

Rare and Endangered Marine Invertebrates in British Columbia

William C. Austin

Marine Ecology Station and Khoyatan Marine Laboratory
R.R.1, Cowichan Bay, BC, VOR 1N0, Canada
baustin@island.net

ABSTRACT

Most of our knowledge and focus on rare and endangered species in British Columbia is on the large, furry or feathery animals and on leafy plants. We are just beginning to recognize that some local marine invertebrates and seaweeds may be at risk. Approximately 50 species of rarely seen invertebrates were identified for the British Columbia Conservation Data Centre (CDC). Some of these are at the edge of their range or in special habitats in British Columbia, and are common elsewhere. Others are known from only 1 or 2 sites in the province, and are rare or apparently absent in other parts of the world's seas. They occur in a variety of habitats ranging from intertidal lagoons to the depths of fjords, to offshore hydrothermal vents. Amateur naturalists and divers, as well as specialists, have played a role in identifying habitats where some of these animals occur.

Key words: disjunct populations, marine invertebrates, peripheral populations.

Assessments of rare and endangered species in British Columbia have emphasized terrestrial vertebrates and plants (e.g., Stace-Smith et al. 1980, Munro 1993, Harding and McCullum 1994). Scudder (1996) compiled and annotated a list of rare and endangered terrestrial and freshwater invertebrates in British Columbia. However, little has been published on rare and endangered marine species in the province (e.g., Farr and Bunnell 1980, Hawkes 1994, Nagorsen 1994, Peden 1994).

In 1996 and 1997 I collaborated with 6 specialists (M. Hawkes, seaweeds; A. Peden, fish; J. Watson, mammals; A. Burger, birds; N. McDaniel, underwater habitats; and J. Harper, marine geomorphology) in compiling a list of marine inventory requirements in British Columbia for the British Columbia Conservation Data Centre (CDC; Austin et al. 1997). This inventory includes lists of about 50 potentially rare and endangered species in each of 3 major categories (invertebrates, vertebrates, and seaweeds). The inventory also includes a list of 59 collections with major holdings of British Columbia coastal marine biota, and a list of 180 experts on the systematics of British Columbia marine animals and plants. In 1997-98 I worked with J. Booth and Associates under contract with the CDC to convert the list of invertebrate records into a database (Austin and Booth 1998). In the present paper I summarize the data from the invertebrate records.

METHODS

Species were intentionally selected from a broad range of invertebrate higher taxa. However, I only included readily visible and identifiable species, thus excluding groups such as nematodes and gastrotrichs. The selection drew on records from a species list (Austin 1985), communications with a range of specialists on marine groups (see acknowledgements), and a survey of collection records at the Royal British Columbia Museum. Species selected have been recorded at 5 or fewer sites in British Columbia.

RESULTS

The selected species are listed together with occurrence records in Table 1. The information sources for these records are given in Table 2. The details of these records may be found in the database created by Austin and Booth (1998) and housed at the CDC. I have clustered the species according to known occurrences in both protected and unprotected habitat (Table 3).

DISCUSSION

RANKING OF SPECIES

Of the 52 species listed, all but 1 or 2 might fit the S1 category of the CDC. This category is defined as including species that are critically imperilled in the province because of extreme rarity (5 or fewer extant occurrences or very few

Text continued on p. 63.

Table 1. Distribution of rare and endangered marine invertebrates.

