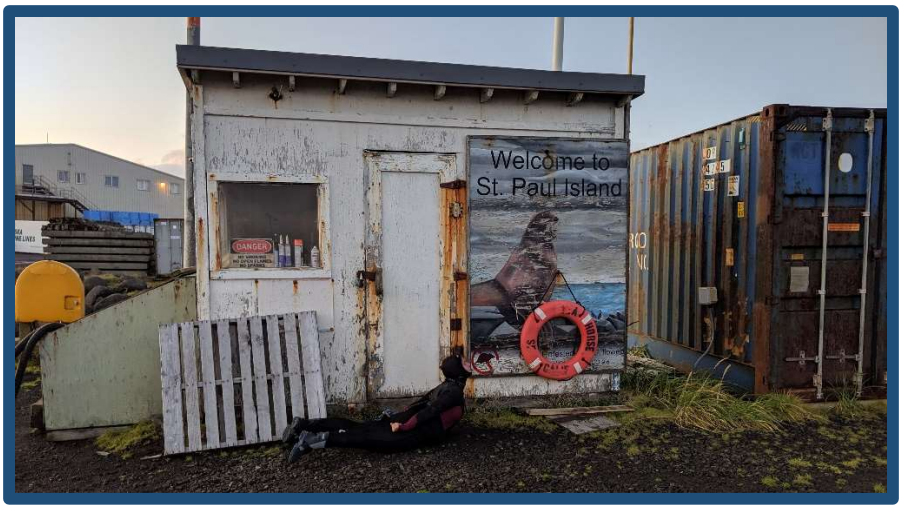
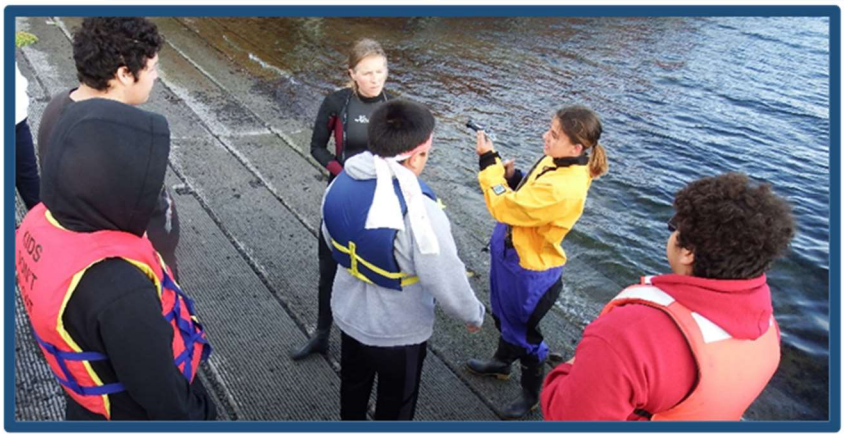


Bering Sea Days



Smithsonian
Environmental Research Center

Bering Sea Days

Job # 1125V.20

NOAA Award No. NA18NMF4370235

Final Report

Prepared for the
Pacific States Marine Fisheries Commission

By

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Smithsonian
Environmental Research Center

NOAA FISHERIES

Summary

St. Paul in the Pribilof Islands, Alaska is a unique and isolated community in the Bering Sea that depends on fisheries and fur seal harvests for income and subsistence needs. Expanded fishing and shipping activity combined with climate change threaten biodiversity there through the potential to spread invasive species. To recognize and understand ecosystem change in response to these forces, it is critical to establish measures of coastal ecosystem health that can be easily quantified and repeated. Educating the local student population and involving the community in taking these measures strengthens local marine knowledge and ownership, and builds long-term monitoring capacity.

Working with the local community in St Paul, our objectives were to:

- Create and deliver educational outreach activities during the annual Bering Sea Days.
- Engage the local community through schools and citizen science outreach, to raise awareness and ownership of monitoring, best management practices and control of marine invasive species.
- Assess the baseline marine invertebrate biodiversity within St. Paul harbor.
- Document marine invertebrate communities of St Paul, including banking of genetic material in a national repository.

These objectives were achieved through a combination of educational outreach activities and a baseline biodiversity assessment, bringing enhanced learning to support ongoing monitoring for invasive species to this strategically located Arctic Gateway community. The project contributed to Bering Sea Days multimedia curriculum classroom lessons for invertebrate and invasive species biology that included student investigation, laboratory hands on learning, and field surveying. St. Paul artificial structures, near shore waters and intertidal areas were also surveyed for marine invertebrate specimens to contribute to baseline knowledge and detect any non-native species. Surveys included specimen collection, preservation, and transport for genetics banking, analyses and reporting.

During the surveys more than 245 specimens were collected for morphological and genetic analyses. 83 taxa from seven phyla were identified. In addition, water samples collected for eDNA analysis have been sent to the Smithsonian National Museum of Natural History for analysis. To date, no species was recognized as non-native to the area.

In reference to online open-access databases, none of the 54 species identified in the present study were already recorded from the area. Only thirteen of the fifty-two genera sampled were previously recorded from the area. This uptick reflects both the paucity of studies from the area in general, and the different survey approach used here compared to previous studies.

Continued monitoring and outreach efforts will be important to the future protection of this unique community in the Bering Sea.

Background

St. Paul is a unique and isolated island community in the Bering Sea. The population of about 400 is heavily dependent on the sea for income (halibut and king crab fisheries) and subsistence (fur seal harvest). The Pribilof Canyon area on the continental shelf off the islands is a hot spot for deep sea coral and sponge diversity, habitat that may help sustain the productive fisheries there. Offshore surveys for the area have focused on spatial attributes of target fisheries species, fur seals and the prey communities for both (e.g. Schwartzman et al. 2002; Pinchuk et al. 2008; Hollowed et al. 2012). Survey records of coastal areas in the Pribilofs are rare, and largely limited to unpublished studies by researchers from the University of Alaska, Fairbanks (e.g. Weems et al. 2016, 2017).

Expanded fishing activity and shipping traffic through the Arctic are increasing the threat of introduced species to Alaska (Ruiz and Hewitt, 2009; Ware et al. 2014; Miller and Ruiz 2014). Non-native species to Alaska may cause economic or environmental harm, threaten native species, and impact human health (Millennium Ecosystem Assessment 2005). In order to detect novel introductions, baseline data need to be established ahead of the uptick. The local community is ideally situated to implement continued monitoring. In addition, citizen science initiatives have been demonstrated to support conservation both directly by having citizens on the ground responsible for site and species management, as well as indirectly through research, education and policy impacts (Ballard et al. 2017). Local community involvement was a key aim of the current project.

Expert knowledge is also necessary to design and provision suitable programs, and ensure collected data meets the standards of global biogeographic and genetic databases for comparison.

To highlight the connection between man and the sea and educate the island's young people, the Ecosystems Conservation Office in St Paul hosts Bering Sea Days. The event brings in teachers and scientists from a broad range of disciplines to spend a week educating students pre-k to high school age about the science and issues facing the Bering Sea. The event is an ideal venue to raise awareness of non-native species through lesson plans at all levels.

Associated events involving the whole community offer the opportunity to enhance local knowledge not only of the marine environment, but of the ways in which invasive species may arrive to the Pribilofs, the risks that they pose to the Bering Sea, and encourage them to take an active interest in the issues that impact the sea around them.

