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Research Document 2002/122

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Document de recherche 2002/122

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Hexactinellid Sponge Reefs: Areas of Interest as Marine Protected Areas in the North and Central Coast Areas

Récifs d'éponges hexactinellides : zones présentant un intérêt comme zones marines protégées sur la côte Nord et la côte Centrale

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ISSN 1480-4883

ABSTRACT

The four known sponge reef complexes in the Central and North Coasts of British Columbia (BC) are thought to be unique in the world and are presently protected in BC by voluntary shrimp trawl fishery closures, and as of July, 2002, regulatory groundfish trawl closures. There is evidence of past damage to the reefs by fishing activities, notably trawling. Fishing on them has been reduced since 1999, when voluntary avoidance by groundfish fishers was requested, but avoidance of the reefs has not been complete and recent visual surveys show continuing damage to them. The dynamics of reef-building and the ecosystem that the reefs support are unknown, with the only available biological data from limited submersible visual observations (not considered here) and fishery dependent observations and recordings. We have analysed the latter, and document fishing activity on the reefs and within the voluntary shrimp trawling closure zones established around them. The four reef complexes differ in the relative abundance's of targeted species around them, with Reef A (the most northern one) having proportionately larger flatfish populations. There has been little fishing activity around Reef B, and hence little biological data are available. The area around Reef D, the most southerly reef, has been the most intensively fished, with rockfish the most targeted species. For the areas analysed, highest fishing yields came not from the reefs themselves, but from the areas immediately adjacent to them. We did not assess how these landings compared to areas further away from the reefs, i.e. totally outside the voluntary fishery closures. Within the voluntary closure areas and excluding the reefs, landings for all four reefs combined averaged about 1320 t per year, comprised of about 80 % targeted individual vessel quota (IVQ) species and 15 % targeted non-IVQ species. Recommendations are that for effective reef protection, an additional 9 km buffer zone around the recently introduced groundfish trawl closures should be established; the existing closure boundries are often much closer to the main reef complex borders. Fishing activity in this potential buffer zone should be closely monitored to ensure that gear is not straying on to the reefs. Research should also be initiated to determine the ecosystem importance and associated population dynamics relating to the sponge reefs. Marine Protected Area designations are preferable to fishery regulation for long-term protection and conservation of unique living resources such as these sponge reef complexes.

RÉSUMÉ

On considère les quatre complexes récifaires identifiés sur la côte Centrale et la côte Nord de la Colombie-Britannique comme uniques au monde. Il sont actuellement protégés de la pêche des crevettes au chalut par le biais de fermetures volontaires et de la pêche du poisson de fond au chalut, par le biais de fermetures réglementaires imposées depuis juillet 2002. Les récifs portent des signes de dommages passés imputables aux activités de pêche, notamment le chalutage. La pêche dans les eaux où gisent ces récifs est moins intense depuis 1999, lorsque l'on a demandé aux pêcheurs de poisson de fond de les éviter, mais ils ne le font pas tous car de récents relevés visuels ont révélé de nouveaux dommages. On ne sait rien de la dynamique de la construction de ces récifs et de l'écosystème qu'ils constituent, les seules données biologiques disponibles étant des observations visuelles limitées faites de véhicules sous-marins, ainsi que des données et des observations issues de la pêche. Nous analysons ces dernières et documentons les activités de pêche sur les récifs et dans les zones d'interdiction de chalutage des crevettes établies autour de ceux-ci. Les quatre complexes récifaires diffèrent par l'abondance relative des espèces ciblées qu'ils abritent. Le récif A (le plus au nord) abrite des populations proportionnellement plus abondantes de poissons plats. Comme peu d'activités de pêche ont été pratiquées au voisinage du récif B, peu de données biologiques sont disponibles. La région dans le périmètre du récif D, le plus au sud, est la plus intensément pêchée, le sébaste y étant l'espèce davantage ciblée. Pour les zones analysées, les meilleurs rendements de la pêche ont été obtenus dans les zones immédiatement adjacentes des récifs et non sur les récifs mêmes. Nous n'avons pas évalué comment ces prises se comparent à celles obtenues plus loin des récifs, c'est-à-dire complètement à l'extérieur des zones d'interdiction de chalutage. Dans ces dernières et à l'exclusion des récifs principaux, les prises sur les quatre complexes récifaires combinés s'élevaient en moyenne à quelque 1 320 t par année et se composaient d'espèces ciblées assujetties à un quota individuel de bateau (QIB) à 80 % et d'espèces ciblées non assujetties à un QIB à 15 %. Afin que les récifs soient adéquatement protégés, nous recommandons qu'une autre zone tampon de 9 km de large soit établie sur le périmètre des zones d'interdiction de chalutage du poisson de fond récemment créées car les limites actuelles de ces dernières sont souvent trop près du récif principal. La pêche dans cette zone tampon éventuelle devrait être étroitement surveillée afin de veiller à ce que les engins ne se retrouvent pas sur les récifs. En outre, des recherches devraient être entreprises afin d'établir l'importance de ces écosystèmes et la dynamique des populations qu'ils abritent. Aux fins de leur protection à long terme et de la conservation des ressources marines vivantes qui y vivent, les récifs devraient être désignés des zones marines protégées plutôt qu'être visés par un règlement de pêche.

1 INTRODUCTION

Hexactinellid, or “glass”, sponges are one of four classes of sponges in the Phylum Porifera, and are exclusively found in the marine environment. Hexactinellids are characterised by skeletons composed of overlapping, siliceous, 6-rayed spicules called hexactines. Three species of the Order Hexactinosa are the primary framebuilders of described sponge reefs: *Heterochone calyx* (Schulze, 1887), *Farrea occa* (Bowerbank, 1862), and *Aphrocallistes vastus* (Schulze, 1887). Although these species are found in other marine areas of the world and are even common at other locations within British Columbia, the North and Central coast sponge reefs are the only documented examples of “living hexactinellid sponge reefs” in the world.. Four reef complexes were discovered in 1987-1988 by the Geological Survey of Canada during geophysical surveys of the western continental shelf, located in seafloor troughs of Queen Charlotte Sound and Hecate Strait (Figures 1, 2). A small reef was more recently discovered in 2001 in Georgia Strait within the plume of the Fraser River (J. Galloway, DFO, Sidney, BC, pers. comm.). The global uniqueness of these features is well documented (Conway et al. 1991, Conway et al. 2001, Krautter et al. 2001), and research is ongoing as a joint scientific project between the Geological Survey of Canada – Pacific (GSCP) and researchers from the University of Stuttgart. Over the past decade, impacts of bottom trawling activity on the reefs by the Pacific fishery have been identified (Conway 1999, Conway et al. 2001, Krautter et al. 2001), prompting calls for some degree of protection for this unique habitat. One recommendation for providing some protection for the sponge reefs was through the establishment a Marine Protected Area (MPA) by the government of Canada (Stocker and Pringle 2000).

To provide a framework to discuss ecological criteria useful for the establishment of MPAs, Levings and Jamieson (1999) consulted a related MPA strategy discussion document (Canada/BC 1998) that listed six objectives, three of which were science related and were accompanied by qualitative criteria, namely:

- Protection of marine biodiversity, representative ecosystems and special natural features (abbreviated below as the biodiversity objective)
- Protection and conservation of fishery resources and their habitats (abbreviated below as the sustainability objective)
- Providing opportunities for increased scientific research on marine ecosystems, organisms (e.g., long term monitoring of undisturbed populations, special features, and sharing of traditional knowledge (abbreviated below as opportunities for increased scientific research).

Following site selection, the additional elements required to build an effective MPA are identification of site-specific goals, site surveys and data collection, data analyses and data synthesis, and formulation of site-specific management plans. MPAs have no specific levels of habitat or species protection per se, with the characteristics of each proposed MPA determined by the specific objectives identified. Both an MPA’s outer boundary and the possibility of having internal zonation, with different zones having different restrictions in it, are determined on a site-specific basis.

To date, all regulation of human fishing activities has been effected by fishery closures under the Fisheries Act. Only species scheduled in Regulation in the *Fisheries Act* can be protected. There is no global Canadian provision that allows species not scheduled in Regulation in an area to be protected. New species can be scheduled in Regulations, but this may take a number of years to achieve, since the process is relatively complicated and time-consuming. Thus, until passage of the *Oceans Act* in January, 1997, the Department of Fisheries and Oceans, which alone has the mandate for renewable marine resource conservation, had no convenient and timely process whereby it could legally control all potential harvests of species in an area.

Protection of specific areas or resources can sometimes be effected through voluntary avoidance by fishers. This is often an effective mechanism over the short-term if all relevant fishers are willing to participate, but may not be particularly effective over the long-term, as there is no process to enforce compliance. An example of such voluntary closures are the shrimp trawling closures recommended by the Shrimp Trawl Sectoral Committee, Pacific Coast Shrimpers' Cooperative Association and DFO for designated areas around the four sponge reefs being considered here (DFO 2000, 2001) (Figures 1,2).

In Canada, the term Marine Protected Area (MPA) is the legislated designation under the *Oceans Act*, for which the Minister of Fisheries and Oceans can establish areas of protection in the marine environment. Subsections 35 (1) and (3) of the *Oceans Act* define MPAs, describes the basis for their establishment, and outlines the regulations that may be prescribed for them as follows:

35. (1) A marine protected area is an area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada and has been designated under this section for special protection for one or more of the following reasons:

(a) the conservation and protection of commercial and non-commercial fishery resources, including marine mammals, and their habitats;
(b) the conservation and protection of endangered or threatened marine species, and their habitats;
(c) the conservation and protection of unique habitats;
(d) the conservation and protection of marine areas of high biodiversity or biological productivity; and
(e) the conservation and protection of any other marine resource or habitat as is necessary to fulfil the mandate of the Minister.

35. (3) The Governor in Council, on the recommendation of the Minister, may make regulations

(a) designating marine protected areas; and
(b) prescribing measures that may include but not be limited to
    (i) the zoning of marine protected areas,
    (ii) the prohibition of classes of activities within marine protected areas, and
    (iii) any other matter consistent with the purpose of the designation.

Under the *Oceans Act*, the most appropriate reason for establishment of an MPA for the sponge reef areas is section 35(1)(c), "the conservation and protection of unique habitats". Additional potential benefits of conservation and protection could also be provided under clauses "a" and "d" of section 35(1).

In response to a paper (Conway 1999) presented to the Pacific Scientific Advice Review Committee (PSARC), the Habitat Subcommittee recommended that long-term protection for the sponge reefs be provided by DFO through MPA designation (Stocker and Pringle 2000). However, the Resource Management Executive Committee (RMEC) did not support the MPA recommendation in 1999 "... because criteria for MPAs ha(d) not yet been established. Once criteria have been established, MPAs may be appropriately applied to the protection of such reefs in the future" (RMEC 2000). They recommended that the industry be encouraged to implement voluntary closures so as to provide immediate protection, with the option of DFO fishery regulations to also be considered. Voluntary groundfish trawl restrictions were subsequently advocated, but with recent visual evidence that trawling impacts were still occurring (T. Conway, Natural Resources Canada (NRC), Sidney, BC, pers. comm.), DFO established regulatory groundfish trawl closures, with boundaries in close proximity to the reefs, in July, 2002.

Here, we discuss community characteristics of the sponge reefs, and the fisheries implications of potential closures, assuming that all habitat-impacting fishery activities, i.e., trawl, long-line and trap fishing, were to be banned on the reefs and in a buffer zone around them. Four potential MPAs are identified, as there are four, spatially distinct, geographically separated reef complexes, each of which might be protected through MPA designation.

1.1 Objectives and Methods

To date, no relevant site-specific biological data have been analysed or collected to characterise the relative species abundances and their size-frequency structures present at the sponge reefs as an Areas of Interest (AOI) for MPAs. This information is important, as:

1) Without initial baseline data, it will be difficult to later quantify consequences of protection;
2) Stock abundance data may be required for determination of zoning and MPA boundaries for the reefs (where not yet done); and
3) Credible, objective data are required both to convince stakeholders and others that MPAs can benefit them and to help in the ultimate optimal design of a network of functional MPAs.

Specific objectives of this study are to review relevant data, and where possible:

1) To identify locations in the AOIs where specific species are found, and to estimate abundances and population characteristics for the species observed;

Available data (fishing logbook information, previous research studies, etc.) will be assessed in a preliminary determination of the spatial locations of species' abundances. Where possible, the seasonal patterns of species occurrence (estimated from fishing activity) will be assessed and considered, since specific areas may be inhabited by species for only a portion of the year.

2) To review historical abundance and size frequency data of exploited species in the sponge reef areas from publications, research and fishing logs, etc.; and

Some research data may be available for characterising certain communities or species size frequency structures. Relevant data from these sources, and others if available, will be compiled and analysed to document the recent past history of human impacts on the populations and ecosystems at the sponge reef sites.

3) To refine, and develop, where necessary, appropriate non-destructive survey protocols for the quantitative assessments of abundance and population size frequency structures of targeted, spatially persistent relevant species.

The Department already has sampling protocols for the non-destructive sampling of many species guilds: the Shorekeepers' Guide and clam sampling protocols for the intertidal; benthic algae and invertebrate sampling protocols for the shallow subtidal; and protocols for crude quantitative assessment of videotaped observations. However, development of appropriate assessment approaches for deep water habitats is more challenging, and it may be that only videotaping from ROVs or remotely-sensed acoustic classification is appropriate.

This study will be a Phase 0 ecosystem assessment (i.e., literature searches to identify relevant information; analyses of information from local knowledge, other studies, etc.; meta-analysis of data to determine distribution of parameters; and development of proposed management approaches) for species (marine plants, invertebrates and fish) at potential sponge reef AOIs. This study brings together available relevant data on species in the area, and indicates the nature and quality of data that at best may be available for perhaps most other deeper-water marine habitats that might in the future be considered for MPA establishment.

The outer boundary of each "reef" actually encompasses a conglomeration of continuous and discontinuous sponge bioherms and biostromes, as opposed to one continuous reef. Locations of reefs were updated by the GSCP in March 2002, and are based on field information collected in June 2001 and a re-examination of archived data (K. Conway, pers. comm.). Figure 2 maps closure area boundaries surrounding each sponge reef. The co-ordinates for each area's boundaries were provided by the GSCP to DFO in 1999 as guidelines for the management of shrimp trawl activity in the vicinity of the sponge reefs (K. Conway, pers. comm.). Although the area boundaries were conservatively estimated based on the known location of the reefs in 1999, in some cases the updated reef location has expanded considerably, so that the reefs are now known to occur in some areas relatively close to closure area borders. In our subsequent analyses here of fishery data, we use the revised, updated irregular sponge reef boundaries and the 1999 closure area boundaries. We present below a review of relevant fishery activities in Hecate Strait and Queen Charlotte Sound. The most significant fishery is groundfish trawling, with some more limited activity by the groundfish hook and line, shrimp by trawl, and crab trap fisheries.

2 NORTH AND CENTRAL COASTS GENERAL DESCRIPTION

Hecate Strait is located between the Queen Charlotte Islands and the mainland coast of northern BC and is mostly within the North Coast Planning Area of DFO. Queen Charlotte Sound is situated off the BC mid-coast north of Vancouver Island within DFO's Central and North Coast Planning Areas. Marine boundaries for the two areas are under review, based on ecosystem characteristics; and all four sponge reefs could ultimately be assigned to the latter Area (Figure

3). Parks Canada has included these areas within the Hecate Strait Marine Region and the Queen Charlotte Sound Marine Region, respectively, in their plans for the development of a national system of marine conservation areas (Booth et al. 1998). The BC Land Use Co-ordination Office (LUCO) has also included both areas as two of the twelve defined Marine Ecosections for planning, resource management, and a provincial marine protected areas strategy (Howes et al. 1997).

2.1 Physiography

Hecate Strait and Queen Charlotte Sound are both located on the gentle slopes of the western Canadian continental shelf within the physiographic province of the Hecate Depression. The present morphology of Hecate Strait and Queen Charlotte Sound is dominated by the Quaternary glacial history of the shelf, with some influence by active tectonics, rapid sea level fluctuations, and moderation by coastal oceanographic conditions (Barrie et al. 1991). Three major troughs 10 to 40 km wide, intersect Queen Charlotte Sound perpendicular to the mainland coast with depths up to 300 to 400 m, and these are separated by extensive, shallow banks less than 100 m deep. The most northerly, Moresby Trough, is the largest, and extends northward into the North Coast to form the deepest portion of Hecate Strait (Bornhold and Barrie 1991).

Barrie et al. (1991_ noted that the series of advances and retreats over the shelf by Wisconsinian glaciers probably formed the troughs, deposited the sediments within them, and contributed to their surface features evident today. Sediment deposits within the troughs are generally glacial tills overlain with glaciomarine muds and Queen Charlotte muds at greater depths. Relict iceberg furrows are present in the central and southern troughs to depths up to 200 m, and the furrows in the northern extension of Moresby Trough in Hecate Strait occur at depths greater than 110 m. The combination of lower sea level on the shelf, due to eustatic and isostatic conditions, and the formation of a floating ice shelf during glacial retreat, allowed rafting ice bergs to scour the shelf bed. The resulting furrows are generally linear with gouge depths in the substrate of less than 3 m, but occasionally as deep as 7 m (Barrie et al. 1991). These relict features have been preserved due to a lack of terrigenous sediment reaching the continental shelf. The fjords and inlets of the mainland coast are typically 50-100 km long and are approximately 100 m deep. Shallow sills at the mouths of the fjords restrict the movement of coastal eroded sediment into Hecate Strait and Queen Charlotte Sound (Crawford and Thomson 1991).

2.2 Oceanography

Thomson (1981) considered the northern shelf of the Canadian west coast a hybrid oceanographic region, influenced by deep-sea processes, tides, winds, and freshwater discharge within a semi-exposed marine environment. In the absence of winds and freshwater discharge, surface water circulation is dominated by tidal streams moving in a clockwise-rotary motion that switch direction and speed in a semidiurnal cycle. In Queen Charlotte Sound, the principal direction of flooding is to the north-east and principal ebbing to the south-west, while the bathymetry of Hecate Strait produces a more rectilinear flow that floods to the north and ebbs to the south. Maximum surface currents of 50 cm s^{-1} occur during spring tides, but fall by half during neap tides (Thomson 1981). The speed and direction of near-bottom currents are more greatly influenced by bathymetry, but have been measured in excess of 65 cm s^{-1} in southern and central portions of Hecate Strait (Barrie and Bornhold 1989). Northerly flows predominate in the eastern and northern portions of Hecate Strait, but flow towards the south along the south-west (Crawford and Thomson 1991). In Queen Charlotte Sound, characteristic near-bottom currents are lower, in the range of 15 - 25 cm s^{-1} (Thomson 1981).

In the northern shelf region, water temperatures and salinity vary seasonally with inputs of solar radiation and storm events. Average surface water temperatures are lowest in April at about 5 - 6°C, and peak in August around 14°C. In general, surface water temperatures decrease further to the north, but can be moderated by wind-driven currents bringing in relatively cooler or warmer waters. Conversely, seasonal variations in surface water salinity exhibit maximum values in winter of 32 ‰, and minimum values in summer of 28 ‰ when freshwater discharge peaks. In contrast, bottom temperatures are lowest in the summer at about 5°C, and rise in autumn and early winter to about 7°C, with increases in south-easterly winds and storm activity promoting downwelling and mixing of the water column. These events also reduce salinity at depth in the summer (Thomson 1981, Crawford and Thomson 1991, Crawford 2001).

2.3 Potential offshore oil and gas exploration activity

Activities related to the exploration of oil and gas deposits on the western Canadian continental shelf have taken place off the BC coast since the late 1950s. Presently, the federal government has a moratorium on exploratory drilling and tanker traffic in Hecate Strait and Queen Charlotte Sound. The Province of BC also has a moratorium on offshore exploration and development within their self-declared *Inland Marine Zone*, which includes Hecate Strait and Queen Charlotte Sound (Whitford 2001). The BC government has lifted a moratorium to determine if these resources can now be extracted in a scientifically sound and environmentally responsible manner. The federal government moratorium is under review. The sponge reef areas of Queen Charlotte Sound and Hecate Strait have been leased by the oil and gas industry (Figure 4), although there is presently no available data on any potential reserves that might be present.

