

BC Parks Living Lab for Climate Change and Conservation Final Report (Contract #TP19JHQ008)

Baeria Rocks Ecological Reserve - Subtidal Survey 2018

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8 February 2019

Dive surveys of fish and invertebrates were carried out at Baeria Rocks Ecological Reserve on 7 June 2018, to continue a monitoring effort that began in 2007. Twelve divers (7 students from the Scientific Diving class of the Bamfield Marine Sciences Centre (BMSC), two Sci Diving Instructors, two course teaching assistants, and one additional diver) were present. All divers were well trained in survey techniques and identification. On each dive, one diver was assigned to tending duties, leaving 11 divers in the water. Surveys were conducted between 10.00 and 13.30 by five dive teams. Two teams conducted timed roving surveys and three teams conducted transects. As in previous years, the teams were deployed around the north islets for the first dive, and around the south islet for the second dive, alternating roving and transect teams along the shore (Figure 1).

Roving survey method

Each roving team carried out a 40-50 min roving survey, from a maximum depth of 50 ft (14.5 m) depth (where possible), to the top of the reef, swimming in a semi-systematic zigzag pattern from deep to shallow water. Both divers counted every individual observed of each species listed on an underwater roving survey sheet. When a species was very abundant (i.e. more than ~100 individuals), surveyors recorded numbers as 'lots'. Divers noted the duration of each roving survey, as well as the depth range surveyed.

The maximum number of each species recorded between the two divers in each buddy pair was retained, and maximum numbers were averaged across roving teams for each islet. This method generates an index of abundance for each species expressed in number of individuals per 30 min.

The roving survey datasheet used in 2018 is attached.

Transect survey method

The transect method used in 2018 is identical to that used since 2009. Each transect team ran three transects, one at each of three depths (10 ft, 25 ft and 40 ft; 3 m, 8 m, 13 m). Each transect was 20 m long and 4 m wide when the visibility allowed it (2 m when visibility was poor). Once a team had laid a transect line, the divers waited for three

minutes away from the line to allow fish to re-enter the transect area. The divers then swam slowly along either side of the transect in one direction, recording the number of individuals of all fish species listed on a printed transect survey sheet. In the return direction, they recorded all individuals of all invertebrates species on the survey sheet. Each member of a buddy pair surveyed one side of the transect.

For each species, the numbers were summed within a buddy pair for each transect, and then averaged across teams for each depth at each site. This method generates estimates of absolute density.

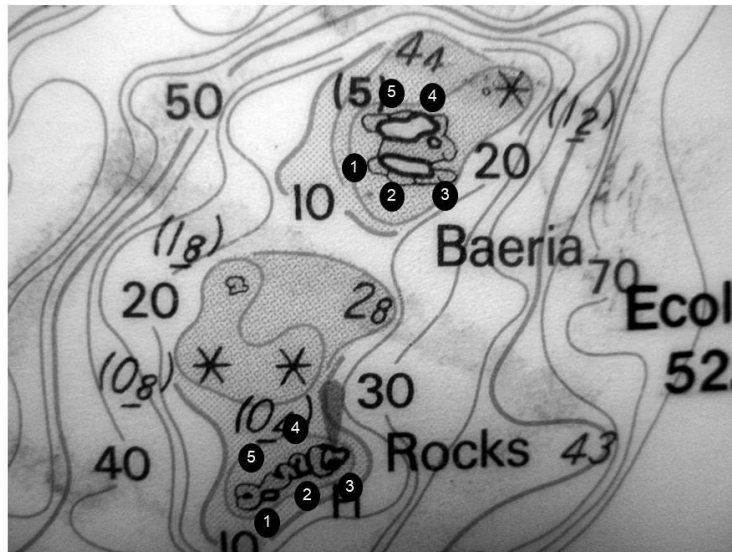


Figure 1. Location of subtidal survey teams around the north and south islets of Baeria Rocks. Teams 2 and 4 carried out roving surveys, and teams 1, 3 and 5 carried out transect surveys.

Results and Discussion

Descriptive summary

Two roving surveys (total time: 97 min) were carried out around the North islets, and two surveys around the South islets (total time: 100 min), at depths ranging from 50 ft (14.5 m) to 10 ft (3.6 m).

A total of seven transects (total area: 400 m²) were surveyed around the North islets.

