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Status of the glass sponge reefs in the Georgia Basin

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Abstract

The purpose of this paper is to describe the status and general faunal composition of sponge reefs in the Georgia Basin (GB), British Columbia, Canada. Fourteen distinct deep water glass sponge (Hexactinellid) reefs have been mapped using multibeam bathymetry and sidescan sonar in the GB. Seven of these have been surveyed visually using video from Remotely Operated Vehicles (ROVs). Analysis of video data indicated that three reefs were undamaged, two were damaged and the other two were damaged but potentially recovering. The nature of the damaged reefs, with large areas of scattered dead sponge skeleton fragments and few live reef-building sponges (*Aphrocallistes vastus* and *Heterochone calyx*), as well as video evidence of tracks suggest they were damaged mechanically by mobile fishing gear.

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Relative abundance of the megafauna associated with the reefs is discussed in the context of oceanographic conditions, such as sediment accumulation and organic flux, as well as overall reef status. Of particular interest for fisheries conservation efforts in the area was the fact that one undamaged reef in the southern GB showed higher taxonomic richness and abundance of rockfish (*Sebastes* spp.), both adult and juvenile, compared to an adjacent damaged reef. This result suggests that undamaged reefs may act as refugia for these endangered stocks.

Keywords: Georgia Basin; Continental shelf; Glass sponge reefs; Hexactinellida; Multibeam; Sidescan sonar; Effects – bottom trawling; Megafauna; Relative abundance; Reef status; Rockfish

1. Introduction

Glass sponge reefs built by sponges of Class Hexactinellida, Order Hexactinosida, are found along the continental shelf of the Pacific Northwest. Sponges of this order have a skeleton of fused silica spicules that remains remarkably intact after the death of the sponge (Krautter et al., 2006) and that can be used by sponge larvae for settlement. These large, suspension-feeding animals act as baffles that slow currents at the seabed, causing entrained sediment to drop out of suspension (Krautter et al., 2006). This process results in the development of three-dimensional mound structures composed of massive, clay-rich sediments and siliceous sponge skeletons, with live reef-building sponges attached to exposed sponge skeletons on the reef surface (Conway et al., 2005a; Krautter et al., 2006). Individual reef mounds grow with time, and aggregations of these mounds form large reef complexes, which have been identified off British Columbia, Canada, discontinuously covering over 700 km² of the continental shelf in the Queen Charlotte Basin (QCB) (Conway et al., 1991; Krautter et al., 2001). A number of smaller complexes have also been described in the Georgia Basin (GB) (Conway et al., 2004; Conway et al., 2005a; Conway et al., 2007), and these are the focus of this paper.

The Strait of Georgia, which forms a large part of the Georgia Basin, is an enclosed body of water with moderately strong tidal currents and large fresh water input from the Fraser River. The Fraser River strongly influences sedimentation rates and organic flux in the GB (Burd et al., this issue; Hill et al., this issue). Multibeam mapping, geophysical surveys and textural data from grab samples indicate a complex pattern of sediment accumulation, transport and erosion in the southern strait (Barrie et al., 2005). The

oceanographic and geologic settings of the reef complex on the Fraser Ridge (reef 1) and the McCall Bank complexes (reefs 2 – 4) (see Fig. 1 for locations) in the GB are described by Conway et al. (2004) and Conway et al. (2005a), respectively. The geologic setting of the reef complexes near the entrance to Active Pass in the GB is described by Conway et al. (2007).

The QCB reef complexes support diverse communities that are distinct from surrounding shelf communities and play a role as nursery habitats for rockfish (*Sebastes* spp.) (Cook, 2005). Rockfish are commercially important and have been subject to conservation efforts in recent years (DFO, 2006). Juvenile rockfish have been found at abundances five times higher on live reefs than on adjacent dead reef and off-reef areas in the QCB (Cook, 2005). Dead portions of the reefs, which are less structurally complex and mainly consist of sponge skeleton rubble, were also found to have significantly lower taxonomic richness and abundance of invertebrate fauna than live reef areas (Cook, 2005). There have not yet been any studies characterizing the community associated with the reef complexes in the GB.