The current project used a combination of educational outreach activities during Bering Sea Days and a baseline biodiversity assessment to bring enhanced learning to support ongoing monitoring for invasive species to this strategically located Arctic Gateway community. In addition to new surveys, we reviewed previously species records from the Pribilof Islands and Bering Sea. Such a dataset allows assessment of research gaps for the area, identification of potential non-native species that have already been introduced (including those that may not yet be recognized as such) and facilitates detection and identification of marine non-native species in the future.

Objectives

Work with the local community in St Paul to:

- Create and deliver educational outreach activities during the annual Bering Sea Days.
- Engage the local community through schools and citizen science outreach, to raise awareness and ownership of monitoring, best management practices and control of marine invasive species.
- Assess the baseline marine invertebrate biodiversity within St. Paul harbor.
- Document marine invertebrate communities of St Paul, including banking of genetic material in a national repository.

Methods

Two SERC staff and two NOAA staff traveled to St Paul during September 14-22, 2019 for the duration of Bering Sea Days and several extra sampling days. The time during the trip was focused on education and outreach during the weekday mornings, the remainder of the time was dedicated to surveying local natural and man-made habitats for marine invertebrates (with a focus on non-native species), and processing of those collections.

Community Engagement

- *Bering Sea Days*

  Together with NOAA staff, we developed and delivered lesson plans to all students attending Bering Sea Days (~70 students), a total of approximately 20 contact hours during the week. Curriculum included multimedia and interactive classroom teaching combined with laboratory hands on learning and field surveying.

  Lessons were adapted to 4 age groups in line with the St Paul school system: 2nd/3rd grade, 4th/5th grade, 6th/7th grade & 8th-12th grade. Lesson themes included:

  - Introduction to Invertebrates (with local focus)
  - Invertebrate adaptations (what makes a good invader)
  - Ballast Water game (how are species transported around the globe)
  - World's Most Awesome Invertebrate (bringing the previous lessons together in production of a poster presentation)

- *Community outreach*

  On September 21st, the wider St Paul community was invited to participate in a community outreach day associated with Bering Sea Days. Students presented posters that they had created in our lessons during the week. We also hosted a desk of information on marine invertebrates in general and marine invasive species more specifically.

- *Bioblitz*

  We demonstrated standard survey and bioblitz protocols to students in grades 6-12 in two separate field trips.

Biodiversity survey

- *Biodiversity survey using taxonomic methods*

  Settlement plates that had been deployed in St Paul for 3 and 12 months, following the Platewatch protocols (platewatch.nisbase.org), were retrieved and we documented all biota that had settled on the panels. Ten plates from each time period were retrieved, all plates were analyzed using a 50 point count grid and species list. Specimen vouchers representing all observed morphotypes were also collected from five of the plates (50%). We surveyed the shallow nearshore and intertidal areas of all man-made structures in the harbor as well as intertidal surfaces in several more natural habitats (Figure 1). Natural habitats outside of the harbor were harder to access because of fur seal activity on the island.

- *Biodiversity survey using metagenetic methods*

  We collected sea water samples from both inside (57.119993 N, 170.270679 W) and outside (57.124269 N, 170.279324 W) of the harbor for future analysis using eDNA protocols. Water was collected at peak ebb and flood tide on three successive days (September 16-18) from each location, i.e. 12 sampling events. At each event, 1L of water was passed through a sterivex 0.45um filter cartridge before being preserved in 95% nondenatured EtOH and shipped to the Smithsonian National Museum of Natural History for processing.

- *Review of historic records*

  Online open-access databases are the most efficient accessible source of biodiversity data and information. The largest, most complete datasets including marine invertebrates from the area were queried for records of marine taxa in the Arctic and more specifically the Beaufort Sea and Prudhoe Bay. These databases are updated regularly but are not an

exhaustive resource, either individually or as a whole (see omissions described by Dispas 2019, Goldsmit 2015).

The Ocean Biogeographic Information System (OBIS) is a global open-access data and information clearing-house on marine biodiversity for science, conservation and sustainable development. One node of OBIS is the Arctic Biodiversity Data Service (ABDS), the data-management framework for the Conservation of Arctic Flora and Fauna (CAFF), the biodiversity working group of the Arctic Council, and its programs and activities including the Circumpolar Biodiversity Monitoring Programme (CBMP). OBIS was queried for records shallower than 150ft in the Bering Sea (area 34310) and the East Bering Sea (area 40001).

The Global Biodiversity Information Facility (GBIF) incorporates many diverse databases and also includes terrestrial and freshwater taxa. GBIF was queried for invertebrate (Animalia that were not Chordata) records in the “Bering Sea”, “Bering Sea, Alaska”, “Bering Sea, Oceans”, “Bering Sea, Alaska, Aleutians”.

The Smithsonian’s National Museum of Natural History (NMNH) holds and curates a large number of historic and contemporary collections of marine invertebrates. The NMNH collection database is accessible via an online database which was queried for all invertebrate records within the Bering Sea.

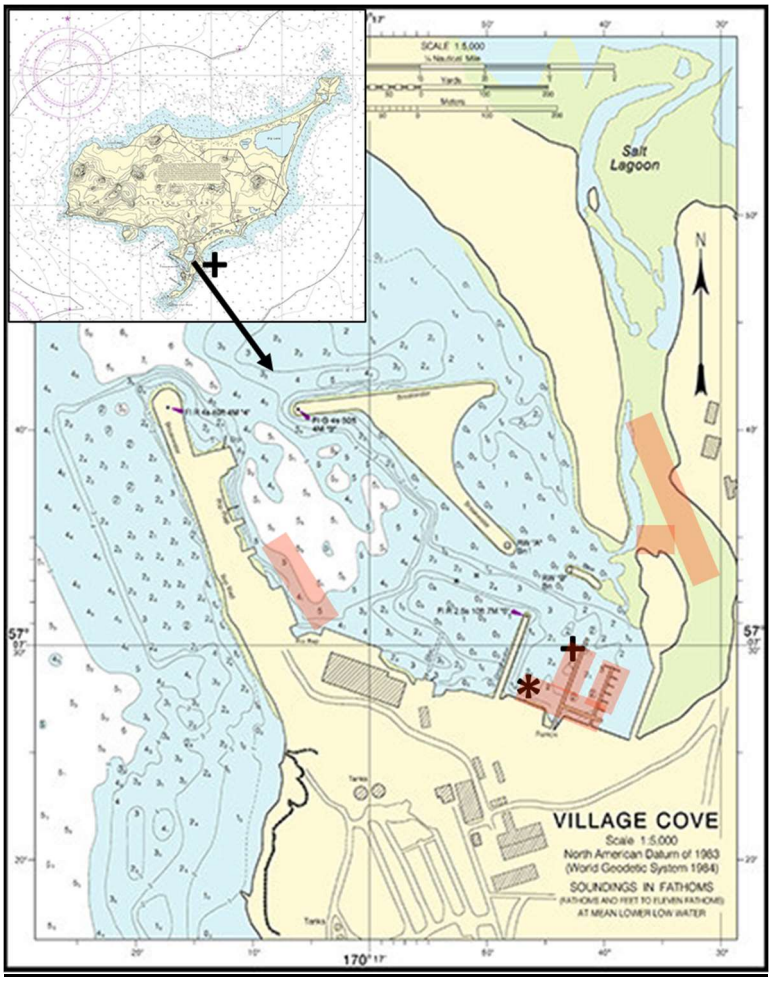

Figure 1 Map of the St Paul Island harbor (Village Cove) showing location of settlement plates (*), eDNA collections (+, inside the harbor and on the outer shore), and surveyed manmade and natural habitats within the Village Cove (shaded in red).

