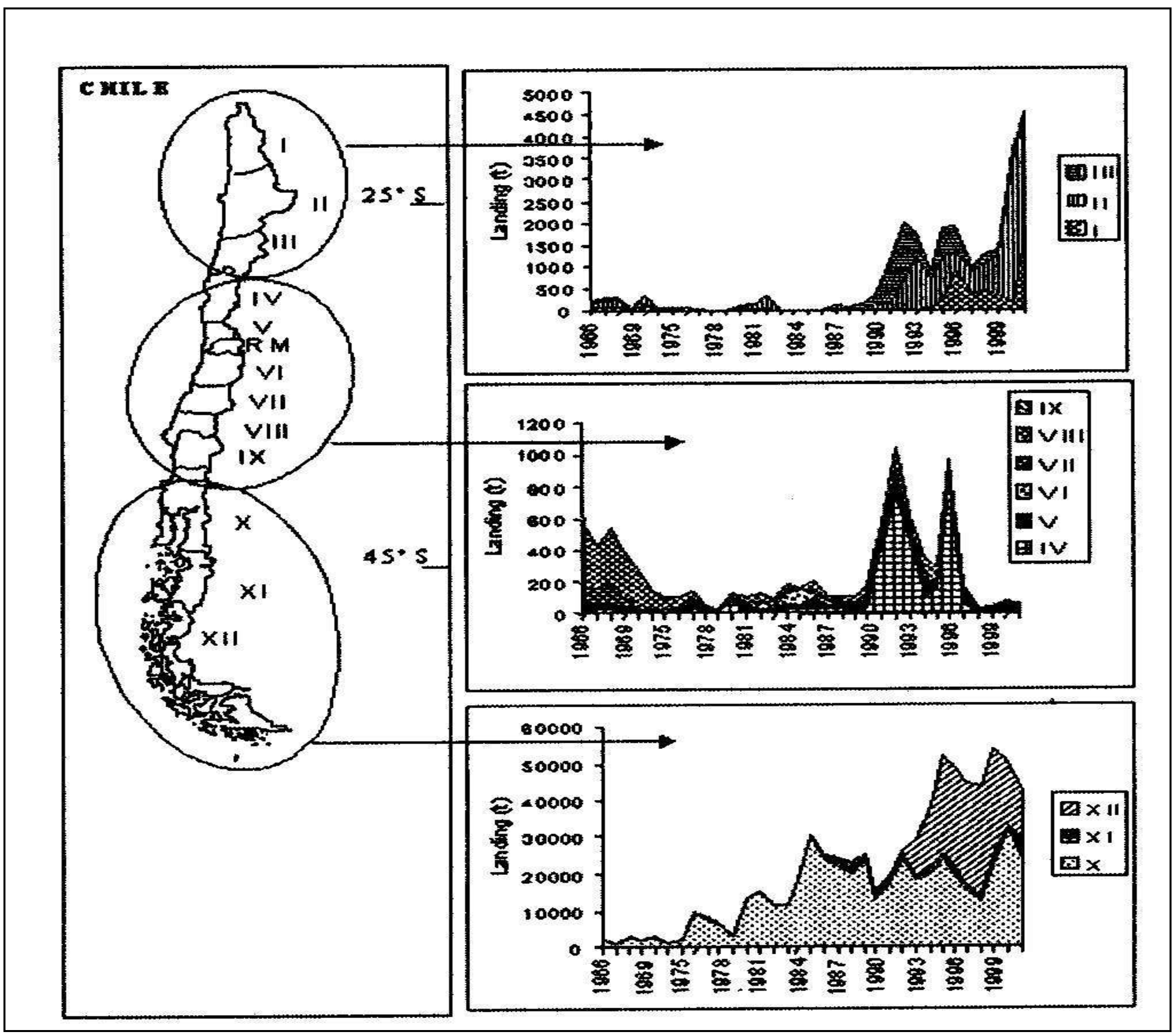

Figure 30: Chilean coast with regions and urchin catch history (Stotz 2004).

5.3.1 Development of Chile's Fishery

The main fishing zone in the south is known as South Patagonia (Figure 31), an area comprising approximately 3,000 islands and a multitude of channels which runs down the fjord-lined west coast from Puerto Montt to Cape Horn at the Southern extension of the Americas. This area includes the Magellan Straits - a major shipping lane connecting the Atlantic and Pacific Oceans lying about 350 km north of Cape Horn. The coastline in Northern and Central Chile by contrast largely comprises cliff-faces rising abruptly from the shoreline which then form an unbroken wall, largely devoid of harbours, some hundreds of miles long.

The large-scale fishery got its start in 1975, starting in Area X at the northern end of the Patagonia region with landings of about 10,000 t/yr. It quickly moved into Areas XI and XII in years 2 and 3, boosting its production capacity by adding new fishing areas. Production seemed to increase in waves, with a big jump in one year followed by a fall-down in production over the next few and then another increase as the fleet extended it reach again into new richer areas (Stotz 2004). This sort of scenario is generally known as serial depletion and results in lower catches with greater variability between years as the stocks are fished down to the point of not being able to renew themselves. The catch in Areas XI and XII was not attributed to those areas at first because the it was landed and registered at ports in Area X. The fishery only officially moved into Area XII in 1995, again displaying the same pattern of successive development of fishing zones.

Figure 31: Main urchin fishing areas in southern Chile.

The main landing ports for the Southern Area (Areas X through XII) are Puerto Fatales, Punta Arenas and Puerto Williams, depending on where the fishing is actually occurring (Stotz 2004). It appears that these ports are separated by distances approaching 200 - 300 miles meaning that the packers used to transport the urchins from the grounds to the plants must be packing product about the same sort of distances as packers on the North and Central coast of BC. A difference between the two jurisdictions though is that the processing plants in Chile are located in the same towns where the product is landed whereas product landed in northern BC the product must be trucked for a further 20 hours from Prince Rupert to the Lower mainland for processing.

5.3.2 Fishing Operations

Over 60 species of invertebrates, including the Chilean red sea urchin *L. albus*, are harvested in Chile by about 70,000 artisanal fishers, a number which includes more than 10,000 registered divers (Castilla et al 1998). The primary capture method used in the fishery is by divers on hookah. The fishery in the south uses vessels (Figure 32) 7-9 m (21- 28 ft) long, generally with a cabin so the divers and crews can live on the boat during the fishing season although they also set up beach camps so they have a bit more room. The same sort of vessels are used in the North and Central areas of the country, although they do not generally have cabins as these fisheries are better characterized as day fisheries from which the fishermen return to their ports each night (Stotz 2004).

Figure 32: urchin dive vessel in use in Southern Chile.

Many of the operations in the North and Central parts of the country depend more on intertidal collections of urchins by independent or loosely organized groups of fishermen at low tides (Stotz 2004). These fishermen also generally then return to their home ports daily and sell their catch into local markets for the tourist or other small scale specialist trade (high relative value, low volume) although some dive operations in the northern area (Areas I - III) sell at least part of their catch to large processors for export. Fishermen fishing for expert receive only about 10 - 15% of the price on a unit basis as they do when selling smaller volumes for the local market but they can move much higher volumes (Stotz 2004).

The fishery in the Central area is generally restricted to a few days each year when the weather is calm because the target urchins are found mainly in dense aggregations in the surge (intertidal and upper sub-tidal) zone. Urchins living in deeper areas along this part of the coast are quickly eaten by the Rock Shrimp *Rhynchocinetes typus* so their distribution is best described as patchy. Under a conventional management regime, any aggregations encountered are totally cleaned up as the fishermen have no incentive to restrict their harvest because if they left any urchins, someone else would just come along and clean them up. The upshot of this was that the reproductive capacity of the stock was eliminated for many years before the aggregation would again be reestablished. In these circumstances, significant harvests are recorded only once or perhaps twice each decade, even in what might considered dependable sites, and the fishery is forced to move to different sites each year. Harvesting only a portion of the aggregation has a number of acknowledged advantages, including more stable and higher average productivity, and an innovative management system

Figure 33: Chilean diver with dive bag.

involving exclusive area rights is being expanded to provide the required incentives to conserve accessible portions of the stock for subsequent stock renewal.

The fishery operations in the southern parts of the country, by contrast, use divers (Figure 33) who are not independent but are instead most often employed by a processing company. The fleet in these operations moves around and through the area setting up transient ports or camps (Figure 34) where each days's harvest is transferred to a larger packer (Figure 35) which also provisions the dive boats. The large companies front the fishermen their operating expenses, often in the form of a loan, which is then deducted from the fishermen's wages during the season. The fishermen are then obligated to, and therefore working for, a single processor throughout the season.

All, or at least most, of the production from the larger producers is frozen for export, primarily to Japan, and these operations can be fairly characterized as industrial (low value, high volume) in comparison to the more northerly urchin fisheries which, as mentioned above, generally produce smaller amounts of higher value products for local sale. The landed prices for the high production fisheries ranges from about US$ 0.21 - 0.36 per dozen while good prices for production destined for the local markets range from about US$ 0.25- 0.35 per urchin, or US$ 3.00 - 4.20 per dozen (Stotz 2004).

Figure 34: Chilean urchin harvesters beach camp.

Figure 35: Larger Chilean fishing vessel more typical of the packers used in the urchin fishery.

5.3.3 Fisheries Management in Chile

The country has a well established fisheries management and regulation regime but the enforcement has not been notably successful. Chilean fisheries authorities themselves suggest that many catches are likely not reported and that the statistics do not represent the true economic and social values of the fishery. Chilean fisheries authorities project the eventual emergence of highly fluctuating catches of between 2,000 to 24,000 t/year for the Area XII fishery, as opposed to a fairly steady 20- 25,000 MT/yr, if the current management regime, based largely on size and season restrictions, is not improved (Stotz 2004).