Scientific name	Common name	BC sites ^a	Other sites ^a	Comments
Phylum PORIFERA	SPONGES			
Class CALCAREA	calcareous sponges			
<i>Grantia</i> sp. aff. <i>compressa</i>	flattened sac sponge	1	?	littoral cave, endangered
Class HEXACTINELLIDA	six rayed glass sponges	many ^b	0	uniquely shallow
<i>Rhabdocalyptus dæwsoni</i>	boot sponge			+ unique bioherms
<i>Aphrocallistes vastus</i>	cloud sponge			
Class DEMOSPONGIAE	other sponges			
<i>Halichondria</i> sp. aff. <i>fibrosa</i>	thick white felt sponge	1	0	1 specimen, 70 m
<i>Hymen amphistra cyanocrypta</i>	blue encrusting sponge	2	CA, OR	edge of range?
<i>Plocamilla igzo</i>	red crust sponge	2	CA	10 m, QCI, disjunct?
<i>Chelonaplysilla polyraphis</i>	purple slippery sponge	4	CPAC	littoral caves
<i>Psammopemma</i> new sp.	sand sponge	1	0	littoral cave, threatened
Phylum CNIDARIA	STINGING THREAD ANIMALS			
Class HYDROZOA	hydroids			
<i>Corymorpha</i> sp.	raspberry hydroid	3	0	1 local region, 10–30 m
<i>Stylaster</i> ? sp.	white stubby hydrocoral	1	0?	18 m, Biosphere Reserve
Class ANTHOZOA	sea anemones, corals			
<i>Isadella</i> sp.	bamboo coral	2	?	238+ m, fjord, seamount
<i>Synhalcurias</i> sp.	tall, deep sea anemone	1	0	80 m, unique habitat?
Phylum PLATYHELMINTHES	FLATWORMS			
Class TURBELLARIA	free living flatworms			
<i>Hoploplana californica</i>	knobby flatworm	1	CA	1 specimen, cryptic
Phylum ECHINODERMATA	SPINY SKINNED ANIMALS			
Class CRINOIDEA	sea feather stars			
<i>Antedon</i> sp. aff. <i>petasus</i>	brooding feather star	2	?	2 specimens, N. fjords
Class HOLOTHUROIDEA	sea cucumbers			
<i>Pentamera trachyplaca</i>	fat Pentamera	5	CA	uncommon over range
<i>Ekmania diomedea</i>	a white sea cucumber	0	AK	just N of B.C. border
<i>Thyonidium kurilensis</i>	purple tentacled sea cucumber	4	AK, WA	uncommon over range?
Class ECHINOIDEA	sea urchins & allies			
<i>Echinarachnius parma</i>	regular sand dollar	1?	AK, NF	extirpated or ID error?
Class ASTEROIDEA	sea stars			
<i>Ceramaster arcticus</i>	Arctic cookie star	5	AK	cold water, peripheral
<i>Pisaster giganteus</i>	giant spined sea star	1?	CA	extirpated or ID error?
Class OPHIUROIDEA	brittle stars			
<i>Ophiopteris papillosa</i>	brown spiny brittle star	2	CA	peripheral or disjunct
<i>Ophioplocus esmarki</i>	husky tan serpent star	1	CA	disjunct, live bearer
Phylum HEMICHORDATA	ACORN WORMS & ALLIES			
Class ENTEROPNEUSTA	acorn worms			
<i>Saccoglossus</i> sp.	orange acorn worm	5	?	lagoons, threatened
Phylum CHORDATA	VERTEBRATES & ALLIES			
Class ASCIDIACEA	sea squirts			
<i>Eudistomia purpuropunctatum</i>	purple lobular sea squirt	3	WA	1 local area: Clayoquot
<i>Ritterella aequalisiphonis</i>	sandy lobed sea squirt	2	WA/CA	insufficient sampling
<i>Megalodicopia hians</i>	megabyte sea squirt	2	DEEP	1 fjord in B.C.
<i>Pyura</i> sp. cf. <i>tesselata</i>	brown spot plated sea squirt	1	?	unique habitat, 30 m

Table 1. Continued.

Scientific name	Common name	BC sites ^a	Other sites ^a	Comments
Phylum BRACHIOPODA	LAMP SHELLS			
Class INARTICULATA	unhinged lamp shells			
<i>Discinisca lamellosa</i>	smooth tiny lamp shell	2	SEPAC	80+ m, small, cryptic
Class ARTICULATA	hinged lamp shells			
<i>Platidia horni</i>	tiny shouldered lamp shell	4	CA	30+ m, small, cryptic
Phylum MOLLUSCA	SOFT BODIED ANIMALS			
Class POLYPLACOPHORA	sea cradles			
<i>Hanleyella oldroydi</i>	tiny black spotted sea cradle	5	AK, CA	40+ m, small, cryptic
Class GASTROPODA	snails, sea slugs, limpets			
<i>Lepetodrilus corrugatus</i>	corrugated limpet	1	0	2,400 m, vent species
<i>Calliostoma bernardi</i>	beaded white top shell	1	1 - CA	130 m, 2 specimens, disjunct?
<i>Arctomelon stearnsi</i>	Alaskan volute	1	AK	210 m, peripheral
<i>Fucaria striata</i>	vent snail	1	0	2,400 m, vent species
<i>Anidolyta spongotheres</i>	limpet like yellow sea slug	2	0	100+ m, rare, 2 specimens
<i>Okenia vancouverensis</i>	Vancouver's okenia sea slug	2	0	20 m, cryptic
<i>Flabellina iodinea</i>	Spanish shawl sea slug	1	CA	conspicuous, peripheral
<i>Flabellina</i> sp.	snowy flabellina sea slug	2	?	harbours, introduced?
<i>Cuthona punicea</i>	pomegranate aeolid sea slug	1	0	on red <i>Corymorpha</i>
<i>Cumanotus fernaldi</i>	Fernald's sea slug	2	CA	harbours, introduced?
Class BIVALVIA	clams, mussels, scallops, etc.			
<i>Rhamphidonta retifera</i>	walking clam	2	CA	few sites over range
Phylum POGONOPHORA	BEARD WORMS			
<i>Lamellibrachia barhami</i>	seep tube worm	1	CA	restricted to seeps, vents
Phylum ANNELIDA	SEGMENTED WORMS			
Class POLYCHAETA	paddle footed worms			
<i>Spinther ?alaskensis</i>	grub-like sponge worm	1	AK?	2 specimens, rare
<i>Hediste limnicola?</i>	colourful red nereid	2	CA	introduction?, disjunct?
<i>Lindaspio southwardorum</i>	vent spionid	1	?	restricted to vents
Phylum ARTHROPODA	JOINT LEGGED ANIMALS			
Subphylum UNIRAMIA	INSECTS & ALLIES			
Class CHILOPODA	centipedes			
? <i>Lionyx hedgpethi</i>	intertidal centipede	1	CA	disjunct, rare?
Subphylum PYCNOGONIDA	SEA SPIDERS			
<i>Sericosura venticola</i>	vent sea spider	2	CPAC	restricted to vents
Subphylum CRUSTACEA	HARD SHELLED ANIMALS			
Class CIRRIPEDIA	barnacles			
<i>Pollicipes polymerus</i>	goose barnacle	2	0	subtidal pops., unique
Class MALACOSTRACA	crabs, shrimp and allies			
<i>Mursia gaudichaudi</i>	laterally spined crab	1	CA	accidental, 1 specimen
<i>Hapalogaster grebnitzkii</i>	fuzzy lithode crab	1	AK	peripheral
<i>Lebbeus polaris</i>	polar lebbeid shrimp	1	AK	peripheral
<i>Emerita analoga</i>	sand or mole crab	2+	CA, AK	non-breeding El Nino

