Parks Canada Parcs Canada

Preliminary Assessment of Subtidal Habitat at Thirteen Anchorages in Gulf Islands National Park Reserve of Canada

Prepared for Gulf Islands National Park Reserve
By: Western & Northern Service Centre 2012

Canada

Preliminary Assessment of Subtidal Habitat at Thirteen Anchorages in Gulf Islands National Park Reserve of Canada

Submitted to

Gulf Islands National Park Reserve of Canada

Prepared by

Western & Northern Service Centre
Resource Conservation

Parks Canada
Vancouver, BC

January 2012

Contents

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LIST OF ABBREVIATIONS AND ACRONYMS

<	Less than
≤	Less than or equal to
>	Greater than
BC	British Columbia
CDC	British Columbia Conservation Data Centre
cm	centimetre
CO_2	carbon dioxide
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
GBRMPA	Great Barrier Marine Park Authority
GINPR	Gulf Islands National Park Reserve of Canada
GIS	geographic information system
km^2	square kilometre
m	metre
m^2	square metre
MarLIN	Marine Life Information Network
NW	northwest
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
ROV	remotely operated vehicle
S	south
SARA	Species at Risk Act
SE	southeast
SSG	southern Strait of Georgia
SW	southwest
UV	ultra violet
VEC	valued ecosystem component
W&NSC	Western and Northern Service Centre

APPENDICES VOLUME 1: Supporting Reports

Appendix 1

Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Methods & Definitions

Prepared for Parks Canada by Matthew Drake. May 1st 2011

Appendix 2

Metadata for the Subtidal Habitat Assessment for Gulf Islands National Park Reserve

Prepared for Parks Canada by Matthew Drake. May 1st 2011

Appendix 3

Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Results

Prepared for Parks Canada by Matthew Drake. May 1st 2011

APPENDICES VOLUME 2: Maps

ACKNOWLEDGEMENTS

We would like to thank the many people whose efforts made this project possible. Firstly, thanks to Wayne Bourque for having the foresight to initiate this work, and in requesting the involvement of the Western and Northern Service Centre marine science group. Meetings with Gulf Islands National Park Reserve (GINPR) managers and staff (Wayne Bourque, Carolyn Stewart, Rob Walker, John Marczyk, Laurie Peerenboom, and Todd Shannon) helped clarify expectations for the project, and identify key issues to include in the assessment. Thanks to Todd Shannon for making park vessels and operators available for the field work portion of the study. The operators themselves (Frank Gee, Tom Lafortune, Jay Zakaluzny, Todd Shannon) deserve special recognition for patiently driving the boats very slowly along imaginary transect lines, often in conditions with just enough wind to make holding a steady course very challenging. Tara Sharma and Jason Winchester provided access to required orthophotographic coverage. Jason also shared the results of eelgrass mapping within GINPR from airphoto interpretation.

Matthew Drake was hired by contract to analyse the video tapes, classify and database the results, and report on the findings. He also assisted in the field collection of the video tape transects. He undertook this work with a high degree of focus, and was a cheerful and reliable team member both in the office and the field. The results of his work formed the basis of this report. Doug Hrynyk capably took over the GIS analysis and mapping work after Matthew's contract was completed. Steve Trewhella, a well known UK diver, photographer and marine conservation advocate, kindly agreed to let us use a photograph he took showing heavy anchor chain impacts to eelgrass meadows in Studland, Dorset, UK. Steve and others are presently working hard to implement measures to protect the seagrass meadows and wild sea horse population in Studland Bay, Dorset.

Everyone's contributions to the success of the GINPR anchorage benthic habitat assessment project are recognised and greatly appreciated.

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EXECUTIVE SUMMARY

Purpose of Study

In the autumn of 2010 and winter of 2011, Parks Canada used a remotely operated vehicle (ROV) and towed underwater camera to video tape benthic (bottom) habitat in the thirteen most heavily used recreational boat anchorages within Gulf Islands National Park Reserve of Canada (GINPR). Three valued ecosystem components (VECs) were identified based on a literature review of ecosystem sensitivity to recreational boat anchoring and mooring. The objective of the work was to provide an overview of the relationship between valued ecosystem components and spatial overlap with anchoring suitability at each anchorage that will inform recreational boating management discussions during the park marine planning process.