The Minimum Legal Size Limit for Sea Urchins in Chile is 70 mm TD a size which provides assurance that the urchins will have a chance to spawn at least once or twice before being caught. Unfortunately, enforcement of this limit is lax and this guideline is not respected as well as it should. When the fishery was focussed on virgin stocks this limit was not restrictive but now that the stocks are being fished down more much of the catch comprises urchins down to 50 mm TD or less (Stotz 2004). The closed seasons for the various areas are:

XII Region: a 7 month closed season from running from August 15 to March 15;
X and XI Regions: 3 month closed season from October 16 to January 14 and an open season between January 15 and October 15 but with quotas; for example in 2005 the quotas are 7200 MT for the X Region and 12,000 MT for the XI Region; and
For the rest of the country: 3 month closed season from October 16 to January 14 without quotas.

5.3.4 Sustainability

Knowledge on Chile's urchin resource and fisheries, particularly in the southern area, is very poor although it is fairly widely acknowledged that the catch of urchins is expected to, at best, remain fairly much the same or, somewhat more likely, fall even with the annual closed season. Chilean authorities have been advised that the fishery under the current system is not sustainable and that, as a minimum, the currently applied measures to protect the reproductive capacities of the stocks (legal size @ 70 mm, seasonal closures) must be augmented with measures to:

- restrict the number of divers (limited entry);
- advance fishing area rotation;
- establish quotas; and
- control the above criteria through transport vessels.

The species itself is not likely to be threatened with extinction because of the presence of a couple of natural refuges, but the viability and sustainability of the commercial fishing activity is at risk (Stotz 2004). The first of the refuges includes extensive areas where the urchin densities are not high enough to be commercially interesting while the other comprises a number of areas where the colour of the uni is too dark to be of any value. A large population of sea urchins in the south of Chile have brown gonads and therefore have no value as an export item because the Japanese markets has stringent quality requirements with regard to colour, taste and texture.

Interestingly, taste tests comparing the brown and yellow gonads using a trained tasting panel in Chile found no significant taste or texture differences between the two (Bustos et al 2004). The most interesting point here may be the simple presence and use of the trained tasting panel by the industry in Chile. This has been proposed for the Canadian industry as part of the effort to develop a uniform grading system but some resistance from processors has slowed the process.

The management regime in the southern areas of Chile are apparently in transition because of inadequacies in the enforcement or in the attention given to it by the fishermen. The Fishing Administration is looking to reconcile the interests of the more mobile fleet and artisanal groups which are both accessing the fishery in localized areas with the need to more effectively and efficiently manage the resource on a sustainable basis using a more consensual management, or perhaps co-management, mechanism.

One of the more important issues facing the fishery is the number of un-registered divers involved. Economists have estimated that the Area XII fishery could, based on the record landings recorded in 1999, support about 428 divers and crew getting a minimum salary. That same year, 2,013 people were officially registered as participants in the fishery. However, other independent estimates of the total number of people involved that year concluded that only 40% were actually registered suggesting that there were between 5,500 and 7,848 people working in that area that year (Stotz 2004). This makes it more difficult to enforce the regulations as nobody really has too much at risk and nobody loses too much if the whole thing collapses.

5.3.4 Innovative Management

The fishery in the Central area is generally restricted to a few days each year when the weather is calm because the target urchins are found mainly in dense aggregations in the surge (intertidal and upper sub-tidal) zone. Urchins living in deeper areas along this part of the coast are quickly eaten by the Rock Shrimp *Rhynchocinetes typus* so their distribution is best described as patchy. Under a conventional management regime, any aggregations encountered are totally cleaned up as the fishermen have no incentive to restrict their harvest because if they leave any urchins, someone else will come along and clean them up. The upshot of this is that the reproductive capacity of the stock is eliminated and it takes many years to re-establish the aggregation. In these circumstances, significant harvests are recorded only once or perhaps twice each decade, even in what might considered dependable sites, and the fishery is forced to move to different sites each year. Harvesting only a portion of the aggregation has a number of acknowledged advantages, including more stable and higher average productivity, and exclusive area rights provide the required incentives to conserve accessible portions of the stock for subsequent stock renewal.

Chilean authorities have recently started to experiment with area management strategies in at least the central areas of the country by granting exclusive rights to harvest defined geographical areas of coast are given to an organization of fishermen (Stotz 2004). This is similar to the rights-based regime strategy that has been used in Japan for many centuries and represents a distinct move away from the Olympic style fishery management strategy that has been pursued until recently in the country. It is being adopted first in the Central Region because the fishery in this area is generally directed to local markets whereas the fisheries in the North and South Areas are much larger scale and target the export market through the large processing companies.

The Chilean Fishery and Aquaculture Law was passed in 1991 with of aim of providing the necessary management tools to ensure rational and sustainable exploitation of the country's small scale fishery resources. This law contains two sets of regulations. The first set resolves past conflict between artisanal and company owned (industrial) fleets by assigning exclusive fishing access rights to grounds within 8 km of shore to the artisanal fleet. The artisanal fleet comprised about 11,000 vessels, including about 9,000 7-8 m long wooden boats with crews of 2- 4, in 1998. The second regulation relates more specifically to the benthic resources, including sea urchins, clams, kelp, etc, by allowing the assignment of exclusive rights to inshore sea bottom fishery resources on defined Management and Exploitation Areas (MEAs) to registered organizations or communities of artisanal fishers. Traditional small scale unions known as syndicatos and comprising at least 25 members organized around artisanal, technical or professional activities, have been around for some decades. They operate in the fisheries context in many small coastal villages, where they are known as Caletas, and are eligible to adopt and co-manage a local MEA. By 1998 there were about 190 active and recognized caletas and typical memberships listed include one with 139 members with 24 summer and 42 winter registered divers and 31 7-8 m vessels, another with 90 members with 25 and 36 summer and winter registered divers with 28 wooden vessels to another with 27 members with 15 summer and 26 winter registered divers and a fleet of 25 wooden vessels (Castilla et al 1998).

5.3.5 Enhancement

Urchin hatchery technology is being studied at the experimental and semi massive scale in Chile at institutes such as the Instituto de Fomento Pesquero in Puerto Montt, Chile. Their facilities now produce about 4 million seed with a 5 mm diameter per year but while efficiency improvements at all stages provide opportunities to increase this number, its economic justification as a commercial venture depends on demand for the seed from industry and on industry's ability and willingness to pay. A number of the artisanal fishing groups which have property rights in the fishery are expressing rising interest in using hatchery production to increase their productivity (Carcamo 2004). The farmed sea urchin sector is still in its early stages of development, although it is worth mentioning that in the last decade, a rising number of R&D projects have been carried out to diversify into cultivated/farmed sea urchins in order to diminish commercial extraction (R. Pouffe. Pers Comm. Dec. 2005).

5.4 United States

The United States has commercial fisheries on the east and west coasts. Red Sea Urchins (*S. franciscanus*) are fished in California, Washington, Oregon and Alaska while Green Sea Urchins (*S. droebachiensis*) are fished in Maine and Alaska. The production history is illustrated in Figure 36.

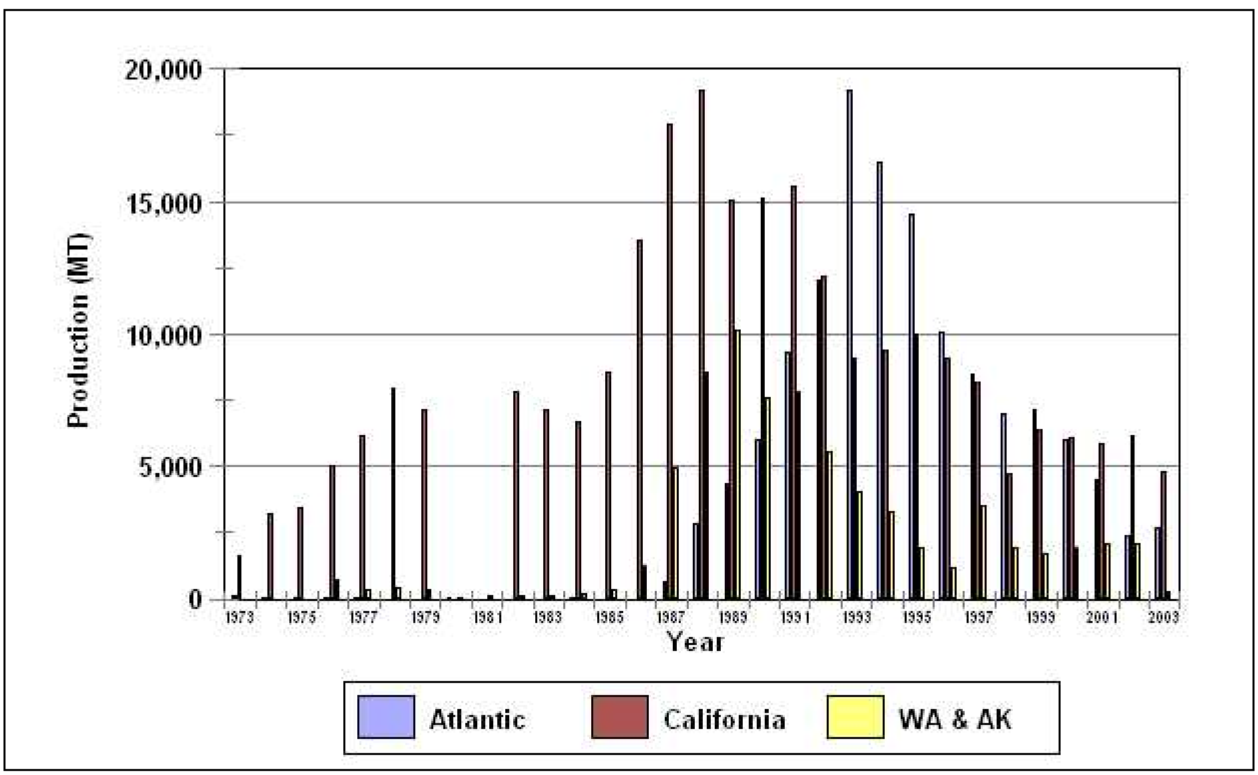

Figure 36: Production history US sea urchin fisheries.