The reef-building sponge species in the GB are *Aphrocallistes vastus* and *Heterochone calyx*. The reef-building species are found on gravel and rock substrates, such as glacial till ridges (Krautter et al., 2006), which can be found in very close proximity to the Fraser River on the Fraser Ridge (see Fig. 1) (Conway et al., 2004). The GB reef complexes are found in water depths of 90-300 m where bottom currents prevent sediment from accumulating (Conway et al., 2005a). The GB reefs grow in linear patterns along ridges,

sometimes forming distinctive 'chevron' (Conway et al., 2007) or wave-form shapes (Conway et al., 2005a). The reef mounds in the GB have been recorded to heights of 14 m above the sea-floor (Conway et al., 2004; Conway et al., 2005a).

Sidescan sonar and video surveys in the QCB undertaken between 1991 and 2002 revealed that damage had been done to some of the reef complexes in areas heavily fished by bottom trawlers (Krautter et al., 2001; Conway et al., 2001). Fisheries and Oceans Canada closed the QCB reefs to bottom trawling in July 2002 in recognition of their susceptibility to the effects of fishing gear and is considering designating them as Marine Protected Areas (Jamieson and Chew, 2002).

Conway et al. (2007) qualitatively described the health of the sponge reef complexes (healthy or unhealthy) in the GB; however, this was not a systematic description from the video and the terms 'healthy' and 'unhealthy' were not defined. This study builds upon that work with the goals of using a systematic analysis of the ROV video surveys to make a preliminary assessment of the status, or condition, of the surveyed sponge reef complexes in the Georgia Basin, and of characterizing the megafaunal communities associated with each. Possible reasons for status and differences in associated fauna among reef complexes will be discussed.

2. Materials and methods

2.1. Reef status

Sponge reefs in the GB were originally mapped using multibeam bathymetry and sidescan sonar collected and analyzed to determine possible locations and extents of sponge reef complexes in the GB (Conway et al., 2005a). In this paper, the status of the reefs and their associated megafaunal organisms were assessed using video transects collected by the Pacific Geoscience Centre between 2002 and 2006 (see Table 1). These transects were collected using a digital video camera mounted on either a Phantom HD2 Remotely Operated Vehicle (ROV) or the Remotely Operated Platform for Ocean Science (ROPOS). Both vehicles had laser pointers mounted 10 cm apart that were visible in the video. The remotely operated vehicle transects ranged from 420 to 5718 m in length, and the compiled video segments provide a transect for each complex.

The categories of reef status are: undamaged, damaged, damaged and possibly recovering, and unknown. Observations of the condition of the reef-building sponges were made along the on-reef portions of each transect, by recording estimates of percent alive or dead as well as the condition of the dead sponge (standing or fragmented and broken). Status was assigned based on the condition of the majority (>50%) of the transect. An undamaged reef consists mainly of areas of live reef-building sponges (Fig. 2a) (*Aphrocallistes vastus* and *Heterchone calyx*) and areas of standing dead sponge (Fig. 2b) growing on mounds of dead sponge skeletons and skeletal fragments in a sediment matrix. A damaged reef consists mainly of areas of broken and fragmented dead sponge, possibly with small areas of standing dead sponge (Fig. 2c), and few isolated live reef-building sponges. A damaged and possibly recovering reef consists of mostly broken and fragmented dead sponge, but with widespread areas where young

reef-building sponges are colonizing the fragmented, dead sponge skeletons (Fig. 2d).
Unknown status indicates that the reef complex has been identified but not yet surveyed
using video techniques.