^a AK = Alaska; BC = British Columbia; CA = California; CPAC = central Pacific; DEEP = >200 m; NF = Newfoundland; OR = Oregon; SEPAC = southeast Pacific; WA = Washington.

^b These species occur in many shallow sites in B.C. but in other jurisdictions they are known only from deeper water.

Table 2. Sources of information on species distribution, including published sources and unpublished personal communications and observations.

Scientific name	Information source(s) ^a
Phylum PORIFERA	
Class CALCAREA	
<i>Grantia</i> sp. <i>aff.</i> <i>compressa</i>	Austin (1985)
Class HEXACTINELLIDA	
<i>Rhabdocalypus dawsoni</i>	Conway et al. (1991)
<i>Aphrocallistes vastus</i>	Austin et al. (1985)
Class DEMOSPONGIAE	
<i>Halichondria</i> sp. <i>aff.</i> <i>fibrosa</i>	Austin (1985)
<i>Hymenamphiastra cyanocrypta</i>	Austin (1985), N. McDaniel (pers. comm.)
<i>Plocamilla igso</i>	Austin (1985)
<i>Chelonaplysilla polyraphis</i>	Austin (1985), N. McDaniel (pers. comm.)
<i>Psammopemma</i> new sp.	Austin (unpubl. data)
Phylum CNIDARIA	
Class HYDROZOA	
<i>Corymorpha</i> sp.	Millen (pers. comm.), N. McDaniel (pers. comm.)
<i>Stylaster?</i> sp.	Radcliffe et al. 1991, N. McDaniel (pers. comm.)
Class ANTHOZOA	
<i>Isadella</i> sp.	Austin (1985)
<i>Synhalcurias</i> sp.	Tunnicliffe (1985), D. Dunn (pers. comm.)
Phylum PLATYHELMINTHES	
Class TURBELLARIA	
<i>Hoploplana californica</i>	Austin (1985), S. Millen (pers. comm.)
Phylum ECHINODERMATA	
Class CRINOIDEA	
<i>Antedon</i> sp. <i>aff.</i> <i>petasus</i>	Austin (1985)
Class HOLOTHUROIDEA	
<i>Pentamera trachyplaca</i>	Lambert (1984, 1997), RBCM
<i>Ekmania diomedae</i>	Lambert (1997)
<i>Thyonidium kurilensis</i>	Lambert (1997), A. Lambe (pers. comm.)
Class ECHINOIDEA	
<i>Echinarachnius parma</i>	Bush (1918), Clark (1925), Mortensen (1928)
Class ASTEROIDEA	
<i>Ceramaster arcticus</i>	Lambert (1981), N. McDaniel (pers. comm.), Austin (unpubl. data)
<i>Pisaster giganteus</i>	Austin (1985), Feder (1980), Fisher (1930), Can. Geol. Survey (?)
Class OPHIUROIDEA	
<i>Ophiopteris papillosa</i>	Austin (1970, 1985), N. McDaniel (pers. comm.)
<i>Ophioplocus esmarki</i>	Austin (1985), RBCM
Phylum HEMICHORDATA	
Class ENTEROPNEUSTA	
<i>Saccoglossus</i> sp.	Austin (1985), D. Quayle (pers. comm.), C. Cameron (pers. comm.)
Phylum CHORDATA	
Class ASCIDIACEA	
<i>Eudistomia purpuro-punctatum</i>	Lambert (1989), Radcliffe et al. (1991), R. Harbo (pers. comm.)
<i>Megalodicopia hians</i>	Austin (1985), C. Monniot (pers. comm.)
<i>Pyura</i> sp. <i>cf.</i> <i>tesselata</i>	Austin (1985), Austin (1975)
<i>Ritterella aequalisiphonis</i>	Austin (1985)

Table 2. Continued.