The federal and provincial governments share a joint mandate on environmental matters off Canada's Pacific coast. This includes a joint initiative to develop a strategy for marine protected areas. Minimum protection standards defined by a 1998 discussion paper include prohibiting the exploration for, or the development of, non-renewable resources (Anon. 2000). Areas of high hydrocarbon potential have not been identified near the hexactinellid sponge reefs (Whitford 2001) although exploration is incomplete, and the sponge reefs lie with the leased area. However, there is still potential for such activity to impact the sponge reefs, regardless of whether or not they are in MPAs. DFO Science staff are currently reviewing the environmental impacts of offshore mineral exploration activity on the fisheries and aquatic resources in Hecate Strait and Queen Charlotte Sound (W. Cretney, DFO, Sidney, BC, pers. comm.).

3 DESCRIPTION OF SPONGE REEFS

Fossilised hexactinellid sponge reefs have been documented back to the Middle Triassic [245 – 208 million years ago (mya)], but reached their maximum extent during the Late Jurassic (208 – 146 mya). A discontinuous reef belt facies extends for more than 7,000 km across southern Europe and the Atlantic Ocean margins, and was the largest known bioconstruction ever built on earth (Conway 1999), and so the geomorphological and ecological dynamics of sponge reefs are of particular scientific interest.

Present-day reefs are found in four locations in the seafloor troughs crossing the continental shelf of Queen Charlotte Sound and Hecate Strait (Figures 7-10) at depths between 165 and 240 m (Krautter et al. 2001), and in total cover an estimated area of over 700 km^2 (Conway 1999). The reef complexes are formed of sponge bioherms (steep-sided reef mounds) up to 19 m in height, and biostromes (sheet-like accumulations) 2-10 m thick and up to several kilometres wide, with individual sponges up to 1.5 m in height above the substrate (Conway et al. 2001, Krautter et al. 2001). Radiocarbon dating of two of the four cored bioherms suggests that the oldest date of reef formation ranges from approximately 9,000 y BP (before present) to 2,000 y BP (Conway et al. 1991).

Figures 1 and 2 show the shrimp trawl voluntary closure areas (with a slight modification to the most northern reef for data analysis convenience, as the actual closure has a diagonal boundary line), and the most recent, updated estimated areas of sponge coverage (K. Conway, GSCP, Sidney, BC, pers. comm.) as of March, 2002. All the fishing activity and catch data reported in this paper references to the shrimp closure areas, and the updated areas of sponge occurrence. (Note: the recently established groundfish trawl closures were established after this report had been largely written, so while reference is made to them, all analyses presented utilise the only voluntary shrimp closure boundaries. Because the latter closure areas are larger than the former, this allowed our evaluation of fishing in a potential “buffer zone” around the reefs.) Initial (1998) estimates of sponge reef areas were smaller than is now known to be the case, and so in some instances, the closure areas established now no longer allow for an effective protective buffer area around all the reefs. The recent (2002) updated areas of sponge occurrence has increased the areas of Reefs A and C, bringing them now much closer to the fishery closure box boundaries. These boxes originally had the areas of sponge occurrence generally well within the boxes. This is relevant for all reefs except perhaps Reef B, which has had few trawl tows within the closure box around it, presumably because of poor fishing there.

3.1 Unique conditions for sponge reef formation

The combination of specific bathymetric, oceanographic, and substrate conditions found in the troughs of Hecate Strait and Queen Charlotte Sound have created the unique environment for the formation of the sponge reefs. The stable seafloor conditions of the western continental shelf experience low sedimentation rates, and areas of reef growth are associated with currents between 0.15 – 0.30 ms^{-1} that can transport suspended sediment in clay-fine sand particle fractions. Sponge bioherms have not been found in trough areas that receive significant amounts of sediment, suggesting there is an upper limit to the sponge’s tolerable sedimentation rate. These relatively stable conditions have also contributed to preservation of the relict iceberg-scoured seafloor where sponge reef growth has occurred. The substrate of the seafloor surrounding the furrows is generally stratified sandy mud/muddy sand of variable thickness, but iceberg scouring has produced a much coarser texture that provides the hard substrate required for good attachment by sessile benthic organisms (Conway et al. 1991, Conway 1999). Because framebuilding hexactinosan species observed in the reefs are not known to anchor to muddy or sandy seafloor sediments (Conway et al 1991), substrate conditions play an important role in sponge reef development, and any factor that might affect sedimentation rate has the potential to impact reef development.

Core analysis of the bioherms shows sponges amongst a sediment matrix of silty clay with variable sand content, demonstrating a cyclicity of sponge habitation and coverage by sediment (Conway 1999). The reef building process appears to begin with the attachment and growth of individual sponges to the boulders and gravely lag deposits on the winnowed berms of iceberg furrows, and through subsequent growth by attachment to the skeletons of dead sponges (Conway et al. 1991, Conway 1999). The sponges may utilise a trapping and baffling mechanism to incorporate sediments of silty clay or clayey silt, with some minor sand fractions (Barrie et al. 1991), or this process may result from feeding or active removal and deposition. Nevertheless, through continuous growth, these mounds eventually consolidate into the biohermal and biostromal structures that form the reef. Orientation of the reef complexes is parallel to the specific trough's axis, due mainly to the bathymetric focussing of currents (Conway et al. 1991). It has been suggested that construction of the complexes may be initiated in a central zone that extends laterally from the central core (Barrie et al. 2000). Although growth rates for hexactinosan sponges may vary from a minimum of 0–7 cm y^{-1} (Krautter et al. 2001), radiocarbon dating of some bioherms indicates that the approximate rate of reef growth during the late Holocene was 1 mm y^{-1} (Conway et al. 1991). This framebuilding process is analogous to coral reef construction, and is the first documented study of this process for hexactinellid sponges (Conway 1999).

Jergen Westrheim (DFO, Nanaimo, BC, retired) referred Jeff Fargo (DFO, Nanaimo, BC, pers. comm.) to a report he published in the early 1970s that contained mention of 'excessive' catches of sponge during BC trawl surveys by the R/V G.B. Reed. There may thus be other sponge concentrations in BC as well.

3.2 Sponge biology

Aphrocallistes vastus, also known as the cloud sponge, has been documented to host a variety of other animals within its cavities including juvenile rockfishes and other small fishes, crabs and various shrimp (Harbo 1999). In addition to the three framebuilding species, four other rosselid species of loose spicule sponges from the Order Lyssacinosa also inhabit the reefs: *Rhabdocalyptus dawsoni, Staurocalptus dowlingi, Acanthascus platei and Acanthascus cactus* (Conway et al. 1991). The surfaces of the sponge reefs are intermittently covered with living sponges, and sponge skeletons that are sometimes covered with sediment but have maintained their structure. Other portions of the reefs consist of a sandy mud matrix with abundant worm tubes, echinoderm plates, and foraminifera (Conway 1999). These sponge species are not rare in BC, but their occurrence as reefbuilders is, and it is their presence in abundance in marine reefs that is presently unique in the world.

The Marine Ecology Station (Khyotan Marine Laboratory) has just initiated a project titled "Understanding and Protecting Shallow Water Glass Sponge Reefs", supported by a grant from the Habitat Stewardship Program. Other partners in this project are the Victoria Dive Club and Applied Microsystems. The target species are *Heterochone calyx*, the Chalice Sponge, and *Aphrocallistes vastus*. Shallow water populations of these species in the Strait of Georgia and in certain B.C. fjords were identified as rare and endangered in a report by Khoyatan Marine Lab to the Conservation Data Centre and in a paper presented at a conference in Kelowna (Austin 2000). The B.C. Conservation Data Centre has subsequently placed them on the Provincial Red List. The Marine Ecology Station project will focus on populations near Senanus Island in Saanich Inlet. Divers will assess the potential impacts of prawn and crab traps, near bottom fishers, and divers on the sponge beds. Studies are focusing on sponge rates of growth, skeleton repair, recruitment over the course of one year; rate of water movement through the sponges; rate and volume of sediment removal, and responses of organisms which contact the sponge surfaces. These studies will be done both in situ and, where practical, in a sea water system on a floating barge, which is to be moored for short periods of time directly over the sponge bed and drawing water at sponge bed depths. Some of this research may be directly relevant to our understanding of the biology of deeper water sponges.

It is not known why hexactinellids occur in shallow water and form bioherms in BC. Austin has argued that the high level of silicates in fjords, the Strait of Georgia and the heads of canyons is correlated with hexactinellid presence (Austin 1984, 1999).

Growth rates: Levings and McDaniel (1974) observed a 60cm high *Aphrocallistes vastus* on an underwater cable laid down 52 years previously. The average growth rate would then be ~1cm y^{-1}. More recently (June 2000), Randy Haight of Vacilador Productions Ltd. (Bill Austin, pers. comm.) video recorded moderately large populations of *A. vastus* during a pipeline survey. Bill Austin calculated that the sponges attached to the pipe ranged up to 64 cm in height. The pipeline was laid down only nine years previously, indicating an average minimum growth rate of about 7cm y^{-1}, and rates could be considerably faster if it took several years for the sponges to become established. Leys and Lauzon (1998) and Jeff Marliave (Vancouver Aquarium, Vancouver, BC, pers. comm.) have both independently recorded growth rates in the boot sponge *Rhabdocalyptus dawsoni*. Marliave monitored tagged sponges with videotaping, and also mapped colonies. Basically, there is a huge variation in early growth rate, which translates into a few sponges growing quickly to a small adult size within a year or two, and others perishing. Growth can be fairly rapid as long as the sponges remained tubular in simple form (either "boot" shape on cliff or "chimney" on flat rock). Once secondary oscula are formed, they may become large in size or deteriorate (often because of some mechanical aspect, either filling up with debris or failing to withstand currents or gravity). When the osculum flares, they often blacken and deteriorate within a year. About a decade seems to be the lifespan for most of the sponges that were monitored.

Given the lack of growth data for reef-building hexactinellids, if data from rossellid (loose-skeleton) hexactinellids that also live in the reefs, and which form sponge mats but not reefs, provides any indication of growth, then data from the Anarctica (Dayton 1989) and B.C. fjords (Leys and Lauzon 1998) indicates that as might be expected, the sponges grow relatively quickly as juveniles and that growth decreases with age.

These sponges are unique in the animal kingdom in possessing syncytial rather than cellular tissues, which allows them to communicate with electrical impulses even though they lack nerves. This means that these sponges can respond to disturbances, either a mechanical knock, or excessive siltation. Their response is to instantly stop their feeding current (reported in Leys and

Mackie 1997). Typically, these sponges will try to feed again after 20-30 min, but if the levels of silt or disturbance remain high, they will again stop feeding. Consequently, disturbances to the sediment around the sponges, or direct physical injury, might have a continued impact on the livelihood of these animals.

Longevity: While there is indirect evidence of longevities of several centuries for some sponge species (e.g., some sclerosponges), there is no known data on hexactinosan sponges. Bill Austin has considered the feasibility of measuring Si^{32}. Leys and Lauzon's (1998) work on the ecology of the rosselid *R. dawsoni* in Barkley Sound and Saanich Inlet suggests that this species is one of the longest living animals in the world (large individuals there 1 m or longer may be more than 220 years old).

Persistence of post-mortem skeletons: One of the keys to reef development is the persistence of the structural integrity of the main frame skeleton of hexactinosan species such that it can serve as a substrate for settlement of sponge larvae. While there is considerable information on solubility rates of diatom siliceous skeletons, only a few papers address the issue in sponges. However, indirect evidence suggests that mainframe skeletons may last a considerable amount of time. Basal attachments of *Aphrocallistes vastus* have been observed in Saanich Inlet at depths devoid of living organisms due to low oxygen levels. At some time in the past, the waters at these depths must have been continuously well oxygenated to support growth of this sponge (Levings et al. 1983). Bill Austin observed similar skeletons in azoic regions of Muchalot Inlet where the periodically anoxic condition in deeper waters extends back to at least 1959 (pers. comm). Sally Leys' (Univ. Alberta, Edmonton, AB, pers. comm.) current research program using SCUBA and the ROPOS, includes studies of dissolution rates of sponge skeletons, settlement and growth of juveniles, larval behaviour, and physiology and cell biology of adults. The only source population of hexactinellids where larvae can be obtained is off Marseilles, France. Leys and V. Tunnicliffe (University of Victoria, Victoria, BC) have requested funds to study Strait of Georgia sponge reefs to:

1) Determine the fecundity and recruitment success of hexactinellid (scopularid and rossellid) sponges;
2) Determine the rate of dissolution of siliceous skeletons of scopularid hexactinellids, and to estimate the length of time these skeletons persist;
3) Estimate the rate of growth and ages of cloud sponges; and
4) Accurately estimate the population structure, size class distribution, and preferred habitats of both scopularid and rossellid sponges in Barkley Sound for comparison with earlier information collected during PISCES dives on population structure in inland fjords (Howe Sound, Jervis and Knight and Saanich Inlet).

Recruitment: Henry Reiswig (now Univ. Victoria, Victoria, BC), a foremost hexactinellid biologist, has been looking for evidence of past recruitment. Leys will be using a settling plate system to assess recruitment during the ROPOS survey in August, 2002 (Bill Austin, Khyotan Marine Lab, Sidney, BC, pers. comm.) and has looked for settled larvae in sectioned hexactinosans.

3.3 Biotic associations around sponge reefs

The existing knowledge of the biotic habitat associations for the sponge reefs is based on high-resolution geophysical data, still photography, videotape transcriptions, and direct observations taken during submersible dive transects and geophysical surveys. Catch data from fishing activity over and adjacent to the reefs provides additional data. Differences occur in the fish and invertebrates found on the reefs and the adjacent seafloor. Species identified from visual observations of the sponge reef include annelid worms (*Terebella* sp., serpulids), bryozoans, and rare occurrences of bivalves (*Thyasira*) and gastropods. Local abundances of several species of rockfish, spider crab, box crab, king crab, shrimp, prawns, and euphausiids were also observed. Flatfish were rarely observed on the reefs. Localised observations of echinoderms, primarily sea stars and urchins, have been associated with dying sponges or those in poor condition, and have been suggested as potential indicators of sponge health (Conway 1999, Conway et al. 2001, Krautter et al. 2001), although Bill Austin (pers. comm.) has suggested. Microfaunal observations of surface and subsurface core samples noted over 200 species of foraminifera, composed primarily of *Epistominella vitrea* and *Bolivina decussata.* Coarser fractions of foraminifera were found to contain a greater proportion of arenaceous species (Krautter et al. 2001).

Epifauna observed on the seafloor adjacent to the sponge reefs included sea whips, soft corals, anemones, and large individual sponges such as *Heterochone* (*Chonelasma*) *calyx*, *Mycale bellebellensis*, and *Iophon chelifer*. Burrows of unknown species were also commonly observed on the seafloor, but not on reef surfaces. Ophiuroids were found both on and off the sponge reefs (Conway 1999, Conway et al. 2001).

Bill Austin (pers. comm.) made a qualitative assessment of the fauna associated with the sponge reefs during his DELTA dives in 1999. The species data are incorporated in the report on marine invertebrates in Gwaii Haanas (Sloan et al. 2001).

3.4 Documented impacts of trawling on sponge reefs

Bottom trawling impacts have been documented from side-scan sonar observations at the two reef sites in Hecate Strait, and the southern reef in Queen Charlotte Sound. The trawling impacts are visible as parallel tracks generally 70 to 100 m apart made by the otter doors (Figure 5). Individual tracks may extend for several kilometres at water depths from 210 to 220 m (Conway 1999, Conway et al. 2001, Krautter et al. 2001). A comparison of side-scan sonar observations between 1988 and 1999 demonstrated increasing evidence of trawling on the most southern reef (Reef D in this report) in Queen Charlotte Sound (Conway 1999). Although relatively less harmful (Kulka and Pitcher 2001), there is also potential for reef damage from hook and line and crustacean trap fishery activity (K. Conway, , pers. comm). Traps at this depth are fished in long lines, and for both gear types, when the gear is hauled up, the horizontal long lines, and traps, are dragged across the bottom, which may break corals or sponges. At the two reefs in Hecate Strait, submersible dive observations have documented the types of damage from fishing occurring to sponge reefs. Evidence of broken projections of sponges (stumps) and sponges with abraded distal edges were observed, in addition to sightings of broken sponges lying on the seafloor (Figure 6). In some cases, broken sponges were piled into a linear ridge roughly 40 cm high, presumably by the plowing action of mobile fishing gear. Sponge sites that had not been disturbed by fishing impacts could be distinguished from impacted sites by the density and patterns of sponge skeletons present, all of which would eventually become blanketed with sediment (Conway 1999, Conway et al. 2001, Krautter et al. 2001).

The structural damage caused by bottom trawling activity is believed to have detrimental effects on the growth and development of sponge reef complexes. Because skeletons are the only available substratum for the attachment of new sponges on the reefs, skeleton fragmentation and there potentially more rapid burying may inhibit the recruitment rate of new sponges (Conway et al. 2001, Krautter et al. 2001). In addition, the increased turbidity associated with the plowing action of the otter doors and traps (Churchill 1989) could disrupt filter feeding and hence growth rates, further impacting the reefs (Conway et al. 2001). Based on the naturally slow growth rates of these sponges and the unique conditions required for reef formation, recovery time for damaged sponge reefs has been estimated at between 50 to 200 years (Conway 1999, Conway et al. 2001).

4 FISHERY ACTIVITY AND SPECIES CATCHES IN THE VICINITIES OF SPONGE REEFS

Canadian fisheries waters of the Pacific Ocean and the inshore waters of the province of British Columbia have been divided into Pacific Fishery Management Areas (PFMAs) and subareas for the purposes of regulating activities under the *Fisheries Act*. Figure 1 presents the location of the sponge reefs within the PFMAs for the North and Central BC Coasts.

4.1 Groundfish trawl

The groundfish trawl fishery in the North and Central coasts primarily uses otter trawls, with a large, bag-shaped net dragged over the ocean floor. The PacHarvTrawl database at the Pacific Biological Station (PBS) contains historical catch and effort information for the Pacific groundfish trawl commercial fishery. Prior to 1996, georeferenced fishing location co-ordinates and catch information were incomplete. However, since 1996, there has been 100% observer coverage for the fishery, resulting in a substantial increase in the amount and quality of data available, including bycatch data. Consequently, all of the fishing activity, catch and effort data presented in this paper utilises information from 1996 to 2001. Fishing activity for 2001 is underestimated due to the unavailability of some fourth quarter data in the PacHarvTrawl database. In order to obtain an understanding of all fishing events taking place within the sponge reef boundary boxes shown in Figure 2, the fishing activity, species lists, and catch data provided below are presented in four different scenarios. For each groundfish trawling event, a latitude and longitude co-ordinate provides the set location for the start and end point for each trawl event, or tow. Therefore, in order to obtain a minimum estimate of all fishing activity that has taken place within the existing voluntary closures, the first scenario is based on all tows that either started and/or ended within the closures (Figures 7-10) (BOX). Finer resolution of data is achieved considering fishing events within the closure that either started and /or ended on the reef (REEF AND ADJACENT). Finally, the most accurate estimates for fishing on the reefs considers fishing events that only started and ended on the sponge reefs (REEF ONLY). In order to evaluate fishing activity that took place around the vicinity of the sponge reefs, but that was not actually on the reef itself, fishing events that both started and/or ended within the closure but that were not on the sponge reef (ADJACENT ONLY) were considered.

4.1.1 Groundfish trawl activity in the vicinities of the sponge reefs

Table 1 presents groundfish trawl fishing activity (number of CFVs, fishing events, and effort) in the vicinity of each sponge reef from 1996 to 2001 based on the four different analytical scenarios described above. The reefs have been labelled A, B, C, and D from north to south. The number of commercial fishing vessels (CFVs) describes the number of unique fishing boats that participated in the fishery. Either trips or sets can describe fishing activity, a trip being a fishing event distinguished by a Hail Number, i.e., the unique number assigned to a fishing trip when the vessel master hails in to the contractor to indicate a fishing trip is ending. Within each trip, there can be numerous sets, in which the fishing net has been deployed. Because the length of time that a net has been deployed can vary between trips or sets, the most accurate description of "fishing effort" is the timed duration that the net has been deployed for each set; effort data are expressed in minutes the gear was on the sea floor.

The greatest groundfish trawling activity in this study took place in the vicinity of Reef D. Reefs A and C had less fishing activity (Figures 7-10). Little fishing effort was expended on Reef B. For all reefs, the majority of fishing activity occurred around the vicinity of the actual sponge reefs (BOX), and with the exception of reef A, few tows started or ended on the reef itself. In 1998 and 2000, there were more tows starting or ending on the actual reef (REEF AND ADJACENT) than in the adjacent area surrounding reef A (ADJACENT ONLY). In all cases, the least number of fishing events took place solely within (i.e. tows start and end) the reef boundary (REEF ONLY).