Nine transects (total area: 560 m²) were surveyed around the South islets. Two transects at 10 ft (3 m) could not be done because of air limitation.

Visibility, at about 1 m, was poorer than in previous years.

Comparisons with previous years

Sixteen species of fish (of 34 listed on the spreadsheet) and 30 species of invertebrates (of 85 listed) were recorded during roving surveys, which is similar to previous years (2016: 17 fish and 29 invertebrates; 2014: 19 fish and 31 invertebrates). Five species of invertebrates (of 9 listed) and seven species of fish (of 33 listed) were recorded on the linear transects. Spreadsheets of raw and summary data can be found in the Excel file 'Baeria Survey 2018'.

Invertebrates

In both Howe Sound (Schultz et al. 2016) and at Baeria Rocks, we documented a large increase in abundance of green urchins in 2015/2016 following the heavy mortality of sunflower stars in 2013/2014. The 2018 survey of Baeria allows us, for the first time, to follow the dynamics of these populations beyond the immediate aftermath of the mass mortality. We discover that green urchins declined by 95% between 2016 and 2018, returning to densities similar to those observed prior to the seastar mortality (Fig. 2).

The 2018 survey also reveals a similar pattern for purple urchins (Fig. 2), bat stars (Fig. 3) and ochre stars (Fig. 3). The latter appear to have been unaffected by the seastar wasting disease, unlike intertidal populations along most of the Pacific coast of the US and Canada (Schiebelhut et al. 2018). Another notable trend is the seven-fold increase in the abundance of abalone since 2007, which is found in the roving data (Fig. 2). However, the transect data suggests a continued decline of abalone density, which roughly halved between 2014 and 2016, and declined by a further 25% between 2014 and 2016.

There is no evidence that the seastars most affected by the seastar mass mortality of 2014, i.e. the sunflower star *Pycnopodia helianthoides* (Fig. 2), have begun to recover. Divers found only one small sunflower star (6-7 cm diameter) across all transect and roving surveys.

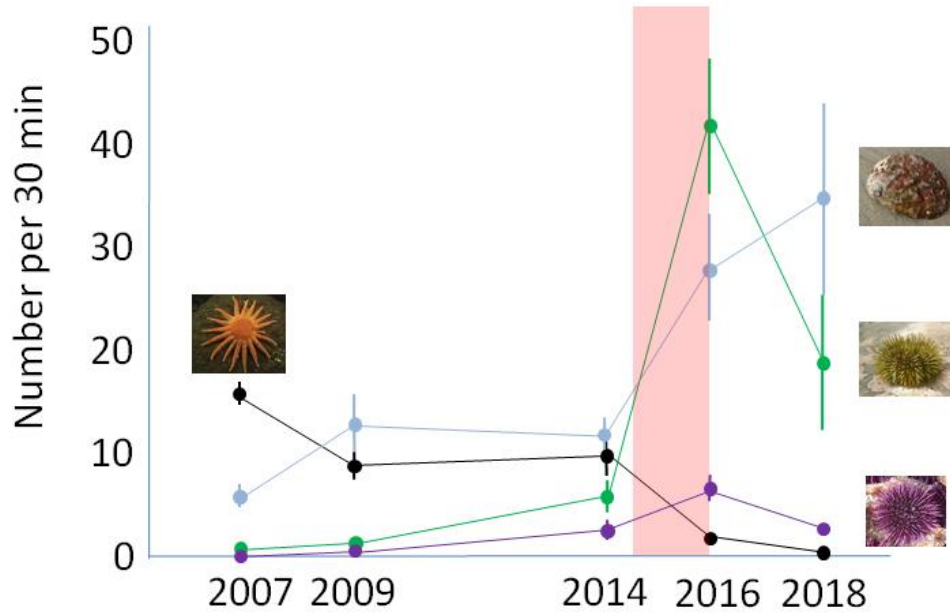


Figure 2. Abundance of invertebrate species from 2007 to 2018, derived from roving surveys, at Baeria Rocks Ecological Reserve. The invertebrates are: sunflower star (black line; effect of year in General Additive Model, $F = 3.86$, $P = 0.012$), purple urchin (purple line; $F = 6.17$, $P = 0.02$); green urchin (green line; $F = 8.17$, $P = 0.008$); northern abalone (blue line; $F = 5.31$, $P = 0.03$). Means are shown with standard errors. The pink area denotes the time window during which seastar mortality and marked sea warming occurred.