5.4.1 California

California has a large established fishery for red sea urchins and is currently the benchmark supplier of high quality Red Sea Urchin roe to the Japanese market, both in terms of volume and value. The red urchin fishery in California was for many years the largest and most valuable commercial fishery in the state, even though production has declined from a peak of about 22,000 MT in 1990 to about 10,000 MT in 1994 and saw further decline to about 5,813 MT by 1999. The fishery is exclusively a dive fishery with divers typically working either alone or in pairs using surface supplied air and a line tender.

The California fishery is probably most correctly considered as two fisheries, one north of Point Conception and one to the south(Figure 37), each with different characteristics and diverging production histories (Figure 38). There is a large suitable area for sea urchins off at least its southern coast extending out to the Channel Islands whereas in the northern California fishery the sea urchins are taken off a relatively narrow strip of subtidal reef from the intertidal to a depth of about 22 metres. Sea otters are abundant on the central coast and there are, as a consequence, few harvest able urchins in those areas. The habitats preferred by the urchins broadly coincide with the bull kelp, *Nereocystis leutkeana*, in the north , an area estimated to cumulatively cover about 14.5 km^2 while in the south an analogous estimate is made using the *Macrocystis pyrifera* coverage, and are estimated at 45 km^2. These kelps comprise the major feed resource for the urchins areas and the quality of the uni is impacted by warm water, particularly during El Ninos because the warm water damages very hard on the Macrocystis and therefore on the knocks the gonad quality down.

Figure 37: Map of California showing southern and northern oceanographic areas separated at Pnt. Conception.

Production of red sea urchin was very high when the fishery first opened on virgin stocks, first off in Southern California in 1971 and then in Northern California in 1985. Although the fishery ranges over a wide area, effort has focussed on small hot spots that change through time (Andrew et al 2002). The fishery saw peak

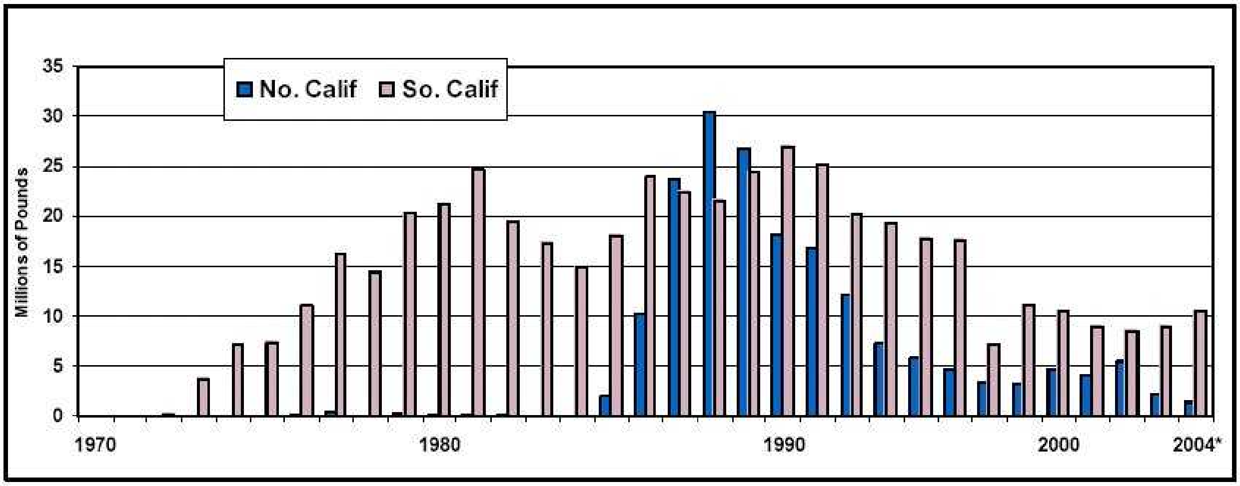

Figure 38: RSU landings history for N. and S. California sea urchin fisheries (CDFG 2005).

production levels around 11,312 MT by 1980 in the south and 13,575 MT by 1988 in the north. Production has since dropped to less than 6,000 MT annually, with the greatest drop occurring in the North. The fishery in the South appears to be more steady, probably because the water circulation and eddy patterns in the Southern California Bight favour larval retention and increasing larval settlement but also because of the additional suitable habitat provided by the Channel Islands (Dewees 2004). Other factors are the seasonality of the drift kelp abundance at sites and the algal standing crops north Point Conception are low relative to sites further south (Tegner 2001).

Despite remaining productive in the south, harvestable stocks have apparently been in decline since about 1990. Fishing has reduced the density in many areas as the accumulated stocks are fished down but so far, strong, localized recruitment has thus far replenished the population. This has left the fishery increasingly dependant on recruitment to sustain harvests (Andrew et al 2002). There has been some talk of enhancing red sea urchin stocks in California but no one is willing to spend money in an area where anyone else can move in and reap the benefits of that effort. There are no legislative plans to assign any kind of area tenure - and without that there are just no incentives and it just will not fly.

5.4.1.1 Product Quality and Value

The relationship between the fishermen and the processors in California is, as in most fisheries, difficult. When the fishery was young, processors in California took full advantage of the harvesters preconceptions about the value of the urchins when they were still considered a pest and made very nice margins on product they were only paying $0.08 per pound for during the first 5 years of the fishery. Now that the fishers have more experience and knowledge about the fishery, this has steadied out a bit and the ex-vessel prices averaged $0.60/lb in 2004 (CDFG 2005) although spot prices are occasionally much higher or lower (Table 3).

A large focus for sales into Japan remains the sushi restaurant trade as ongoing monitoring reports a net increase of 300 restaurants per year (Chambers 2005). One of the California quality criteria was a smaller sized roe skein which was well suited for the end use as sushi in Japan. BC initially

Table 3: 2004 landed prices in California.

Price	Receipts	Pounds	%
$0-0.1	40	26,856	0.2%
0.1-0.2	344	322,673	2.7%
0.2-0.3	217	209,006	1.8%
0.3-0.4	2,439	2,824,761	23.9%
0.4-0.5	465	512,254	4.3%
0.5-0.6	480	440,014	3.7%
0.6-0.7	2,467	1,651,827	14.0%
0.7-0.8	2,488	2,729,877	23.1%
0.8-0.9	1,708	1,877,713	15.9%
0.9-1	625	630,428	5.3%
1-1.1	558	459,698	3.9%
1.1-1.2	101	41,950	0.4%
1.2-1.3	52	37,988	0.3%
1.3-1.4	24	25,093	0.2%
1.4-1.5	10	10,038	0.1%
1.5-1.6	5	2,107	0.0%
1.7-1.8	10	1,463	0.0%
2-2.1	17	394	0.0%
2.5-2.6	2	30	0.0%
>$3	34	2,209	0.0%
Total	**12,086**	**11,806,377**	**100.0%**

fell into a trap of sorts when they started fishing red sea urchins because they harvested whatever they saw and our roe gained the reputation for being too large. The best grades are sold domestically to sushi restaurants and Asian stores in the US while only B grade and lower goes over to Japan any more. Even with this in mind, as a general rule California roe gets a better price than BC roe in Japan. This is no doubt due in part to the California industry's marketing efforts to distinguish the product as superior quality but it also quite likely reflects differences in the between the two fisheries. This may be reflected by the fact that product from Southern California generally obtains a higher price than that from the North (Andrew et al 2002), so there may some inherent quality difference associated with the different water temperatures in southern and northern areas.

It also appears however that the California fishermen recognize the value that is directly inherent in high quality and are focussing on quality while Canadian fishermen are still driven as much by product volumes. The fishing rates are very different in the two jurisdictions with the normal production per diver per day in California between 600-800 pounds for a good diver (B. Steele, pers. comm.) whereas in BC a good diver will generally harvest 4,000 to 5,000 lbs. on an average day. The industry in California also has product available to the market all year round as an important marketing move to maintain their price (Table 4). Divers in California are looking for ways to keep the uni in prime condition, including measuring ambient water temperatures and placing the urchins into chilled water to reduce temperature fluctuations, with the aim of adding a day or two shelf life to make it that much more attractive and easier to market (Chambers 2005).

Table 4: Monthly RSU landings in CA (CDFG 2005)

Month	Receipts	Pounds	Value
Jan	1,200	1,263,970	$823,768
Feb	724	704,208	$428,803
Mar	1,270	1,157,934	$653,512
Apr	815	674,129	$388,334
May	1,016	962,779	$574,249
Jun	858	787,083	$500,137
Jul	639	625,661	$380,265
Aug	1,230	1,260,015	$733,125
Sep	1,201	1,158,628	$677,053
Oct	1,007	998,594	$577,466
Nov	1,251	1,354,088	$820,765
Dec	874	859,251	$518,548
Total	**12,085**	**11,806,340**	**$7,076,026**

The operations in all areas except for the Channel Islands are also characterized as day-fisheries wherein the vessel returns with its harvest to its home port each night and the urchins are generally in the plant within a few hours of being removed from the water. This contrasts to the situation on the North and Central coast in BC where the urchins can be out of the water for upwards of 72 or 96 hours before they reach dock much less the processing plant.