Results

Community engagement outcomes

- Lesson plans were developed that have wide application and can be used in the future by SERC, NOAA, and other interested parties.
- Posters created by the older students (8^{th}-12^{th} grade) were displayed on the community outreach evening and used as a tool in discussions with the wider community.

- Enhanced local knowledge of marine invertebrates living in the nearshore marine ecosystem.
- Enhanced awareness by the local community of the issue of marine invasive species, particularly with reference to the movement of fishing vessels through the harbor.
- A new PlateWatch monitor in St Paul was given a demonstration of the protocols used throughout the state of Alaska, ensuring the continued participation of St Paul students in the long-term monitoring program.

Baseline biodiversity

- Data and specimens were collected from settlement plates that had been deployed in St Paul for both 3 and 12 months.
- Specimens and water samples were also collected from within the harbor, with additional water samples being collected from the outer shore of the island.
- Specimens and water samples were preserved and transported for genetic analyses and banking by the Smithsonian Environmental Research Center and National Museum of Natural History. Preliminary results do not suggest any new marine invasive species in the St Paul/Pribilofs region.

Settlement plates

Spatial cover of the settlement panels was low (~20%) after both 3 and 12 months in-situ (Fig. 1 Figure 3). Taxonomic diversity was higher on those panels left in situ for 12 months, with an average of 17 unique invertebrate taxa recorded from panels deployed for 3 months and 27 unique taxa recorded from panels deployed for 12 months. The spatial cover of bryozoans, ascidians (chordata) and barnacles (cirripedia) increased between 3 month and 12 month panels. Hydroids were the only group with reduced spatial cover after 12 months.
Sixty-four unique taxa were recorded from panels.

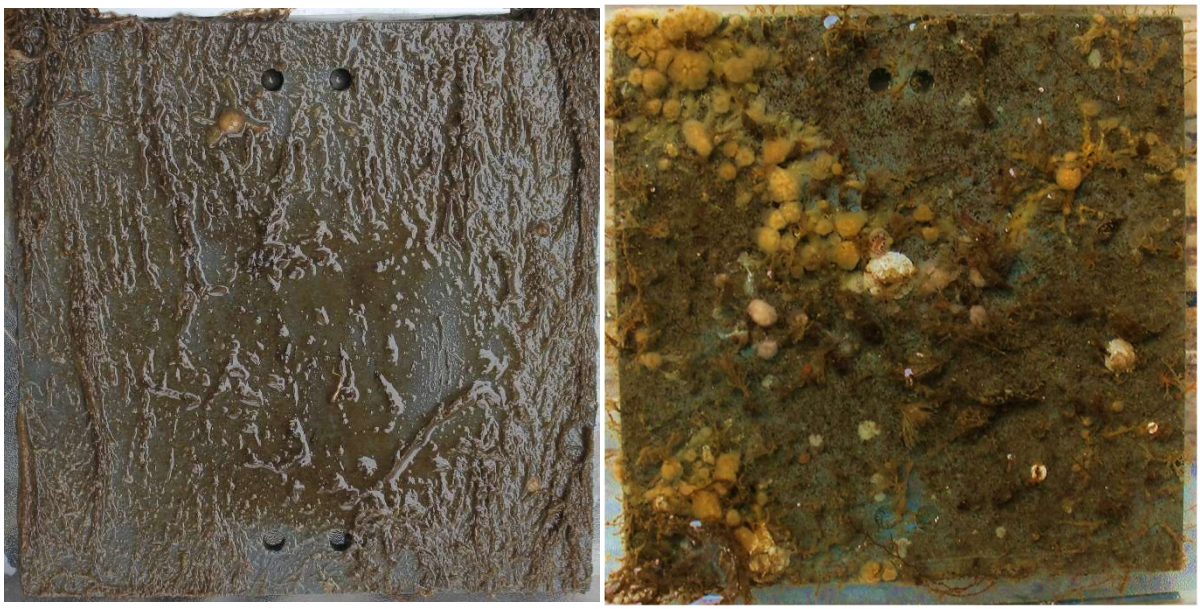

Figure 2 Settlement plates retrieved after 3 month (left) and 12 month (right) soak times.

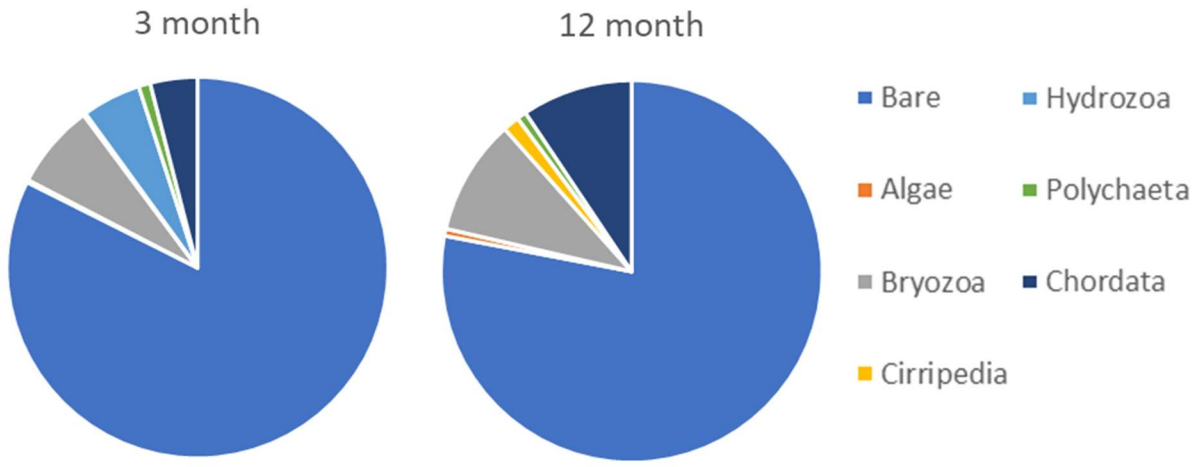

Figure 3 Spatial cover by functional groups growing on settlement plates retrieved after 3 month (left) and 12 month (right) soak times.

Biological collections

245 samples collected for morphological and genetic analyses, were analyzed using taxonomic techniques (Figure 4). 83 taxa from seven phyla were identified: 49 only from panels, 19 only from the dock and 15 from both (Appendix 1). No species was recognized as non-native to the

area, although taxonomic records for the area are limited and we are seeking further resolution for several species.

In addition, water samples collected for eDNA analysis have been sent to the Smithsonian National Museum of Natural History for analysis.

Figure 4 Images of taxa sampled from St Paul in 2019. *Top: brittle star, amphipod, branching bryozoan* Crisia *sp.; Middle: phyllodocid polychaete* Eulalia quadrioculata*, encrusting bryozoan* Membranipora villosa*, sea star* Leptasterias sp.*; bottom: polynoid polychaete* Arctonoe pulchra*, encrusting bryozoan* Cribrilina annulata*, nereid polychaete* Nereis sp..