2.2. Associated Fauna

The whole of each transect was viewed, and all visible megafauna were identified to the
lowest taxonomic level possible aided by digital photos taken by ROPOS (see Table 2).
Reef 4 was not included in this analysis, because the video became corrupted after the
reef status was determined. Each transect was divided into sections based on whether
the video was on-reef or off-reef. The abundance of organisms was recorded for the on-
reef sections in a semi-quantitative way, either by counting the number of individuals, or,
if the number of individuals was difficult to establish due to visibility, complex terrain or
very high abundance, by estimation. Counts and estimates were converted into a
measure of relative abundance (Few<Some<Many) for each reef complex, in recognition
of the fact that accurately quantifying some organisms was not feasible (criteria for the
conversion to relative abundance are described below; Table 2). The relative abundance
of different taxa is useful for comparing differences in faunal composition among reefs.

3. Results

3.1. Reef distribution and status

Fig. 1 shows the locations of reef complexes in the Georgia Basin as identified from
analysis of multibeam swath bathymetry data (Conway et al., 2007). Table 1 lists the reef
complexes by number, with geographic location, dive number, date surveyed and current

status as determined from video analysis. The reefs are numbered in order of their discovery (after Conway et al., 2007). Seven of the 14 identified reef complexes in the GB have been surveyed visually.

Four of the seven surveyed reefs (3, 6, 9 and 13) were classified either as damaged (3 and 9), or as damaged and possibly recovering (6 and 13), based on video surveys. The remaining three (1, 4 and 7) were classified as undamaged.

3.2. Associated fauna

Table 2 presents the reef complexes on which each taxon was present. Only four taxa were found on all six classified reef complexes for which there was usable video: spot prawns (*Pandalus platyceros*), squat lobsters (*Munida quadrispina*), blood stars (*Henricia* sp.) and ratfish (*Hydrolagus colliei*), which are all common species in British Columbia's subtidal coastal waters (Cook, unpublished data from video surveys of B.C. coast). The reef complex with the highest number of observed taxa (24) was undamaged reef 7. Six of the taxa at this reef complex were species of rockfish (*Sebastes* spp.). The lowest number of taxa (8) was observed at reef complex 1 (undamaged). The damaged reef in the southern part of the GB (reef 9) had 12 taxa, and the damaged reefs in the northern GB (3, 6 and 13) had between 15 and 20 taxa each.

Table 3 includes relative abundance data for each of the taxonomic groups identified in Table 2 for each reef complex. The northern group of reefs (3 (damaged), 6 and 13 (damaged and possibly recovering)) had the highest relative abundance of lyssacine

sponges and demosponges, and was the only set of reefs where shortspine thornyheads (*Sebastolobus alascanus*) were present. Brittle stars and sea urchins were only observed at high relative abundance at reef 9 (damaged). Reef complex 7 (undamaged) had the highest relative abundance of rockfish (*Sebastes* spp.). All other reefs had relatively few rockfish. For example, 176 juvenile and adult rockfish were observed on reef 7 (undamaged), and only 4 rockfish were observed on reef 9 (damaged). Corals, mostly large Gorgonians, were observed on reefs 1 and 7 (both undamaged) in the southern GB, although the highest abundance of corals was on reef 13 (damaged and possibly recovering) in the northern GB.

4. Discussion

4.1. Reef distribution and status

Glass sponge reefs are distributed across a diverse range of oceanographic conditions and depths in the Georgia Basin; however, more than half of the surveyed reef complexes in the GB have been damaged. Reef-building glass sponges are brittle and prone to fragmentation with physical contact. The nature of damaged reefs surveyed in this study, with highly fragmented dead sponge skeleton and little or no standing dead sponge, suggests that the reef complexes were damaged mechanically. It is well documented that certain forms of fishing, such as bottom trawling, can cause this type of damage to large sessile benthic fauna, including glass sponges on sponge reefs (Krautter et al., 2001), other megafaunal sponges (Freese et al., 1999) and deep-water corals (Hall-Spencer et al., 2002; Fosså et al., 2002; Reed et al., 2005). Sidescan sonar data from damaged reef complex 3 shows relatively continuous and frequently parallel

tracks or marks on the seabed (Fig. 3), which were likely left by mobile fishing gear, such as heavy net doors on otter trawls. These marks have been described on reef complexes in QCB in areas where the trawl fisheries are or have been active (Conway et al., 2001; Krautter et al., 2001).