Scientific name	Information source(s) ^a
Phylum BRACHIOPODA	
Class INARTICULATA	
<i>Discinisca lamellosa</i>	Bernard (1971, 1972)
Class ARTICULATA	
<i>Platidia horni</i>	Bernard (1971, 1972), Austin (unpubl. data)
Phylum MOLLUSCA	
Class POLYPLACOPHORA	
<i>Hanleyella oldroydi</i>	Ferreira (1979), RBCM
Class GASTROPODA	
<i>Lepetodrilus corrugatus</i>	McLean (1993)
<i>Calliostoma bernardi</i>	McLean (1994)
<i>Arctomelon stearnsi</i>	Rice (1973), RBCM
<i>Fucaria striata</i>	Waren and Bouchet (1989)
<i>Anidolyta spongotheres</i>	Bertsch (1980), Behrens (1991)
<i>Okenia vanancouverensis</i>	Behrens (1991), S. Millen (pers. comm.), O'Donoghue (1921)
<i>Flabellina iodinea</i>	Behrens (1991), S. Millen (pers. comm.)
<i>Flabellina</i> sp.	Behrens (1991), S. Millen (pers. comm.), N. McDaniel (pers. comm.)
<i>Cumanotus fernaldi</i>	Behrens (1991), S. Millen (1983), N. McDaniel (pers. comm.)
<i>Cuthona punicea</i>	Behrens (1991), S. Millen (1985 and pers. comm.)
Class BIVALVIA	
<i>Rhamphidonta retifera</i>	Cowan (1964), Bernard (1975), R. Forsyth (pers. comm.)
Phylum POGONOPHORA	
<i>Lamellibrachia barhami</i>	Juniper et al. (1992), Tunnicliffe (pers. comm.)
Phylum ANNELIDA	
Class POLYCHAETA	
<i>Spinther ?alaskensis</i>	Austin (1985)
<i>Hediste limnicola?</i>	Carl (1937), V. MacDonald (pers. comm.), Austin (unpubl. data)
<i>Lindaspio southwardorum</i>	Blake and Maciolek (1992)
Phylum ARTHROPODA	
Subphylum UNIRAMIA	
Class CHILOPODA	
? <i>Lionyx hedgpethi</i>	Austin (1985)
Subphylum PYCNOGONIDA	
<i>Sericosura venticola</i>	Child (1987), Child and Segonzac (1996)
Subphylum CRUSTACEA	
Class CIRRIPEdia	
<i>Pollicipes polymerus</i>	N. McDaniel (pers. comm.)
Class MALACOSTRACA	
<i>Mursia gaudichaudi</i>	Hart (1982), RBCM
<i>Hapalogaster grebnitzkii</i>	Hart (1980, 1982)
<i>Lebbeus polaris</i>	Green and Butler (1988), Jensen (1995)
<i>Emerita analoga</i>	Efford (1969), Hart (1982)

^a RBCM = Royal British Columbia Museum collection records

Table 3. Clustering of species by habitat.

Habitat	Species
PROTECTED HABITATS	
Gwaii Haanas	<i>Plocamilla igzo</i> , <i>Pentamera trachyplaca</i>
Stubbs Island	<i>Corymorpha</i> sp., <i>Cuthona punicea</i>
Clayoquot Sound	<i>Stylaster</i> sp., <i>Eudistomia purpuropunctatum</i>
Broken Group	<i>Pyura</i> cf. <i>tesselata</i> , <i>Saccoglossus</i> sp., <i>Pentamera trachyplaca</i>
Race Rocks	<i>Ceramaster arcticus</i>
Juan de Fuca Ridge	<i>Lepetodrilus corrugatus</i> , <i>Fucaria striata</i> , <i>Lamellibrachia barhami</i> , <i>Lindaspio southwardorum</i> , <i>Sericosura venticola</i> ,
UNPROTECTED HABITATS	
Portland Canal	<i>Megalodicopia hians</i> , <i>Isadella</i> sp., <i>Ceramaster arcticus</i> , <i>Antedon</i> aff. <i>petasus</i> , <i>Hapalogaster grebnitzkii</i> , <i>Lebbeus polaris</i>
Dixon Entrance	<i>Arctomelon stearnsi</i>
Hecate Strait	hexactinellid bioherms
Queen Charlotte Sound	hexactinellid bioherms
Dean Channel	<i>Antedon</i> aff. <i>petasus</i>
Slingsby Channel/Nakwakto Rapids	<i>Pollicipes polymerus</i> deep, <i>Ceramaster arcticus</i>
Nahwitti Bar	<i>Discinisca lamellosa</i>
Harvey Cove	<i>Ophioplocus esmarki</i>
Double Island, Esperanza	<i>Flabellina iodina</i>
Louie Creek	<i>Saccoglossus</i> sp., <i>Rhamphidonta retifera</i>
Slope off Clayoquot	<i>Spinther</i> ?alaskensis
Jervis Inlet	<i>Anidolyta spongotheres</i>
Diana Island	? <i>Lionyx hedgpethi</i>
Execution Rock	<i>Grantia</i> sp., <i>Chelonaplysilla polyraphis</i> , <i>Psammopemma</i> sp., <i>Hymenamphiastra cyanocrypta</i> , <i>Ritterella equalisiphonis</i>
Dixon Island	<i>Ophiopteris papillosa</i> , <i>Hoploplana californica</i>
Halibut Bank	hexactinellid bed, <i>Calliostoma bernardi</i>
Saanich Inlet	<i>Halichondria</i> aff. <i>fibrosa</i> , <i>Synhalcurias</i> sp., <i>Platidia horni</i> , <i>Hediste limnicola</i>
Selkirk Waterway	<i>Okenia vancouverensis</i> , <i>Cumanotus fernaldi</i> , <i>Flabellina</i> sp.
Cobb Seamount	<i>Isadella</i> sp.
Spieden Island	<i>Thyonidium kurilensis</i>