The harvest in California appears to be sustainable in part because the high prices they receive means everyone is willing to limit their harvest rate because they still make a reasonable living. The logical conclusions from this are that conservation depends on high prices and that the fishers, not the processors, have to control the harvest. The processors have shown again and again in California, BC and other jurisdictions that they want to maximize their volume and that they'll force the fishers to sacrifice quality, and the high ex-vessel prices that goes with it, in the pursuit of quantity (P. Helmay, pers. comm.).

5.4.1.2 Fishery management

Active management of the fishery commenced in 1987 with the formation of the Department of Fish and Game (DFG) Director's Sea Urchin Advisory Committee (DSUAC) which comprised appointed representatives from each of the dive and processing sectors, the California Sea Grant Program and a DFG member. DSUAC was mandated to advise DFG on enhancement and management proposals and quickly established itself as an effective forum for consensus-based management of the fishery. Research and monitoring programs implemented under this program were funded through a $0.01/pound landing tax to provide a total of over $1 M over the 15 year existence of the program (1987- 2002) (Dewees 2004). About 50% of this money was directed to monitoring and management of the fishery while the rest was used to fund collaborative research.

The primary initial focus for the Committee was resource enhancement including programs such as seed collection from the wild, hatchery production, out-planting of juveniles, feeding studies to examine the economics of increasing gonad quality and translocation of urchins from food poor to food rich areas. Most of these studies revealed serious economic feasibility and institutional policy barriers but the translocation experiments presented the most promise. Fishermen and scientists were rewarded by not just the knowledge gained about RSU in the process but equally by that gained about the collaborative research process itself.

State regulators passed limited entry laws only after repeated demands from divers participating in the fishery. Other industry groups argued they were being unfairly excluded so the state allowed a 6 month grace period for new entrants to make landings to qualify for a permit. Everybody thought the permits were going to be transferable and the new entrants raised the number of permits from about 300 to 938. Regulators and industry took about 15 years to reduce the number of licences again to the 300 level by giving out only 1 licence (by lottery) for each six that retired. Certain landing requirements had to, and must still, be met if a licence is to remain active.

Fishing activities became more tightly controlled, and fishing times decreased year by year, with the result that returns per boat are not expected to increase. Management of this fishery was reactive, as opposed to proactive, in these early days to "points of concern" highlighted by shifts in the fishery indices used to track the resource. These indices included:

- ✧ subtidal surveys using SCUBA to determine the relative abundance, size distributions and recruitment rates for the stocks

- CPUE and catch data by area and depth from logbook data
- size distribution of the catch from market sampling of the catches as they are landed
- fishing pressure (Kalvass, 1992).

Interestingly, virtually all of the regulations currently governing the fishery were developed cooperatively by DSUAC and DFG between 1987 and 1992, a process made possible because both industry and government were concerned about sustainability and limiting fishing effort (Dewees 2004). The concerns of the two groups diverged somewhat in 1993 and the DFG unilaterally wrote a draft management plan for the 1994 fishery which included a TAC, maximum size limit, and October through May season and separate permitting for the Northern and southern California fisheries. This did not go over well with the DFG's "partners" on the DSUAC and in industry and as a workable compromise, the plan was sent out for scientific review by a mutually acceptable expert panel. The panel agreed that things had taken a turn for the worse and that extra measures were required but it did not endorse the DFG draft as the most likely effective option, putting a stop to further implementation. Things stood this way until 2004, and while no revised plan has been developed or implemented, the relationship between industry and the DFG has deteriorated and things have moved to a more adversarial footing.

A 2001 status report on the California RSU fishery concluded that this species is fully exploited in California with some evidence supporting claims that it is over fished in northern California and in parts of Southern California. It goes on to say that the currently applied management measures (minimum size limits, restricted access and temporal closures) have not been effective in stopping the harvestable stock declines and that further measures, including further reductions in the number of divers, establishing a maximum size limit to enhance reproductive capacity of the stock, establish separate northern and southern region management zones and establish annual quota's based on the five-year average catch.

Industry's priority goals, as identified and catalogued in 2002 at an industry sponsored workshop, remain, as in Canada, focussed on the business economics behind the fishery. Interestingly the first of these is, as it has been for many years, a year round steady supply as a critical element of maintaining a presence in the market to support a higher price. They also endorsed continuing cooperation with the processing sector but seemed somewhat worried about compensation for market share lost to imports (#3). Market driven scheduling came in at #4 while maximizing resource value at #5. Making the permits transferable, stock and fishery sustainability and collaborative data collection and management with DFG were also highly placed priorities.

This whole process is a key difference between the US and BC situations- in Canada the DFO alternative is generally imposed, in the US the regulators cannot do this- they must consult and collaborate. Many of the goals and techniques being discussed in this regard in California are related to economic as well as resource sustainability issues and both types will be important in the future management of the fishery. Any number of alternative models are on the table at this point and all parties expect the stable of options to continue evolving as experience and research provide additional guidance on what does and does not work. The most likely scenario over the next few years is continuing to muddle through with the current regulations with variations in landings arising from changes in recruitment (to fishery), feed resource conditions, exchange rates, demand, fishing area due to MPA and/or sea range expansion. Down the road, perspectives of the

DFG and industry will have to be reconciled through negotiation and collaboration between the two will remain a key element to a sustainable and successful RSU fishery.

DSUAC was disbanded and its remaining funding transferred to a new urchin industry foundation in 2002 and there remains some hope that this new organization will reinvigorate the management plan development and implementation process but there are also a couple of new developments exacerbating the split between the government and industry perspectives. On the one hand, a Fishery management Plan for the Red Sea Urchin fishery is required under the Marine Life Management Act (1998). This plan must be coordinated and reconciled with the Marine Life Protection Act (1999) which mandates the development of a statewide network of Marine Protected Areas (MPA's). A number of these areas intersect with active fishing urchin areas and the whole thing has, unsurprisingly, turned out to be very contentious with industry groups. In November 2002, about 21% of the Channel Islands grounds, including about one half of the best urchin fishing areas, was converted to a no-take zone under the Channel Islands MPA Project (Anon 2003) and the industry remains concerned that these areas are targeted for further expansion by environmental interests.

Andrew et al (2002) suggests that small scale management holds the highest promise for long term sustainability. Included in this category are Marine Protected Areas which provide assurance against species extinction. Establishing networks of reserve areas through which fishing can then be rotated might constitute another option while a third would include variations on the territorial use rights as used in Japan. The third option need not involve the same degree of "private property" rights as in the Japanese case but it would nonetheless present opportunities for a more comprehensive co-management strategy incorporating market based planning, improved and direct recovery of benefits from enhancement actions leading to increased incentives to manage for maximum long-term productivity and direct accountability for management and operational decisions. There are of course allocation issues that will no doubt intrude, given the radical departure from current resource management this would represent to vested interests, but experimentation should help define the potential benefits.

Other issues facing the implementation of an ITQ regime in the California urchin fishery include allocating the initial quota shares, determining the TAC, processor - diver relationships, cost recovery mechanisms and aggregation (stacking) limits. The benefits of a harvest rights system over the current method include increased potential for market-based year round fishing which could lead to increased profitability, more effective small-scale spatial management of the resource, reduced management cost for the state (reduced enforcement?) and the transformation of the permit into a valuable and likely appreciating asset.

The fleet is aging in California's urchin fishery and there are few mechanisms to get new entrants into the fishery. A transferability element was just added to the permits so with the average age of divers now about 50, with a number of guys continuing into their 70's, more are taking the opportunity to sell their permits and train younger fishermen to ensure the quality is maintained and the markets remain stable (Chambers 2005).

As a bit of an aside, US Federal wildlife biologists recommended abandonment of an otter-free zone for Southern California in October 2005. This multi-million dollar program has been flawed from the start and has not met its objective of establishing a colony comprising 150 animals in the

Channel Islands, on San Nicolas Island, where they would be isolated from conflicts with fishermen. The otters have not been cooperating and have been moving off their designated reserve into areas used by lobster and urchin fisheries. The consequences of this will put further pressure on the urchins available to the fishery and may lead further curtailment of the commercial urchin fishery.

5.4.2 Alaska

Sea urchin harvesting in Alaska began in 1980 and landings peaked at 757,000 pounds in 1987. Red sea urchins were harvested near Ketchikan, while greens were harvested in Kodiak in the western Gulf and Homer in the Cook Inlet area. Alaska's sea urchin fisheries remain in developmental stages and the potential for a sea urchin industry in Alaska has not been determined. Management has utilized harvesting permits that have specified harvest areas, time, and size limits while area specific harvest quotas are set for reds in the southeast region following stock assessment surveys. Expanding populations of sea otters, a major sea urchin predator, may ultimately limit fisheries in parts of Alaska .

There are about 40 eligible, permit holding divers in Alaska's Red Sea Urchin fishery although there are a number of these sitting on the sidelines at present because of dissatisfaction over prices. The landed prices for RSU in Alaska declined from USD 0.35 per pound five years ago declined to an average of $0.32 in 2003-04 with many divers seeing lows of between $0.18 - 0.20 (Ess 2006). This is despite the higher marine diesel prices in SE Alaska which were about USD 3.00 per gallon ($C 0.92 per litre) in November 2005 (Ess 2006).

A new processing operation to crack the urchins and then spoon, wash, grade, brine and pack the uni for subsequent air shipment through Anchorage to Narita is being set up in Ketchikan with the assistance of an $US 83,000 grant from the state government (Ess 2006). In previous years the green product was shipped to Seattle for processing, presumably via ferry to Prince Rupert and then by truck. The new setup will save considerable shipping expense and should provide a higher quality product with a longer shelf life for the Japanese consumer.