From 1996 to 2001, annual variability of fishing activity differed for each reef (Table 1). For Reef D, effort halved between 1997 and 2001, with a steady decline in the number of vessels fishing in the vicinity of the reef from 1997 to 1999; vessel number has stabilised in recent years. The number of vessels fishing close to the sponge reefs peaked in 1997, corresponding directly to fishing effort. The 2001 effort level was only about 40 % of that in 1997.

At Reef A from 1996 to 2001, the number of vessels fishing annually declined from about 20 to 8, but the number of vessels fishing close to the sponge reefs remained fairly constant at about five. Fishing effort was variable for Reef A, with activity surrounding the reefs greatest in 1999, and peaking on the sponge reefs in 2000.

The number of fishing vessels fishing near Reef C remained fairly constant at about seven throughout the six-year period. Fishing effort on the reef peaked in 2001.

Seasonal variability in fishing activity is described in Table 2. For Reef D, the greatest fishing activity in the closure occurred during May and June. However, fishing activity closest to the sponge reefs was greatest during February and March; the least amount of fishing took place during late summer and early winter. A similar seasonal trend occurred at Reef C, while in contrast, the greatest fishing activity around Reef A occurred in the fall, with the least activity during the winter.

4.1.2 Groundfish trawl species lists

Tables 3 - 6 presents species catch lists (targeted and bycatch species) by reef location during the six–year period from 1996 to 2001. Target species in groundfish bottom trawling were: scorpionfishes (Family Scorpaenidae), which includes the genera *Sebastolobus* (thornyheads) and *Sebastes* (rockfish); flatfish; skates; tuna; mackerels; and roundfish, such as Pacific cod (*Gadus macrocephalus*), Pacific hake (*Merluccius productus*), walleye pollock (*Therara chalcogramma*), sablefish (*Anoplopoma fimbria*), lingcod (*Ophiodon elongatus*), sculpins (Family Cottidae), greenlings (Family Hexagrammidae), and spiny dogfish (*Squalus acanthias*).

Bycatch included both non-commercial fishes, and commercial fishes that were allocated to other fisheries. Commercial species included Pacific halibut (*Hippoglossus stenolepis*), Pacific herring (*Clupea pallasi*), eulachon (*Thaleichthys pacificus*), Pacific tomcod (*Microgadus proximus*) and species of Pacific salmon (*Oncorhynchus spp.*). Non-commercial bycatch fish species commonly caught at all reefs included spotted ratfish (*Hydrolagus colliei*), eelpouts (Family Zoarcidae), grenadiers (Family Macrouridae), and poachers (Family Agonidae). A relatively large number of species of sharks (Family Elasmobranchii) were caught at Reef D, and there, the bycatch also included green sturgeon (*Acipenser medirostris*), designated as of “Special Concern” by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), (COSEWIC 2002). The targeted-species bocaccio (*Sebastes paucispinis*) and the bycatch-species eulachon are respectively currently under review and being planned for immediate review by COSEWIC. Table 7 lists targeted commercial and non-commercial species on the COSEWIC candidate list, suggesting that reports may be prepared for them in the future (COSEWIC 2002).

Invertebrate bycatch included both non-commercial and commercial species: sponges, corals, segmented worms, sea stars, urchins, cucumbers, bivalves, cephalopods, shrimp and prawn, and crabs. One occurrence each of pinniped and bird bycatch was reported over the six-year period.

The total numbers of both targeted and bycatch species caught declines with closer proximity to the sponge reefs (Tables 3-6). Whether this is an artefact due to a similar decline in fishing effort closer to the sponge reefs or is due to an actual change in species composition associated with the sponge reef ecosystem is not clear at this time.

Tables 8 and 9 list the species catch lists (targeted and bycatch species) by reef location that were either only caught on the sponge reef, or adjacent to the sponge reef, respectively. Only eight species were caught on REEF ONLY, of which four are targeted by groundfish trawl, in comparison to the relatively large number of targeted and bycatch species caught exclusively adjacent to the sponge reef (ADJACENT ONLY).

4.1.3 Groundfish trawl species catch data

Commercial catch statistics for the sponge reef areas are not reportable due to confidentiality requirements under the Access to Information and Privacy Secretariat (ATIP) operating under the Access to Information Act. Therefore, Tables Alternative 10-12 present (where possible) summaries of the annual and accumulated catch per unit effort (CPUE) and percentage breakdown (by weight) of catch at reefs A, C and D for the major species groupings rockfish/thornyheads, flatfish, and other (includes skates, dogfish, tuna, mackerel, and roundfish) from 1996 to 2001, on the REEF ONLY, REEF AND ADJACENT, and ADJACENT areas, respectively. No catch data for Reef B can be presented due to the limited number of fishing vessels in the vicinity of that reef. Tables Alternative 8-10 also present the CPUE of bycatch, which is broken down as sponges, species not permitted (i.e., non-retention due to allocation to other fisheries or conservation concerns), and incidental catch not targeted by groundfish trawling.

The vast majority of catch was flatfish at Reef A, followed by rockfish/ thornyheads, and others. When considering fishing tows that include the surrounding area adjacent to the reef (REEF AND ADJACENT, and ADJACENT), the percentages of rockfish/thornyheads and other species increases. In all cases, the bycatch comprises only a small percentage (<5%) of the total catch, with no major differences between species groups on or adjacent to the reef. In comparison, the majority of the catch at Reefs C and D is rockfish/thornyheads, with an increased percentage when including the surrounding area adjacent to the reef. Differences in sponge bycatch are also evident when comparing fishing tows on the reefs and tows adjacent. At the two reefs in Queen Charlotte Sound, sponges alone comprise about 15% of the total catch for the entire period, with declining percentages for tows surrounding the reefs. The bycatch percentage for other species also declines when considering tows adjacent to Reefs C and D.

Tables 10-12 summarise the annual catches of targeted and bycatch species by groundfish trawl from 1996 to 2001 for REEF ONLY, REEF AND ADJACENT, and ADJACENT ONLY areas, respectively. The data for 2001 is incomplete due to the unavailability of some fourth quarter data in the PacHarvTrawl database at the time the tables were compiled.

Table 13 lists the total landings for all species from 1996-2001 (last year is incomplete) and provides an overall perspective of the importance of the shrimp voluntary closure, and its internal zones around each reef. Reefs D, C and A had 62, 22 and 16 % of the total landing from all four reefs (7923 t; about 1320 t per year) respectively, and 77, 20 and 3 % of the landing came from ADJACENT ONLY, REEF AND ADJACENT, and REEF ONLY areas, respectively.

A relatively small percentage of the catch (3 %) came from the REEF ONLY area, and in the ADJACENT ONLY area, which comprised 77 % of the total landing, 81 and 15 % was from targeted IVQ and targeted non-IVQ species, respectively. The remaining 4 % comprised all other species. Among the targeted IVQ species, there has been a 90 % decrease in yellowtail rockfish landings (341 to 36 t) over the six years, and a gradual increase in yellowmouth landings from 9 to 41 t. Redstripe rockfish landings tripled in 1997-1998, but have since declined, while 1996 was a peak year for dover sole landings. The landings of most other species have remained relatively constant over this time period. Among targeted species without an IVQ, redbanded rockfish and boccacio landings have decreased, while arrowtooth flounder and rex sole landings have fluctuated substantially, but were at a relatively high level in 2001.

At Reef D (REEF ONLY), an attempt was made to identify all of the sponge catch in 1997, 58% (Table 10) of which was listed as calcareous sponge (Class Calcarea), as opposed to the glass sponge (Class Hexactinellida) which comprises the sponge reef. Calcarerous sponges are common at shallow to moderate depths of 30 m or so, although a few can occur as deep as 200 m, unlike glass sponges which are typically found in deeper waters (Harbo 1999) such as in the troughs of Queen Charlotte Sound and Hecate Strait. Therefore, it seems likely the recording of almost 11 t of calcareous sponge catch on this sponge reef was a misidentification of glass sponges by the observer. Another possible misidentification is crown-of-thorns starfish, as this species has not been reported for BC . However, there is now no way of confirming identifications, as specimens were discarded. The majority of the remaining bycatch species on Reefs C and D was stony coral (up to 4 t per reef per year) (Order Madreporia).

4.2 Groundfish hook and line

The PacHarvHL database at PBS contains historical catch and effort information for the Pacific hook and line commercial fishery. Information is primarily based on fishers' logs, but some observer log data was also included. Since 1994, latitude and longitude co-ordinates for the starting point of fishing events (tows or sets) have been entered, and since 2001, corresponding end points have been included. Therefore, information for fishing activity around the sponge reefs presented here is based primarily on the starting points of fishing events, and may not totally reflect the actual activity. Furthermore, although maximum depth was recorded, there is no way of knowing at what point in the set that depth occurred, so it is not possible to determine whether fishing activity occurred at depths likely to cause potential damage to sponge reefs.

Table 14 presents historical hook and line fishing activity in the vicinity of the sponge reefs from 1994 to 2001. Most hook and line fishing activity took place around reef A, with the greatest number of vessels and highest effort expended in 2001, up over 500 % from 2000. Targeted species (data only recorded since 1998) for this groundfish fishery around the sponges reefs included rockfish, thornyheads, lingcod, and Pacific halibut. Table 15 lists targeted and recorded bycatch species caught by the groundfish hook and line fishery in the vicinity of the four sponge reefs. Because catch data were based primarily on fisher's logs rather than observer data, it is likely that relative to groundfish trawl data, bycatch data here are under-reported.

4.3 Shrimp trawl

Shrimp trawling occurs in Hecate Strait and Queen Charlotte Sound, but has been limited in the vicinity of the sponge reefs. Shrimp trawl logbook records have only recorded fishing location by latitude and longitude since 1996. Since 2000, the Shrimp Trawl Sectoral Committee, the Pacific Coast Shrimpers' Cooperative Association, and DFO have collectively requested that fishers avoid trawling in the sponge reefs areas (DFO 2000, 2001). Table 16 thus only represents known shrimp trawling activity around the sponge reefs from 1997 to 1999. Among targeted shrimp species, only pink shrimp (*Pandalus borealis*) and sidestripe shrimp (*Pandalopsis dispar*) were caught near the reefs. No bycatch information is available for tows.

4.4 Crab trap

The present crab trap fishery in Hecate Strait and Queen Charlotte Sound targets Dungeness crab (*Cancer magister*). Catch information only records target species; no bycatch information is provided. The majority of historical information for crab trap fishing does not provide specific information on fishing locality, and such data are only available by PFMA area and subarea. Table 17 presents crab fishing activity for the PFMA subareas that include the sponge reefs. The majority of fishing took place from 1995 to 1999 in subarea 105-2, which contains the most northern reef in Hecate Strait. Of the 120 fishing events there, only two occurred at depths greater than 55 m. Consequently, it appears that crab fishing did not take place near the sponge reefs. The crab database also shows one fishing event taking place in 1998 in subarea 107-1, but there was no accompanying depth or locality information.

4.5 Salmon troll

All commercial salmon catch statistics for the Pacific region are only available by PFMA (B. Patten, DFO, Nanaimo, pers. comm.), and the lack of precise spatial resolution prevents documentation of possible salmon fishing activity in the vicinity of the sponge reefs. However, since most commercial salmon fishing in Hecate Strait and Queen Charlotte Sound is by trolling, there is likely no impact on the sponge reefs.

5 SAMPLING METHODS AND PROTOCOLS FOR COLLECTING DATA

The utility of the historic fishery-dependent data in the estimation of stock abundances for demersal shelf rockfish species has been questioned (Leaman and Nagtegaal 1986, O'Connell and Carlile 1993, Scott 1995, Yamanaka and Lack 2001). An historical review of the inshore rockfish fishery in British Columbia is available (Yamanaka and Lacko 2001). They summarised both coast-wide commercial and recreational landings of rockfish based on logbook and creel survey data, and related catch trends to management changes in the fishery. Limitations in the use of catch data for the estimation of rockfish abundance are also listed, including data gaps of rockfish catches in commercial halibut, recreation, and First Nations fisheries; and a lack of standardisation in the collection of all rockfish catch data. The characteristics of rockfish biology contribute to the limitations of utilising catch data to estimate stock abundances. Rockfish are slow growing and long-lived, and as sedentary adults are often associated with habitats with structural complexity, such as reef habitats. Within a statistical area, catch rates can be maintained as fishers move from reef to reef, until all reefs within an area have been depleted of rockfish, at which point depleted populations of long-lived species could take decades to recover (Leaman 1991). Until then, serial depletion of populations is often not evident unless precise fishing locations are documented. With the increase in observer coverage for the groundfish trawl fishery, enhanced spatial resolution of fishing activity has been available since 1996. This now allows catch data for specific areas to be analysed for species composition (targeted and bycatch) and catch trends. Unfortunately, not all landings are publishable due to confidentiality requirements under the Access to Information and Privacy Secretariat (ATIP) operating under the Access to Information Act. Therefore, catch data have been modified from those presented at the PSARC Subcommittee meeting to exclude the proprietary information they contain.

The need for development of fishery independent methods for rockfish stock assessment is recognised. Yamanaka and Lacko (2001) reviewed catch age analysis from commercial fishery and research surveys conducted at specific index sites along the coast, and concluded that catch age data collected from research surveys provides the most informative population indices. This information, combined with fishery CPUE indices, could potentially be extrapolated over larger spatial scales to estimate relative species' abundances (Yamanaka and Lacko 2001). The majority of rockfish studies have been conducted utilising SCUBA surveys. However, the deep depth of the sponge reefs in the troughs of Queen Charlotte Sound and Hecate Strait restricts survey methodologies to indirect methods, or by direct observations and by video camera only from manned submersibles and Remotely Operated Vehicles (ROVs). These may allow visual assessment of rockfish abundance at specific sites. An indirect method of estimating abundance has been proposed by Scott (1995), who used preferred water mass characteristics of temperature and depth to predict changes in catch rates of Pacific ocean perch in Queen Charlotte Sound, but the utility of this broad-brush methodology to specific geographic areas such as around sponge reefs is unlikely. In the Gulf of Alaska, Kreiger et al. (2001) compared rockfish abundance estimates derived acoustically using echo integration to bottom trawl catches, and were able to derive a significant relationship between rockfish catch rates and acoustic indices. However, at some sites abundance estimates were inflated by the presence of other bottom-dwelling species such as walleye pollock and Pacific hake.

Submersibles have been utilised for habitat assessments, and in conducting line transects for estimating yelloweye rockfish (*Sebastes ruberrimus*) density in Alaska (O'Connell and Carlile 1993). In a subsequent study, biomass estimates were derived by combining line transect densities, estimates of area of suitable habitat, and the average weight of fish from port samples for the corresponding management area (O'Connell et al. 1998). Habitat-specific densities were also estimated, but were found to vary due to changes in survey techniques. The inclusion of a second video camera increased fish detection levels on the transect line, increasing density estimates. Methodological limitations included obtaining precise line length estimates, accurately quantifying available habitat, and the high cost of the survey (O'Connell et al. 1998). Another limitation of submersible observations was found by Richards (1986), who noted a higher variance in rockfish density with increasing habitat complexity due to the increased probability that fish were not visible in cracks or crevices in areas of higher relief. Delta submersible observation has also been utilised to study the distribution and abundance of Pacific ocean perch, and Krieger (1993) reported that the composition of larger fish (≥ 25 cm) was highly correlated to trawling catches at trawlable and marginally trawlable sites.

The usefulness of submersibles for surveys, as opposed to traditional methods such as bottom trawling and camera sleds, has particularly been noted for complex bottom habitats such as reefs (Uzmann et al. 1977, cited in Richards 1986; Krieger 1993). A comparison between the capabilities of the manned Delta submersible and the MiniROVER MKI ROV in estimating rockfish abundance found the submersible to be far superior in rocky, high-relief areas typically inhabited by demersal shelf rockfishes (O'Connell and Carlile 1994). Although the ROV was logistically easier and less expensive to operate, it manoeuvred poorly in rocky terrain, and abundance estimates determined from its video camera observations were problematic due to the limited field of view, poorer lighting system, and the higher probability of double-counting fish, resulting in an increased coefficient of variation. By comparison, the submersible operated well in rugged terrain, provided a superior field of view, and allowed for direct observations by an observer in the sub, increasing observation detail and increasing the accuracy of abundance estimation. As to the utility of trawl catch rates, for adult Pacific ocean perch, catches were found to be highly correlated at trawlable sites, but extrapolation to untrawlable sites characterised by rugged habitats in high-relief bottom environments would have resulted in overestimation of their abundance (Krieger 1993).

6 DISCUSSION

The majority of fishing activity in the vicinity of the sponge reef complexes has been groundfish trawl. Since 1996, the decline in bottom trawling activity occurring within the sponge boundary box is probably more than just coincidence. Although the sponge reefs were discovered in 1991, DFO has been aware of the impacts of trawling disturbance since 1999 (Conway 1999), and has informed the groundfish trawling fleet of the location of the four sponge reef complexes and urged that they refrain from harvesting over them. Most sponge reef bycatches and the fouling of trawling nets on reef biostromes and bioherms seems to have occurred prior to 1999 (Tables 10-12). However, trawling activity continues to take place both on and adjacent to the reefs, particularly Reefs A, C and D. Analysis of groundfish trawl catches for tows on and adjacent to the sponge reefs does reveal some trends in catch rates for both target and bycatch species. However, for some species such as rockfish and flatfish, the trends are not consistent for all reefs. Section 5 outlines the limitations of utilising catch data to estimate stock abundance for demersal shelf fish species, particularly for complex bottom habitats. Other studies have raised similar questions for the analysis of bycatch. Based on an analysis of catch, a relatively low quantity of detached macrobenthos is retained by the otter trawl, resulting in an underestimate of the degree of disturbance (Moran and Stephenson 2000, Pitcher et al. 2000). Therefore, the requirement for alternative methods to both estimate stock abundance and assess impacts to trawling disturbance has been recognised.

Physiographic characteristics of the benthic habitat and the resident species' characteristics can influence both the degree of impact and recovery rates arising from bottom trawling disturbance. Differences in trawling gear type and design, and the distribution and intensity of trawling effort can influence the degree of impact (Van Dolah et al. 1987, Auster et al. 1996, Thrush et al. 1998, Freese et al. 1999, Moran and Stephenson 2000, Pitcher et al. 2000). The cumulative effect of chronic trawling disturbances should be considered (Thrush et al. 1998), particularly for benthic fauna such as sponges (Auster et al. 1996) that may have a low tolerance to physical disturbance and/or slow recovery rates (Pitcher et al. 2000).

Trawling impacts benthic community structure and biological diversity (Van Dolah et al. 1987, Auster et al. 1996, Collie et al. 1997, Sainsbury et al. 1997, Engel and Kvitek 1998, Thrush et al. 1998, Watling and Norse 1998, Freese et al. 1999, Moran and Stephenson 2000, Pitcher et al. 2000). Damage to sessile, emergent epifauna, such as sponges, hydroids, and bryozoans, varies depending on their sensitivity to physical disturbance (crushing or removal), growth rates, fecundity, degree of aggregation, and the relative size of the organisms in comparison to other benthic fauna such as corals, or bottom features such as boulders. Trawl disturbance experiments have demonstrated varying removal rates for different sessile species, with per trawl removal rates for larger sponges ranging from 20% (Pitcher et al. 2000) to 67% (Freese et al. 1999). The recruitment and growth rates of benthic epifauna affect the recovery rate (Van Dolah et al. 1987; Moran and Stephenson 2000). Once impacted by bottom trawling, estimates of recovery periods for large, sessile epifauna range from several years to decades (Pitcher et al. 2000).

All groundfish bottom trawling in the vicinity of the sponge reefs has been conducted by otter trawl, a technique considered to have less impact than beam trawls (Kaiser et al. 1998). Several studies have documented the impact of otter trawling disturbance to benthic habitat.

Both biotic and abiotic components provide structural habitat to the seafloor environment (Auster et al. 1996, Watling and Norse 1998). Studies have documented changes to the physical habitat due to bottom trawling disturbance (Auster et al. 1996, Collie et al. 1997, Engel and Kvitek 1998, Freese et al. 1999). A reduction in the heterogeneity of benthic habitats was observed through the removal or disturbance of physically complex sedimentary structures such as sand waves, depressions, and boulders. Boulders not only contribute to bottom habitat complexity, but also serve as substrate for the growth of benthic epifauna such as sponges (Watling and Norse 1998). The physiographic characteristics of the bottom environment, such as oceanographic conditions, water depth, sediment grain size and organic content, influence the degree of impact and subsequent recovery rates from bottom trawling disturbance (Thrush et al. 1998). In general, characteristics of bottom environments subject to frequent levels of natural disturbance, such as storms and tidal flows, have more mobile sediments such as sand, a more rapid recovery from bottom fishing disturbance, and lesser overall evidence of past disturbances (Kaiser 1998, Kaiser et al. 1998). In comparison, more stable areas subject to little natural disturbance often have a mud bottom and seem to show longer recovery rates from activities such as trawling (Collie et al. 1997).