remaining individuals) or because of factor(s) that make them especially vulnerable to extirpation or extinction (Harcombe et al. 1994). However, to varying degrees, the few records for marine invertebrate populations may reflect limited observations rather than limited occurrences. Among the species considered here, the distribution of the mole crab (*Emerita analoga*) is the best documented (e.g., Efford 1969, Hart 1982). This species has stable populations along the outer sand beaches of California and southern Oregon, but populations occur only intermittently in Washington and British Columbia. These occurrences are correlated with El Niño events and a well-developed countercurrent running north along the coast. *E. analoga* larvae are in the plankton for more than 4 months. This is an unusually long period for marine invertebrate larvae and would be an adaptive advantage for long-distance larval transport by ocean currents (Thorson 1961, Efford 1969). I would classify *E. analoga* populations as SA in the CDC ranking system. This is defined as an element that is considered accidental or casual in the province: a species that does not appear on an annual basis (Harcombe et al. 1994).

POTENTIALLY DISJUNCT POPULATIONS

Ten species in Table 1 have apparently disjunct distributions. They are recorded from British Columbia and California, but there are no published records from Oregon or Washington. For example, a small population of brittle stars (*Ophioplocus esmarki*) was found at 1 location at the entrance to Quatsino Sound, but the species is otherwise known only from central California and further south. *O. esmarki* is a live bearer, thus precluding planktonic larval transport as in *E. analoga*. However, this brittle star often inhabits the interstices of kelp holdfasts and would be a candidate for rafting on dislodged kelp holdfasts.

The Californian giant kelp (*Macrocystis pyrifera*) has been reported in Alaska, but not in British Columbia to date (Scagel et al. 1989, O'Clair et al. 1996). The holdfast of this kelp does get dislodged and individuals can subsequently float along the course of the prevailing currents. It has a holdfast of up to 1 m in height. The pneumatocysts, which provide flotation, reportedly lose their buoyancy after about a week at sea (O'Clair et al. 1996). However, kelp wrapped around floating logs provides another vehicle for rafting. Anthropogenic introductions, such as from ballast water and fouled boat hulls, might be suggested for a few disjunct populations associated with commercial harbours (e.g., *Hediste limnicola*, *Cuthona fernaldi*). Some deep-water species found in British Columbia fjords, such as the bamboo coral (*Isadella* sp.) and the "megabyte" sea squirt (*Megalodicopia hians*), might be isolated from deep-sea populations as a result of isostatic rebound of portions of the coastline.

Could some of these disjunct populations represent separate incipient or cryptic species? There is no compelling

evidence for intertidal or shallow subtidal marine refugia over the last period of glaciation, and re-population of ice-free coastal areas would not have occurred more than 10,000–15,000 years ago (e.g., Hebda and Frederick 1990). This is a short period of time for speciation among the macro-invertebrates considered here.

PERIPHERAL POPULATIONS

Species with populations primarily in the arctic and subarctic, but with isolated occurrences in British Columbia, are typically found in cold-water fjords such as Portland Canal at the northern end of coastal British Columbia (e.g., *Hapalogaster grebnitzkii*) or in the open waters at Dixon Entrance (e.g., *Artomelon stearnsi*). However, others also occur farther south in particularly cold waters such as at Race Rocks (e.g., *Ceramaster arcticus*). The apparently disjunct occurrences of the typically southern forms noted above would be better classified as peripheral populations if intervening records are found from Oregon and Washington.

SPECIES APPARENTLY LIMITED TO BRITISH COLUMBIA

Some species are known only from within British Columbia. These include *Okenia vancouverensis*, *Stylaster* sp., *Anidolyta spongothoras*, *Corymorpha* sp., *Cuthona punicea*, *Pyura* cf. *tesselata*, and *Psammopemma* sp. In addition, others are limited to what are perceived as unusual or isolated habitats such as a periodically anoxic fjord (*Halichondria* aff. *fibrosa*, *Synhalcurius* sp.), or restricted to a single hydrothermal vent field (*Lepetodrilus corrugatus*, *Fucaria striata*). It is perhaps premature to characterize these as endemic to British Columbia, given our limited field surveys. However, based on our present knowledge, their rare occurrence within the province coupled with the absence of records from outside the province is cause for concern.

COMMON SPECIES IN UNUSUAL HABITATS

The goose barnacle (*Pollicipes polymerus*) is a common intertidal species on wave-exposed coasts in the northeast Pacific. The subtidal occurrence of a population at Nakwakto Narrows, where tidal currents reach 16 knots, is apparently unique for this species. Similarly, the very shallow water (5 m) occurrence of hexactinellid sponges in British Columbia is apparently unique in the world, as is their occurrence in bioherms (biological reef mounds) up to 10 m in height.

ARE THERE ANY EXTIRPATED MARINE INVERTEBRATE SPECIES IN THE PROVINCE?