The diver association has also applied for an additional grant to study the market dynamics in Japan and is supporting exploration into hydro- packing 'C' grade product in jars for sale to the consumer at a low price (Ess 2006).

5.4.4 Maine

A few fishermen in New England landed a few sea urchins for a local ethnic market in 1987. This was the first step in a fishery that had increased to over 40 million pounds (18,000 MT) just seven years later in 1993 when the fishery had exploded to the second most valuable fishery in the state after lobsters. The dramatic growth of the industry is due to the opening of Asian markets, primarily the Japanese market, for US seafood. A fixed exchange rate until the early 1970's ensured that any imported products coming into Japan could not be sold at competitive prices but the increase in value for the Yen vis a vis other currencies when the floating exchange rate regime was adopted saw other non-Japanese suppliers quickly enter the market. Initially, almost all green sea urchins taken in Maine were shipped whole to Japan, but in 1991, the industry began moving toward stateside extraction of roe to counteract rising air freight costs.

Dragging is still used to harvest some of the catch in Maine but now most sea urchins are harvested by divers. Sea urchin management regulations, which began in 1994, included a closed season from May 15 to August 15, a minimum size limit of 2 inches exclusive of spines, and the prohibition of night harvesting The urchin industry in Maine in 1997 comprised 90 dealers/brokers/transporters, 19 processors, 997 divers and 388 draggers (Lauer 2001).

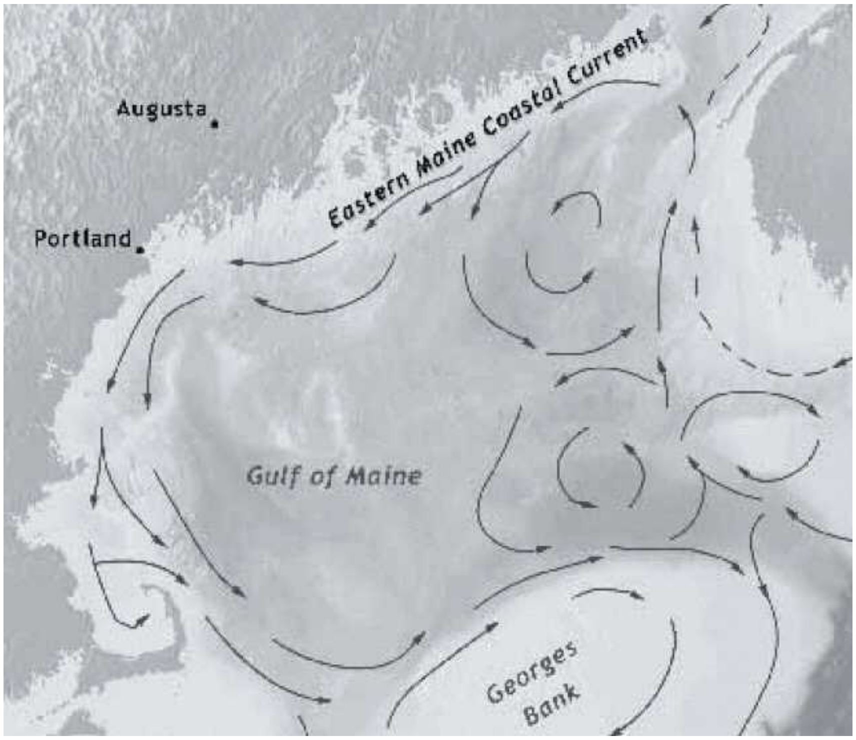

Figure 39: Chart of the Gulf of Maine.

The sea urchin harvest permits in Maine, as in California, reside with the divers as opposed to the vessel. Some permit holders obtained their own vessels so they could access the fishing grounds but many also just partnered up with existing vessel owners and split the proceeds on a 70:30 diver : vessel split. The vessels in the fishery were generally less than 60 feet long and owner operated in a typically flexible manner that allowed continuing participation by the fisherman in a number of inshore fisheries including scallop dragging, lobster fishing and/or groundfish dragging in addition to the urchin fishery. Vessels in Maine are also allowed to land more than one species at a time so the operation benefits from two revenue streams (Lauer 2001) instead of being limited to only one as is the case in Canada.

Consistently poor recruitment of *S. droebachiensis* in the NE Gulf of Maine (Figure 39), in contrast with the higher recruitment generally found in the SW region, has led some to conclude that a sustainable fishery in the NE Gulf of Maine will not possible without the establishment of an artificial stock enhancement program (Andrew et al 2002). The general consensus is that recent landings have far exceeded sustainable limits and the urchin resource is now severely depleted, down from about 65,000 tons in 1992 to about 18,000 tons by 2002. As a result of this depletion, the arrival of young settlers is much lower and the mortality rates of those that settle out are much higher because the decolonization of the urchin barrens by kelp has also increased the density of predators. The fishery is in a state of near collapse and there is general agreement that production will not soon, if ever, return to the levels seen in the 1990's (Taylor 2004).

5.5 Mexico

The main species sustaining the urchin fishery in Mexico are the Red and Purple Sea urchins, both of which are showing strong signs of overfishing (Gonzales and Olguin. 2004). The sea urchin fishery in Mexico is limited to the northern one-third of the Baja Peninsula from the border with the US to El Rosario Bay, about 450 km to the south. This stretch of the coast is divided into four management zones and while the southern-most zone has been the most productive, the catch in the next one to the north has been more predictable in recent years and has gained in importance. About 40% of the divers worked in the southernmost zone in the1999-2000 season while the rest were roughly equally divided amongst the other three (Andrew et al 2002).

The *S. fransiscanus* fishery got started in 1972 and grew quickly to about 5,800 t in 1979. An El Nino blew in the next year and landings declined to about 1,600 t before expanding again to about 8,500 t in 1981. The fishery was unregulated until new regulations introduced in 1987 brought greater stability to the fishery and the number of divers has remained relatively constant since the regulations were introduced at between about 290 - 300. The catch fell through the 1990's as increasingly restrictive management measures were introduced, including a minimum commercial size of RSU of 70 mm.TD (Guisado et al 2004), a closed season between March and June, catch limits of 150 kg/day for each diver, and catch and effort reporting. The catch declined to its lowest level in 1998-99 season at about 1,000 t, again as the result of an El Nino's effect on the *Macrocystis* forests, before again rising the next year to about 2,150 t (Andrew et al 2002). The catch rates declined from a mean rate of 309 kg per diver day in 1989 to 104 kg in 1999-2000.

As part of the regulations introduced in 1987, permit holders were given two year leases, and on application 20 year leases, for exclusive access rights to areas. There were 48 permit holders in 2000 and a total of 291 divers were hired to harvest the urchins within these 48 areas. The permits are tradable and are intended to provide investment security and promote a greater commitment to long-term sustainable use. This sounds pretty good in theory but many of these fisheries continue to receive subsidies to increase short term profitability while the long-term measures, like effective effort regulations, have yet to be effectively applied.(Anon 2003). In addition, the simple lack of legal definitions for particular issues like overfishing and of legal and practical guidelines to face it, is a problem that has yet to be overcome. Generally speaking, the fisheries law should clearly state the need to achieve the sustainable use of all natural marine resources but sustainability has yet to be clearly defined as a management objective. Instead, maximizing catches and profitability continue to be a high priority (Anon 2003).

A Total Allowable Catch is set each year for the whole fishery based on an analysis of survey and catch and effort information. It is used only as a precautionary instrument and is generally increased if the TAC is caught before the end of the season. Approximately one half of the standing stock of legal-sized urchins are caught each year and since the assessments began in 1991 the mean size has fallen from 93 mm to 78 mm in 1996 (Andrew et al 2002) and possibly even further in the interim. A weakness here is that the fisheries research is still financed entirely by federal funds with no possibility of receiving either non-governmental or private funding, thus resulting in a serious constraint for the decision making process.

S. purpuratus has been harvested since 1993 but inconsistent roe quality has retarded progress in developing this fishery. The densities of this urchin have been increasing since about 1992, possibly because of the removals of competitively superior reds and studies into shifting to other tropical species as candidates to diversify the fishery are underway. Biological findings for one species in the Gulf of California, *Echinometra vanbrunti*, make it a good alternative although the expected yield will be lower than urchin fisheries from more temperate areas (Gonzales and Olguin. 2004).

In general, the prospects for sustainable fisheries in Mexico are not great. Fisheries-derived income in Mexico is very unevenly distributed and the 67 % of fishing units in artisanal fisheries receive just 2.8 percent of the total fisheries income. In 2001, more than 90 percent of the fleet was comprised of fiberglass, outboard-engine powered small vessels (up to 36 ft long) called “pangas”, basically the same situation that has existed since the 1940's (Anon 2003). Fisheries in general, including exports, contribution minimally to the national economy (0.8 percent of GDP) and it can be expected that the contribution of fisheries to the Mexican economy will diminish with time if the present situation of widespread overexploitation persists.

New investment is not expected in most fisheries, with possible exceptions in some marginal fisheries like sea urchin and sea cucumber, even as subsidies continue to play a short-term stabilizing role in the fisheries where they are applied, maintaining fishing effort despite the limited profitability. As unemployment and inequalities in distribution of income drive more and more people into activities like fisheries with lax restrictions, managers will be hard pressed to enforce regulations. Mexico faces the dilemma in terms of economic development versus natural resources conservation and social conflicts arising from competition to get access to exploited resources are likely to increase (Anon 2003).