The presence of young reef-building sponges on damaged reefs 6 and 13 is evidence that re-colonization can occur. Individual reef-building sponges were often observed growing on bedrock or glacial till substrate adjacent to the damaged reefs (Fig. 4) (Conway et al., 2007), and these off-reef areas could provide a source of larvae for re-colonization. Possible recovery time for a reef complex can only be suggested based on growth rates and size of the reef complexes. The reef-building sponge *Aphrocallistes vastus* has a calculated mean growth rate of 1 cm per year and a maximum rate of 7 cm per year (Krautter et al., 2001, calculated from data in Levings and McDaniel, 1974). The size of the reefs makes it likely that recovery would occur on a time scale of hundreds of years (Conway et al., 2005b). Lyssacine glass sponges, such as *Acanthascus* (*Rhabdocalyptus*) *dawsoni*, and encrusting and erect forms of demosponges, such as *Vulcanella* sp. or *Desmacella* sp., also colonize dead sponge skeleton (Cook, 2005; Lehnert et al., 2005). These taxa were observed on most of the damaged reefs, suggesting that these sites are still capable of sustaining a large suspension feeding community. It appears that lyssacine sponges can be primary colonizers of dead reefs, which is not surprising since *Acanthascus* (*Rhabdocalyptus*) *dawsoni* has twice the mean growth rate of *Aphrocallistes vastus* (Leys and Lauzon, 1998). However, there is

currently no literature available on the progression of colonization on dead sponge fragments.

Reef complex 1 (undamaged) is unique in that it is beneath the buoyant particulate plume of the Fraser River. Although the ridge at reef complex 1 is a remnant glacial feature rising above the sedimented basin, it is in an area with an unusually high sedimentation rate (see Table 1 and Burd et al., this issue). Leys et al. (2004) and Farrow et al. (1983) suggest that high sedimentation rates are associated with lower abundance of glass sponges, since a sediment veneer can negatively affect the ability of glass sponges to become established. In the case of reef complex 1, tidal currents are sufficiently strong to keep sediment in suspension and the ridge surface non-depositional (Conway et al., 2004), allowing glass sponges to colonize the gravel substrate. The reef mounds on the ridge enlarge as growing sponges baffle the tidal currents and trap suspended sediment (Krautter et al., 2006). The reef-building sponges on reef 1 were observed to be more tube-shaped, with narrower oscula compared to the reef complexes in the QCB (Conway et al., 2004) and to the other reefs in the GB. According to evidence from the fossil record, a narrower osculum can compensate for increased sedimentation rates and reduce the amount of sediment trapped in the sponge cavity. This adaptation helps to prevent sediment from overwhelming cleaning mechanisms, which can cause the death of the sponge (Conway et al., 2004). The presence of a healthy sponge reef beneath the Fraser River plume shows that these organisms can adapt to unusual sedimentation conditions, if current regime, seabed sediment transport rates, temperature, and dissolved oxygen and silica levels are suitable (Leys et al., 2004; Whitney et al., 2005).

The most recently discovered reef complex (14 in Howe Sound, see Fig. 1 for location) was identified by Natural Resources Canada personnel (unpublished data, 2008), subsequent to the publication of the discovery of the other sponge reefs by Conway et al. (2007). Reef complex 14 appears to be undamaged; however, ROV survey videos of that reef have not yet been analyzed and further work will be required to assess the status of this reef complex and its associated faunal community.