Historic data review

OBIS has the greatest number of records in the Bering Sea, but a similar number of taxa to that recorded in GBIF (54112 records of 1558 taxa in OBIS, 13356 records of 1830 taxa in GBIF). NMNH has far fewer records in the region, with only 4000 observations of 599 taxa. Of note, 418 of these were from our previous project (Ashton et al. 2020). Focusing on the Pribilof Islands, OBIS has 696 records of 165 unique taxa from close to the Islands (Figure 5); among these, the most numerous phyla were arthropods (n=88), cnidarians (n=28), echinoderms (n=16) & molluscs (n=13). GBIF has 292 records of 108 invertebrate taxa from close to the Pribilof Islands (Figure 6), the distribution of those records is similar to that seen for records in OBIS. Grey literature records of organisms collected during dive surveys of St Paul, provided by J. Weems, added 49 taxa to those recorded in the open access databases (Weems et al. 2017, Appendix 2).

Aggregating records from the Pribilof Islands across databases and grey literature, at least 319 marine invertebrates have been recorded close to the Islands (Appendix 2). Almost a third of these identifications are at a taxonomic specificity lower than species level (n=97), and likely represent more than one species in most groups. Arthropods continued to be the most diverse group (>103 taxa), followed by molluscs, cnidarians and echinoderms. Interestingly, none of the 54 species identified in the present study were already recorded in these databases. Only thirteen of the fifty-two genera sampled in the present study were among the 207 previously recorded genera.

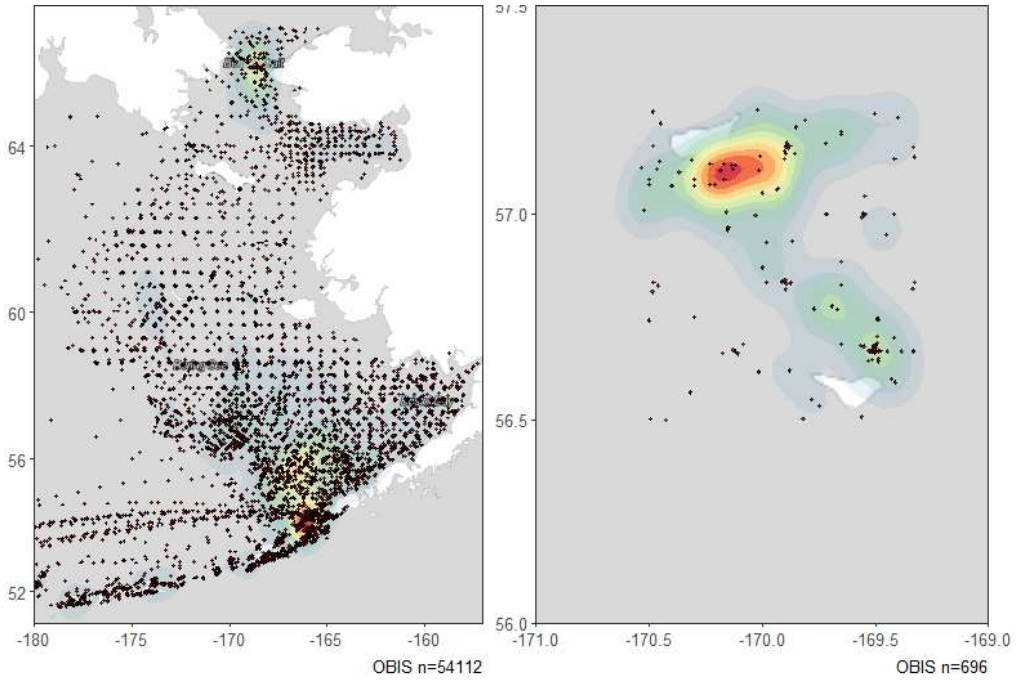

Figure 5 Records of marine species from the eastern Bering Sea (left) and Pribilof Islands (right) captured in the Ocean Biogeographic Information System (OBIS). The heat maps highlight dense aggregations of records within the region e.g. from Unalaska and Diomede within the Bering Sea (left) and from Village Cove Harbor of the Pribilof Islands (right). Accessed June 2021.

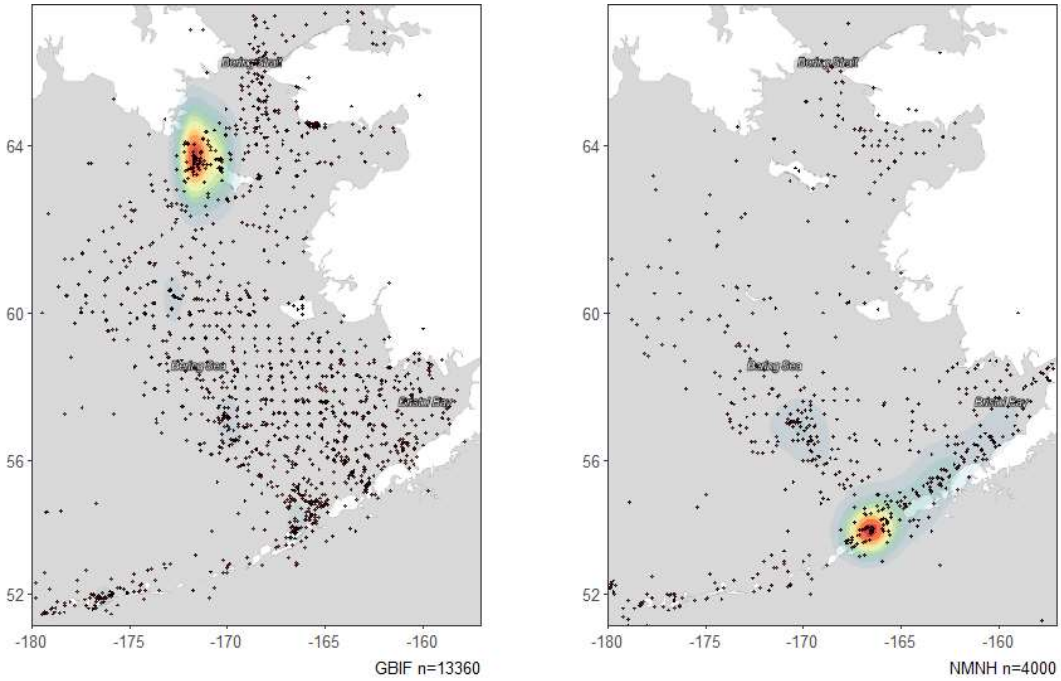

Figure 6 Records of marine species from the eastern Bering Sea captured in the Global Biogeographic Information System (GBIF, left) and National Museum of Natural History (NMNH, right). The heat maps highlight dense aggregations of records within the region e.g. from St Lawrence Island among GBIF records (left) and from Unalaska among NMNH records (right). Accessed June 2021.

Discussion

Community engagement

All community engagement goals were completed successfully. The Bering Sea Days is a fortuitous venue for distribution of marine invasions science material to St Paul students. We were able to engage students in practical and hands on activities, including making physical water measurements, collecting biological specimens, and identification of taxa using taxonomic characters. All students became more aware of marine invertebrates living in the nearby marine habitats. Older students were also able to grasp the concept of non-native species, and traits that make some species adapted to be successful invaders.