Many invertebrate species could have disappeared from the province unnoticed, but I could find only 2 documented assessments. The sand dollar (*Echinarachnius parma*), primarily an arctic species, is recorded by Mortensen (1928) as occurring on this coast from Alaska to Vancouver Island and Puget Sound. Clark (1925) identified a specimen in the

British Museum that was labeled from Puget Sound. I can find no subsequent records from British Columbia or Puget Sound. The sea star (*Pisaster giganteus*) was reported from Saanich Inlet by de Loriol (1897) and from Vancouver Island by Verrill (1909). Fisher (1930) suggests that the figure by de Loriol appears to be *P. ochraceus*, a common species in British Columbia. Although the distribution of *P. giganteus* is often cited as extending into British Columbia (e.g., Feder 1980), I can find no collecting records since those noted above. All of these authors are experts on echinoderms, and the characters distinguishing *E. parma* and *P. giganteus* from other locally occurring species are readily observable.

CONCLUSIONS

1. Most of the listed invertebrate species are known from 5 or fewer provincial records and would be considered extremely vulnerable based on the criteria set by the CDC. However, we cannot exclude the possibility that their apparent rarity is, in part, a reflection of limited field surveys.
2. The species listed are not necessarily the most rare or endangered in British Columbia. Many additional marine invertebrate species in the province are known from 5 or fewer records.
3. Based on limited field data, some species are at the periphery of their range in the province; others have populations in British Columbia, but are otherwise known only from central California south; still others are recorded only within the province.
4. Two species found early in this century in British Columbia have not been recorded since then in the province, although they are common elsewhere within their range. However, extirpation and extinction of marine invertebrates are difficult to substantiate (e.g., Carlton et al. 1991, Glynn and De Weerd 1991, Glynn and Feingold 1992).
5. Approximately 30% of the listed species are found in regions that are designated or officially proposed as protected habitats. In most cases it is not clear what this protection entails, other than discouraging physical removal of benthic species.
6. While it may be argued that, on a global scale, marine extinction rates are lower than those on land, there is clearly a need to address the relatively neglected issue of local extirpation in the marine environment (e.g., Norse 1993, McKenney 1998).

RECOMMENDATIONS

1. Confirm the status of the listed species in the province based on additional existing information by: assessing additional museum material in private hands and outside the province; questioning amateur naturalists and divers; and soliciting reviews by systematic specialists.

2. Visit known species population sites to assess: population sizes; reproductive status; other appropriate aspects of biology; and proximal and more general potential anthropogenic impacts.
3. Increase public awareness of populations at risk through presentations, publications, and Web site displays.
4. Implement appropriate protection for populations at risk.
5. Monitor populations and their habitats.

ACKNOWLEDGEMENTS

I thank the many people who suggested either candidates for status as rare and endangered species or habitats containing these species. These people include: M. Arai, C. Cameron, R. Forsyth, G. Green, G. Jenson, A. Lambe, P. Lambert, N. McDaniel, J. McLean, S. Millen, V. Tunnicliffe, S. Cannings, J. Harper, K. Simmington, and M. Zacharias. J. Booth was instrumental in developing the database and entering some of the data. K. Sendall helped in searching for museum material, and A. Harcombe and L. Ramsay provided guidelines and suggestions on assessment of rare and endangered species status.

The following institutions provided facilities for study of material in museums or in the field: Bamfield Marine Station; Royal British Columbia Museum; Institute of Ocean Sciences; Pacific Biological Station; and University of Victoria. The study was supported by the CDC, and the Corporate Resource Inventory Initiative. Thanks, too, to the CDC for supporting the publication of this paper.

LITERATURE CITED

- Austin, W. C. 1970. A preliminary list of marine invertebrates of the Barkley Sound region. Bamfield Survey, Part V. Bamfield Mar. Stn., Bamfield, BC. Rep. 3. 123pp.
- _____. 1975. Barkley Sound subtidal survey, 14–18 April 1975. Khoyatan Mar. Lab., Cowichan Bay, BC and Bamfield Mar. Stn., Bamfield, BC. Unpubl. rep.
- _____. 1985. An annotated checklist of marine invertebrates in the cold temperate northeast Pacific. Khoyatan Mar. Lab., Cowichan Bay, BC. Unpubl. rep.
- _____, and J. Booth. 1998. Conversion of marine invertebrates inventory priority list. B.C. Conserv. Data Cent., B.C. Minist. Environ., Lands and Parks, Victoria, BC. Unpubl. rep.
- _____, M. Hawkes, A. Peden, J. C. Watson, A. Burger, N. McDaniel, and J. Harper. 1997. Marine inventory requirements in British Columbia. B.C. Conserv. Data Cent., B.C. Minist. Environ., Lands and Parks., Victoria, BC. Unpubl. rep.
- _____, B. Ott, and N. McDaniel. 1985. Distribution of sponges in British Columbia fjords. Third international conference on the biology of sponges. Woods Hole, 17–23 November