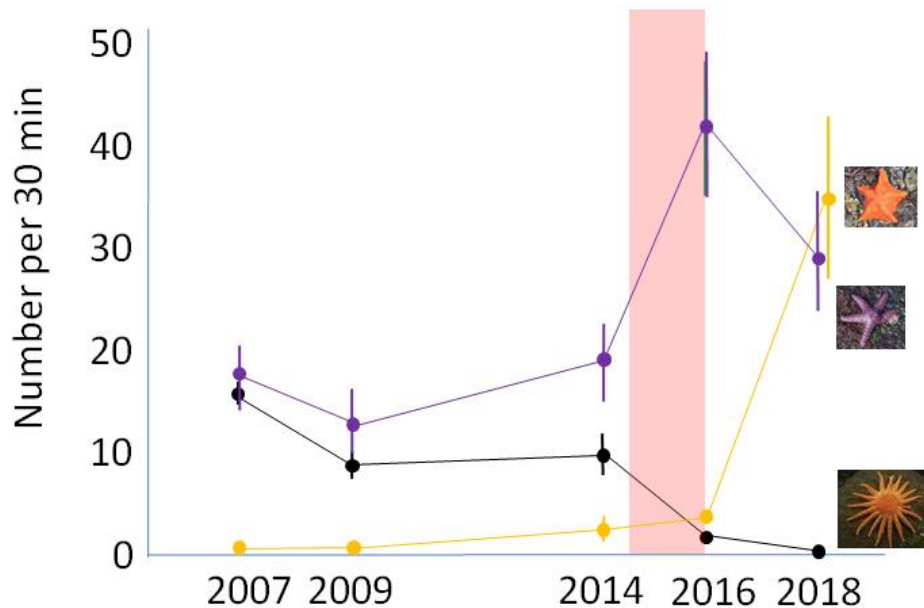


Figure 3. Abundance of invertebrate species from 2007 to 2018, derived from roving surveys, at Baeria Rocks Ecological Reserve. The invertebrates are: sunflower star (black line; repeated from Fig. 2 for reference), ochre star (yellow line; effect of year in General Additive Model, $F = 3.83$, $P = 0.06$); bat star (purple line; $F = 7.88$, $P = 0.0004$). Means are shown with standard errors. The pink area denotes the time window during which seastar mortality and marked sea warming occurred.

Two invasive species – European green crab and gold star tunicate – are still absent from Baeria Rocks. We will keep monitoring these species, although it seems unlikely that they will become established at Baeria because of its isolation and lack of suitable habitat.

Fishes

Seven species of rockfish were recorded across transects and roving surveys, which is the largest number since the start of monitoring. Two new rockfish species were recorded: Puget Sound rockfish and tiger rockfish (the latter including two very gravid individuals; Fig. 4). However, overall rockfish density of rockfish was low on transects, standing at only 6% of the maximum density observed (in 2011). The densities of kelp greenling and lingcod show significant or near-significant, gradual declines since 2009 – in both roving surveys (Fig. 5) and in transect surveys. These patterns of decline clearly predate the period of anomalously warm seawater. Divers reported no evidence of lost or derelict fishing gear on the bottom, but divers did see the remains of a fish carcass on the bottom.



Figure 4. Apparently gravid tiger rockfish, observed on 7 June 2018 at the Baeria Ecological Reserve. Photo credit: Rachel Munger