A priority for future events will be to expand the community knowledge exchange activities. We were able to learn a little of how the community interacts with the marine environment during our time in St Paul. This exchange could be more structured in the future, including a discussion of research areas that the community would benefit from most, and how these could intersect with our own research focus.

Baseline biodiversity

Recruitment and growth of marine fauna is slow at the temperatures experienced in St Paul. After three months in the water, plates were largely bare (<20% coverage) and had low diversity (17 species per panel). Coverage was still low after 12 months, but diversity was slightly higher (27 species per panel). This is a much lower level of coverage compared to panels deployed in Dutch Harbor for 3 months which were ~98% covered with biota. For environments with a similar temperature profile to St Paul (Figure 7), leaving settlement plates in situ for the longer time period gives a better understanding of local diversity. Opportunistic sampling, including from natural shorelines and structural reinforcements, provided more complete sampling of background biodiversity in this environment. However, opportunistic sampling does not offer the same systematic and standardized comparison to plates deployed by the SERC invasions lab throughout the United States, and in particular by citizen scientists in Alaska through PlateWatch (https://platewatch.nisbase.org).

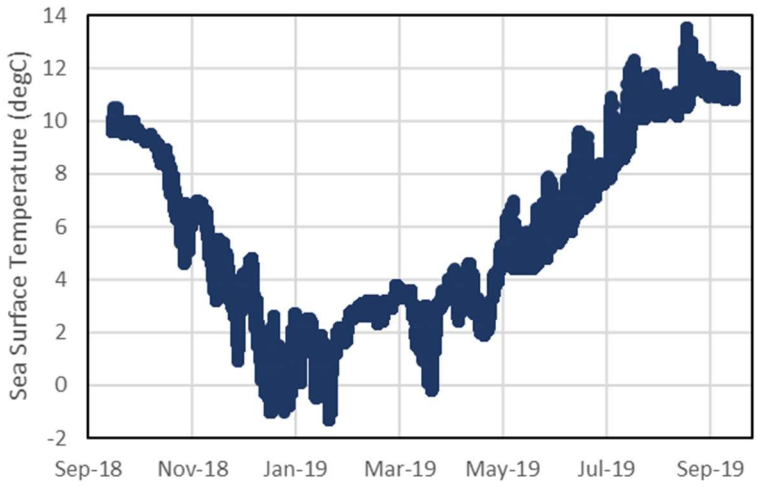

Figure 7 Sea surface temperature recorded by the NOAA National Ocean Service water level observation network Station VCVA2- St Paul Island. Accessed Oct 2021.

We added 54 new species and 39 new genera to the open access databases that cover the region. The low level of species overlap with previous records from the islands is not surprising, due to the paucity of studies in general, and the different approach used here compared to previous studies. The distribution of records in the Bering Sea and around the Pribilof Islands in particular indicates that most sampling to date has been offshore and ship-based. This is supported by the large number of taxa sampled in the current study not being recorded from the Pribilof Islands to date. The same was true for samples collected by Weems et al. (2017) which included many taxa not in OBIS, GBIF nor NMNH. The gaps in open access databases are well known, but the number of global analyses that are based on these resources is increasing, and only by contributing to these resources do the databases improve. Accordingly, all records in the current study are being uploaded to OBIS and will be available for use in the future.

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Acknowledgements

The work in St Paul would not have been possible without the support of many local groups, of note were the School for hosting Bering Sea Days, the Aleutian Pribilof Islands Association for their welcome & support, and the NOAA fisheries division for housing and local support. We are also grateful to expert taxonomists for providing voucher identifications: H Choong, M Dick, T Gosliner, E Keppel, G Lambert, K Larson.

Appendix 1: Identifications (at submission) of vouchers collected in St Paul harbor during September 2019

Identifications are given to the most accurate level available (and will continue to be updated internally as new information becomes available). Note that groups that have not been identified to Species level could include multiple species (---). Where species could be determined, an indication of whether the species is considered native (N), introduced (I), unknown (U) or cryptogenic (C) is indicated under Status. Counts (n) indicate the number of vouchers identified in the current study. PO indicates where the taxa was collected from: panels (P), dock scrapings (O) or both (PO). Taxa counts include all specimens identified to any level.

Phylum	Class	Order	Family	Genus	Species	n	Status	PO
Annelida	Polychaeta	Phyllodocida	---	---	---	1		P
			Nereididae	---	---	1		P
				Nereis	---	3		PO
			Phyllodocida	---	---	1		P
				Eulalia	*Eulalia quadrioculata*	3	N	PO
			Polynoidae	---	---	1		P
				Arctonoe	*Arctonoe pulchra*	1	N	O
				Harmothoe	*Harmothoe imbricata* complex	4	N	P
			Spionidae	*Polydora*	---	1		P
					Polydora limicola	6	U	P
					Polydora websteri	1	U	P
			Syllidae	*Autolytinae*	---	1		P
				Epigamia	*Epigamia alexandri*	13	N	PO
					Epigamia magna	1	N	O
				Exogone	---	2		P
					Exogone verugera	4	N	P
				Pionosyllis	*Pionosyllis gigantea*	4	N	P
				Proceraea	*Proceraea prismatica*	2	N	O
				Typosyllis	---	1		P
		Sabellida	Sabellidae	cf. *Pseudopotamilla*	---	1		P
			Serpulidae	---	---	2		P
				Circeis	*Circeis spirillum*	12	N	PO
				Pseudochitinopoma	*Pseudochitinopoma occidentalis*	5	N	P
		Terebellidae	Terebellidae	---	---	1		P

Phylum	Class	Order	Family	Genus	Species	n	Status	PO
Annelida total					24 taxa	75		
Arthropoda	Malacostraca	Amphipoda	Caprellidae	*Caprella*	*Caprella laeviuscula*	1	N	O
					Caprella rudiscula	1	N	O
	Thecostraca	Balanomorpha	Archaeobalanidae	*Semibalanus*	*Semibalanus cariosus*	1	N	O
			Balanidae	---	---	1		P
				cf. *Balanus*	*Balanus crenatus*	8	N	P
					Balanus nubilus	3	N	P
Arthropoda total					6 taxa	15		
Bryozoa	Gymnolaemata	Cheilostomatida	Bryocryptellidae	*Porella*	*Porella alba*	1	N	P
			Bugulidae	*Crisularia*	*Crisularia pacifica*	10	N	PO
			Calloporidae	*Callopora*	*Callopora craticula*	3	N	P
				Tegella	---	1		P
					Tegella aquilirostris	9	N	PO
					Tegella cf. *unicornis*	1	U	O
			Candidae	*Tricellaria*	*Tricellaria erecta*	1	C	O
			Flustrina	*Cribrilina*	*Cribrilina annulata*	14	C	P
				Cylindroporella	*Cylindroporella tubulosa*	2	N	P
			Membraniporidae	*Membranipora*	*Membranipora villosa*	2	N	O
			Umbonulidae	*Desmacystis*	*Desmacystis sandalia*	2	N	O
		Ctenostomata	Vesiculariidae	*Amathia*	*Amathia* cf. *agreggata*	4	C	PO
	Stenolaemata	Cyclostomata	Crisiidae	*Crisia*	---	2		O
				Filicrisia	---	9		PO
			Lichenoporidae	---	---	4		PO
Bryozoa total					15 taxa	65		
Chordata	Ascidiacea	Aplousobranchia	Didemnidae	---	---	1		O
			Holozoidae	*Distaplia*	---	4		P
					Distaplia alaskensis	7	N	P
					Distaplia cf. *occidentalis*	1	N	P
		Stolidobranchia	Molgulidae	*Molgula*	---	2		P
					Molgula cf. *retortiformis*	2	N	P