5.6 Russia

Strongylocentrotus droebachiensis, *S. polycanthus*, and *S. pallidus* are all found along the east coast of Kamchatka and adjacent waters and the first two species seem to offer reasonable opportunities for new fishery development. Initial attempts by industry in the mid-1990's saw harvests of about 80 t per annum but progress has been slow because of a lack of marketing experience on the part of the companies and ongoing difficulties of harvesting in the severe weather conditions found off the Kamchatka coast (Bazhin 1998).

Russia’s urchin resource was virtually untapped during the Cold War (Chambers 2005) and the virgin stocks are substantial, particularly in Russia’s far east. Juvenile urchin densities, and therefore recruitment, are controlled at least in part by normal ecological processes including predation. The predators include a number of commercially targeted groundfish species and crabs which find the newly settled urchins pretty easy picking so the growth of these stocks has also likely been abetted in part by more local unregulated fishing that broke out as subsidized Soviet domestic and international fishing was curtailed with the collapse of the USSR and fishermen were forced to support themselves by whatever means they could.

The transition of Russia to a market economy severely crippled many fishing enterprises and fisheries research institutes because of the loss of subsidies, especially for fuel, that soon followed.

In the case of the research institutes, they were forced to approach fishing companies to solicit funding to continue their work, funding which the vast majority of these companies just could not even contemplate given their own dire financial straits. The staff and facilities at these institutes were therefore severely downsized with the result that monitoring of even local fish stocks quickly became very difficult (Ivanov 1998).

The fisheries institutes are surviving as they have managed to attract funding over the interceding years from foreign fishing firms interested in taking part in a government authorized research fisheries in which the companies recover their costs, with perhaps some profit, from dedicated research quotas on high value species established for this very purpose. Domestic and foreign fishing companies do now value and are not particularly interested in maintaining the fisheries science capabilities *per se* and provide continuing support only because of these quotas. The federal fisheries regulatory body, the Fisheries Committee of the Russian Federation, recognizes this and continues to make these quotas available.

The Pacific Research Institute of Fisheries and Oceanography (TINRO) is the largest fisheries institute in Russia's far east but even here the resources and staffing have declined to the point where they cannot provide detailed assessments for all the shellfish stocks under their mandate (Ivanov 1998). Divisions of this institute in addition to the existing satellite station in Sakhalin were established in Petropavalovsk-Kamchatsky and Magadhan to help relieve the personnel problem but full resolution is still a distant objective. Scientific personnel are not being replaced at many laboratories and the average age of the staff is rising (Ivanov 1998). The budget situation of the Federal Russian government has improved since about 2003 with the rapid escalation of the country's energy revenues but thus far there has been little indication of how this might be devolving to fisheries research and management operations.

Some of the changes have been beneficial and some improvements have been noted. Shellfish stock assessment has become more applied and laboratories have been getting access to more modern IT resources because of their increasing collaboration with foreign firms and scientists. The declining influence of the state on people is reflected in lower levels of censorship and less restrictions on foreign travel as well as in the more rigorous quality of their work (Ivanov 1998).

There are many dedicated and capable people working providing fisheries management services, including management, advice and enforcement etc., but the resources available to them are simply inadequate. For example, the total urchin landings in Japan each year from the Kuriles total approximately 10,000 MT of urchins even though the official quota for the area has only been recently raised from 1,200 MT to 2,000 MT. This implies that about 8,000 MT are from Illegal, Unregulated and Unreported urchin fisheries.

However, for most people in this area life must still be very difficult, if only because of the lack of opportunity, and the development of a legitimate and sustainable fishing industry is apparently completely subsumed by the requirements for simple survival. Russia's far east has long been a frontier of opportunity, and punishment. Sakhalin Island, site of a very large energy development project in Russia's Far east, was for many years a giant prison camp and considered by some in the know to be the most depressing place in Russia. The Island is now developing into a caricature of a petro-state. This includes inequality in the distribution of the benefits of the development with virtually all of the Russian share of the revenues from the project going straight to Moscow even as the towns on the Island remain in a dismal state, factories in disrepair, and much of the fishing fleet rusting on the water. Life for many here, particularly in the north, consists of poaching, drinking and killing one another (Anon. 2005 f).

Even when considering those people who are gainfully employed their wages are likewise generally characterized as inadequate and corruption is everywhere in Russia. The problem is even more pervasive because its spread is not so much as a result of policies pursued by the government and of events but seemingly the main reason behind it. A system of mutual blackmail has established itself with people being promoted even in government because of their corruption since their superiors feels this makes them more pliable (Anon 2005 b). This state of affairs is poisoning peoples relations with police, bureaucrats and politicians and it is getting worse. Russia’s rating by Transparency International has now fallen to rank alongside Niger, Sierra Leone and Albania (Anon 2005 b).

Police and politicians are now considered crooks to a greater extent than burglars and, as might be typical of Russian humour, things are said to have gotten so bad that Moscovites commonly hold the view that uniformed extortionists have at least crowded out the mafia. This is not always the case in the regions though where organized crime is thought to have assassinated state governors and taken control of whole sections of economy, including the coastal fishing industry Glavin 2006). The official government-appointed general in charge of fisheries management in the Russian Far East was assassinated a couple of years ago, presumably because of his efforts to get control of the situation and get a handle on all the poaching going on. Even the politicians in Primorsky, the region including Vladivostok, have shady histories. The Mayor of Vladivostok served time in jail for violent crime and was elected only after his rival was wounded in a grenade attack. The Governor of the region, who, like all other Governors in Russia, was appointed by President Putin, is somewhat shady but at least is not a pliant billionaire as many other governors in Russia are (Anon 2005 f).

5.6.1 Kurile Island IUU Fisheries

One of the biggest challenges facing the Canadian sea urchin industry is an Illegal, Unregulated and Unreported (IUU) Russian urchin fishery in the Kurile Islands. The first reports of low-cost Russian product in the Japanese market came to light in 2000 when it started impacting prices and demand for GSU from BC in Hokkaido. The landed prices for this product range from about ¥150 /kg when the market is in poor shape to about ¥600/kg when it is strong. This compares with CIF prices for live Canadian GSU ranging between about ¥ 850- 1,020/kg which incorporates a shipment cost of about ¥295/kg which also applies to the approximate 20% throw-away weight for packaging. The Japanese market for BC GSU products collapsed in 2001 and only 60% of the GSU TAC was harvested. Russian production from the Kuriles was still affecting the market in 2002 when Japan imported 11,926 mt of live sea urchin in 2002, 88.9% (10,597 MT) of which was again imported from Russia according to the Japan Fisheries Market Report May 2003 published by the Agriculture, Fisheries and Consumer Products Section of AgriFood Trade Service in Ottawa.

In past years, imports of live sea urchin from Russia generally ended around October and supplies from other countries (particularly Canada) took over. In recent years however, the Russian shipments have continued and even increased through the end of the year, a feature which in itself has had dramatic effects on the market. The import price of live sea urchins generally ranges from 830 ¥/kg (CIF) to 1,020 ¥/kg for Canadian and the US product compared to the live Russian product which remained at about 550 ¥/kg in 2002. According to the above report, the constant volume increase from Russia are the result of unregulated and illegal urchin harvests urchins by Russian vessels in the Kurile Islands.

Russia is a major supplier of sea urchins into Japan and has increased shipments of live product since 1998 from about 1,500 MT to upwards of 10,000 MT per year, a level which basically exceeds previous live urchin imports from all nations into Japan. There are two main flows of urchins from Russia into Northern Japan through the Ports of Hanosaki on the south-eastern edge of Hokkaido and Wakkanai on northern margin (Figure 40). The urchins coming into Wakkanai are harvested legally along the adjacent Russian coastline around Primoria and up around Sakhalin Island to the north. These fisheries are well regulated and controlled, thereby allowing slower product flows which support price stability, and are seasonally affected by ice conditions from about mid-October to the end of March each year. In contrast, much of the product coming into Hanosaki is not affected by ice and is not regulated and large landings often glut the market throughout the country between October and January, causing price declines and disrupting the market so much that regulated sources are rendered uneconomic. This has particularly affected the market for live Canadian Green Sea Urchins (GSU) as demand for higher priced product has basically collapsed in response to the increased IUU supply.

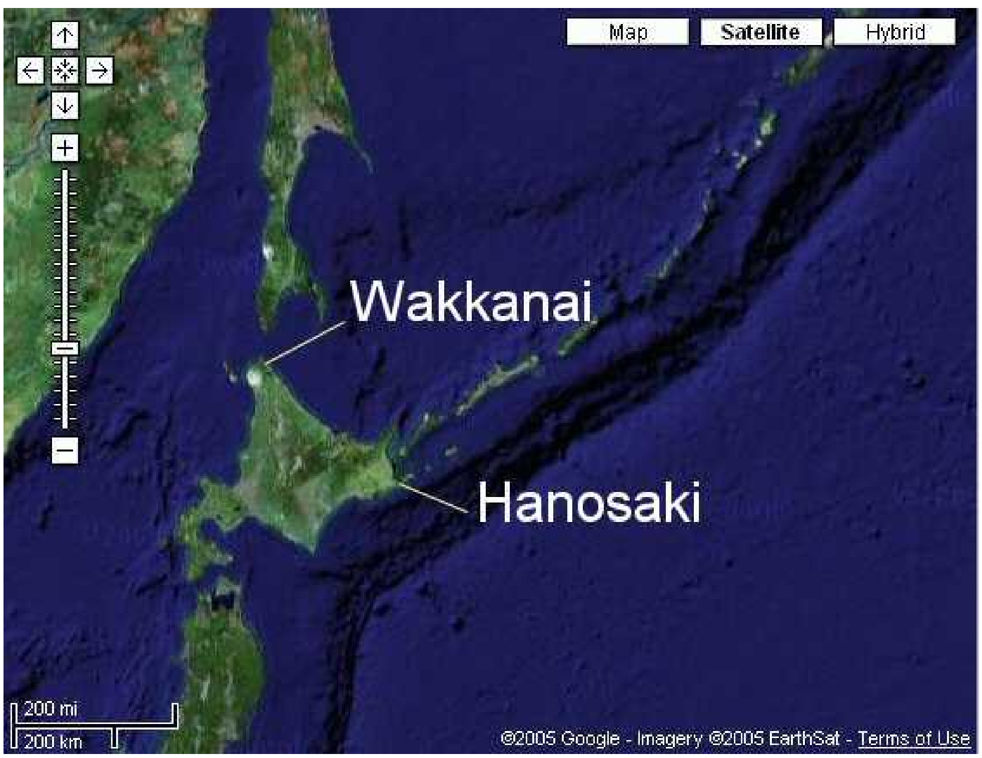

Figure 40: Large scale satellite photo of Hokkaido

The industry in Japan is however suffering because the volume coming from Russia is excessive with much of the excess being due to IUU urchin fishery in the Kurile Islands around Nemuro. The ramifications of this extend to the loss of domestic production capacity as trained and experienced workers are being forced to find other employment and are abandoning the industry. The IUU urchin fishery is clearly unsustainable over the long term but if the Japanese industry