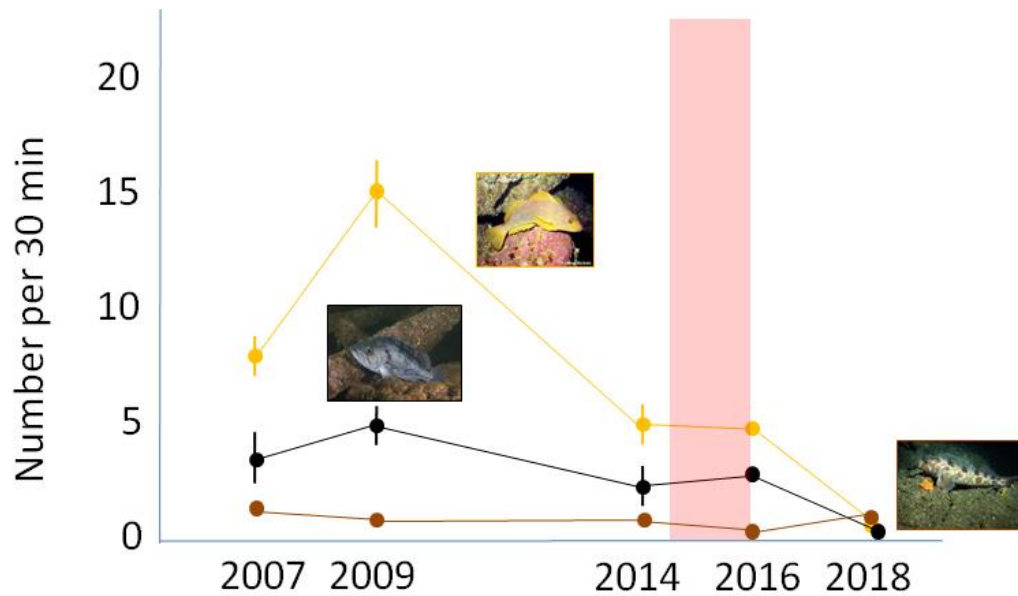


Figure 5. Abundance of select fish species from 2007 to 2018, derived from roving surveys, at Baeria Rocks Ecological Reserve. The fish species are: kelp greenling (yellow line; effect of year in General Additive Model, $F = 10.04$, $P = 0.004$), black rockfish (black line; $F = 1.68$, $P = 0.21$); lingcod (brown line; $F = 3.49$, $P = 0.07$). Means are shown with standard errors. The pink area denotes the time window during which seastar mortality and marked sea warming occurred.

Bird and mammal surveys

For the first time, the monitoring team included an experienced bird surveyor, Dr John Reynolds (SFU). A total of 14 species of birds (Table 1) and one mammal species (harbor seal, $N = 7$ individuals) was recorded. No one went ashore.

The bird sightings were uploaded onto the citizen science site e-bird, and can be found at: <https://ebird.org/hotspot/L4882533>

Table 1. Birds present on and around Baeria Rocks Ecological Reserve on 7 June 2018

| Species | Common name | Number |
|-------------------------------------|----------------------|--------|
| <i>Haliaeetus leucocephalus</i> | Bald eagle | 1 |
| <i>Larus glaucescens</i> | Glaucous-winged gull | 220 |
| <i>Larus californicus</i> | California gull | 20 |
| <i>Chroicocephalus philadelphia</i> | Bonaparte's gull | 3 |
| <i>Haematopus bachmani</i> | Black oystercatcher | 13 |
| <i>Phalacrocorax penicillatus</i> | Brandt's cormorant | 22 |
| <i>Phalacrocorax pelagicus</i> | Pelagic cormorant | 3 |
| <i>Histrionicus histrionicus</i> | Harlequin duck | 2 |
| <i>Brachyramphus marmoratus</i> | Marbled murrelet | 2 |
| <i>Cephus columba</i> | Pigeon guillemot | 1 |
| <i>Ptychoramphus aleuticus</i> | Cassin's auklet | 1 |
| <i>Aechmophorus occidentalis</i> | Western grebe | 2 |
| <i>Tringa incana</i> | Wandering tattler | 1 |
| <i>Corvus caurinus</i> | Northwestern crow | 12 |

Baeria species list

The ongoing compilation of the Baeria Rocks subtidal species is attached. The list currently stands at 122 species, 49 of which were added in 2018.

One notable species observed in 2018 by diver Rachel Munger is shown on Fig. 6. According to Dr Leslie Harris, manager of the polychaete collection at the LA County Museum of Natural History, this might be an undescribed species in the genus *Bispira*, temporarily named *Bispira* sp. 8.



Figure 6. *Bispira* sp. 8 – possibly a new species of tube-dwelling polychaete observed at Baeria Rocks Ecological Reserve. Photo credit: Rachel Munger.

A Baeria Rocks Ecological Reserves project was initiated on **iNaturalist** to provide a pictorial record of species found in the reserve. There are currently 71 species recorded, and this number is sure to grow with every monitoring survey.