Section 3.4 documented impacts to the hexactinellid sponge reefs due to bottom trawling disturbance. Both the biotic characteristics of the sponges and the unique, abiotic conditions under which reef formation occurs make them highly susceptible to impacts from bottom trawling activity. Because impacts to emergent epifauna and physical bottom structures can alter habitat complexity, trawling disturbance to the sponge reefs can also have cascading effects on demersal fish assemblages (Van Dolah et al. 1987, Auster et al. 1996, Sainsbury et al. 1997, Kaiser et al. 1998, Thrush et al. 1998, Freese et al. 1999, Moran and Stephenson 2000), particularly for juvenile fishes (Watling and Norse 1998). On the Atlantic coast, increased survivorship and density of Atlantic cod was found for juveniles that settled in more complex habitats, likely due to an increase in shelter and a reduction in predation (Tupper and Boutilier 1995). The loss of refugium provided by complex habitats has also been related to increased predation on juvenile fishes, resulting in decreased recruitment (Walters and Juanes 1993). The potential for this to occur at hexactinellid sponge reef complexes on the Pacific coast has been recognised (Conway et al. 2001). The potential loss or damage of juvenile fish habitat for depleted species such as *Sebastes* is particularly relevant due to recent DFO initiatives to protect inshore rockfish stocks (Anon. 2002), and thus should be avoided.

Studies have demonstrated that for many commercially exploited rockfish species, preferred habitat is associated with areas of higher habitat complexity. Submersible dive surveys at depths of 21 – 140 m in the Strait of Georgia (Richards 1986) found the highest densities of yelloweye rockfish at depths of 41 – 100 m in wall and complex habitats. Quillback densities were also high in complex habitats, but more often at depths of less than 60 m, indicating a depth segregation between the two species. For both species, higher densities of juveniles were also observed in association with dense concentrations of cloud sponges, which appeared to be important nursery areas for small fish. However, density of greenstriped rockfish increased in less complex, fine-sediment habitats. Delta and PICES IV submersible surveys in Alaska (O'Connell and Carlile 1993) and Saanich Inlet (Murie et al. 1994), respectively, also observed higher densities of adult yelloweye and quillback, respectively, in boulder fields and broken rock, particularly in association with cracks, caves or overhangs. Increases in yelloweye density were also noted in deeper water for the same habitat type (O'Connell and Carlile 1993). The strong affinity and year round preference by these species for high relief rocky habitats may be related to the stability and for them, higher quality of habitat at the structurally more-complex sites. Seasonal variations in rockfish distribution may relate to changes in habitat requirements, and/or changes in habitat quality due to the availability of resources such as mates, shelter and food (Baker 1978, cited in Matthews 1990).

From analysis of presumed trawl tracks (straight line distances between trawl start and end locations), the sponge reef complexes themselves appear to be relatively poor fishing grounds, as evidenced by the relative lack of trawling on them prior to 1999. This may have been because of excessive sponge bycatch, and the extra work it entailed, or because of relatively low yields. However, there continues to be considerable effort expended adjacent to the edges of the sponge reef complexes (Figures 7-10). Figures 7-10 only show those trawl paths that start or end within the closures, and there is considerable trawling (not mapped here, and hence not shown) in the immediate areas that surround the trawl tracks shown.

The fact that trawling occurs right up to the reefs raises conservation concerns. First, Conway has documented (Conway 1999; pers. comm., arising from subsequent surveys) that the borders of known reef complexes are very irregular, and are likely still poorly documented. Thus, the outer boundaries of the reef complexes are almost certainly still poorly described, and this is likely to remain so until the areas surrounding them are fully mapped with multibeam technology. Secondly, there are almost certainly other areas in the immediate vicinity where smaller reefs exist. Thirdly, the ecological role of the reefs are poorly described, and it may be that they provide important habitat (e.g., nursery ground) for a range of species and thus should be preserved. It is thus important to prevent habitat damage to this potential source of recruitment, particularly in this period of stock rebuilding for depleted, commercially-important demersal fish species such as rockfish. Fourthly, our mapping of trawl paths is not accurate. We know from start and end locations that tows are long, often in the tens of kilometres, and anecdotally, it is reported that they are often not straight. There is presently no available data on either tow length or tow path.

We thus recommend for the establishment of effective buffer zones around the reefs to ensure their structure and function are not negatively impacted by fishing. However, criteria to define optimal protected areas are largely unknown. They should, however, be created using best knowledge in conjunction with the precautionary principle. We thus recommend a minimal buffer zone of an average tow length, i.e. 9 km (average of 1627 sets between 1996-2001 at Reef

D was 8.89 km), around the reefs. Boundaries should also be easily determined by both fishers and enforcement personnel, and so should consist of straight lines.

Given our current lack of understanding of sponge reef building dynamics (e.g. persistence of sponge skeletons; sponge recruitment, growth and natural mortality rates; etc.) and the ecosystem role of these reef complexes (e.g., importance to other species; characterisation of the sponge reef ecosystem biodiversity, etc.), exclusion of fishing activity, and possibly other human-impacting activities as well, should be coupled with the initiation of an active research program to address data gaps, described below, as developed by experts:

Sponge reef environment characteristics:

1. Annual oceanographic conditions;
2. Sediment composition and annual rates of deposition at and near sponge reefs, as influenced by tides, meteorological and oceanographic conditions, and seasons;.
3. Nutrient concentrations and contaminant levels at and near sponge; and
4. The possible impacts of Global Warming should also be considered since long term changes in coastal upwelling processes and mid-depth water properties may have an impact on reef characteristics.

Sponge reef complex characteristics:

1. Determine sponge recruitment, growth and mortality rates, and sponge skeleton breakdown rates;
2. Improve the mapping of sponge reef spatial locations and areal extent through multibeam mapping and substrate profiling; and
3. Monitor recovery rates around recent fishing impact damage.

Sponge reef ecosystem dynamics:

1. Determine sponge reef biodiversity characteristics and community structure; and
2. Assess the ecological contribution (e.g. filtering capacity significance, etc) to the regional shelf ecosystem.

Fishing impact studies:

1. Monitor trawl towing vessel paths adjacent to the protected areas to ensure intrusions do not occur;
2. Assess relative amounts of fishing effort expended and catches obtained in relation to proximity to the protected areas; and
3. Continue data analyses to optimise boundary locations around the reef protected areas.

The designation of the Central and North Coast hexactinellid sponge reefs as MPAs would allow DFO to provide greater protection to the reefs from human-caused physical disturbances. The establishment of marine protected areas has been recognised as a potential opportunity to both protect habitats for particularly vulnerable fauna, and to create relatively undisturbed reference sites for studies of impacted ecosystems (Auster et al. 1996, Thrush et al. 1998, Pitcher et al. 2000).

Given the unique ecosystems represented by the sponge reefs in central British Columbia, there is scientific merit in both:
a) Protecting the entire marine sponge reefs, and to
b) Initiate scientific studies to determine the ecological significance of these habitats.

Scientific information that is required includes species inventories by depth, habitat type and relative spatial location, and habitat substrate classification by depth over all the reefs. However, detailed knowledge is available for only a few locations world-wide, and attempting to identify all relevant information *a priori* that might be desired for optimal MPA boundary determination could oppose precautionary resource management. Common sense needs to be applied, using the information that is available now. To err on making potential MPAs too large better meets the precautionary principle than would to err on making such areas too small, since activities within a MPA can be modified as needed, and no restrictions are predetermined. Not all fishing activities need to be restricted in MPAs, and on reef MPAs, some fishing activities that do not impact the sea bottom might still be permitted. The main advantages of having MPA designation are the greater level of protection potentially available, and the relative future ease of modifying internal MPA boundaries for the restriction of specific activities, i.e., by facilitating opportunity for adaptive management.

A smaller sponge bioherm was just discovered off the mouth of the Fraser River in the Strait of Georgia (Fig. 11). In addition, there is a hexactinellid sponge mat south east of Halibut Bank (Austin 1984, Conway et al 1991, Austin et al. 2002). Bill Austin sampled this mat in the 1960s with a dredge and made a PISCES submersible dive over the mat in 1983. The sponges there are primarily rossellids (three+ species) which have a woven rather than a fused mainframe skeleton. The mat is formed from disassociated rossellid skeletons, and it presumably serves as a solid substrate for settlement of larval rossellids (see Conway et al. 1991). The mat is at a depth of 30-110 m, and the area is primarily mud with a local outcropping of rock. The rossellids and their associated fauna are only found on the mat and on rocks. At least one rossellid species harbours a well-developed surface fauna, as well as sediment. The sponge epifauna is likely to be partially removed since the outer layer of spicules is shed periodically by the sponge (Leys and Lauzon 1998, Marliave 1992). Two species of Hexactinosans also occur there, as well as on the rock cliffs of nearby fjords. In contrast to the rossellids, hexactinosan surfaces are free of attached fauna and sediment.

Mats of rossellid sponge spicules have been observed elsewhere only in the Antarctic, and are reported to play a primary role in determining the species composition of sponges and associated fauna. It has been the subject of considerable study at McMurdo Sound (e.g. Dayton 1979, Barthel and Gutt 1992).

Both the Strait of Georgia bioherm and sponge mat should also be considered for status as MPAs based on their unique occurrence, their production of a structurally modified habitat with associated fauna differences from the surrounding soft sediment, and their ease of destruction by physical means, such as trawling.

In July, 2002, DFO, with the support of the Canadian Groundfish Research & Conservation Society and the Groundfish Trawl Advisory Committee, announced the implementation of measures to help preserve unique sponge reefs in waters off central and northern British Columbia. Trawl fishing closures with boundaries relatively tight to the current known boundaries of the reefs were established (Figs. 7-10). There is thus a minimal buffer zone around the reefs. Future research will determine whether established boundaries allow sufficient protection. Although no trawling should occur within the closure zones, the lack of precise vessel towpath data available to DFO makes this operationally impossible to evaluate from fishery data alone. Nevertheless, the willingness of the trawl industry to avoid the reefs is commendable, and if damage to the reefs continues to occur, then it would seem likely that they will be willing to expand the closure areas.

7 RECOMMENDATIONS

1. **Protection should be quickly established to conserve the functional integrity of the world-unique sponge reefs in BC's Central and NorthCoast Areas. MPAs offer the greatest level of protection and flexibility re future potential management options, and are thus recommended. The fragmented nature and irregular boundaries of each reef necessitate that for effective protection, there should be a buffer zone around the currently known area for each reef to minimise the potential for future reef damage.**

Seabed features such as banks and reefs are typically associated with higher productivity, as opposed to troughs that are often associated with lower productivity, In part, this may be because the periphery of banks is adjacent to troughs, which are sources for water exchanges, resulting in increased benthic primary production (Booth et al. 1998). The location of the sponge reefs within the troughs of Hecate Strait and Queen Charlotte Sound is thus especially significant, being areas of unanticipated unique high biological productivity and diversity. There is evidence that considerable fishing activity has occurred in the past, and may still be occurring to some extent, and while voluntary closure measures may help minimise fishing impacts, the largely still-unknown ecological significance of these sites and their rarity rationalises a more effective level of fishery protection. The establishment of groundfish trawl closure zones was a recent announcement by DFO, but this action will not provide as large a potential overall protection as would MPAs, which was the rationalisation for the need to establish legislation to allow for MPAs in the first place.

The boundaries of the areas evaluated in this report are those of the voluntary shrimp trawl closures, but they were established before the full extent of the sponge reef complexes was known. We now know that in some instances, the reef borders now extend right to these closure lines, which is not a desirable situation. A minimum distance of at least five-eight kilometres from the outer boundary of each complex is suggested as desirable to prevent intrusion of fishing gear onto reef habitat. Available navigational equipment (e.g., GPS) is now sufficiently accurate to ensure that accidental fishing intrusion would be unlikely. A rectangular box shaped boundary around each reef complex, based on rounded latitude and longitude values, might provide the clearest boundary definition, but regardless, fishing exclusion boundaries should be the same for all benthic fishing gears.

2. **That research and monitoring programs to evaluate the nature and importance of the reefs to the overall shelf ecosystem be initiated.**

Commercial fishing bycatch data is the main current source of community structure. There are no comprehensive size frequency data available for any species, commercial or otherwise, and data is limited by the extent of fishing activity, the relatively long tow lengths involved (which prevent precise location biodiversity evaluation), and the selectivities of the gear used. Observer monitoring of bycatch species is also limited.

3. **That both the Strait of Georgia bioherm and sponge mats be recommended for Marine Protected Area status, based on their unique occurrence, their production of a structurally modified habitat with associated fauna differences from the surrounding soft sediment, and their ease of destruction by physical means, such as trawling.**

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Table 1. Groundfish trawl activity in the vicinity of the four sponge reefs. † = total underestimated due to missing data in that year.

Sponge Reef	Year	CFVs Box	CFVs Adj. Only	CFVs Reef & Adj.	CFVs Reef Only	Sets Box	Sets Adj. Only	Sets Reef & Adj.	Sets Reef Only	Effort Box	Effort Adj. Only	Effort Reef & Adj.	Effort Reef Only
A	1996	22	21	5	3	106	83	23	12	16665	12963	3702	1229
	1997	12	11	5	1	69	43	26	8	8165	5219	2946	349
	1998	14	11	7	2	81	39	42	6	12263	6000	6263	464
	1999	14	14	5	2	129	84	45	14	18072	11331	6741	1146
	2000	9	9	5	1	79	34	45	18	11427	4874	6553	1908
	2001	4	3	4	1	30	14	16	9	5246	2909	2337	1044
B	1996	0	0	0	0	0	0	0	0	0	0	0	0
	1997	1	1	0	0	2	2	0	0	41	41	0	0
	1998	0	0	0	0	0	0	0	0	0	0	0	0
	1999	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	2	1	1	1	2	1	1	1	145	130	15	15
C	1996	7	7	4	1	50	43	7	2	3610	3201	409	89
	1997	9	6	8	0	75	51	24	0	6721	5138	1583	0
	1998	9	8	3	1	38	35	3	1	4157	3971	186	60
	1999	9	8	5	1	120	105	15	2	11000	9793	1207	138
	2000	6	5	3	1	142	125	17	1	9586	7739	1847	76
	2001	7	6	3	0	113	95	18	0	8676	6498	2178	0
D	1996	64	59	31	5	384	312	72	7	†54247	†43855	10392	929
	1997	60	59	35	7	441	367	74	8	†61992	†53770	8222	632
	1998	44	42	21	3	256	205	51	4	†34575	†27551	†7024	492
	1999	29	28	12	0	141	120	21	0	21153	17959	3194	0
	2000	33	33	10	1	211	193	18	1	†24889	†22810	2079	33
	2001	31	30	10	0	206	192	14	0	22942	21679	1263	0

Table 2. Accumulated monthly groundfish trawl activity from 1996 to 2001. † = total underestimated due to missing data in that year.

Sponge Reef		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Box													
A	CFVs	2	1	6	5	8	14	14	12	15	9	12	3
	Sets	2	1	12	21	52	68	70	41	63	59	100	5
	Effort	289	44	1309	3120	7841	8612	8859	6056	8601	8191	18283	633
B	CFVs	0	0	0	0	1	1	0	1	0	0	0	0
	Sets	0	0	0	0	2	1	0	1	0	0	0	0
	Effort	0	0	0	0	41	15	0	130	0	0	0	0
C	CFVs	4	8	8	3	6	5	6	8	6	5	6	2
	Sets	52	110	43	50	43	40	42	41	34	23	37	23
	Effort	3947	7218	2510	2997	3317	3970	4032	5028	3500	2036	3426	1769
D	CFVs	24	42	34	32	38	51	29	20	32	28	23	12
	Sets	73	200	199	126	226	333	91	49	132	96	96	18
	Effort	†9342	23160	25775	†16312	34127	†43648	†11564	6392	†18546	13517	13568	3847
<u>Adj. Only</u>													
A	CFVs	0	0	5	5	7	13	12	10	12	8	12	3
	Sets	0	0	10	17	36	45	44	25	27	25	64	4
	Effort	0	0	1039	2513	5365	5632	5347	3804	3697	3528	11844	527
B	CFVs	0	0	0	0	2	0	0	1	0	0	0	0
	Sets	0	0	0	0	1	0	0	1	0	0	0	0
	Effort	0	0	0	0	41	0	0	130	0	0	0	0
C	CFVs	4	6	8	3	6	5	4	7	6	5	5	2
	Sets	41	103	38	47	37	35	27	28	29	19	29	21
	Effort	2944	6586	2283	2894	3069	3438	2341	3426	3028	1807	2880	1644
D	CFVs	22	39	31	32	35	50	26	16	32	28	23	11
	Sets	62	146	135	113	207	297	80	44	122	91	75	17
	Effort	†7722	17060	17004	†15049	31656	†38150	†10247	5702	†16626	13017	11644	3747

Table 2 cont. Accumulated monthly groundfish trawl activity from 1996 to 2001. † = total underestimated due to missing data in that year.

Sponge Reef		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Reef and Adj.</u>													
A	CFVs	2	1	2	2	4	5	5	5	6	6	8	1
	Sets	2	1	2	4	16	23	26	16	36	34	36	1
	Effort	289	44	270	607	2476	2980	3512	2252	4904	4663	6439	106
B	CFVs	0	0	0	0	0	1	0	0	0	0	0	0
	Sets	0	0	0	0	0	1	0	0	0	0	0	0
	Effort	0	0	0	0	0	15	0	0	0	0	0	0
C	CFVs	4	4	4	1	2	1	4	3	2	2	4	1
	Sets	11	7	5	3	6	5	15	13	5	4	8	2
	Effort	1003	632	227	103	248	532	1691	1602	472	229	546	125
D	CFVs	9	26	21	8	15	20	8	5	7	4	8	1
	Sets	11	54	64	13	19	36	11	5	10	5	21	1
	Effort	1620	6100	8771	1263	2471	†5498	1317	690	1920	500	1924	100
Reef Only													
A	CFVs	0	1	0	1	1	2	2	3	4	3	2	0
	Sets	0	1	0	1	7	9	11	10	10	12	6	0
	Effort	0	44	0	28	715	534	871	955	996	1385	612	0
B	CFVs	0	0	0	0	0	1	0	0	0	0	0	0
	Sets	0	0	0	0	0	1	0	0	0	0	0	0
	Effort	0	0	0	0	0	15	0	0	0	0	0	0
C	CFVs	0	1	1	1	0	0	1	0	0	0	1	0
	Sets	0	1	1	1	0	0	2	0	0	0	1	0
	Effort	0	50	60	39	0	0	138	0	0	0	76	0
D	CFVs	0	3	4	3	2	1	0	0	0	1	2	0
	Sets	0	4	6	3	2	1	0	0	0	1	3	0
	Effort	0	550	904	228	42	165	0	0	0	85	112	0

Table 3. Targeted and bycatch species list of groundfish trawl activity in the vicinity of sponge reef A. * Indicates species for which an Individual Vessel Quota (IVQ) applies.