4.2. Associated fauna

Reef-building sponges appear to be foundation species, as defined by Dayton (1975), since they are organisms that create habitat for other organisms, and thereby exert a disproportionately large influence on community structure. Therefore, fauna associated with the reefs could be affected by changes to the status of the reef. To determine the effect of reef status on the associated community, a comparison was made between reefs 7 (undamaged) and 9 (damaged) in the southern basin, which are located close together (~8 km apart) and were surveyed only days apart. The higher number of taxa and greater abundance of both adult and juvenile rockfish at reef 7 (undamaged) is consistent with published results that link increased habitat complexity, or structural heterogeneity, to increased taxonomic richness and abundance of individuals (Crowder and Cooper, 1982; Diehl, 1992; Garcia-Charton and Perez-Ruzafa, 1998; Wyda et al., 2002; Garcia-Charton et al., 2004). It is therefore likely that undamaged sponge reefs in the GB can provide refugia for adult rockfish and a nursery habitat for juveniles, as found in the QCB (Cook, 2005). However, it should be noted that the other undamaged reef

where fauna were assessed (reef 1), had the lowest number of taxa of all the surveyed reefs. This result seems inconsistent with the supposition that sponge reefs in the GB are refugia supporting enhanced bio-diversity. However, as mentioned in section 4.1, this reef complex is in a unique oceanographic setting, with a high concentration of suspended sediment and a high sedimentation rate, which may be less than ideal for the settlement of other sessile species typically associated with the reefs. Regional variations in physical and biological factors have been shown to affect the distribution and abundance of fish assemblages (Garcia-Charton et al., 2004); the same may be true for invertebrate fauna. A statistically rigorous comparison of reef fauna between damaged and undamaged reefs was not possible using this dataset; however these results provide a preliminary basis for more in-depth assessment of the reefs in the future.

Reef 6 (damaged, possibly recovering) had the highest number of taxa of the northern GB complexes. Unfortunately, there were no undamaged reefs in the northern GB on which the fauna could be assessed for this study, so it cannot be determined whether the taxonomic richness observed on reef 6 was typical of the area. Reef 13 (damaged, possibly recovering), also in the northern GB, had a higher relative abundance of sessile filter feeders than did the other reef complexes. Hydrodynamic conditions or biological factors, such as abundance of suspended food particles, may encourage settlement of these sessile filter feeders at damaged reef sites.

One of the consequences of trawling damage is to decrease habitat complexity (Watling and Norse, 1998; Kaiser et al., 2000). This could be especially detrimental for the juvenile

fish that use these complex structural habitats. For example, it was observed that the shortspine thornyheads (*Sebastolobus alascanus*) on the damaged reefs in the northern GB, which were almost all in the juvenile to intermediate colour phase (Love et al., 2002), were frequently observed within or near the scattered areas of higher relief, such as patches of standing dead sponge. Juvenile rockfish (*Sebastes* spp.) also have an affinity for structurally complex habitats (O'Connell and Carlile, 1994; Cote et al., 2003; Diaz et al., 2003). Rockfish are a dwindling fisheries resource throughout the Pacific Northwest and have been the focus of conservation initiatives in recent years (Ralston, 1998; Musick et al., 2000; Yamanaka, 2000; DFO, 2006). Protection of refugia and nursery habitat, such as sponge reefs, would be consistent with this conservation strategy (Yoklavich, 1997).

5. Conclusions

The sponge reefs in the GB exist in a range of bathymetric settings and oceanographic conditions, and are distributed throughout the GB. Over half of the reefs that have been visually surveyed show significant damage, likely by fishing activities, such as bottom trawling. The damaged reefs appear to be capable of recovery, although the time required for sponge and reef re-growth is unknown. Undamaged reefs appear to have the potential to act as refugia and nursery habitat for commercially valuable fish species. Trawl closures have been implemented as a fisheries management measure at the large sponge reef complexes in the Queen Charlotte Basin in recognition of their fragile nature and importance to fisheries resources; similar protection may be warranted for the sponge reefs in the Strait of Georgia.

308

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Figure Titles

Fig. 1. Location of known glass sponge reef complexes in the Georgia Basin. They are numbered in order of discovery by multibeam swath bathymetry surveys conducted by the Geological Survey of Canada (after Conway *et al.*, 2007). Only six complexes (1,3,6,7,9,13) have been surveyed using visual techniques.