The Baeria project can be accessed at: <https://www.inaturalist.org/projects/baeria-rocks-ecological-reserve>

Recommendations for future years

The Baeria Rocks surveys now span the years 2007 to 2018, and represent a valuable time-series of information on an area that experiences relatively limited human impact. Surveying the sites every other year, coinciding with the offering of Scientific Diving at BMSC, is a convenient way to continue high-quality surveys with a team of well-trained divers.

We did not provide survey datasheets with a fixed list of species to a few of the most experienced roving divers. Instead, these divers listed all species that they could positively identify, along with estimated numbers seen. We will continue to do this in the future so that we can develop a more exhaustive list of marine species present at Baeria Rocks.

One possible addition for the future could be to take photographs of the bottom to

generate a permanent record of the substrate composition. The decline in herbivorous urchins detected at Baeria over the past 2 years might be linked to food limitation, but we cannot definitely ascribe cause to effect without baseline information about benthic community composition.

We should like to invite one or more seaweed experts on future monitoring expedition because this is a species-rich taxon that BMSC divers are not well trained at identifying. Finally, we will seek permission to sample a few individuals of *Bispira* sp. 8, to aid in its identification (and possibly naming).

Acknowledgements

Thank you to BMSC for providing the staff and logistical support, and to the BC Parks Living Lab for Climate Change & Conservation Program for funding, which made the 2018 Baeria Rocks survey possible.

References

- Schiebelhut, L.M., Puritz, J.B., and Dawson, M.N. 2018. Decimation by sea star wasting disease and rapid genetic change in a keystone species, *Pisaster ochraceus*. Proceedings of the National Academy of Sciences of the USA 115, 7069-7074.
- Schultz, J.A., Cloutier, R.N., and Côté, I.M. 2016. Evidence for a trophic cascade on rocky reefs following sea star mass mortality in British Columbia. PeerJ 4:e1980.

Total list of birds of Baeria Rocks Ecological Reserve (to June 2018)

| | |
|-------------------------------------|--------------------------|
| <i>Corvus caurinus</i> | Northwestern crow |
| <i>Uria aalge</i> | Common murre |
| <i>Haliaeetus leucocephalus</i> | Bald eagle |
| <i>Larus glaucescens</i> | Glaucous-winged gull |
| <i>Larus californicus</i> | California gull |
| <i>Chroicocephalus philadelphia</i> | Bonaparte's gull |
| <i>Haematopus bachmani</i> | Black oystercatcher |
| <i>Phalacrocorax auritus</i> | Double-crested cormorant |
| <i>Phalacrocorax penicillatus</i> | Brandt's cormorant |
| <i>Phalacrocorax pelagicus</i> | Pelagic cormorant |
| <i>Histrionicus histrionicus</i> | Harlequin duck |
| <i>Brachyramphus marmoratus</i> | Marbled murrelet |
| <i>Cephus columba</i> | Pigeon guillemot |
| <i>Ptychoramphus aleuticus</i> | Cassin's auklet |
| <i>Aechmophorus occidentalis</i> | Western grebe |
| <i>Tringa incana</i> | Wandering tattler |

List of marine species from Baeria Rocks Ecological Reserve (updated 2018)

(species in bold were added in 2018; rough guide to abundance score: Abundant = > 100 per dive; Common = 10 – 100 per dive; Occasional = 5-10 per dive; Uncommon = 2-5 per dive; Rare = 0-1 per dive)

Sponges

| | | |
|----------------------------|--------------------------|----------|
| <i>Cliona californiana</i> | Yellow boring sponge | Common |
| <i>Tethya californiana</i> | Orange rough ball sponge | Uncommon |

Cnidarians

Anemones

| | | |
|-----------------------------------|-----------------------|----------|
| <i>Anthopleura artemisia</i> | Burrowing anemone | Abundant |
| <i>Anthopleura elegantissima</i> | Aggregating anemone | Abundant |
| <i>Anthopleura xanthogrammica</i> | Giant green anemone | Abundant |
| <i>Epiactis prolifera</i> | Brooding anemone | Uncommon |
| <i>Metridium farcimen</i> | Giant plumose anemone | Common |
| <i>Metridium senile</i> | Short plumose anemone | Common |
| <i>Pachycerianthus fimbriatus</i> | Tube-dwelling anemone | Common |
| <i>Urticina coriacea</i> | Stubby rose anemone | Abundant |
| <i>Urticina lofotensis</i> | White-spotted anemone | Common |
| <i>Urticina piscivora</i> | Fish-eating anemone | Abundant |