1985. Unpubl. rep.
- Behrens, D. W. 1991. Pacific coast nudibranchs: a guide to the opisthobranchs from Alaska to Baja California. Sea Challengers, Monterey, CA.
- Bernard, F. R. 1971. British Columbia marine faunistic survey report on the Brachiopoda. Fish. Res. Board of Can., Tech. Rep. 268.
- _____. 1972. The living Brachiopoda of British Columbia. *Syesis* 5:73–82.
- _____. 1975. *Rhamphidonta* gen. n. from the northeastern Pacific (Bivalvia, Leptonacea). *J. Conchylologie* 112(3-4):105–115.
- Bertsch, H. 1980. A new species of Tylodinidae (Mollusca: Opisthobranchia) from the northeastern Pacific. *Sarsia* 65: 233–237.
- Blake, J. A., and N. J. Maciolek. 1992. Polychaeta from deep-sea hydrothermal vents in the eastern Pacific: III. A new genus and two new species of Spionidae from the Guaymas Basin and Jan de Fuca Ridge. *Proc. Biol. Soc. Washington*, 105:723–732.
- Bush, M. 1918. Key to the echinoderms of Friday Harbor, Washington. *Publ. Puget Sound Biol. Stat.* 2(33).
- Carl, G. C. 1937. Flora and fauna of brackish water. *Ecology* 18(3):446–453.
- Carlton, J. T., G. J. Vermeij, D. R. Lindberg, D. A. Carlton, and E. C. Dudley. 1991. The first historical extinction of a marine invertebrate in an ocean basin: the demise of the eelgrass limpet *Lottia alveus*. *Biol. Bull.* 180:72–80.
- Child, C. A. 1987. *Ammothea verenae* and *Sericosura venticola*, two new hydrothermal vent-associated pycnogonids from the northeast Pacific. *Proc. Biol. Soc. Washington* 100: 892–901.
- _____, and M. Segonzac. 1996. *Sericosura heterosclela* and *S. cyrtoma*, new species, and other Pycnogonida from Atlantic and Pacific hydrothermal vents, with notes on habitat and environment. *Proc. Biol. Soc. Washington* 109(4):664–676.
- Clark, H. L. 1925. A catalog of the recent sea-urchins (Echinoidea) in the collection of the British Museum (Natural History). British Mus., Oxford Univ. Press, Oxford, U.K.
- Conway, K. W., J. V. Barrie, W. C. Austin, and J. L. Luternauer. 1991. Holocene sponge bioherms on the western Canadian continental shelf. *Coastal Shelf Research* 11:771–790.
- de Loriol, P. 1897. Notes pour servir a l'étude des Échinoderms, no. 5. *Mém. soc. phys. et hist. nat. Genève.* 32. 26pp.
- Efford, I. E. 1969. Recruitment to sedentary marine populations as exemplified by the sand crab, *Emerita analoga* (Decapoda, Hippidae). *Crustaceana* 18.
- Feder, H. M. 1980. Asteroidea: The sea stars. Pp. 117–135 in R. H. Morris, D. P. Abbott, and E. C. Haderlie, eds. *Intertidal invertebrates of California*. Stanford Univ. Press, Stanford, CA.
- Ferreira, A. J. 1979. The family Lepidopleuridae (Mollusca: Polyplacophora) in the Eastern Pacific. *Veliger* 22(2):145–165.
- Fisher, W. K. 1930. Asteroidea of the North Pacific and adjacent waters. Part 3: Forcipulata (concluded). *Smithsonian Inst. U.S. Nat. Mus. Bull.* 76.
- Glynn, P. W., and W. H. de Weerd. 1991. Elimination of two reef-building hydrocorals following the 1982–83 El Niño warming event. *Science* 253:69–71.
- Glynn, P. W., and J. S. Feingold. 1992. Hydrocoral species not extinct. *Science* 257:1845
- Green, G., and T. H. Butler. 1988. Range extensions of three Caridean shrimps to British Columbia waters. *Contr. Nat. Sci. (Roy. British Columbia Mus.)* 8:1–7.
- Harcombe, A., B. Harper, S. Cannings, D. Fraser, and W. T. Munro. 1994. Terms of endangerment. Pp. 11–28 in L. E. Harding, and E. McCullum, eds. *Biodiversity in British Columbia: our changing environment*. Can. Wildl. Serv., Pacific and Yukon Reg.
- Harding, L. E., and E. McCullum, eds. *Biodiversity in British Columbia: our changing environment*. Can. Wildl. Serv., Pacific and Yukon Reg.
- Hart, J. F. 1980. New records and extension of range of important decapod Crustacea from the northeastern Pacific Ocean. *Can. J. Zool.* 58:757–769.
- _____. 1982. Crabs and their relatives of British Columbia. B. C. Prov. Mus., Victoria, BC.
- Hawkes, M. W. 1994. Benthic marine algal flora (seaweeds) of British Columbia: diversity and conservation status. Pp. 113–117 in L. E. Harding, and E. McCullum, eds. *Biodiversity in British Columbia: our changing environment*. Canadian Wildlife Service, Pacific and Yukon Reg.
- Hebda, R., and S. G. Frederick. 1990. History of marine resources of the northeast Pacific since the last glaciation. *Trans. Roy. Soc. Can.* 1(1):319–341.
- Jensen, G. C. 1995. Pacific coast crabs and shrimps. Sea Challengers, Monterey, CA.
- Juniper, S. K., V. Tunnicliffe, and E. C. Southward. 1992. Hydrothermal vents in turbidite sediments on a northeast Pacific spreading centre: organisms and substratum at an ocean drilling site. *Can. J. Zool.* 70:1792–1809.
- Lambert, G. 1989. A new species of the compound ascidian *Eudistoma* (Ascidiacea, Polycitoridae) from the northeastern Pacific. *Can. J. Zool.* 67: 2700–2703.
- Lambert, P. 1981. The seastars of British Columbia. B.C. Prov. Mus. Handb. 39.
- _____. 1984. British Columbia marine faunistic survey report: holothurians from the northeast Pac. *Can. Tech. Rep. Fish. Aq. Sci. No.* 1234.
- _____. 1997. Sea cucumbers of British Columbia, southeast Alaska and Puget Sound. *Roy. B.C. Mus. Handb. Univ.*