Fig. 2. A) Dense live reef-building sponges (undamaged reef 7), B) Standing dead sponge skeleton (damaged and possibly recovering reef 13). Crimson anemones (*Cribrinopsis fernaldi*), boot sponges (Rosselid sponges) and a small reef building sponge are attached, C) Fragmented dead sponge skeleton spread over the seabed (damaged reef 9), D) Small reef-building sponges attached to fragmented dead sponge skeleton (damaged but possibly recovering reef 6). Several tube-dwelling anemones (*Pachygerianthus fimbriatus*) are also present.

Fig. 3. Sidescan sonar and interpretation from reef complex 3 (McCall Bank) showing parallel lines in the reef surface that are interpreted as the marks left from the heavy doors of bottom trawl gear.

Fig. 4. Reef-building sponges growing on glacial till adjacent to the reef complexes in the McCall Bank area.

Figure1

Figure2a

Figure2b

Figure2c

Figure2d

Figure3

Figure4

Table 1

Current status of the glass sponge reefs in the Georgia Basin. The reef complexes are numbered in order of their discovery, after Conway et al. (2007).

Reef Complex	Geographic Location	Dive Number	Date Sampled (Video)	Status [†]	Depth Range (m)	Duration (min)	Distance (m)	Sedimentation Rate* (g/cm ² /yr)	Organic Flux** (mgC/cm ² /yr)
1	Fraser Ridge	PGC02004, dives 1-4	July 2002	Undamaged	150-190	371	3470	>4	>30
2	McCall Bank	N/A	N/A	Unknown	120-210			<0.75	<15
3	McCall Bank	ROPOS dive 760	October 2003	Damaged	120-210	258	3244	<0.75	<15
4	McCall Bank	ROPOS dive 761	October 2003	Undamaged [‡]	90-210	62	663	<0.75	<15
5	Parksville	N/A	N/A	Unknown	90-110			<0.75	<15
6	Nanaimo	ROPOS dive 873	November 2004	Damaged, possibly recovering	110-150	154	5718	<0.75	<15
7	Active Pass North	ROPOS dive 930	October 2005	Undamaged	95-105	171	1920	>2.5	>25
8	Active Pass South	N/A	N/A	Unknown	90-100			>2.5	>25
9	Active Pass South	ROPOS dive 931	October 2005	Damaged	120-140	154	1770	>2.5	>25
10	Active Pass South	N/A	N/A	Unknown	90-100			>2.5	>25
11	Active Pass South	N/A	N/A	Unknown	100-110			>2.5	>25
12	Active Pass South	N/A	N/A	Unknown	100-130			>2.5	>25
13	"Coulee Bank"	ROPOS dive 1029	November 2006	Damaged, possibly recovering	240-290	211	4780	<0.75	<15
14	Howe Sound	N/A	N/A	Unknown	50-160			<0.75	<10

[†]See section 2.2 for definitions.

[‡]Described as undamaged in Conway et al. (2005a); however the video was corrupted so faunal associations were not assessed.

*Estimated from figures in Burd et al. (this issue) and Hill et al. (this issue).

**Estimated from figure in Burd et al. (this issue).

10

11 Table 2

12 All observed megafaunal fish and invertebrate taxa as identified to the lowest taxonomic level possible, rolled into higher
 13 level taxonomic groups. The reef complexes each taxon was observed on is listed.