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
<u>Commercial Fish</u>					
• <u>Rockfish and Thornyheads</u>					
X	X	X	X	Rougheye Rockfish*	*Sebastes aleutianus*
X	X	X	X	Pacific Ocean Perch*	*Sebastes alutus*
X	X	X		Shortraker Rockfish*	*Sebastes borealis*
X	X	X	X	Silvergray Rockfish*	*Sebastes brevispinis*
X	X			Copper Rockfish*	*Sebastes caurinus*
X	X			Widow Rockfish*	*Sebastes entomelas*
X	X	X	X	Yellowtail Rockfish*	*Sebastes flavidus*
X	X			Quillback Rockfish*	*Sebastes maliger*
X	X	X	X	Canary Rockfish*	*Sebastes pinniger*
X	X	X	X	Redstripe Rockfish*	*Sebastes proriger*
X	X	X	X	Yellowmouth Rockfish*	*Sebastes reedi*
X	X	X		Yelloweye Rockfish*	*Sebastes ruberrimus*
X	X	X	X	Redbanded Rockfish	*Sebastes babcocki*
X	X	X		Darkblotched Rockfish	*Sebastes crameri*
X	X	X		Splitnose Rockfish	*Sebastes diploproa*
X	X	X		Greenstriped Rockfish	*Sebastees elongatus*
X	X			Rosethorn Rockfish	*Sebastes helvomaculatus*
X	X			Black Rockfish	*Sebastes melanops*
X	X	X	X	Bocaccio	*Sebastes paucispinis*
X	X	X	X	Sharpchin Rockfish	*Sebastes zacentrus*
X		X		Thornyheads*	*Sebastolobinae* (Subfamily)
X	X	X	X	Shortspine Thornyhead*	*Sebastolobus alascanus*
• Roundfish					
X	X	X	X	Pacific Cod*	*Gadus macrocephalus*
X	X	X	X	Pacific Hake*	*Merluccius productus*
X	X	X	X	Walleye Pollock*	*Theragra chalcogramma*
X	X	X	X	Sablefish*	*Anoplopoma fimbria*
X	X	X	X	Lingcod*	*Ophiodon elongatus*
X	X	X	X	Sculpins	*Cottidae* (Family)
X	X			Pacific Staghorn Sculpin	*Leptocottus armatus*
X	X			Greenlings	*Hexagrammidae* (Family)
• Flatfish					
X	X	X	X	Petrale Sole*	*Eopsetta jordana*
X	X	X	X	Rock Sole*	*Pleuronectes bilineatus*
X	X	X	X	Dover Sole*	*Microstomus pacificus*
X	X	X	X	English Sole*	*Pleuronectes vetulus*
X	X	X	X	Pacific Sanddab	*Citharichthys sordidus*
X	X	X	X	Arrowtooth Flounder	*Atheresthes stomias*
X	X			Deepsea Sole	*Embassichthys bathybius*

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
X	X	X	X	Rex Sole	*Errex zachirus*
X	X	X	X	Flathead Sole	*Hippoglossoides elassodon*
X	X	X		Slender Sole	*Eopsetta exilis*
X	X	X		C-O Sole	*Pleuronichthys coenosus*
X	X			Curlfin Sole	*Pleuronichthys decurrens*
X	X			Sand Sole	*Psettichthys melanostictus*
• Skates					
X	X	X	X	Skates	*Rajidae* (Family)
X	X			Abyssal Skate	*Bathraja abyssicola*
X	X	X	X	Big Skate	*Raja binoculata*
X	X	X		Roughtail Skate	*Bathyraja trachura*
X	X	X	X	Sandpaper Skate	*Bathraja interrupta*
X	X	X	X	Longnose Skate	*Raja rhina*
X		X	X	Starry Skate	*Raja stellulata*
• Tuna and Mackerel					
X	X	X	X	Jack Mackerel	*Trachurus symmetricus*
X	X			Chub Mackerel	*Scomber japonicus*
• Other Target Species					
X	X	X	X	Spiny Dogfish*	*Squalus acanthias*
<u>Bycatch</u>					
• Commercial Fish					
X	X	X	X	Eulachon	*Thaleichthys pacificus*
X		X	X	Pacific Tomcod	*Microgadus proximus*
• <u>Noncommercial Fish</u>					
X	X			Unknown Fish	
X	X	X	X	Spotted Ratfish	*Hydrolagus colliei*
X	X	X		American Shad	*Alosa sapidissima*
X	X	X	X	Eelpouts	*Zoarcidae* (Family)
X	X			Shortfin Eelpout	*Lycodes brevipes*
X		X		Wattled Eelpout	*Lycodes palearis*
X	X	X		Grenadiers	*Macrouridae* (Family)
X		X		Pacific Sand Lance	*Ammodytes hexapterus*
X	X			Sturgeon Poacher	*Podathecus acipenserinus*
X	X			Lumpfishes and Snailfishes	*Cyclopteridae* (Family)
• <u>Commercial Invertebrates</u>					
X	X	X		Sea Cucumbers	*Holothuroidea* (Class)
X	X	X		Squid	*Teuthoidea* (Order)
X		X		Red Squid	*Berryteuthis magister*
X	X	X	X	Octopus	*Octopoda* (Order)
X	X	X		Pink Shrimp (Smooth)	*Pandalus jordana*
X	X	X	X	Prawn	*Pandalus platyceros*
X		X	X	Sidestripe Shrimp	*Panadalopsis dispar*
X	X			Dungeness Crab	*Cancer magister*
X		X	X	Tanner Crabs	*Chionoecetes* Spp.

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
• Noncommercial Invertebrates					
X		X	X	Hydroid	*Hydrozoa* (Class)
X	X	X	X	Jellyfish	*Scyphozoa* (Class)
X		X	X	Anthozoa	*Anthozoa* (Class)
X		X		Zoantharia	*Zoantharia* (Subclass)
X	X	X	X	Stony Corals	*Madreporia* (Order)
X	X	X	X	Anemone	*Actiniaria* (Order)
X	X	X		Soft Corals	*Alcyonacea* (Order)
X	X	X	X	Gorgonian Corals	*Gorgonacea* (Order)
X	X	X		Sea Pens	*Pennatulacea* (Order)
X	X	X	X	Starfish	*Asteriodea* (Class)
X	X			Crown of Thorns	*Acanthaster planci*
X	X			Sunflower Starfish	*Pycnopodia helianthoides*
X	XX			Purple Starfish	*Pisaster ochraceus*
X	X	X	X	Ophiuroidea	*Ophiuroidea* (Class)
X	X	X		Brittle Stars	*Ophiurae* (Order)
X	X			Basket Stars	*Euryalae* (Order)
X	X	X	X	Sea Urchins	*Echinoida* (Order)
X	X			Heart Urchins	*Atelostomata* (Superorder)
X	X	X	X	Segmented Worms	*Annelida* (Phylum)
X	X			Polychaete Worms	*Polychaeta* (Class)
X	X			Sea Mouse	*Aphrodita* Spp.
X	X	X		Gastropods	*Gastropoda* (Class)
X	X			Oregontriton	*Fusitriton Oregonensis*
X	X	X		Bivalve Molluscs	*Bivalvia* (Class)
X	X	X	X	Shrimp	*Nantantia*
X	X	X	X	Crab	*Repiantia*
X		X		Anomura	*Anomura* (Section)
X	X			Hermit Crabs	*Paguridae* (Family)
X	X	X	X	Box Crabs	*Lopholithodes* Spp.
X	X			Cancer Crabs	*Cancridae* (Family)
X	X	X	X	Spider Crabs	*Oxyrhyncha* (Superfamily)
• <u>Sponges</u>					
X	X	X	X	Sponges	*Porifera* (Phylum)
X	X	X		Glass Sponges	*Hexactinellida* (Class)
• Other species					
X	X	X	X	Inanimate Object(s)	
X	X				*Pinnipedia* (Suborder)
• Species not permitted [to be retained] by groundfish trawl					
X	X	X	X	Pacific Halibut	*Hippoglossus stenolepis*
X	X	X	X	Pacific Herring	*Clupea pallasi*
X	X			Pacific Salmon and Native Trout	*Oncorhynchus* (Genus)
X	X			Chum Salmon	*Oncorhynchus keta*
X	X			Coho Salmon	*Oncorhynchus kisutch*

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
X	X	X		Chinook Salmon	*Oncorhynchus tshawytscha*
X	X			Pink Salmon	*Oncorhynchus gorbuscha*
X	X	X	X	Wolf Eel	*Anarrhichthys ocellatus*

Table 4. Targeted and bycatch species list of groundfish trawl activity in the vicinity of sponge reef B. * Indicates species for which an Individual Vessel Quota (IVQ) applies.

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
Commercial Fish					
• Rockfish and Thornyheads					
X	X	X	X	Pacific Ocean Perch*	*Sebastes alutus*
X	X	X	X	Redbanded Rockfish	*Sebastes babcocki*
X	X	X	X	Silvergray Rockfish*	*Sebastes brevispinis*
X	X	X	X	Widow Rockfish*	*Sebastes entomelas*
X	X			Yellowtail Rockfish*	*Sebastes flavidus*
X	X			Bocaccio	*Sebastes paucispinis*
X	X			Canary Rockfish*	*Sebastes pinniger*
X	X			Redstripe Rockfish*	*Sebastes proriger*
X		X	X	Yellowmouth Rockfish*	*Sebastes reedi*
X		X	X	Sharpchin Rockfish	*Sebastes zacentrus*
• Roundfish					
X	X			Lingcod*	*Ophiodon elongatus*
• Flatfish					
X		X	X	Dover Sole*	*Microstomus Pacificus*
X	X	X	X	Arrowtooth Flounder	*Atheresthes stomias*
• Skates					
X	X			Big Skate	Raja binoculata
• Other species					
X	X	X	X	Spiny Dogfish*	Squalus acanthias
Bycatch					
• Noncommercial Fish					
X	X	X		Spotted Ratfish	*Hydrolagus colliei*
• Species not permitted [to be retained] by groundfish trawl					
X	X			Pacific Halibut	*Hippoglossus stenolepis*

Table 5. Targeted and bycatch species list of groundfish trawl activity in the vicinity of sponge reef C. * Indicates species for which an Individual Vessel Quota (IVQ) applies.

Box	Adj. Only	Reef & Adj,	Reef Only	Common Name	Latin Name
<u>Commercial Fish</u>					
• Rockfish and Thornyheads					
X	X	X		Rougheye Rockfish*	*Sebastes aleutianus*
X	X	X	X	Pacific Ocean Perch*	*Sebastes alutus*
X	X	X		Shortraker Rockfish*	*Sebastes borealis*
X	X	X	X	Silvergray Rockfish*	*Sebastes brevispinis*
X	X	X	X	Widow Rockfish*	*Sebastes entomelas*
X	X	X	X	Yellowtail Rockfish*	*Sebastes flavidus*
X	X			Quillback Rockfish*	*Sebastes maliger*
X	X			Tiger Rockfish*	*Sebastes nigrocinctus*
X	X	X		Canary Rockfish*	*Sebastes pinniger*
X	X	X	X	Redstripe Rockfish*	*Sebastes proriger*
X	X	X	X	Yellowmouth Rockfish*	*Sebastes reedi*
X	X	X	X	Yelloweye Rockfish*	*Sebastes ruberrimus*
X	X			Aurora Rockfish	*Sebastes aurora*
X	X	X	X	Redbanded Rockfish	*Sebastes babccki*
X	X	X	X	Darkblotched Rockfish	*Sebastes crameri*
X	X	X		Splitnose Rockfish	*Sebastes diploproa*
X	X	X		Greenstriped Rockfish	*Sebastes elongatus*
X	X			Chilipepper Rockfish	*Sebastes goodei*
X	X	X	X	Rosethorn Rockfish	*Sebastes helvomaculatus*
X	X			Shortbelly Rockfish	*Sebastes jordani*
X	X			Black Rockfish	*Sebastes melanops*
X	X			Blue Rockfish	*Sebastes mystinus*
X	X	X	X	Bocaccio	*Sebastes paucispinis*
X	X			Harlequin Rockfish	*Sebastes variegatus*
X	X			Pygmy Rockfish	*Sebastes wilsoni*
X	X	X	X	Sharpchin Rockfish	*Sebastes zacentrus*
X	X	X	X	Shortspine Thornyhead*	*Sebastolobus alascanus*
X	X			Longspine Thornyhead*	*Sebastolobus altivelis*
• Roundfish					
X	X	X	X	Pacific Cod*	*Gadus macrocephalus*
X	X	X		Pacific Hake*	*Merluccius productus*
X	X	X		Walleye Pollock*	*Theragra chalcogramma*
X	X	X	X	Sablefish*	*Anoplopoma fimbria*
X	X	X	X	Lingcod*	*Ophiodon elongatus*
X	X	X		Sculpins	*Cottidae* (Family)
X	X	X		Cabezon	*Scorpaenichthys*
• Flatfish					
X	X	X		Petrale Sole*	*Eopsetta jordani*
X	X			Rock Sole*	*Pleuronectes bilineatus*

Box	Adj. Only	Reef & Adj,	Reef Only	Common Name	Latin Name
X	X	X		Dover Sole*	*Microstomus pacificus*
X	X	X		English Sole*	*Pleuronectes vetulus*
X	X	X	X	Arrowtooth Flounder	*Atheresthes stomias*
X	X	X		Rex Sole	*Errex zachirus*
X	X			Flathead Sole	*Hippoglossoides elassodon*
• Skates					
X	X	X		Skates	*Rajidae* (Family)
X	X	X		Big Skate	*Raja binoculata*
X	X			Roughtail Skate	*Bathyraja trachura*
X	X	X		Sandpaper Skate	*Bathyraja interrupta*
X	X	X		Longnose Skate	*Raja rhina*
X	X			Starry Skate	*Raja stellulata*
• Tuna and Mackerel					
X				Jack Mackerel	*Trachurus symmetricus*
• Other Target Species					
X	X	X	X	Spiny Dogfish*	*Squalus acanthias*
Bycatch					
• Commercial Fish					
X	X			Eulachon	*Thaleichthys pacificus*
• Noncommercial Fish					
X	X			Unknown Fish	
X	X	X	X	Spotted Ratfish	*Hydrolagus colliei*
X	X			American Shad	*Alosa sapidissima*
X		X		Eelpouts	*Zoarcidae* (Family)
X		X		Grenadiers	*Macrouridae* (Family)
X	X	X		Poachers	*Agonidae* (Family)
X	X			Flathead Chub	*Platygobio gracilis*
• Commercial Invertebrates					
X	X	X		Sea Cucumbers	*Holothuroidea* (Class)
X	X	X		Squid	*Teuthoidea* (Order)
X	X			Red Squid	*Berryteuthis magister*
X	X	X	X	Octopus	*Octopoda* (Order)
X	X	X		Prawn	*Pandalus platyceros*
X	X	X		Sidestripe Shrimp	*Pandalopsis dispar*
X	X			Tanner Crabs	*Chionoecetes* Spp.
• Noncommercial Invertebrates					
X	X	X		Invertebrates	
X	X			Coelenterates	*Cnidaria* (Phylum)
X	X			Hydroid	*Hydrozoa* (Class)
X	X			Jellyfish	*Scyphozoa* (Class)
X	X	X		Anthozoa	*Anthozoa* (Class)
X	X	X		Zoantharia	*Zoantharia* (Subclass)
X	X	X	X	Stony Corals	*Madreporaria* (Order)
X	X	X		Soft Corals	Alcyonacea (Order)

Box	Adj. Only	Reef & Adj,	Reef Only	Common Name	Latin Name
X				Sea Pens	*Pennatulacea* (Order)
X	X			Radiata	*Radiata* Spp.
X	X	X		Starfish	*Asteroidea* (Class)
X		X		Leather Star	*Dermasterias imbricata*
X	X	X		Bat Star	*Patiria miniata*
X	X	X		Ophiuroidea	*Ophiuroidea* (Class)
X	X	X		Brittle Stars	*Ophiurae* (Order)
X		X		Basket Stars	*Euryalae* (Order)
X	X			Echinoidea	*Echinoidea* (Class)
X	X	X		Sea Urchins	*Echinoida* (Order)
X	X			Ascidians and Tunicates	*Ascidiacea* (Class)
X	X	X		Segmented Worms	*Annelida* (Phylum)
X	X			Seaslugs	*Nudibranchiata* (Order)
X	X			Oregontriton	*Fusitriton oregonensis*
X	X			Shrimp	*Nantantia*
X	X	X		Crab	*Repiantia*
X		X		Anomura	*Anomura* Spp.
X		X		Bristly Crab	*Acantholithodes hispidus*
X		X		Lithodes	*Lithodes* Spp.
X	X	X		Box Crabs	*Lopholithodes* Spp.
X	X			Squat Lobster	*Munida quadrispina*
X	X	X	X	Spider Crabs	*Oxyrhyncha* (Superfamily)
• Sponges					
X	X	X	X	Sponges	*Porifera* (Phylum)
X		X		Calcareous Sponges	*Calcarea* (Class)
X	X	X		Glass Sponges	*Hexactinellida* (Class)
• Other species					
X	X	X	X	Inanimate Object(s)	
X	X			Western Gull	*Larus occidentalis*
• Species not permitted [to be retained] by groundfish trawl					
X	X	X		Pacific Halibut	*Hippoglossus stenolepis*
X	X			Pacific Herring	*Clupea pallasi*
X	X			Chinook Salmon	*Oncorhynchus tshawytscha*
X	X			Wolf Eel	*Anarrhichthys ocellatus*

Table 6. Targeted and bycatch species list of groundfish trawl activity in the vicinity of sponge reef D. * Indicates species for which an Individual Vessel Quota (IVQ) applies.

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
Commercial fish					
• Rockfish and Thornyheads					
X	X			Scorpionfishes	*Scorpaenidae* (Family)
X	X			Rockfishes	*Sebastinae* (Subfamily)
X	X	X		Rougheye Rockfish*	*Sebastes aleutianus*
X	X	X	X	Pacific Ocean Perch*	*Sebastes alutus*
X	X	X		ShortrakerRockfishe*	*Sebastes borealis*
X	X	X	X	Silvergray Rockfish*	*Sebastes brevispinis*
X	X			Copper Rockfish*	*Sebastes caurinus*
X	X	X	X	Widow Rockfish*	*Sebastes entomelas*
X	X	X	X	Yellowtail Rockfish*	*Sebastes flavidus*
X		X		Quillback Rockfish*	*Sebastes maliger*
X	X			Tiger Rockfish*	*Sebastes nigrocinctus*
X	X	X	X	Canary Rockfish*	*Sebastes pinniger*
X	X	X	X	Redstripe Rockfish*	*Sebastes proriger*
X	X	X	X	Yellowmouth Rockfish*	*Sebastes reedi*
X	X	X		Yelloweye Rockfish*	*Sebastes ruberrimus*
X	X			Aurora Rockfish	*Sebastes aurora*
X	X	X	X	Redbanded Rockfish	*Sebastes babcocki*
X	X	X	X	Darkblotched Rockfish	*Sebastes crameri*
X	X	X	X	Splitnose Rockfish	*Sebastes diploproa*
X	X	X	X	Greenstriped Rockfish	*Sebastes elongatus*
X	X			Chilipepper Rockfish	*Sebastes goodei*
X	X	X	X	Rosethorn Rockfish	*Sebastes helvomaculatus*
X		X		Black Rockfish	*Sebastes melanops*
X	X	X	X	Bocaccio	*Sebastes paucispinis*
X	X			Stripetail Rockfish	*Sebastes saxicola*
X	X			Harlequin Rockfish	*Sebastes variegatus*
X	X			Pygmy Rockfish	*Sebastes wilsoni*
X	X	X	X	Sharpchin Rockfish	*Sebastes zacentrus*
X	X	X	X	Shortspine Thornyhead*	*Sebastolobus alascanus*
X	X			Thornyheads*	*Sebastolobinae* (Subfamily)
X	X	X	X	Longspine Thornyhead*	*Sebastolobus altivelis*
• Roundfish					
X	X	X	X	Pacific Cod*	*Gadus macrocephalus*
X	X	X	X	Pacific Hake*	*Merluccius productus*
X	X	X	X	Walleye Pollock*	*Theragra chalcogramma*
X	X	X	X	Sablefish*	*Anoplopoma fimbria*
X	X	X	X	Lingcod*	*Ophiodon elongatus*
X	X	X	X	Sculpins	*Cottidae*
X	X	X		Cabezon	*Scorpaenichthys*