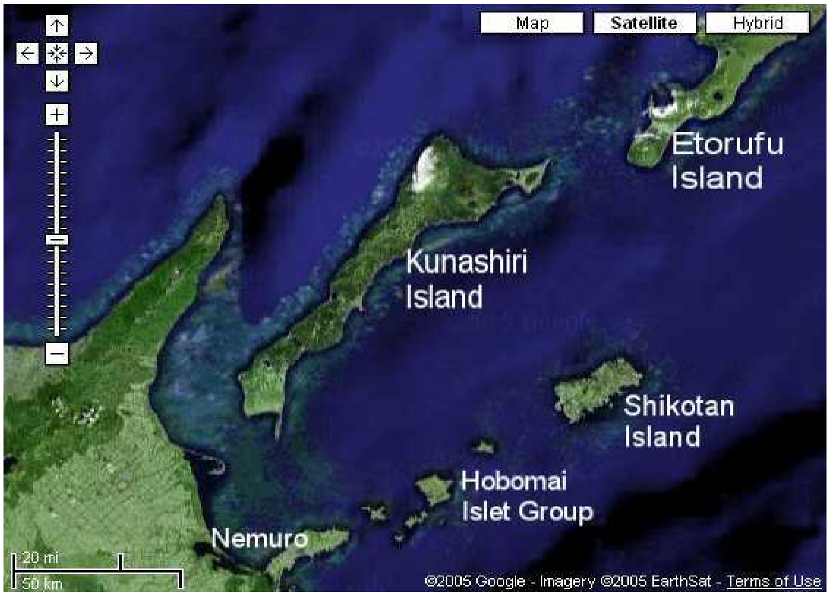

Figure 41: Satellite shot of the Kurile Islands including the main IUU urchin grounds around the Hobomai Grp and Shikotan Isl.

capacity deteriorates too much, it will not be able to take up the slack when the IUU supply collapses. Japanese industry sources acknowledge that eliminating the Russian trade is not in their interest but that getting 50% of the trade from Russia under some kind of regulated control would alleviate many of the problems. It would also extend the Russian supply so the otherwise inevitable collapse might just be avoided.

There are some complications to seeing such a transition. Ownership of Kurile Islands, including all of the islands marked on Figure 41, is disputed between Japan and Russia as the islands were seized by Russia in the closing days of WWII. There are ongoing discussions between the Russian and Japanese governments over the sovereignty of the islands although these appear to have hit an impasse as both countries have not so far been able to move off claims. In Russia's case this is likely due in part to the influence of quite strong nationalist sentiments and the need for the Federal Government to retain the support of such groups for domestic political reasons. The continuing success of the transition of Russia to a modern democratic and more prosperous state will eventually reduce the influence of such groups and further progress towards an equitable settlement may be possible but this is not likely for some time yet. In the meantime, the unsustainable harvest(s) may make sense as viewed from a Russian perspective that it is better to get as much advantage out of the resources in as short a time as possible so Russia, as opposed to Japan, gets the benefits before sovereignty of the islands reverts to Japan. It's a bit of an irony here but it may also make sense for Japan to promote such 'mining' activities despite the economic impacts to speed things along a bit. In short, the IUU fisheries in the Kuriles is likely to continue until such time as the resource is depleted and/or more serious negotiations are underway.

There have been questions as to why the trade is not better controlled, particularly as both countries maintain substantial radar coverage over the border area at all times. The reason it seems lies largely in the remoteness of the Kuriles from the home base for the Russian Coast Guard (RCG) vessels. Russia has made a commitment to increase the RCG oversight in the area but the vessels involved work out of Vladivostok and the distance between their port and the Kuriles is too large to permit a constant presence. The Japanese authorities are constrained from keeping a better check on the legitimacy of each load. There are a number of other legal fisheries, including crab (landings @~ 20 - 30 KMT/yr), legal urchins (import and domestic), scallops (domestic) and pollock (domestic), landing product at Hanosaki so the Japanese Coast Guard (JCG) is likewise hard-pressed to regulate all the traffic.

Still, it seems there is a bit of a disconnect here somewhere because the Russian boats with the illegal product are not apparently impeded whatsoever by the Japanese Coast Guard or Port Authorities. It seems that the RCG is the only authority with the ability to establish the legality of the product on board the vessels while the JCG is limited to only ensuring that the import documentation is in order and this may not reference the legal harvest licence documentation because it could be seen as a encroachment on Russian sovereignty.

The majority of the IUU urchin fishery is reportedly prosecuted in the Hobomai Group out to Shikotan Island. The transit times to Hanosaki Port from these are in the neighbourhood of six hours so while stocks are reported in other areas of the Kuriles, the shipping distances and costs are that much greater. Still, the shipping cost for the currently fished Russian IUU product is reported to come in about ¥1/kg, so there would seem to be some room to extend out into other areas. There are also some reports of large stocks of old Green Sea Urchins, *S. droebachiensis,* around the eastern half of Etorufu Island, the Kurile lying furthest from Hokkaido, but these have never been fished and their condition etc. is reported to be pretty poor which, along with the extra transport costs involved, means fishing them is not worth the effort at this point.

The prices for the currently available Russian product are, like their costs, very low and the volumes involved are such that the market is spending much more time in a weak condition because of an over-supply situation. As a result, many of the smaller processing companies in Northern Japan are (almost) forced to use the IUU product simply to keep their doors open. Legitimate urchin producers, including importers competing during the winter months when the Russian IUU fishery is active, and larger and perhaps more diversified processors are being severely disrupted as legally obtained product simply cannot compete.

The quota for the Kuriles was raised in 2005 although the reasons behind it are somewhat convoluted. In part it reflects the reality of the IUU harvest but on the other hand it simply disregards the over-harvesting that is occurring as a result. In one respect the government has (possibly) increased the proportion of the catch which is subject to taxation but on the other hand the stock depletion is not being factored in. The official Fisheries Institute resources for the Sakhalin area, which has jurisdiction over the Kuriles, are not sufficient to allow direct research to estimate the biomass and/or set area quotas in the Kuriles so they rely instead on a private contractor to conduct the work. The company involved apparently uses only the official Russian harvest estimates which do not recognize or acknowledge the IUU harvest as significant. The contractors reportedly recycle the same data each year and they would seem to be factoring in some biomass increases in the area that might be expected because of the sustainable utilization rate obtained from the official harvest numbers.

Acknowledgement that stopping the illegal fisheries is also in Russia's interest was reported in the May 2005 issue of Euro Fish magazine. In this article, President Vladimir Putin said that 80% of Russian seafood exports left the country through illegal channels, thus getting around the Russian revenue authorities. "We have to modernize this industry – that is the only way to de-criminalize it" said Putin. A large share of the coastal fishing industry is reportedly in the hands of the Mafia and corrupt regional officials (Glavin 2006) and while the Russian Coast Guard has made some arrests and the courts assessed some substantial fines and prison sentences for poachers caught in the area (Anon 2006 a), the situation remains very difficult.

5.7 China

At present, there is a limited wild urchin fishery on some islands in the South China Sea and these are probably supplemented by opportunistic harvests obtained from the extensive macro-algae farms dotting the coast. Sea urchin imports from China into Japan rank 4th behind the US, Chile and Canada. In addition, Chinese companies are reportedly joint venturing with Japanese interests by bringing in juvenile urchins from Japan for ponding and then shipping the final processed product back.

As mentioned, the emergence of China as a global economic superpower is affecting global business, including their growing capacity in fisheries production and processing. Companies from around the world are using Chinese processors to custom process their product, and in the process changing the very nature of the business and in this regard, their eventual impact on the sea urchin products industry if they develop a full echinoculture capacity, even as an offshoot of their other substantial culture capacities, likewise holds the potential to redefine the economics of the business.

On the production side, wild fishery stocks in China are, not surprisingly, getting somewhat depleted but the government has been actively promoting aquaculture for some time to the extent that as fishing licences have been retired, the fishermen often move on to aquaculture as a livelihood. China has a very strong tradition in aquaculture and continues to push it as a source of sustainable economic growth and activity. A recent tour of Guangdong Province revealed the extent of their commitment.