Zoanthids

| | | |
|-----------------------------|-----------------|--------|
| <i>Epizoanthus scotinus</i> | Orange zoanthid | Common |
|-----------------------------|-----------------|--------|

Corals

| | | |
|------------------------------|------------------|----------|
| <i>Balanophyllia elegans</i> | Orange cup coral | Abundant |
| <i>Ptilosarcus gurneyi</i> | Orange sea pen | Uncommon |

Hydrocorals

| | | |
|----------------------|-----------------|--------|
| <i>Stylaster</i> sp. | Pink hydrocoral | Common |
|----------------------|-----------------|--------|

Hydroids

| | | |
|--------------------------------|----------------------------|----------|
| <i>Clava</i> sp. | White hydroid | Common |
| <i>Plumularia setacea</i> | Glassy plume hydroid | Abundant |
| <i>Schizoporella unicornis</i> | Orange encrusting bryozoan | Abundant |
| <i>Selaginopsis</i> sp. | Fish-bone hydroid | Abundant |
| <i>Sertularella</i> sp. | Garland hydroid | Abundant |

Stalked jellies

| | | |
|--------------------------|-------------------|----------|
| <i>Manania gwilliami</i> | Red stalked jelly | Uncommon |
|--------------------------|-------------------|----------|

Ectoprocts (bryozoans)

Crisia sp.
Heteropora pacifica
Phidolopora pacifica

White tuft bryozoan
Northern staghorn bryozoan
Lattice-work bryozoan

Abundant
Abundant
Uncommon

Molluscs

Bivalves

Crassadoma gigantea
Mytilus californianus

Giant rock scallop
California mussel

Abundant
Common

Limpets

Acmaea mitra
Diodora aspera

Whitecap limpet
Rough keyhole limpet

Abundant
Common

Chitons

Placiphorella velata
Tonicella insignis

Veiled-chiton
White-lined chiton

Rare
Occasional

Gastropods

Amphissa columbiana
Astraea gibberosa
Calliostoma annulatum
Calliostoma ligatum
Cerastoma foliatum
Fusitriton oregonensis
Haliotis kamtschatkana
Tegula pulligo

Wrinkled amphissa
Red turban
Purple-ring topsnail
Blue topsnail
Leafy hornmouth
Oregon triton
Northern abalone
Dusky turban

Abundant
Abundant
Uncommon
Abundant
Abundant
Uncommon
Common
Abundant

Nudibranchs

Acanthodoris lutea
Cadlina luteomarginata
Ceratosoma amoenum
Diaulula sandiegensis
Dendronotus iris
Dirona albolineata
Doris montereyensis
Flabellina triophina
Hermisenda crassicornis
Tritonia festiva

Orange-peel nudibranch
Yellow-margin nudibranch
Clown nudibranch
Leopard dorid
Giant nudibranch
Frosted nudibranch
Monterey sea lemon
Red flabellina
Opalescent nudibranch
Diamond-back nudibranch

Uncommon
Common
Uncommon
Uncommon
Uncommon
Occasional
Uncommon
Occasional
Common
Rare

Annelids

Polychaetes

Bispira sp. 8
Demonax medius
Dodecaceria concharum
Dodecaceria fewkesi

Unnamed
Parasol feather-duster
Coralline-encased filament-worm
Fringed filament-worm

Uncommon
Abundant
Abundant

Myxicola infundibulum
Serpula columbiana

Slime-tube feather-duster
Red-trumpet calcareous tubeworm

Abundant
Common

Arthropods

Shrimp

Pandalus danae

Coonstripe shrimp

Occasional

Crabs

Cancer antennarius
Cancer oregonensis
Cancer productus
Cryptolithodes sitchensi
Lopholithodes mandtii
Loxorhynchus crispatus
Mimulus foliatus
Oregonia gracilis
***Petrolisthes* sp**
Pugettia productus
Scyra acutifrons

Spot-bellied rock crab
Pygmy rock crab
Red rock crab
Umbrella crab
Puget Sound king crab
Moss crab
Foliate kelp crab
Graceful decorator crab
Porcelain crab
Northern kelp crab
Sharpnose crab

Uncommon
Occasional
Occasional
Rare
Rare
Occasional
Occasional
Occasional
Occasional
Occasional
Common