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
X	X			Pacific Staghorn Sculpin	*Leptocottus armatus*
X	X			Blackfin Sculpin	*Malacocottus kincaidi*
X	X			Greenlings	*Hexagrammidae* (Family)
X	X			Kelp Greenling	*Hexagrammos*
• Flatfish					
X	X	X	X	Petrale Sole*	*Eopsetta jordani*
X	X	X	X	Dover Sole*	*Microstomus pacificus*
X	X	X	X	English Sole*	*Pleuronectes vetulus*
X	X	X	X	Rock Sole*	*Pleuronectes bilineatus*
X	X	X		Pacific Sanddab	*Citharichthys sordidus*
X	X	X	X	Arrowtooth Flounder	*Atheresthes stomias*
X	X	X	X	Rex Sole	*Errex zachirus*
X	X	X		Flathead Sole	*Hippoglossoides elassodon*
X	X			Slender Sole	*Eopsetta exilis*
X		X		Curlfin Sole	*Pleuronichthys decurrens*
X	X	X		Sand Sole	*Psettichthys melanostictus*
• Skates					
X	X	X	X	Skates	*Rajidae* (Family)
X	X			Abyssal Skate	*Bathyraja abyssicola*
X	X	X	X	Big Skate	*Raja bionculata*
X	X	X		Sandpaper Skate	*Bathyraja interrupta*
X	X	X		Longnose Skate	*Raja rhina*
X	X			Starry Skate	*Raja stellulata*
• Tuna and Mackerel					
X	X	X		Jack Mackerel	*Trachurus symmetricus*
X	X			Chub Mackerel	*Scomber japonicus*
X	X			Albacore	*Thunnus alalunga*
• Other Target Species					
X	X			Smelts	*Osmeridae* (Family)
X	X	X	X	Spiny Dogfish*	*Squalus acanthias*
Bycatch					
• Commercial Fish					
X	X	X		Pacific Sardine	*Sarcinops sagax*
X	X			Eulachon	*Thaleichthys pacificus*
X	X			Pacific Tomcod	*Microgadus proximus*
X		X		Sauries	*Scomberesocidae* (Family)
• Noncommercial Fish					
X		X		Unknown Fish	
X	X			Bigeye Thresher	*Hexanchus griseus*
X	X			Sixgill Shark	*Galeorhinus zyopterus*
X	X			Soupfin Shark	*Prionace glauca*
X	X			Blue Shark	*Prionace glauca*
X	X	X	X	Spotted Ratfish	*Hydrolagus colliei*
X	X	X		American Shad	*Alosa sapidissima*

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
X	X	X		Eelpouts	*Zoarcidae* (Family)
X		X		Bigfin Eelpout	*Lycodes cortezianus*
X	X			Wattled Eelpout	*Lycodes palearis*
X	X	X		Grenadiers	*Macrouridae* (Family)
X	X			Ragfishes	*Icosteidae* (Family)
X	X			Poachers	*Agonidae* (Family)
X	X			Sturgeon Poacher	*Podathecus acipenserinus*
X	X			Blackfin Poacher	*Bathyagonus nigripinnis*
X	X			Lumpfishes and Snailfishes	*Cyclopteridae* (Family)
• Commercial Invertebrates					
X	X			Sea Cucumbers	Holothuroidea (Class)
X	X	X	X	Squid	*Teuthoidea* (Order)
X	X	X		Opal Squid	*Loligo opalescens*
X	X	X		Neon Flying Squid	*Ommastrephes bartramii*
X	X			Red Squid	*Berryteuthis magister*
X	X			Nail Squid	*Onychoteuthis*
X	X	X		Octopus	*Octopoda* (Order)
X	X			Pink Shrimp	*Pandalus borealis*
X	X	X		Pink Shrimp (Smooth)	*Pandalus jordani*
X	X	X	X	Prawn	*Pandalus platyceros*
X	X			Sidestripe Shrimp	*Pandalopsis dispar*
X	X			Dungeness Crab	*Cancer magister*
X	X			Tanner Crabs	*Chionoecetes* Spp.
• Noncommercial Invertebrates					
X	X			Invertebrates	
X	X			Coelenterates	*Cnidaria* (Phylum)
X	X			Hydroid	*Hydrozoa* (Class)
X	X			Jellyfish	*Scyphozoa* (Class)
X	X	X	X	Stony Corals	*Madreporia* (Order)
X	X			Anemone	*Actiniaria* (Order)
X	X			Sea Pens	Pennatulacea (Order)
X	X			Sea Lilies and Feather Stars	Crinoidea (Class)
X	X	X	X	Starfish	*Asteriodea* (Class)
X	X			Striped Sun Starfish	*Solaster stimpsoni*
X	X	X		Ophiuroidea	*Ophiuroidea* (Class)
X	X			Brittle Stars	*Ophiurae* (Order)
X	X			Basket Stars	Euryalae (Order)
X	X	X	X	Sea Urchins	*Echinoida* (Class)
X	X			Heart Urchins	*Atelostomata* (Superorder)
X	X			Bryozoa	Bryozoa *(Phylum)*
X	X			Molluscs	*Mollusca* (Phylum)
X	X			Gastropods	*Gastropoda* (Class)
X	X	X		Oregontriton	*Fusitriton oregonensis*
X	X			Abalones	*Haliotidae* (Family)
X	X			Giant Squid	*Moroteuthis robusta*

Box	Adj. Only	Reef & Adj.	Reef Only	Common Name	Latin Name
X	X			Giant Pacific Octopus	*Octopus dofleini*
X	X	X		Crustaceans	*Crustacea* (Subphylum)
X	X	X		Shrimp	*Nantantia*
X	X			Crab	*Repiantia*
X	X	X		Anomura	*Anomura* (Spp.)
X	X	X		Box Crabs	*Lopholithodes* Spp.
X	X			Spider Crabs	*Oxyrhyncha* (Superfamily)
X	X			Toad Crab	*Hyas Lyratus*
• Sponges					
X	X	X	X	Sponges	*Porifera* (Phylum)
X	X	X	X	Calcareous Sponges	*Calcarea* (Class)
X	X			Bath Sponges	*Demospongiae* (Class)
• Other species					
X	X	X	X	Inanimate Object(s)	
• Species not permitted [to be retained] by groundfish trawl					
X	X	X	X	Pacific Halibut	*Hippoglossus stenolepis*
X	X	X		Pacific Herring	*Clupea pallasi*
X	X	X		Pink Salmon	*Oncorhynchus gorbuscha*
X	X	X		Chum Samon	*Oncorhynchus keta*
X	X			Coho Salmon	*Oncorhynchus kisutch*
X	X			Sockeye Salmon	*Oncorhynchus nerka*
X	X	X	X	Chinook Salmon	*Oncorhynchus tshawytscha*
X	X			Green Sturgeon	*Acipenser medirostris*
X	X	X		Wolf Eel	*Anarrhichthys ocellatus*

Table 7. Candidate species for COSEWIC that are being caught as targeted or bycatch species by the groundfish trawl fishery in the vicinity of the sponge reefs. Priority referes to assessment need.

Priority	**Target**	**Bycatch**	**Common Name**	**Latin Name**
High	X		Big skate	*Dipturus binoculata*
	X		Longnose skate	*Raja rhina*
	X		Pacific cod	*Gadus macrocephalus*
		X	Sixgill shark	*Hexanchus griseus*
Intermediate	X		Rougheye rockfish	*Sebastes aleutianus*
	X		Pacific Ocean Perch	*Sebastes alutus*
	X		Yelloweye rockfish	*Sebastes ruberrimus*
	X		Petrale sole	*Eopsetta jordani*
		X	Pacific herring	*Clupea pallasi*
		X	Blackfin sculpin	*Malacocottus kincaidi*
Low	X		Deepsea skate	*Bathyraja abyssicola*
	X		Roughtail skate	*Bathyraja trachura*
	X		Rock sole	*Pleuronectes bilineatus*
		X	Wolf-eel	*Anarrhichthys ocellatus*

Table 8. Targeted and bycatch species list for tows in REEF ONLY.

Reef A	Reef B	Reef C	Reef D	Common Name	Latin Name
Commercial Fish					
• Rockfish					
	X			Yellowmouth Rockfish*	*Sebastes reedi*
	X			Sharpchin Rockfish	*Sebastes zacentrus*
• Flatfish					
	X			Dover Sole*	*Microstomus Pacificus*
• Skates					
X				Starry Skate	*Raja stellulata*
Bycatch					
• Commercial Fish					
X				Pacific Tomcod	*Microgadus proximus*
• Commercial Invertebrates					
X				Sidestripe Shrimp	*Panadalopsis dispar*
X				Tanner Crabs	*Chionoecetes* Spp.
• Noncommercial Invertebrates					
X				Hydroid	*Hydrozoa* (Class)
X				Anthozoa	*Anthozoa* (Class)

Table 9. Targeted and bycatch species list for tows in ADJACENT ONLY.

Reef A	Reef B	Reef C	Reef D	Common Name	Latin Name
<u>Commercial Fish</u>					
• Rockfish and Thornyheads					
X			X	Copper Rockfish*	*Sebastes caurinus*
X				Widow Rockfish*	*Sebastes entomelas*
	X			Yellowtail Rockfish*	*Sebastes flavidus*
X		X		Quillback Rockfish*	*Sebastes maliger*
		X	X	Tiger Rockfish*	*Sebastes nigrocinctus*
	X			Canary Rockfish*	*Sebastes pinniger*
	X			Redstripe Rockfish*	*Sebastes proriger*
		X	X	Aurora Rockfish	*Sebastes aurora*
		X	X	Chilipepper Rockfish	*Sebastes goodei*
X				Rosethorn Rockfish	*Sebastes helvomaculatus*
		X		Shortbelly Rockfish	*Sebastes jordani*
X		X		Black Rockfish	*Sebastes melanops*
		X		Blue Rockfish	*Sebastes mystinus*
	X			Bocaccio	*Sebastes paucispinis*
			X	Stripetail Rockfish	*Sebastes saxicola*
		X	X	Harlequin Rockfish	*Sebastes variegatus*
		X	X	Pygmy Rockfish	*Sebastes wilsoni*
		X		Longspine Thornyhead*	*Sebastolobus altivelis*
• Roundfish					
	X			Lingcod*	*Ophiodon elongatus*
X			X	Pacific Staghorn Sculpin	*Leptocottus armatus*
			X	Blackfin Sculpin	*Malacocottus kincaidi*
X			X	Greenlings	*Hexagrammidae* (Family)
			X	Kelp Greenling	*Hexagrammos*
• Flatfish					
		X		Rock Sole*	*Pleuronectes bilineatus*
		X		Flathead Sole	*Hippoglossoides elassodon*
X				Deepsea Sole	*Embassichthys bathybius*
			X	Slender Sole	*Eopsetta exilis*
X				Curlfin Sole	*Pleuronichthys decurrens*
X				Sand Sole	*Psettichthys melanostictus*
• Skates					
X			X	Abyssal Skate	*Bathraja abyssicola*
	X			Big Skate	Raja binoculata
		X		Roughtail Skate	*Bathyraja trachura*
		X	X	Starry Skate	*Raja stellulata*
• Tuna and Mackerel					
X			X	Chub Mackerel	*Scomber japonicus*
			X	Albacore	*Thunnus alalunga*
• Other Target Species					
			X	Smelts	*Osmeridae* (Family)

Reef A	Reef B	Reef C	Reef D	Common Name	Latin Name
Bycatch					
• Commercial Fish					
		X	X	Eulachon	*Thaleichthys pacificus*
			X	Pacific Tomcod	*Microgadus proximus*
• Noncommercial Fish					
			X	Bigeye Thresher	*Hexanchus griseus*
			X	Sixgill Shark	*Galeorhinus zyopterus*
			X	Soupfin Shark	*Prionace glauca*
			X	Blue Shark	*Prionace glauca*
		X		American Shad	*Alosa sapidissima*
X				Shortfin Eelpout	*Lycodes brevipes*
			X	Wattled Eelpout	*Lycodes palearis*
			X	Ragfishes	*Icosteidae* (Family)
			X	Poachers	*Agonidae* (Family)
X			X	Sturgeon Poacher	*Podathecus acipenserinus*
			X	Blackfin Poacher	*Bathyagonus nigripinnis*
X			X	Lumpfishes and Snailfishes	*Cyclopteridae* (Family)
		X		Flathead Chub	*Platygobio gracilis*
• Commercial Invertebrates					
			X	Sea Cucumbers	Holothuroidea (Class)
		X	X	Red Squid	*Berryteuthis magister*
			X	Nail Squid	*Onychoteuthis*
			X	Pink Shrimp	*Pandalus borealis*
			X	Sidestripe Shrimp	*Pandalopsis dispar*
X			X	Dungeness Crab	*Cancer magister*
		X	X	Tanner Crabs	*Chionoecetes* Spp.
• Noncommercial Invertebrates					
		X	X	Coelenterates	*Cnidaria* (Phylum)
		X	X	Hydroid	*Hydrozoa* (Class)
		X	X	Jellyfish	*Scyphozoa* (Class)
			X	Anemone	*Actiniaria* (Order)
			X	Sea Pens	Pennatulacea (Order)
		X		Radiata	*Radiata* Spp.
			X	Sea Lilies and Feather Stars	Crinoidea (Class)
X				Crown of Thorns	*Acanthaster planci*
X				Sunflower Starfish	*Pycnopodia helianthoides*
X				Purple Starfish	*Pisaster ochraceus*
			X	Striped Sun Starfish	*Solaster stimpsoni*
			X	Brittle Stars	*Ophiurae* (Order)
X			X	Basket Stars	*Euryalae* (Order)
		X		Echinoidea	*Echinoidea* (Class)
X			X	Heart Urchins	*Atelostomata* (Superorder)
		X		Ascidians and Tunicates	*Ascidiacea* (Class)
X				Polychaete Worms	*Polychaeta* (Class)
		X		Seaslugs	*Nudibranchiata* (Order)

Reef A	Reef B	Reef C	Reef D	Common Name	Latin Name
X				Sea Mouse	*Aphrodita* Spp.
X		X		Oregontriton	*Fusitriton Oregonensis*
			X	Bryozoa	Bryozoa *(Phylum)*
			X	Molluscs	*Mollusca* (Phylum)
			X	Gastropods	*Gastropoda* (Class)
			X	Abalones	*Haliotidae* (Family)
			X	Giant Squid	*Moroteuthis robusta*
			X	Giant Pacific Octopus	*Octopus dofleini*
		X		Shrimp	*Nantantia*
			X	Crab	*Repiantia*
X				Hermit Crabs	*Paguridae* (Family)
X				Cancer Crabs	*Cancridae* (Family)
			X	Spider Crabs	*Oxyrhyncha* (Superfamily)
			X	Toad Crab	*Hyas Lyratus*
		X		Squat Lobster	*Munida quadrispina*
• Sponges					
			X	Bath Sponges	*Demospongiae* (Class)
• Other species					
X					*Pinnipedia* (Suborder)
		X		Western Gull	*Larus occidentalis*
• Species not permitted [to be retained] by groundfish trawl					
	X			Pacific Halibut	*Hippoglossus stenolepis*
		X		Pacific Herring	*Clupea pallasi*
X				Pacific Salmon and Native Trout	*Oncorhynchus* (Genus)
X				Pink Salmon	*Oncorhynchus gorbuscha*
X				Chum Salmon	*Oncorhynchus keta*
X			X	Coho Salmon	*Oncorhynchus kisutch*
			X	Sockeye Salmon	*Oncorhynchus nerka*
		X		Chinook Salmon	*Oncorhynchus tshawytscha*
			X	Green Sturgeon	*Acipenser medirostris*
		X		Wolf Eel	*Anarrhichthys ocellatus*

Table 10. Catch per unit effort (CPUE) by species grouping for Reef A. * Data unreportable due to confidentiality requirements under ATIP.

	Catch per unit effort (kg/minute)							% of Total Reef Catch
	1996	1997	1998	1999	2000	2001	1996-2001	
REEF A ONLY								
Total Rockfish/Thornyheads	*	*	*	*	*	*	2.863	11.50%
Total Flatfish	*	*	*	*	*	*	20.474	82.21%
Total Other	0.740	*	*	*	*	*	0.887	3.56%
Total Sponges	0.028	0.000	0.955	0.000	0.026	0.000	0.086	0.35%
Total Species not permitted	0.014	0.017	0.099	0.007	0.101	0.065	0.055	0.22%
Total Species not targeted	0.229	0.169	0.080	0.115	0.625	1.538	0.539	2.16%
REEF A ONLY & ADJACENT								
Total Rockfish/Thornyheads	1.898	9.263	3.308	2.932	2.863	0.911	3.353	19.21%
Total Flatfish	8.402	10.421	8.537	13.943	14.894	17.504	12.184	69.80%
Total Other	0.795	1.069	1.262	1.082	0.848	1.887	1.095	6.27%
Total Sponges	0.401	0.000	0.071	0.001	0.117	0.000	0.095	0.54%
Total Species not permitted	0.070	0.032	0.247	0.024	0.051	0.104	0.093	0.53%
Total Species not targeted	0.193	0.347	0.514	0.141	0.580	3.613	0.636	3.64%
REEF A ADJACENT								
Total Rockfish/Thornyheads	4.246	3.827	2.946	1.351	1.438	0.847	2.713	19.90%
Total Flatfish	6.510	5.261	7.247	7.349	9.016	11.054	7.269	53.29%
Total Other	2.015	5.877	1.311	5.046	2.376	2.089	3.222	23.63%
Total Sponges	0.002	0.003	0.001	0.000	0.001	0.031	0.003	0.02%
Total Species not permitted	0.129	0.117	0.135	0.159	0.081	0.044	0.125	0.92%
Total Species not targeted	0.205	1.013	0.052	0.299	0.224	0.181	0.306	2.25%

Table 11. Catch per unit effort (CPUE) by species grouping for Reef C. * Data unreportable due to confidentiality requirements under ATIP.

	Catch per unit effort (kg/minute)							% of Total Reef Catch
	1996	1997	1998	1999	2000	2001	1996-2001	
REEF C ONLY								
Total Rockfish/Thornyheads	*		*	*	*		25.446	71.75%
Total Flatfish	*		*	*	*		0.620	1.74%
Total Other	*		*	*	*		*	0.35%
Total Sponges	22.124		0.000	0.000	0.000		5.424	15.29%
Total Species not permitted	0.000		0.000	0.000	0.000		0.000	0.00%
Total Species not targeted	0.427		0.000	9.862	0.000		3.854	10.87%
REEF C ONLY & ADJACENT								
Total Rockfish/Thornyheads	29.232	31.546	*	38.510	18.631	22.907	26.958	77.36%
Total Flatfish	1.511	0.490	*	1.061	0.551	0.494	0.648	1.86%
Total Other	0.560	15.133	*	0.757	0.455	0.393	3.631	10.41%
Total Sponges	4.814	4.709	0.973	0.075	0.491	2.270	2.098	6.02%
Total Species not permitted	0.061	0.025	0.000	0.050	0.075	0.042	0.048	0.14%
Total Species not targeted	0.117	0.182	1.027	3.817	1.863	1.041	1.463	4.20%
REEF C ADJACENT								
Total Rockfish/Thornyheads	31.101	28.468	30.680	32.554	45.590	34.490	34.766	85.30%
Total Flatfish	0.754	0.981	0.498	0.568	0.090	0.159	0.460	1.12%
Total Other	5.270	1.131	1.904	0.968	0.501	0.247	1.244	3.05%
Total Sponges	0.436	0.673	1.265	0.324	4.861	3.674	2.051	5.03%
Total Species not permitted	0.058	0.062	0.046	0.043	0.044	0.035	0.046	0.11%
Total Species not targeted	0.361	1.063	2.350	1.119	4.030	3.303	2.189	5.37%

Table 12. Catch per unit effort (CPUE) by species grouping for Reef D. * Data unreportable due to confidentiality requirements under ATIP.

	Catch per unit effort (kg/minute)							**% of Total Reef Catch**
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**1996-2001**	
REEF D ONLY								
Total Rockfish/Thornyheads	29.792	22.217	*		*		30.501	74.10%
Total Flatfish	*	0.475	*		*		0.669	1.62%
Total Other	*	0.823	*		*		0.460	1.12%
Total Sponges	0.000	19.940	0.000		0		6.041	14.68%
Total Species not permitted	0.001	0.090	0.000		0.242		0.032	0.08%
Total Species not targeted	0.038	3.880	9.404		2.788		3.454	8.39%
REEF D ONLY & ADJACENT								
Total Rockfish/Thornyheads	21.916	22.874	23.941	15.881	19.000	32.209	22.219	84.45%
Total Flatfish	1.351	1.578	2.181	6.549	3.126	2.066	2.249	8.54%
Total Other	0.369	1.113	1.064	0.431	1.892	0.454	0.819	3.13%
Total Sponges	0.000	2.350	0.010	0.000	0.025	0.000	0.604	2.30%
Total Not permitted	0.045	0.053	0.019	0.018	0.101	0.024	0.041	0.16%
Total Species not targeted	0.070	0.368	1.071	0.090	0.291	0.057	0.380	1.45%
REEF D ADJACENT								
Total Rockfish/Thornyheads	16.614	14.889	14.056	10.305	16.751	18.268	15.348	72.16%
Total Flatfish	3.728	2.604	3.733	3.345	6.386	1.819	3.473	18.95%
Total Other	3.781	1.197	1.409	0.881	6.431	0.866	2.400	8.15%
Total Sponges	0.000	0.002	0.001	0.000	0.001	0.000	0.001	0.00%
Total Not permitted	0.060	0.063	0.050	0.019	0.046	0.039	0.051	0.24%
Total Species not targeted	0.075	0.099	0.163	0.171	0.096	0.094	0.109	0.51%

Table 13: A. Summed six-year landings (t) for all species by zone for each of the four sponge reefs (2001 incomplete). B. Summed six-year landings (t) for targeted IVQ, targeted non-IVQ and other species by the ADJACENT ONLY area by reef.