Taxonomic Group	Phylum	Class	Taxa	Common Name	Reef Complexes
Anemones	Cnidaria	Anthozoa	<i>Cribrinopsis fernaldi</i>	Crimson Anemone	1,3,7,9,13
			<i>Pachycerianthus fimbriatus</i>	Tube-Dwelling Anemone	1,7,13
Corals	Cnidaria	Anthozoa	Order Gorgonacea	Gorgonian Corals	13
			Poss. <i>Lophelia pertusa</i>		1
				Hydrocorals	7
Hydroids	Cnidaria	Hydrozoa		Hydroids	6,13
Lyssacine Sponges	Porifera	Hexactinellida	Order Lyssacinosida	Boot Sponges	1,3,6,7,13
Demosponges	Porifera	Demospongiae	<i>Iophon</i> (?) sp.	Finger Sponge	3,6,13
			<i>Vulcanella</i> sp.	Plate Sponge	3,6
			<i>Stylissa</i> sp.	Trumpet Sponge	7
Gastropods	Mollusca	Gastropoda	Suborder Doridacea	White Dorid Nudibranch	3
			<i>Fusitriton oregonensis</i>	Oregon Whelk	7
Squat Lobsters	Arthropoda	Malacostraca	<i>Munida quadrispina</i>	Squat Lobster	All
Other Crustaceans	Arthropoda	Malacostraca	<i>Oregonia</i> sp.	Decorator crabs	3,7
			<i>Pandalus platyceros</i>	Spot Prawn	All
			<i>Lopholithodes</i> sp.	Box Crab	6,7
Seastars	Echinodermata	Asteroidea	<i>Ceramaster patagonicus</i>	Cookie Star	3,6,7,13
			Family Goniasteridae		3,6,9,13
			<i>Henricia</i> sp.	Blood Stars	All
			<i>Pteraster tesselatus</i>	Cushion Star	3,6,7,9
Sea Urchins	Echinodermata	Echinoidea	<i>Strongylocentrotus</i> sp.		7,9
Brittle Stars	Echinodermata	Ophiuroidea		Brittle Stars	9
Rockfish	Chordata	Osteichthyes	<i>Sebastes</i> sp.	Rockfish	7,9
			<i>Sebastes elongatus</i>	Greenstriped Rockfish	3,6,7
			<i>Sebastes flavidus</i>	Yellowtail Rockfish	7
			<i>Sebastes maliger</i>	Quillback Rockfish	6,7
			<i>Sebastes miniatus</i>	Vermillion Rockfish	6
			<i>Sebastes proriger</i>	Redstripe Rockfish	7
			<i>Sebastes ruberrimus</i>	Yelloweye Rockfish	3,7,9
Thornyheads	Chordata	Osteichthyes	<i>Sebastolobus alascanus</i>	Shortspine Thornyhead	3,6,13
Other Fish	Chordata	Osteichthyes	Family Agonidae	Poachers	7
			Family Gadidae	Codfish	6,7,13
			Family Pleuronectidae	Flatfish	3,6,7,9
			<i>Ophiodon elongatus</i>	Lingcod	6
Cartilaginous Fish	Chordata	Chondrichthyes	<i>Hydrolagus coliei</i>	Ratfish	All
			<i>Squalus acanthias</i>	Dogfish	3,6,13
			Family Rajidae	Skates	3

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Table 3

Relative abundance of invertebrate groups between surveyed reef complexes (F=Few<S=Some<M=Many). A line indicates none were observed. Measure indicates whether individuals were counted (C) or estimated (E). Criteria for converting estimates and counts into a relative abundance is given below the table.

Reef	Anemones	Corals	Hydroids	Lyssacine Sponges	Demosponges	Gastropods	Squat Lobsters	Other Crustaceans	Sea Stars	Sea Urchins	Brittle Stars	Rockfish	Shortspine Thornyhead	Other Bony Fish	Cartilaginous Fish ¹⁹
1	S	F	—	F	F	—	M	F	F	F	—	F	—	—	M
3	F	—	—	S	S	F	M	F	S	—	—	F	S	F	S
6	—	—	S	S	S	—	S	M	M	—	—	S	S	M	M
7	F	F	—	F	F	F	S	M	F	F	—	M	—	F	S
9	F	—	—	—	F	—	F	S	M	M	M	F	—	F	M
13	M	M	M	M	M	—	M	S	S	—	—	—	M	F	S
Measure	E [†]	C*	E	E	E	C	E	C	C**	C	E	C	C	C	E

[†]For all taxa where total number of individuals was estimated F=<10, S=10-50 and M=>50.

*For taxa where individuals were counted (except Sea Stars) F=<10, S=10-20 and M=>20.

**For Sea Stars F=<15, S=15-50 and M=>50; this criteria is different from the other taxa that were counted due to the higher general abundance of this taxon.