Phylum	Class	Order	Family	Genus	Species	n	Status	PO
			Phlebobranchia	*Ascidia*	---	5		P
					Ascidia cf. *callosa*	2	N	PO
			Pyuridae	---	---	2		P
				Halocynthia	*Halocynthia igaboja*	8	N	O
			Styelidae	---	---	1		O
				Styela	*Styela* cf. *truncata*	1	N	O
Chordata total					12 taxa	36		
Cnidaria	Hydrozoa	Leptothecata	Aequoreidae	*Aequorea*	---	2		P
				Obelia	*Obelia dichotoma*	5	C	PO
					Obelia longissima	2	C	PO
			Campanulariidae	*Gonothyraea*	*Gonothyraea inornata*	1	C	O
					Gonothyraea loveni	9	C	PO
			Campanulinidae	*Calycella*	---	1		P
					Calycella syringa	1	C	O
			Lafoeidae	*Filellum*	---	1		P
Cnidaria total					8 taxa	22		
Mollusca	Bivalvia	Adapedonta	Hiatellidae	*Hiatella*	*Hiatella arctica*	8	N	PO
		Venerida	Veneridae	*Turtonia*	*Turtonia minuta*	8	N	P
	Gastropoda	Archaeogastropoda	Margaritidae	*Margarites*	*Margarites helicinus*	3	N	P
		Caenogastropoda	Vermetidae	---	---	1		P
		Littorinimorpha	Littotinidae	*Lacuna*	*Lacuna porrecta*	1	U	P
					Lacuna vincta	2	N	P
		Neogastropoda	Buccinidae	*Buccinum*	*Buccinum* sp.	2		P
			Muricidae	*Nucella*	*Nucella angustior*	2	U	O
		Nudibranchia	Dendronotidae	*Dendronotus*	*Dendronotus venustus*	1	N	O
			Eubranchidae	*Eubranchus*	---	4		P
					Eubranchus rustyus	1	U	P
			Fionidae	*Cuthonella*	*Cuthonella concinna*	2	N	P
			Goniodoridae	*Ancula*	*Ancula pacifica*	1	N	P
			Onchidoridae	*Onchidoris*	*Onchidoris bilamellata*	1	N	P

Phylum	Class	Order	Family	Genus	Species	n	Status	PO
					Onchidoris muricata	2	N	P
			Proctonotidae	*Janolus*	*Janolus fuscus*	1	N	P
Mollusca total					16	40		

Appendix 2 Species list of taxa recorded from waters surrounding the Pribilof Islands.

OBIS, GBIF and NMNH databases were searched for records of marine taxa. *** Grey literature records that were provided by J. Weems were added to the database records to create a more comprehensive list of taxa previously recorded from the Islands.

Annelida	Clitellata				
	Hirudinea	Rhyncobdellida	Piscicolidae	*Beringobdella*	*Beringobdella rectangulata*
	Polychaeta		Orbiniidae	*Scoloplos*	*Scoloplos armiger*
		Echiuroidea	Thalassematidae	*Anelassorhynchus*	*Anelassorhynchus abyssalis*
		Phyllodocida	Glyceridae		
			Nephtyidae	*Nephtys*	*Nephtys caecoides*
					Nephtys paradoxa
			Nereididae	*Nereis*	
					Nereis pelagica
			Phyllodocidae	*Alciopini*	
				Phyllodoce	*Phyllodoce maculata*
			Polynoidae		
				Eunoe	*Eunoe depressa*
					Eunoe oerstedi
			Syllidae	*Exogone*	*Exogone naidina*
				Myrianida	
		Sabellida	Sabellidae	*Eudistylia*	*Eudistylia polymorpha*
			Sabellidae	*Potamilla*	
			Serpulidae		
		Spionida	Spionidae		
Arthropoda	Hexanauplia	Calanoida	Acartiidae	*Acartia*	
					Acartia (Acanthacartia) tumida
					Acartia (Acartiura) longiremis
			Calanidae	*Calanus*	
					Calanus finmarchicus
					Calanus marshallae

Phylum	Class	Order	Family	Genus	Species	
Arthropoda cont.d				*Neocalanus*	*Neocalanus cristatus*	
					Neocalanus plumchrus	
			Clausocalanidae	*Pseudocalanus*		
					Pseudocalanus minutus	
			Eucalanidae	*Eucalanus*	*Eucalanus bungii*	
			Temoridae	*Eurytemora*	*Eurytemora herdmani*	
		Copepoda				
		Cyclopoida	Oithonidae	*Oithona*	*Oithona setigera setigera*	
					Oithona similis	
			Oncaeidae			
		Thoracica				
	Insecta	Coleoptera	Agyrtidae	*Lyrosoma*	*Lyrosoma opacum*	
			Salpingidae	*Aegialites*		
					Aegialites saintgeorgensis	
					Aegialites saintpaulensis	
		Mecoptera	Boreidae	*Boreus*	*Boreus borealis*	
	Malacostraca	Amphipoda	Atylidae	*Atylus*	*Atylus bruggeni*	
					Atylus collingi	
			Caprellidae	*Caprella*		***
			Cyphocarididae	*Cyphocaris*	*Cyphocaris challengeri*	
			Eusiridae			
			Eusiridae	*Eusirus*	*Eusirus cuspidatus*	
			Hyperiidae	*Hyperia*		
					Hyperia medusarum	
				Hyperoche	*Hyperoche medusarum*	
				Themisto	*Themisto libellula*	
			Ischyroceridae	*Ericthonius*	*Ericthonius rubricornis*	
				Ischyrocerus		
			Lysianassidae	*Socarnes*	*Socarnes bidenticulatus*	
			Melitidae	*Megamoera*	*Megamoera dentata*	

Phylum	Class	Order	Family	Genus	Species	
Arthropoda cont.d			Oedicerotidae	*Kroyera*	*Kroyera carinata*	
			Photidae	*Photis*		
			Phoxocephalidae	*Paraphoxus*		
			Pontogeneiidae	*Pontogeneia*	*Pontogeneia ivanovi*	
			Stenothoidae			
			Tryphosidae	*Orchomenella*	*Orchomenella lepidula*	
				Wecomedon	*Wecomedon kurilicus*	
			Uristidae	*Anonyx*		
					Anonyx sarsi	
					Anonyx nugax	
		Cumacea	Diastylidae			
				Diastylis	*Diastylis bidentata*	
			Lampropidae	*Alamprops*	*Alamprops affinis*	
				Lamprops		
					Lamprops fuscatus	
				Mesolamprops	*Mesolamprops japonicus*	
			Leuconidae			
				Eudorella		
			Nannastacidae	*Campylaspis*		
		Decapoda	Atelecyclidae			
			Brachyura			
			Cancridae	*Glebocarcinus*	*Glebocarcinus oregonensis*	***
				Metacarcinus	*Metacarcinus magister*	***
			Caridea			
			Cheiragonidae	*Erimacrus*	*Erimacrus isenbeckii*	
				Telmessus	*Telmessus cheiragonus*	
			Crangonidae	*Argis*	*Argis dentata*	
			Diogenidae			
			Epialtidae	*Pugettia*		***
			Hapalogastridae	*Acantholithodes*	*Acantholithodes hispidus*	***