A.

Reef	**REEF ONLY**	**REEF AND ADJACENT**	**ADJACENT ONLY**	**Total (t)**	***Percentage***
A	152	498	590	1240	*16*
B	4	4	2	10	*0*
C	13	258	1481	1752	*22*
D	86	846	3990	4921	*62*
Total (t)	255	1606	6063	7923	
Percentage	*3*	*20*	*77*		*100*

B.

Reef	**Targeted IVQ species**	**Targeted non-IVQ species**	**Other species**	**Total (t)**	***Percentage***
A	389	183	18	590	*10*
B	2	0	0	2	*0*
C	1155	162	164	1481	*24*
D	3380	590	20	3990	*66*
Total (t)	4926	935	202	6063	
Percentage	*81*	*15*	*4*		*100*

Table 14. Groundfish Hook and Line activity starting in the sponge reef closure areas. † = total underestimated due to missing data in that year.

Sponge Reef	**Year**	**CFVs**	**Sets**	**Effort (minutes)**	**Max. Depth (m)**	**Target Species**
Reef A	1994	8	40	203	36-118	n/a
	1995	5	20	8340	40-109	n/a
	1996	6	8	6720	64-158	n/a
	1997	4	7	3120	58-73	n/a
	1998	7	20	5940	31-200	Rockfish, Thornyheads, Yelloweye Rockfish, Lingcod
	1999	10	17	5100	22-186	Rockfish, Thornyheads, Yelloweye and Quillback Rockfish, Lingcod
	2000	8	14	5254	36-128	Rockfish, Thornyheads, Yelloweye and Quillback Rockfish, Halibut
	2001	17	63	27894	51-182	Yelloweye and Quillback Rockfish, Lingcod, Halibut
Reef B	1994	1	5	50	109-164	n/a
	1998	2	2	720	100-128	Rockfish, Thornyheads
	1999	3	6	3840	54-146	Rockfish, Thornyheads, Yelloweye Rockfish, Lingcod
	2001	1	1	660	64	Lingcod
Reef C	1995	1	1	600	217	n/a
	1999	1	1	240	200	Yelloweye Rockfish
	2001	1	1	162	350	Quillback Rockfish
Reef D	1994	1	3	32	73-164	n/a
	1996	1	2	1080	182-200	n/a
	1997	1	3	840	73	n/a
	1998	2	8	2220	63-146	Yelloweye Rockfish
	1999	1	4	600	128	Yelloweye Rockfish
	2001	5	8	1920†	73-264	Redbanded and Silvergray Rockfish, Lingcod

Table 15. Reported target and bycatch species caught by the groundfish Hook and Line fishery by tows or sets starting in the fishing closure areas.

Sponge Reef A	B	C	D	Common Name	Latin Name
Commercial fish					
• Rockfish and Thornyheads					
X		X	X	Redbanded rockfish	*Sebastes babcocki*
X	X		X	Silvergray rockfish	*Sebastes brevispinis*
X	X		X	Copper rockfish	*Sebastes caurinus*
X				Greenstriped rockfish	*Sebastes elongatus*
X	X			Widow rockfish	*Sebastes entomelas*
X			X	Yellowtail rockfish	*Sebastes flavidus*
X	X		X	Rosethorn rockfish	*Sebastes helvomaculatus*
X	X		X	Quillback rockfish	*Sebastes maliger*
X			X	Black rockfish	*Sebastes melanops*
X			X	Vermilion rockfish	*Sebastes miniatus*
X	X		X	China rockfish	*Sebastes nebulosus*
X	X		X	Tiger rockfish	*Sebastes nigrocinctus*
X	X			Bocaccio	*Sebastes paucispinis*
X	X	X	X	Canary rockfish	*Sebastes pinniger*
X				Redstripe rockfish	*Sebastes proriger*
			X	Yellowmouth rockfish	*Sebastes reedi*
X	X	X	X	Yelloweye rockfish	*Sebastes ruberrimus*
			X	Shortspine thornyhead	*Sebastolobus alascanus*
			X	Thornyhead	*Sebastolobus*
• Other species					
X				Pacific cod	*Gadus macrocephalus*
X	X	X	X	Lingcod	*Ophiodon elongatus*
X			X	Flatfishes	*Pleuronectiformes*
X				Arrowtooth flounder	*Atheresthes stomias*
X				Pacific halibut	*Hippoglossus stenolepis*
X				Big skate	*Raja binoculata*
X				Longnose skate	*Raja rhina*
X		X		Spiny dogfish	*Squalus acanthias*
Bycatch					
X			X	Blue shark	*Prionace glauca*
X				Spotted ratfish	*Hydrolagus colliei*
X				Greenlings	*Hexagrammidae*
X		X	X	Kelp greenling	*Hexagrammos decagrammus*
X				Starfish	*Asteriodea*
X			X	Cabezon	*Scorpaenichthys marmoratus*

Table 16. Shrimp trawl activity in the sponge reef fishing closure areas.

Sponge Reef	Year	CFVs	Sets	Effort (minutes)
Reef A	1998	1	2	135
Reef B	1998	1	6	360
Reef C	1997	1	2	180
	1998	2	17	1610
	1999	1	2	75
Reef D	1997	4	5	430
	1998	2	2	180

Table 17: Crab fishery activity in the relevant PFMA subareas for the sponge reefs.

Sponge Reef	Subarea	Year	CFVs	Sets	Effort (hours)
Reef A	105-2	1995	1	1	288
		1996	1	108	14496
		1997	3	6	504
		1999	1	5	624
Reef C	107-1	1998	1	1	240

Appendix 1: Species observed by Bill Austin from video observations on sponge reef A (modified from Sloan et al. 2001). A. Species are sorted alphabetically, and are repeated to illustrate the number of dives and the site locations (described in B) in which they were observed.

A.

Site Code	Taxon
569	Acanthascus platei
570	Acanthascus platei
577	Acanthascus platei
578	Acanthascus platei
581	Acanthascus platei
584	Acanthascus platei
586	Acanthascus platei
588	Acanthascus platei
577	Acantholithodes hispidus
587	Acarnus cf. erithaceus
569	Allocentrotus fragilis
570	Allocentrotus fragilis
577	Allocentrotus fragilis
578	Allocentrotus fragilis
581	Allocentrotus fragilis
588	Allocentrotus fragilis
583	Ampelisca
582	Amphinomidae
572	Amphissa
570	Amphiuridae
580	Amphiuridae
569	Aphrocallistes vastus
570	Aphrocallistes vastus
572	Aphrocallistes vastus
577	Aphrocallistes vastus
578	Aphrocallistes vastus
579	Aphrocallistes vastus
581	Aphrocallistes vastus
582	Aphrocallistes vastus
578	Asbestopluma occidentalis
589	Asbestopluma occidentalis
584	Ascidia
580	Astarte alaskensis
584	Auletta
585	Axinella
577	Axinopsida serricata
569	Balticina septentrionalis
570	Balticina septentrionalis
577	Balticina septentrionalis
581	Balticina septentrionalis
584	Balticina septentrionalis
588	Balticina septentrionalis
582	Barentsia
582	Biemna cf. megalosigma
584	Biemna rhadia
587	Caberea ellisi
578	Cadlina flavomaculata
577	Cadulus
578	Calliostoma platinum
569	Ceramaster patagonicus
570	Ceramaster patagonicus
577	Ceramaster patagonicus
578	Ceramaster patagonicus
581	Ceramaster patagonicus
584	Ceramaster patagonicus
588	Ceramaster patagonicus
573	Cerebratulus californiensis
569	Chonelasma calyx
570	Chonelasma calyx
571	Chonelasma calyx
572	Chonelasma calyx
574	Chonelasma calyx
575	Chonelasma calyx
577	Chonelasma calyx
578	Chonelasma calyx
579	Chonelasma calyx
581	Chonelasma calyx
582	Chonelasma calyx
583	Chonelasma calyx
587	Chonelasma calyx
569	Chorilia longipes

576	Nephasoma diaphanes
570	Octopus
582	Onuphis geophiliformis
571	Onuphis iridescens
573	Onuphis iridescens
569	Ophiacanthidae
578	Ophiopholis bakeri
588	Ophiura
578	Ophiura leptoctenia
569	Ophiura luetkeni
578	Ophiura luetkeni
578	Ophiura sarsi
575	Oregonia gracilis
578	Oregonia gracilis
577	Owenia collaris
580	Owenia collaris
570	Pachastrellidae
578	Paguridae
581	Paguridae
579	Paguroidea
569	Pagurus
570	Pagurus
577	Pandalus
578	Pandalus
580	Pandalus danae
569	Pandalus platyceros
570	Pandalus platyceros
577	Pandalus platyceros
578	Pandalus platyceros
581	Pandalus platyceros
588	Pandalus platyceros
570	Paragorgia pacifica
577	Paragorgia pacifica
578	Paragorgia pacifica
581	Paragorgia pacifica
569	Parastichopus leucothele
570	Parastichopus leucothele
577	Parastichopus leucothele
581	Parastichopus leucothele
584	Parastichopus leucothele
587	Plumulariidae
582	Poecillastra japonica
584	Poecillastra japonica
587	Poecillastra japonica
572	Polymastia
578	Primnoa willeyi
584	Primnoa willeyi
570	Pseudarchaster alascensis
581	Pseudarchaster alascensis
584	Pseudarchaster alascensis
574	Pseudosuberites
587	Pseudosuberites
570	Psolus squamatus
578	Psolus squamatus
569	Pteraster militaris
570	Pteraster militaris
577	Pteraster militaris
578	Pteraster militaris
579	Pteraster militaris
581	Pteraster militaris
588	Pteraster militaris
573	Puncturella galeata
586	Pyura haustor
587	Pyura haustor
569	Rhabdocalyptus dawsoni
570	Rhabdocalyptus dawsoni
577	Rhabdocalyptus dawsoni
578	Rhabdocalyptus dawsoni
581	Rhabdocalyptus dawsoni
584	Rhabdocalyptus dawsoni
588	Rhabdocalyptus dawsoni
572	Scionella japonica
569	Serpulidae
573	Serpulidae
581	Serpulidae
569	Staurocalyptus dowlingi
570	Staurocalyptus dowlingi
577	Staurocalyptus dowlingi
578	Staurocalyptus dowlingi
581	Staurocalyptus dowlingi
584	Staurocalyptus dowlingi
587	Staurocalyptus dowlingi
584	Strongylocentrotus droebachiensis
569	Stylasterias forreri
578	Stylasterias forreri
581	Stylasterias forreri
584	Stylasterias forreri
575	Suberites simplex
578	Suberites simplex
586	Syllidae
587	Syllidae

582 Terebellidae
573 Terebratulina unguicula
574 Terebratulina unguicula
575 Terebratulina unguicula
581 Terebratulina unguicula
587 Terebratulina unguicula
571 Thyasira flexuosa
572 Thyasira flexuosa
574 Thyasira flexuosa
582 Thyasira flexuosa
582 Topsentia disparilis
584 Topsentia disparilis
586 Topsentia disparilis
587 Topsentia disparilis
578 Tubularia
587 Tubularia marina
583 Tubulipora

B.

Dive Code	Original Site	Latitude	Longitude	Observation Date	Depth (m)
569	54/99	53.143	130.417	19990713	187-205
570	55/99	53.163	130.443	19990713	188
571	56/99	53.187	130.475	19990714	180
572	57/99	53.163	130.445	19990714	192
573	58/99	53.162	130.44	19990714	195
574	59/99	53.155	130.432	19990714	0
575	60/99	53.153	130.428	19990714	193
576	61/99	53.181	130.431	19990715	174
577	62/99	53.18	130.48	19990715	220
578	63/99	53.183	130.398	19990715	197-220
579	64/99	53.178	130.465	19990715	200
580	65/99	53.173	130.497	19990715	200
581	66/99	53.18	130.482	19990716	171-183
582	67/99	52.433	129.695	19990717	215
583	68/99	52.448	129.682	19990717	205
584	70/99	52.437	129.7	19990718	213
585	71/99	52.44	129.667	19990719	215
586	72/99	53.298	130.715	19990719	200
587	73/99	53.338	130.74	19990719	200
588	74/99	53.338	130.74	19990719	200
589	76/99	53.25	130.643	19990719	200

Figure 1: Locations of sponge reefs within Pacific Fisheries Management Areas (PFMAs).

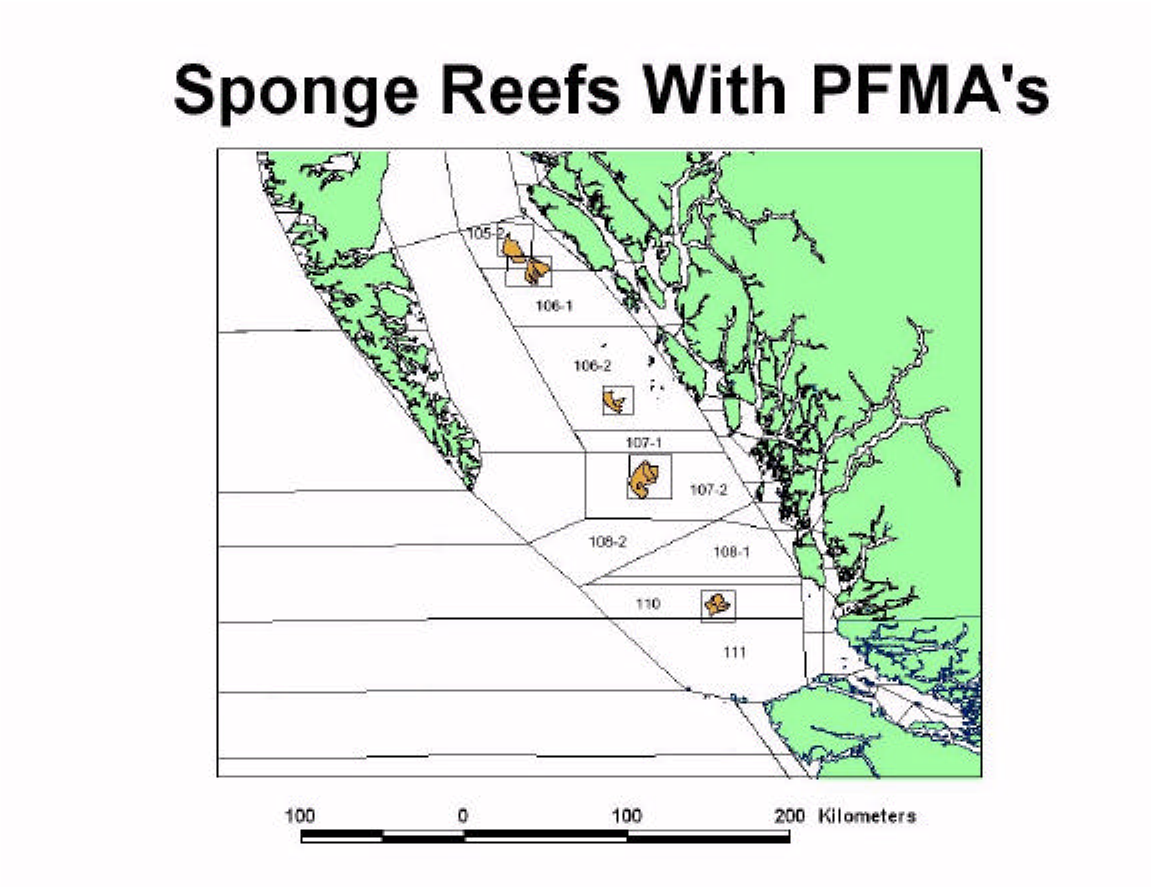


Figure 2: Reference names given to the different sponge reefs in the Central Coast, BC. The black boxes are the voluntary shrimp closure zones.

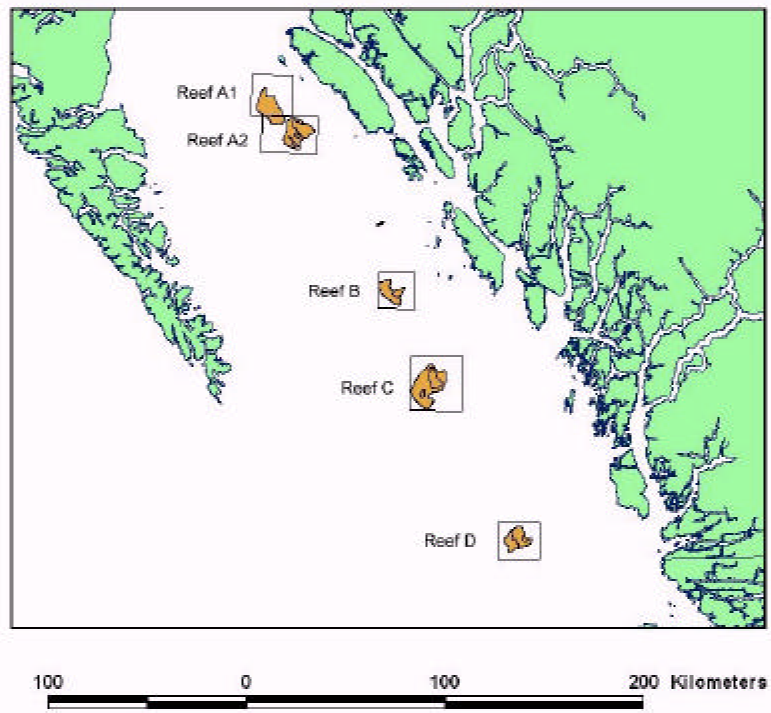


Figure 3: proposed Central Coast Integrated Management boundary (D. Johanssen, DFO, Sidney, BC, pers. comm.) that takes into account the bathymetric and ecosystem features on the continental shelf. This proposed boundary has yet to be finalised.

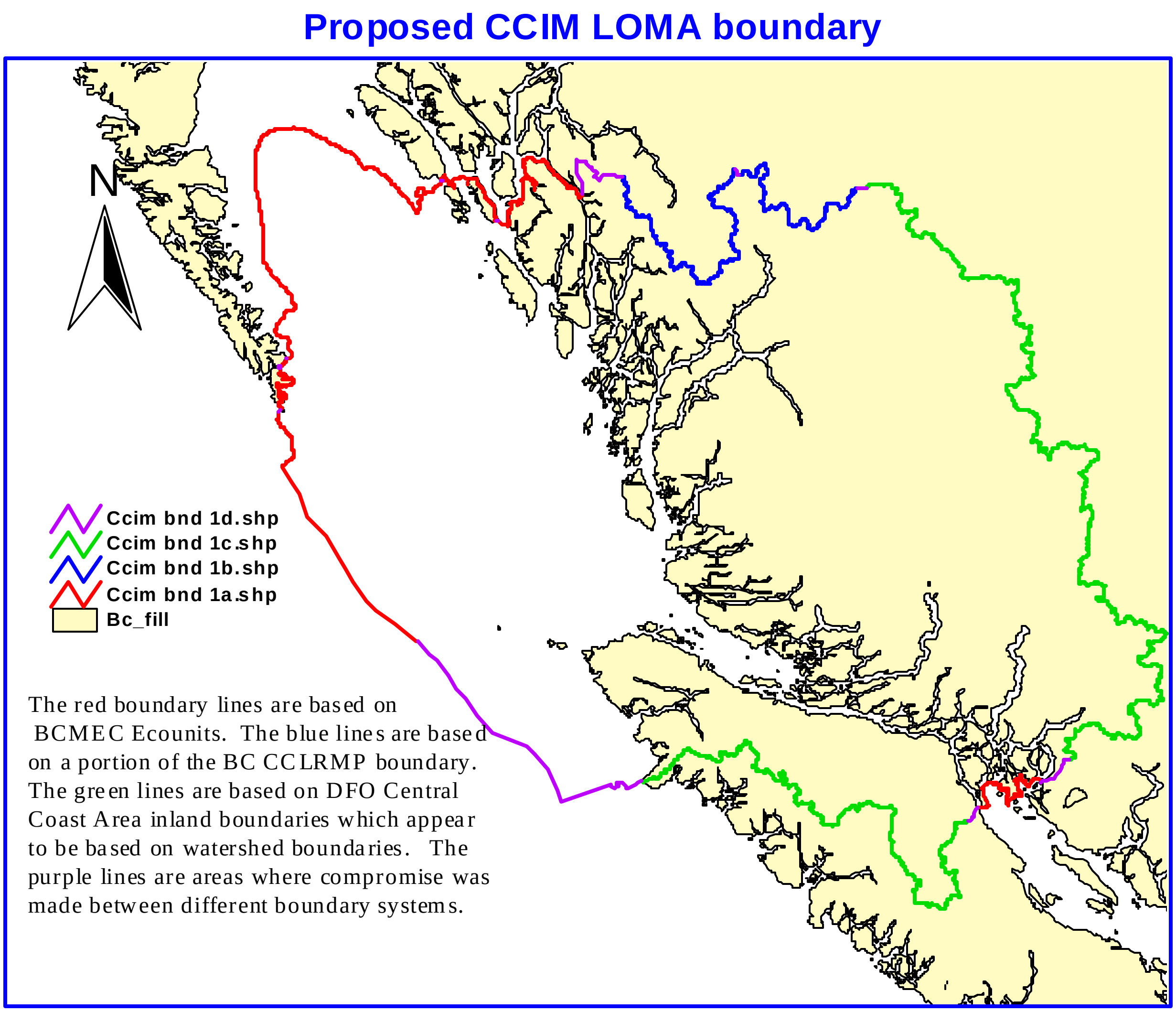


Figure 4: Estimated extent of offshore gas and oil leases, September 14, 2001. Map courtesy of Jeff Ardon, Living Ocean Society, Salt Spring Island, BC, pers. comm..