The colour, size, taste of uni products from China are reported as generally OK (J. Kannada. pers. comm. 2005) with prices at the lower end of the scale. Sanitation is, however an increasingly serious issue, a development which may signal future opportunities in both supply and in processing if their product quality is impacted. The organic pollution load in China has increased in direct proportion to the population but China also accounts for about 70+% of the world’s aquaculture production, particularly on the freshwater side, suggesting that many of these ‘wastes’ are being effectively harnessed as nutrients. The more worrying part of the problem is likely associated with the rapid industrial development and introduction of modern inorganic pollutants into the environment. No comprehensive assessment of the state of the inorganic waste recycling and/or processing capabilities in that country has been examined but the levels of knowledge and innovation in the area will likely support rapid development of effective infrastructure if Chinese authorities decide that this is a priority.

Developing human resource capacity for a company is also becoming more difficult. Competent managers and service oriented personnel are extremely scarce in China and the trend is worsening. China may be the most desired location for R&D but the reality is that while China is now the world’s workshop, it is facing a serious shortage of foremen and other management leaders. People, particularly the more talented, are fiercely individualistic in China and are not given to teamwork on projects. Combining this with the lack of flexibility in the education system, including archaic residency requirements that reserve the vast majority of student places for well connected locals, and one gets into the situation where the companies can expect to have to develop their own managers, a process which takes years, even as poaching of skilled staff accelerates (Grimmer 2005 b).

5.7.1 Aquaculture and Research

The Guangdong Dayawan Fishery Development Centre (GDFDC) is one of a number of such institutes in China pursuing applied fisheries and aquaculture research. Th GDFDC was established in 1987 about 200 km from Gaungzhou on the shores of the South China Sea in Huizhou City to pursue enhancement of the marine resources and environment in Guandong Province. The Chinese government is serious about pursuing any and all ventures which can contribute to increasing the productive capacity of the China and aquaculture retains considerable potential even in this country which already accounts for upwards of 75% of the total world aquaculture production.

The Centre has been formally collaborating with the Japan Overseas Fishery Cooperative Foundation in pursuit of these goals since about 1998.The facility comprises about 35,000 m^2 including the main offices building, the water filtration plant, outdoor raceways and large ponds as well as about 5-6 building containing variously sized concrete tanks and another containing microalgae and rotifer growth labs. The Centre is researching culture technologies and methods for abalone, sea bream, various species of grouper and other fish.

They were actively looking at sea urchins up until a couple of years ago but because of the remaining abundance of wild urchins and a subsequent lack of interest on the part of industry to further develop echino-culture at this time, work on urchin culture has been disbanded. There was some thought to using their hatchery production for stock enhancement but worries about the development of barrens in the enhanced areas also weighed in against this use. They retain their hatchery capacity though and sources at the centre feel urchin culture can be quickly ramped up as soon as the time is ripe.

5.7.2 Additional notes on China's seafood production

The Guanzhou seafood market is the largest live seafood market in the world. A good portion of the seafood sold in China is sold live, in part because the penetration of refrigeration in the country is still limited and the quality of the product will not generally decline significantly while the product is still alive.

Parts of the Chinese seafood industry are very sophisticated but for the most part the industry is pretty low-tech, particularly on the production side. This may well limit their impact on the high end urchin market for some time because the product is not cooled or transported efficiently by the small-scale producers at this point, although this could change quite rapidly if some of the bigger aquaculture players decide it is time to move on urchins.

Ocean water temperature around Southern China are quite warm at about 24-26°C. This means that the fish and shellfish from the area will have faster metabolisms and grow more quickly than those in Canada and, while they may be more resistant to higher temperatures than respective Canadian species, may also deteriorate faster once they have died simply because the bacteria etc behind this are also warmer and therefore reproducing and spreading faster. Urchins, and other seafood, from warmer waters may well also have an inherently lower fat content.

5.7.3 Additional Notes on Economic Sustainability in China

The continuing development of China’s seafood production and processing sector as an significant emerging force that will change the economics of the whole seafood industry will necessarily depend on its long-term vigour. This is however not assured and the sustainability of China’s economic miracle is being questioned on a number of levels, the most surprising perhaps being the inequality that is no so widespread in what is still defined as a Communist country. Sustainable growth in China will require moving from its current export driven economy to one that is driven more by domestic consumption. The growing middle class, now at about 260 million people, is helping with that but most people still remember the bad old days of the Cultural Revolution, which caused the deaths of 10's, if not 100's of millions in the 1960's and 70's, and feel with the disappearance of the social safety net in the country that the only prudent course even now is to save virtually all of their income for a rainy day.

This would seem to be justified in many cases. For example, life in China is still considered fairly cheap- over 210, 000 people were killed and a further 1.75 M injured in 2004 in natural disasters (1/6) and industrial accidents (5/6) in China. These disasters cost about 650 Billion yuan ($C 93 B) each year, an amount equal to about 6% of GDP (Jiang 2006). The social situation sounds pretty much Dickensian as the social safety net has virtually collapsed so that 80% of rural citizens and 45% of registered urban citizens do not have any medical coverage and so cannot access the medical system even when in dire need because they cannot pay for it.

Beijing has recently revised its estimate of the country’s GDP upwards by 17% to US$ 2.4 T so it more accurately reflects the contributions of the service sectors to the economy. This revision moved China up from being the world’s seventh largest economy to its fourth, surpassing Italy, France and Britain and standing just behind Germany. Despite this rosy picture though, the distribution of income is so highly unbalanced it is threatening China’s social stability. Life expectancies in the cities are 10 to 15 years longer than those found in rural areas and the income ratios are estimated at 6:1 (Jiang 2006).

This is apparent in many ways. For example, there are waiting lists in China for new homes ranging upwards in price from $550,000 while at the same time the army of migrant workers behind the housing boom sleep in the partially completed buildings because they have no money, even assuming they do not get stiffed for their labours, for a room away from the job. The division of wealth in China is such that the richest 20% account for 50% of the wealth and consumption while the bottom 20% account for less than 5%. The trend of this distribution is not heading in the right direction and resentment is rising amongst those not so well off because of the common perception that much of the new found wealth is from ill-gotten gains (Grimmer 2005).

This rising inequality is causing an accelerating tendency towards mass demonstrations that are increasingly threatening to destabilize the country. There were more than 87,000 mass protests in 2005 in China (York 2006), up from the 74,000 protests recorded in about 340 cities and 1,955 counties and involving more than 3.7 million protesters in 2004. This amounted to between 120 - 250 such protests daily in urban areas and 90- 160 in rural areas and is up from almost 10 fold from the 10,000 protests in 1994 and by 50% from the 58,000 such protests in 2003 (Grimmer 2005).

Infighting among bureaucracies with competing agendas is endemic across China's industrial landscape and the resulting chaos extends to hurt the most promising two-thirds of the economy that is held in private hands. Entrepreneurs had to bring on state investors for political protection for many years because private enterprise was not a legal option until 1988 and the practice did not change overnight even once it was legal. Government shareholders have often been passive until such time as the company starts succeeding but countless Chinese firms have been held back or driven to bankruptcy because these local governments decide to exercise the legal claims on ownership. One pointed example of this happened with Kelon, a refrigerator manufacturer which was China's largest in 1990 which got a Hong Kong listing and global awards for its products and business practices through the 1990's. The Guangdong provincial government was able to force out the entrepreneurs who built the company's success in the late 1990's, appoint their own bureaucrats to manage the firm who then drove it into the ground in very order because the principals had not shifted the ownership registration to Hong Kong where they would have been immune from such machinations (Anon 2005 g).

Reports of rural communities in China falling under the control of gangsters and thugs, often with the support and/or contrivance of local officials, are becoming increasingly numerous. Authorities in Beijing are clearly embarrassed by these sorts of developments and rail about it from time to time but their ability to control the problem is clearly limited (Anon 2005 h) although it has not spun out of control as yet and it is encouraging that the Chinese Government is recognizing the problem and has made the narrowing of the income gap one of its lead priorities for the coming years (York 2006). Even with this though, it should be remembered that while continuing economic stability in China is not assured, catastrophic collapse in China can, as with the Mutually Assured Destruction that typified the nuclear standoff of the cold war, be expected to have similarly devastating consequences for the rest of the world's economy and it remains in all country's interests to see it succeed.

6.0 Summary Conclusions

This document was produced as a background document for a benchmark study of BC's sea urchin fisheries and the main conclusions and discussion are part of that document. To summarize the views of other authorities though, it is apparent that sea urchin fisheries have a poor record of sustainability, as evidenced by the declines recorded in Japan, Maine, California and South Korea among others, as well as by the ad hoc and/or ineffective management in many sea urchin fisheries (Andrew et al 2002). Very few stocks have been formally assessed, meaning it is near impossible to qualify declines as the fish-down of accumulated biomass, which does not arrest the productivity of the stock, or as a case of over-fishing in which case its productivity may be forced into permanent decline.

Small scale management (on the scale of 10's of kilometres) is mentioned time and again as offering the most promise for ensuring long term sustainability. The strong and consistent spatial structure inherent in sea urchin stocks combined with excessive effort from mobile fleets and inappropriately large scale, and therefore ineffective, management all contribute to declining production in many of the world's sea urchin fisheries. This is particularly the case for the world's largest sea urchins fishery in Chile (Andrew et al 2002) where the risks of collapse cannot be discounted. Given that this fishery alone contributes upwards of 55% of the global harvest, a significant decline in Chile's fishery would likely lead to structural realignment in the market and higher prices for mid-range products until aquaculture production ramped up.

There is also general agreement that some form of exclusive access as a prerequisite condition to promote meaningful enhancement and intelligent harvesting to maximize roe value will provide the best hedge against uncertainties in fisheries productivity and market stability (Andrew et al 2002).

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