Hermit crabs

Pagurus armatus
Pagurus hemphilli

Black-eyed hermit crab
Maroon hermit crab

Common
Common

Barnacles

Balanus nubilus

Giant barnacle

Common

Echinoderms

Sea stars

Asterina miniata
Crossaster papposus
Dermasterias imbricata
Evasterias troschelii
Henricia leviuscula
Hippasteria spinosa
Mediaster aequalis
Orthasterias koehleri
Pisaster brevispinus
Pisaster ochraceus
Pycnopodia helianthoides
Pteraster tessellatus
Solaster dawsoni
Solaster endeca
Solaster stimpsoni
Stylasterias forreri

Bat star
Rose star
Leather star
Mottled star
Blood star
Spiny red star
Vermillion star
Painted star
Spiny pink star
Ochre star
Sunflower star
Cushion star
Morning sun star
Northern sunstar
Striped sun star
Velcro star

Abundant
Rare
Abundant
Uncommon
Common
Rare
Uncommon
Abundant
Rare
Abundant
Rare
Rare
Uncommon
Rare
Uncommon
Common

Urchins

| | | |
|--|---------------|------------|
| <i>Mesocentrotus franciscanus</i> | Red urchin | Abundant |
| <i>Strongylocentrotus droebachiensis</i> | Green urchin | Common |
| <i>Strongylocentrotus purpuratus</i> | Purple urchin | Occasional |

Sea cucumbers

| | | |
|-----------------------------------|------------------------------------|-------------------|
| <i>Cucumaria miniata</i> | Orange cucumber | Abundant |
| <i>Cucumaria pallida</i> | Pale sea cucumber | Occasional |
| <i>Parastichopus californicus</i> | California sea cucumber | Abundant |
| <i>Psolus chitonoides</i> | Creeping pedal sea cucumber | Abundant |

Chordates

Ascidians

| | | |
|--|--------------------------------------|-----------------|
| <i>Boltenia villosa</i> | Hairy tunicate | Uncommon |
| <i>Cnemidocarpa finmarkiensis</i> | Broadbase tunicate | Common |
| <i>Eudistoma purpuropunctatum</i> | Mauve loved compound tunicate | Uncommon |
| <i>Halocynthia aurantium</i> | Sea peach | Uncommon |
| <i>Halocynthia igaboja</i> | Bristly tunicate | Uncommon |
| <i>Metandrocarpa taylori</i> | Orange social tunicate | Abundant |
| <i>Trididemnum alexi</i> | Speckled compound tunicate | Uncommon |

Fish

| | | |
|-------------------------------------|--------------------------------|-------------------|
| <i>Embiotoca lateralis</i> | Striped seaperch | Occasional |
| <i>Artemis harringtoni</i> | Scalyhead sculpin | Common |
| <i>Enophrys bison</i> | Buffalo sculpin | Uncommon |
| <i>Hemilepidotus hemilepidotus</i> | Red Irish lord | Occasional |
| <i>Jordania zonope</i> | Longfin sculpin | Common |
| <i>Nautichthys oculofasciatus</i> | Sailfin sculpin | Rare |
| <i>Scorpaenichthys marmoratus</i> | Cabezon | Uncommon |
| <i>Hexagrammos decagrammus</i> | Kelp greenling | Occasional |
| <i>Hexagrammos stelleri</i> | White-spotted greenling | Uncommon |
| <i>Ophiodon elongates</i> | Lingcod | Occasional |
| <i>Oxylebius pictus</i> | Painted greenling | Occasional |
| <i>Sebastes caurinus</i> | Copper rockfish | Occasional |
| <i>Sebastes emphaeus</i> | Puget Sound rockfish | Uncommon |
| <i>Sebastes flavidus</i> | Yellowtail rockfish | Occasional |
| <i>Sebastes maliger</i> | Quillback rockfish | Occasional |
| <i>Sebastes melanops</i> | Black rockfish | Common |
| <i>Sebastes nebulosus</i> | China rockfish | Occasional |
| <i>Sebastes nigrocinctus</i> | Tiger rockfish | Uncommon |
| <i>Rhinogobiops nicholsii</i> | Blackeye goby | Common |
| <i>Aulorhynchus flavidus</i> | Tubesnout | Occasional |
| <i>Anarrhichthys ocellatus</i> | Wolf eel | Rare |

Mammals

Phoca vitulina

Harbour seal

Common