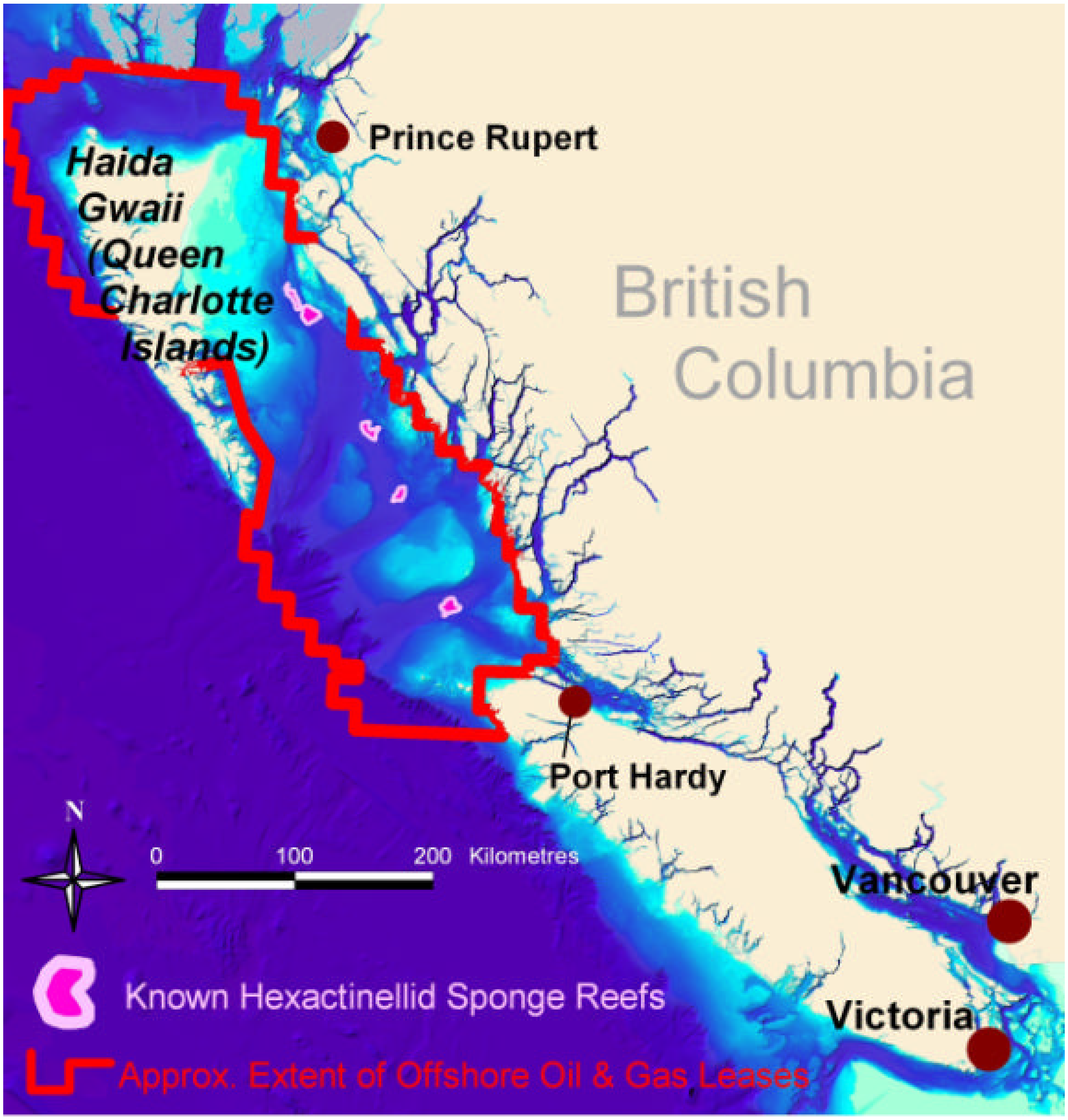
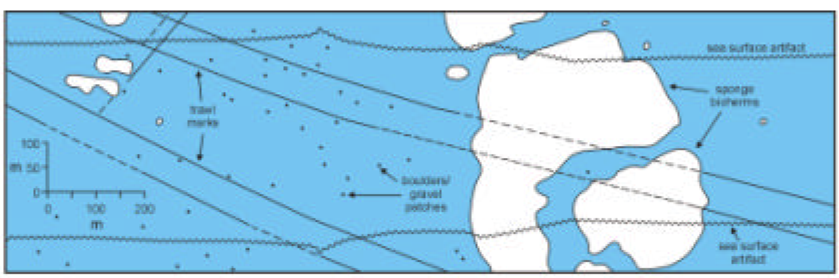


Figure 5: A. A trawl track image from by one trawl door as it traversed the reef surface. Two of these marks were found relatively close together on one ROV dive. The trawl track is about 20 cm wide and 10 cm deep and is cut into sponge reef sediments. It appears to be "unweathered", and recent, because of the sharp near edge. It is in an area that was pristine reef in 1999 and is surrounded by damaged or completely removed reef surface. B. Side-scan sonar image of trawl tracks. (Images courtesy of K. Conway, July, 2002).

A.

B.



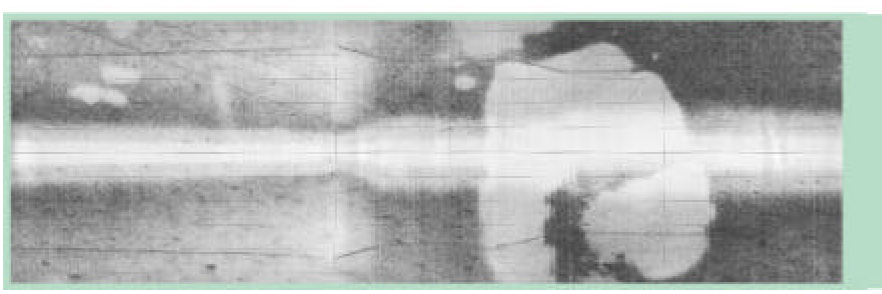


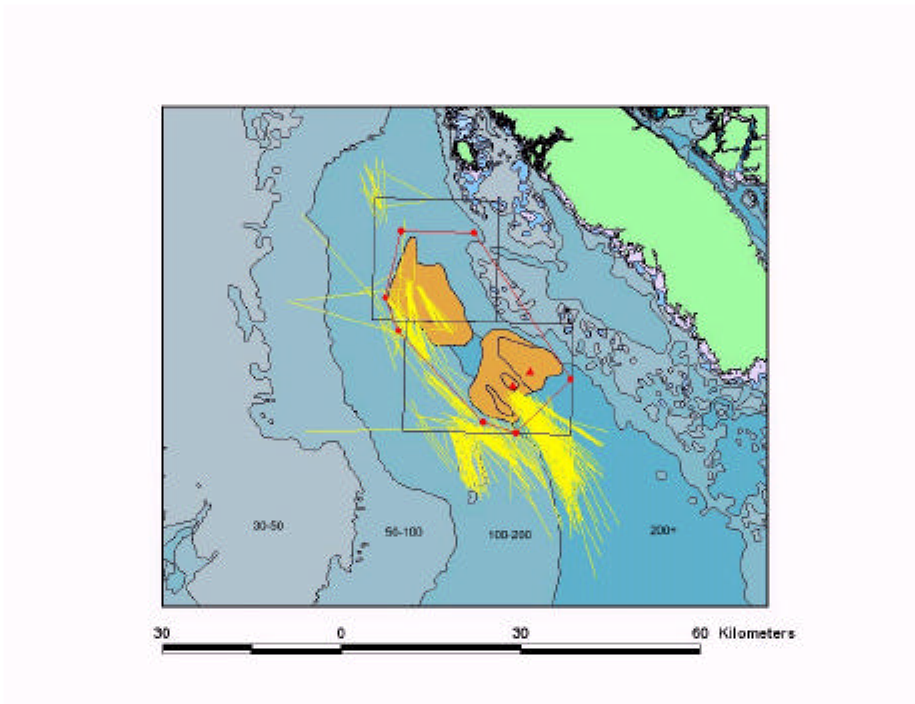
Figure 6: A. Healthy and B. trawl-damaged sponges. (Images courtesy of K. Conway, July, 2002).

A.

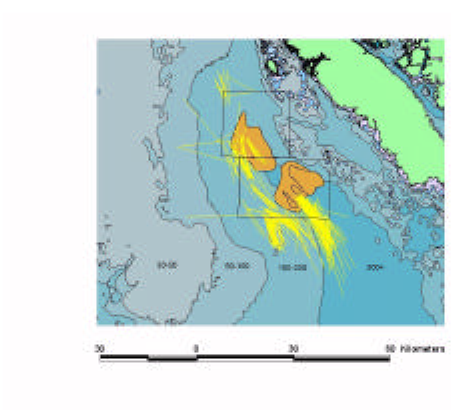
B.

Figure 7. Trawl tow lines (yellow; linear distance between tow start and end locations, so perhaps not truly representative of tow paths) starting or ending within the shrimp trawl closure boxes (black) around sponge reef A (orange). A. 1996-2001. Red lines outline the recently introduced groundfish trawl closure zone, red triangle indicates current moorings. B. 1996-1999. C. 2000-2001.

A.



B.



C.

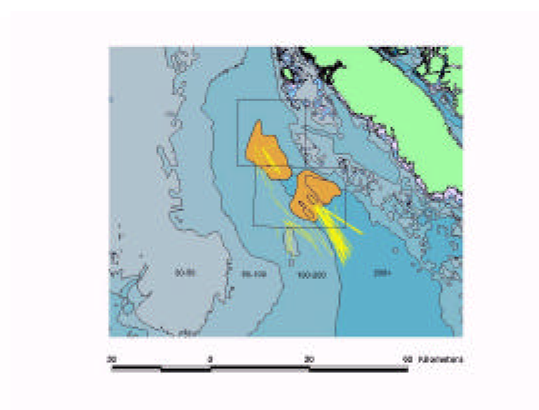
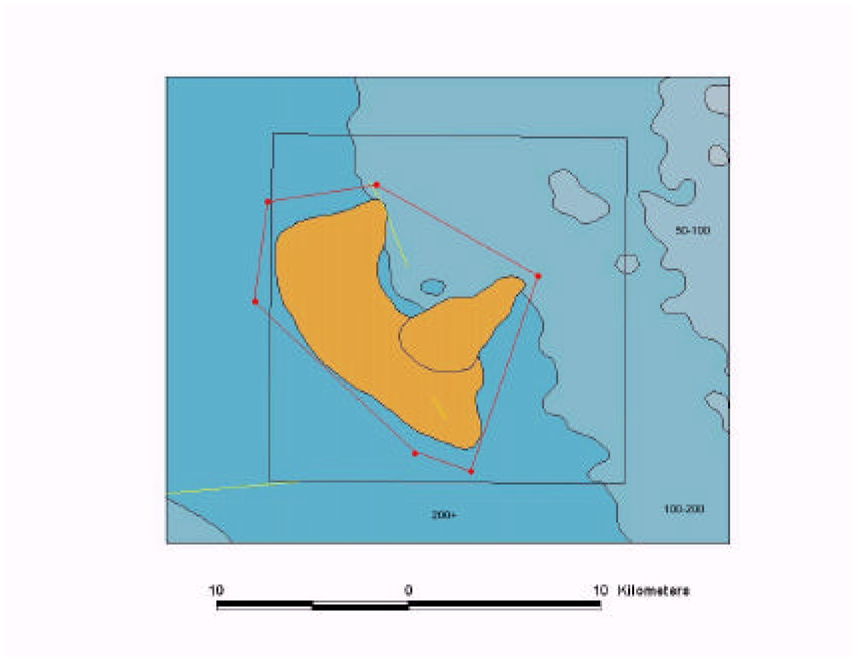


Figure 8. Trawl tow lines (yellow; linear distance between tow start and end locations, so perhaps not truly representative of tow paths) starting or ending within the shrimp trawl closure box (black) around sponge reef B (orange). A. 1996-2001. Red lines outline the recently introduced groundfish trawl closure zone. B. 1996-1999. C. 2000-2001.

A.

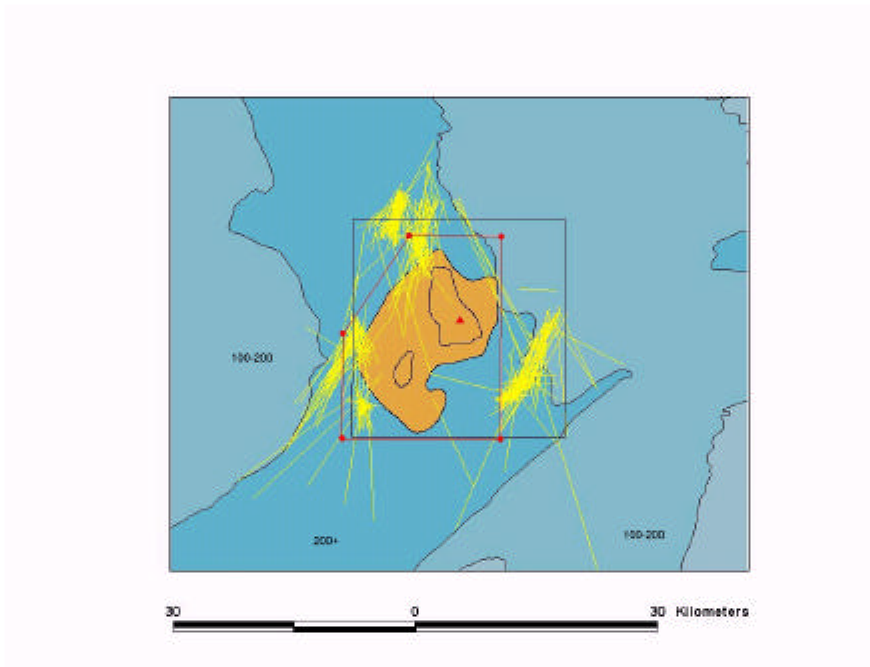


B.

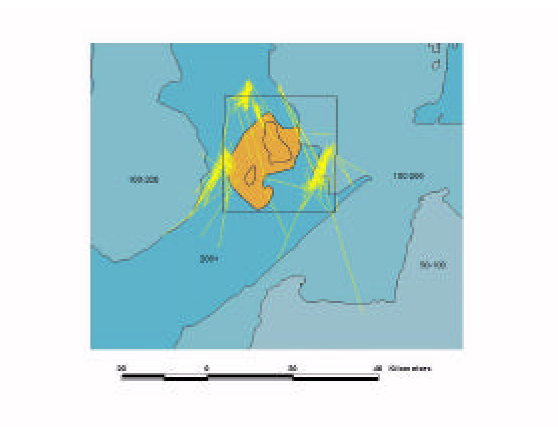
C.

Figure 9. Trawl tow lines (yellow; linear distance between tow start and end locations, so perhaps not truly representative of tow paths) starting or ending within the shrimp trawl closure box (black) around sponge reef C (orange). A. 1996-2001. Red lines outline the recently introduced groundfish trawl closure zone, red triangle indicates current mooring. B. 1996-1999. C. 2000-2001.

A.



B.



C.

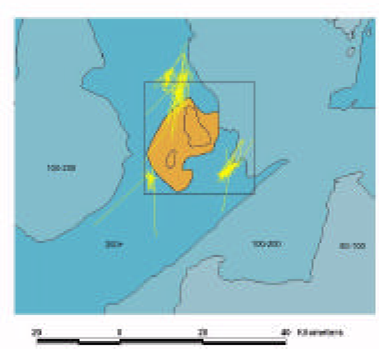
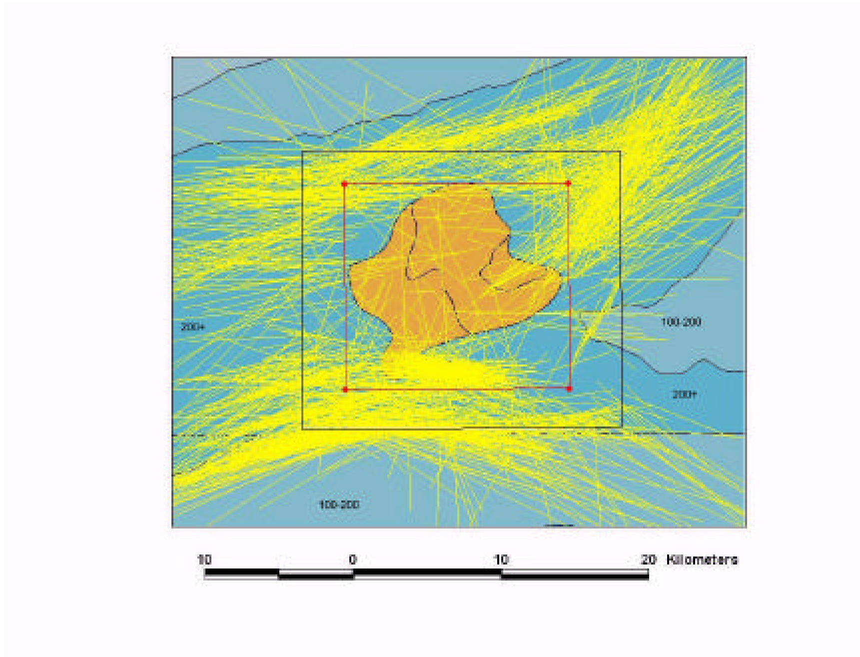
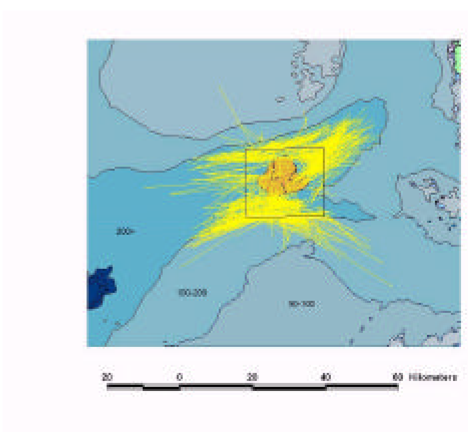


Figure 10. Trawl tow lines (yellow; linear distance between tow start and end locations, so perhaps not truly representative of tow paths) starting or ending within the shrimp trawl closure box (black) around sponge reef D (orange). A. 1996-2001. Red lines outline the recently introduced groundfish trawl closure zone. B. 1996-1999. C. 2000-2001.

A.



B.



C.

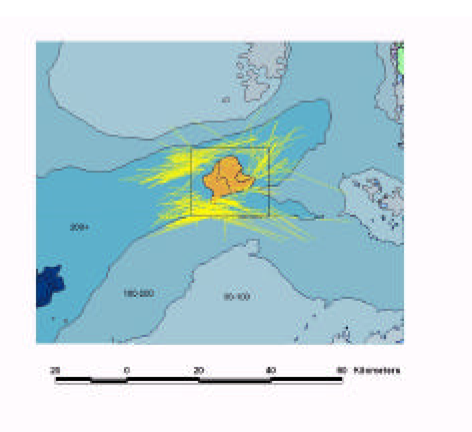


Fig. 11: The location of the small sponge bioherm just discovered off the mouth of the Fraser River in the Strait of Georgia (K. Conway, pers. comm.). brown = Fraser River estuary and intertidal zone.