Arthropoda cont.d		*Dermaturus*	*Dermaturus mandtii*	
		Hapalogaster	*Hapalogaster grebnitzkii*	
		Oedignathus	*Oedignathus inermis*	
	Hippolytidae			
	Lithodidae			
		Paralithodes		
			Paralithodes brevipes	
			Paralithodes camtschaticus	
			Paralithodes platypus	
	Majidae			
	Oregoniidae	*Chionoecetes*		
			Chionoecetes bairdi	
			Chionoecetes opilio	
		Hyas		
			Hyas coarctatus	***
			Hyas lyratus	***
		Oregonia	*Oregonia gracilis*	
	Paguridae			
		Elassochirus	*Elassochirus cavimanus*	
			Elassochirus gilli	
		Labidochirus	*Labidochirus splendescens*	***
		Pagurus		
			Pagurus aleuticus	
			Pagurus brandti	
			Pagurus dalli	
			Pagurus ochotensis	***
			Pagurus undosus	
	Pandalidae			
		Pandalus		
	Thoridae	*Lebbeus*	*Lebbeus groenlandicus*	

Arthropoda cont.d				*Spirontocaris*	*Spirontocaris ochotensis*	
			Xanthidae			
		Euphausiacea				
			Euphausiidae			
				Thysanoessa		
					Thysanoessa inermis	
					Thysanoessa longipes	
					Thysanoessa raschii	
		Isopoda	Arcturidae	*Arcturus*	*Arcturus beringanus*	
			Bopyridae	*Argeia*	*Argeia pugettensis*	
			Epicaridea			
			Idoteidae	*Synidotea*		***
		Leptostraca				
		Mysida	Mysidae	*Neomysis*	*Neomysis rayii*	
	Pycnogonida	Pantopoda	Colossendeidae	*Colossendeis*		***
	Thecostraca	Balanomorpha	Balanidae	*Balanus*	*Balanus balanus*	
				Chirona	*Chirona evermanni*	***
				Semibalanus		***
		Scalpellomorpha	Lepadidae	*Lepas*		***
	Ostracoda	Myodocopida				
Arthropoda totals	**6**	**17**	**56**	**64**	**>116 (70 identified to species)**	
Brachiopoda	Rhynchonellata	Rhynchonellida	Hemithiriididae	*Hemithiris*	*Hemithiris psittacea*	
Brachiopoda totals	**1**	**1**	**1**	**1**	**1**	
Bryozoa	Gymnolaemata	Cheilostomatida	Myriaporidae	*Myriozoella*	*Myriozoella plana*	
		Ctenostomatida	Alcyonidiidae	*Alcyonidium*		***
Chaetognatha	Sagittoidea	Aphragmophora	Sagittidae	*Parasagitta*	*Parasagitta elegans*	
Chordata	Ascidiacea	Enterogona	Agnesiidae	*Agnesia*	*Agnesia beringia*	
			Ascidiidae	*Ascidia*	*Ascidia adhaerens*	

Chordata cont.d		Pleurogona	Molgulidae	*Bostrichobranchus*	*Bostrichobranchus pilularis*	
			Pyuridae	*Boltenia*	*Boltenia ovifera*	
				Halocynthia	*Halocynthia aurantium*	***
			Styelidae	*Styela*	*Styela rustica*	***
Chordata totals		**1**	**4**	**5**	**6**	
Cnidaria	Anthozoa	Actiniaria				
			Actiniidae	*Urticina*	*Urtinina grebelnyi*	***
				Cribrinopsis	*Cribrinopsis albopunctata*	***
			Actinostolidae	*Stomphia*	*Stomphia coccinea*	***
			Metrediidae	*Metridium*	*Metridium farcimen*	***
					Metridium senile fimbriatum	***
		Alcyonacea	Nephtheidae	*Gersemia*		
					Gersemia rubiformis	
			Primnoidae	*Thouarella*		
		Pennatulacea				
			Halipteridae	*Halipteris*		
			Halipteridae	*Halipteris*	*Halipteris finmarchica*	
			Virgulariidae	*Virgularia*		
			Virgulariidae			
	Hydrozoa	Anthoathecata	Bougainvilliidae	*Bougainvillia*	*Bougainvillia superciliaris*	
		Anthoathecata	Pandeidae	*Neoturris*	*Neoturris breviconis*	
		Hydroidolina				
		Leptothecata	Aequoreidae	*Aequorea*		***
			Campanulinidae			
			Haleciidae	*Halecium*	*Halecium muricatum*	
			Lafoeidae	*Grammaria*	*Grammaria abietina*	
			Laodiceidae	*Staurostoma*		***
			Sertulariidae	*Abietinaria*	*Abietinaria gigantea*	
					Abietinaria variabilis	
				Sertularia	*Sertularia robusta*	

Cnidaria cont.d					*Sertularia similis*	
				Thuiaria		
					Thuiaria cylindrica	
					Thuiaria hartlaubi	
					Thuiaria obsoleta	
					Thuiaria thuja	
			Symplectoscyphidae	*Symplectoscyphus*	*Symplectoscyphus tricuspidatus*	
		Trachymedusae	Rhopalonematidae	*Aglantha*	*Aglantha digitale*	
	Scyphozoa	Semaeostomeae	Cyaneidae	*Cyanea*	*Cyanea capillata*	
			Pelagiidae	*Chrysaora*		
					Chrysaora melanaster	***
			Ulmaridae	*Aurelia*	*Aurelia labiata*	***
Ctenophora	Nuda	Beroida	Beroidae	*Beroe*		
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Asterias*	*Asterias amurensis*	
				Evasterias	*Evasterias troschelii*	***
				Leptasterias	*Leptasterias (Hexasterias) polaris acervata*	
					Leptasterias arctica	
					Leptasterias camtschatica	
					Leptasterias polaris	
				Lethasterias	*Lethasterias nanimensis*	***
		Spinulosida	Echinasteridae	*Henricia*	*Henricia eschrichti*	
		Valvatida	Solasteridae	*Crossaster*	*Crossaster papposus*	***
				Solaster	*Solaster endeca*	
					Solaster stimpsoni	***
		Velatida	Pterasteridae	*Pteraster*	*Pteraster obscurus*	
					Pteraster tesselatus	***
	Echinoidea	Camarodonta	Strongylocentrotidae	*Strongylocentrotus*	*Strongylocentrotus droebachiensis*	