- British Columbia Press, Vancouver, BC. 166pp.
- McKenney, M. L. 1999. Is marine biodiversity at less risk?: Evidence and implications. *Diversity and Distributions* 4:3–8.
- McLean, J. H. 1984. New species of northeast Pacific archeogastropods. *Veliger* 26(3):233–239.
- _____. 1993. New species and records of *Lepetodrilus* (Vetigastropoda: Lepetodrilidae) in the hydrothermal-vent habitat. *Veliger* 36:27–35.
- McTaggart-Cowan, I. 1964. New information on the distribution of marine Mollusca on the coast of British Columbia. *Veliger* 7(2):110–113.
- Millen, S. 1983. Range extensions of opishtobranchs in the northeastern Pacific. *Veliger* 25:383–386.
- _____. 1985. Northern, primitive tergipedid nudibranchs, with a description of a new species from the Canadian Pacific. *Can. J. Zool.* 64:1356–1362.
- Mortensen, T. 1928. A monograph of the Echinoidea. I. Cidaroidae. C.A. Reitzel, Copenhagen.
- Munro, W. T. 1993. Designation of endangered species, subspecies and populations by COSEWIC. Pp. 213–227 in M. A. Fenger, E. H. Miller, J. A. Johnson, and E. J. Williams, eds. *Our living legacy: proceedings of a symposium on biological diversity*. Roy. B.C. Mus., Victoria, BC.
- Nagorsen, D. 1994. Endangered mammals in British Columbia. Pp. 143–151 in L. E. Harding, and E. McCullum, eds. *Biodiversity in British Columbia: our changing environment*. Can. Wildl. Serv., Pacific and Yukon Reg.
- Norse, E., ed. 1993. *Global marine biological diversity*. Island Press, Washington, DC.
- O'Clair, R. M., S. C. Lindstrom, I. R. Brodo. 1996. *Southeast Alaska's rocky shores*. Plant Press, Auke Bay, AK.
- O'Donoghue, C. H. 1921. Nudibranchiate Mollusca from the Vancouver Island region. *Trans. Can. Inst.* 13:149–209.
- Peden, A. 1994. Threats to fish diversity in the fresh waters of British Columbia. Pp. 133–142 in L. E. Harding, and E. McCullum, eds. *Biodiversity in British Columbia: our changing environment*. Can. Wildl. Serv., Pacific and Yukon Reg.
- Radeliffe, G., B. Austin, J. Hillaby, R. Laird, G. Porter, and H. Quesnel. 1991. *Clayoquot Sound: life support services and natural diversity*. Strategy for Sustainable Development for Clayoquot Sound. Unpubl. rep. (prep. by Madrone Consultants Ltd., Duncan, BC). 165pp.
- Rice, T. 1973. *Marine shells of the Pacific coast*. ERCO, Tacoma, WA.
- Seigel, R. F., P. W. Gabrielson, D. J. Garbary, L. Golden, M. W. Hawkes, S. C. Lindstrom, J. Oliveira, and T. B. Widdowson. 1989. A synopsis of the benthic marine algae of British Columbia, southeast Alaska, Washington and Oregon. *Phycol. Contrib.* 3. Univ. British Columbia, Vancouver, BC.
- Stace-Smith, R., L. Johns, and P. Joslin, eds. 1980. *Proc. Threatened and endangered species and habitats in British Columbia and the Yukon*. Richmond, BC, 8–9 March 1980. B.C. Minist. Environ., Fish and Wildl. Branch, Victoria, BC.
- Thorson, G. 1961. Length of pelagic larval life in marine bottom invertebrates as related to larval transport by ocean currents. Pp. 455–474 in M. Sears, ed. *Oceanography*. Publ. Amer. Assoc. Advanc. Sci. 67.
- Tunncliffe, V. 1981. High species diversity and abundance of the epibenthic community in an oxygen-deficient basin. *Nature* 294:354–356.
- _____. 1991. The biology of hydrothermal vents: ecology and evolution. *Oceanography and Mar. Biol. Annu. Rev.* 29:319–407.
- Verrill, A. E. 1909. Descriptions of new genera and species of starfishes from the north Pacific coast of America. *Amer. J. Sci.* 28:59–70.
- Waren, A., and P. Bouchet. 1989. New gastropods from East Pacific hydrothermal vents. *Zool. Scripta*, 18:67–102.