Echinodermata cont.d					*Strongylocentrotus pallidus*	
					Strongylocentrotus polyacanthus	***
		Clypeasteroida	Echinarachniidae	*Echinarachnius*	*Echinarachnius parma*	
					Echinarachnius parma obesus	
		Clypeasteroida	Scutelliformes incertae sedis	*Marginoproctus*		
	Holothuroidea	Dendrochirotida	Cucumariidae	*Cucumaria*		
					Cucumaria fallax	
					Cucumaria frondosa	
					Cucumaria vegae	
		Dendrochirotida	Phyllophoridae	*Pentamera*		
		Dendrochirotida	Psolidae	*Psolus*	*Psolus fabricii*	
		Dendrochirotida	Sclerodactylidae	*Eupentacta*		
	Ophiuroidea	Amphilepidida	Ophiopholidae	*Ophiopholis*	*Ophiopholis aculeata*	
		Euryalida	Gorgonocephalidae	*Gorgonocephalus*	*Gorgonocephalus eucnemis*	
		Ophiurida	Ophiopyrgidae	*Stegophiura*	*Stegophiura nodosa*	
			Ophiuridae	*Ophiura*	*Ophiura sarsii*	
Mollusca	Bivalvia	Adapedonta	Hiatellidae	*Hiatella*	*Hiatella arctica*	
		Cardiida	Cardiidae	*Ciliatocardium*	*Ciliatocardium ciliatum*	
				Clinocardium		***
				Keenocardium	*Keenocardium blandum*	
				Serripes	*Serripes groenlandicus*	
				Serripes	*Serripes laperousii*	
			Tellinidae	*Macoma*	*Macoma brota*	
					Macoma obliqua	
		Carditida	Carditidae	*Cyclocardia*		
					Cyclocardia crassidens	
					Cyclocardia crebricostata	
		Myida	Myidae	*Mya*	*Mya pseudoarenaria*	
		Mytilida	Mytilidae	*Modiolus*	*Modiolus modiolus*	***

Phylum	Class	Order	Family	Genus	Species	
Mollusca cont.d				*Musculus*	*Musculus discors*	
				Mytilus	*Mytilus edulis*	
		Nuculanida	Yoldiidae	*Yoldia*	*Yoldia myalis*	
		Pectinida	Anomiidae	*Pododesmus*	*Pododesmus macrochisma*	
			Pectinidae	*Chlamys*		
					Chlamys behringiana	
					Chlamys rubida	
					Chlamys hastata	
					Chlamys jordani	
				Crassadoma	*Crassadoma gigantea*	***
		Venerida	Mactridae	*Mactromeris*	*Mactromeris polynyma*	
		Venerida	Veneridae	*Turtonia*	*Turtonia minuta*	
	Cephalopoda	Octopoda	Enteroctopodidae	*Enteroctopus*	*Enteroctopus dofleini*	***
	Gastropoda	Lepetellida	Fissurellidae	*Cranopsis*	*Cranopsis major*	
				Puncturella	*Puncturella major*	
		Littorinimorpha	Calyptraeidae	*Crepidula*		
					Crepidula grandis	***
				Crepipatella	*Crepipatella lingulata*	
				Grandicrepidula	*Grandicrepidula grandis*	
			Capulidae	*Ariadnaria*	*Ariadnaria insignis*	
			Cymatiidae	*Fusitriton*	*Fusitriton oregonensis*	***
			Falsicingulidae	*Falsicingula*	*Falsicingula aleutica*	
			Littorinidae	*Lacuna*	*Lacuna reflexa*	
				Littorina	*Littorina sitkana*	
			Naticidae	*Cryptonatica*	*Cryptonatica affinis*	
					Cryptonatica aleutica	
				Natica		
			Velutinidae	*Velutina*		
		Neogastropoda	Buccinidae	*Ancistrolepis*	*Ancistrolepis eucosmius*	
				Aulacofusus	*Aulacofusus brevicauda*	

Phylum	Class	Order	Family	Genus	Species	
Mollusca cont.d				*Buccinum*		
					Buccinum baerii	
					Buccinum glaciale	
				Colus		
				Latisipho	*Latisipho hallii*	
				Neptunea		
					Neptunea pribiloffensis	
				Plicifusus		
				Pyrulofusus	*Pyrulofusus harpa*	
				Retifusus	*Retifusus jessoensis*	
				Volutharpa	*Volutharpa ampullacea*	
				Volutopsion	*Volutopsion stefanssoni*	
		Neogastropoda	Columbellidae	*Astyris*	*Astyris rosacea*	
			Mangeliidae	*Propebela*	*Propebela arctica*	
					Propebela turricula	
			Muricidae	*Boreotrophon*		
					Boreotrophon clathratus	
					Boreotrophon pacificus	
		Nudibranchia	Aeolidioidae	*Aeolidia*	*Aeolidia papillosa*	***
			Dironidae	*Dirona*	*Dirona pellucida*	***
			Doridiidae	*Doris*	*Doris odhneri*	***
			Discodoridiidae	*Diaulula*	*Diaulula sandiegensis*	***
			Fionidae	*Fiona*		
				Himatina	*Himatina trophina*	***
			Myrrhinidae	*Hermissenda*	*Hermissenda crassicornis*	***
			Polyceridae	*Triopha*	*Triopha catalinae*	***
		Pteropoda	Clionidae	*Clione*	*Clione limacina*	
			Limacinidae	*Limacina*	*Limacina helicina*	
		Trochida	Margaritidae	*Margarites*	*Margarites argentatus*	
					Margarites helicinus	

Mollusca cont.d		Neogastropoda	Buccinidae	*Buccinum*	*Buccinum morchianum*	
			Cancellariidae	*Admete*		
					Admete viridula	
			Trophonidae	*Boreotrophon*	*Boreotrophon beringi*	
					Boreotrophon dalli	
					Boreotrophon stuarti	
					Boreotrophon truncatus	
			Turridae	*Aforia*	*Aforia circinata*	
				Antiplanes	*Antiplanes thalaea*	
	Polyplacophora	Chitonida	Acanthochitonidae	*Cryptochiton*	*Cryptochiton stelleri*	***
			Mopaliidae	*Amicula*		
				Katharina	*Katharina tunicata*	***
			Tonicellidae	*Tonicella*	*Tonicella lineata*	***
Nematoda	Chromadorea	Ascaridida	Ascarididae	*Ascaris*	*Ascaris canis*	
					Ascaris decipiens	
					Ascaris osculata	
					Ascaris spiculigerum	
				Belascaris		
		Spirurida	Spiruridae			
Nemertea	Anopla	Heteronemertea				
	Enopla	Hoplonemertea	Amphiporidae	*Amphiporus*		
	Pilidiophora	Heteronemertea	Lineidae	*Kulikovia*	*Kulikovia montgomeryi*	
Platyhelminthes	Cestoda	Bothriocephalidea	Bothriocephalidae	*Bothriocephalus*	*Bothriocephalus macrocephalus*	
		Cyclophyllidea	Dilepididae	*Anomotaenia*		
			Tetrabothriidae	*Anophryocephalus*	*Anophryocephalus skrjabini*	
Porifera	Calcarea	Leucosolenida	Sycettidae	*Sycon*		

Porifera cont.d	Demospongiae	Poecilosclerida	Mycalidae	*Mycale*	*Mycale loveni*	
		Suberitida	Halichondriidae	*Halichondria*	*Halichondria panicea*	
					Halichondria lambei	
		Tetractinellida	Ancorinidae	*Stelletta*		
				Polymastia		***
Porifera totals	**2**	**4**	**4**	**4**	**5 (4 identified to species)**	