Approach

Distribution and prevalence of three VECS, eelgrass meadows, sea pens and sea anemones at each anchorage was determined from video tape analysis. VECs were determined from the range of marine resources identified on the video tapes, an extensive literature review on the impact of anchoring and mooring, and expert opinion. Potential anchoring suitability was mapped at each site as the combination of shallow depth (<20m), suitable anchoring substrate (sand or mud) and low energy sites shielded from wind, waves and currents. The spatial distribution of garbage on the seafloor was also determined from the video tapes and was used as a historical valuation of anchoring suitability. The distribution of VEC occurrences and areas of high anchoring suitability were compared to determine potential for interaction between anchoring or mooring, and sensitive seabed features. The anchorages were ranked into 3 main categories based on the percentage overlap between VECs and areas with high anchoring suitability. Anchorages with extensive distributions of VECS and high anchoring suitability were considered to be most vulnerable to anchoring impacts. Conversely, sites with little or no VECs and/or low anchoring suitability were considered to be less vulnerable to anchoring. Note that published literature and grey literature studies were used to understand the impacts of anchoring and mooring on VECs, and no experimental work was undertaken as part of this study to directly investigate the impacts of anchoring on VECs.

The impact assessment is predicated on the principle that sensitive species or habitats, and anchoring and mooring activities must be simultaneously present for impacts to occur. If either component is missing, no impacts will take place. It is also founded on a simple relationship where the probability of impact occurrence increases as the areal extent of sensitive resources in the anchorages expands, and with increased anchoring or mooring activity. Increased activity means more vessels simultaneously anchoring in an anchorage or anchorages, for longer periods of time per visit, or for more visits in the course of the boating season. This study assessed the presence and distribution of VECs only. It did not directly assess the levels of anchoring and mooring activity taking place at each anchorage.

Key Findings

GINPR anchorages contain a variety of subtidal habitat types and exhibit a wide range of VEC presence (See summary table below).

Eelgrass *(Zostera marina)* was the most prevalent VEC both in terms of number of anchorages where it occurred, 11 of 13 sites, and in total area of benthic habitat. VEC vulnerability based on encounter rates with anchor or mooring tackle would be ranked high for eelgrass because it has a large surface area and a clumped, dense distribution pattern. Furthermore, at the majority of sites where eelgrass occurred, there was a high degree of overlap with garbage indicating a high potential for interaction between anchoring and eelgrass.

Orange sea pens *(Ptilosarcus gurneyi),* were half as prevalent as eelgrass in terms of area covered, and number of sites (n=6) in which they were present. Vulnerability for sea pens was considered to be moderate because of a sparse coverage on the seabed and a clumped distribution. At the 5 sites where they occur, there was a high degree of overlap between sea pens and seafloor garbage ranging from 22% at Bennett Bay, to a high of 75% at James Bay indicating an overall moderate level of interaction with anchoring.

Sea anemones were the least abundant organisms and were found in the fewest anchorages (n=5), and covered approximately one tenth the total area of eelgrass. Vulnerability for anemones was considered to be low because of their sparse distribution, typically occurring as solitary individuals, and small area of seabed coverage. They occur in only 5 study sites, at relatively low densities, and overlap with garbage at only 2 sites: Beaumont which receives very high levels of mooring and anchoring use in summer, and Narvaez Bay which receives light to moderate use. Overall, sea anemones likely have a low level of interaction with anchoring and mooring.

Study Site Areas, and percent coverage by VECs and Garbage

Anchorage		VEC Occurrence						Garbage Occurrence
Anchorage Study Site	Study Site Area (hectares)	Eelgrass coverage m^2	Eelgrass coverage %	Sea pen coverage m^2	Sea pen coverage %	Sea anemones coverage m^2	Sea anemones % coverage	Garbage % coverage
Sidney Spit	138.6	327,035	24	143,415	10	0	0	19
Winter Cove	44.1	251,810	57	72,241	16	0	0	33
Bennett Bay	43.2	23, 577	5	114,414	27	0	0	11
James Bay	18.0	6,549	4	65,613	37	18,830	10	29
Reef Harbour	15.0	58,799	39	0	0	0	0	34
D'Arcy	4.1	15,035	37	0	0	0	0	0
Princess Bay	9.3	46,684	50	0	0	0	0	23
Otter Bay	15.7	5,640	4	19,941	13	0	0	11
Richardson Bay	3.0	3,609	12	2,318	8	597	2	0
Narvaez	4.3	1,602	4	0	0	10,356	24	35
Royal Cove	3.5	202	1	0	0	0	0	52
Russell	14.6	0	0	0	0	46,174	32	16
Beaumont	16.4	0	0	0	0	12,292	8	79
Total	329.61	740,542		417,942		88,250		

Valued Ecosystem Component vulnerability rankings for each study anchorage were determined by two methods: percent coverage by each VEC; and percent overlap of garbage on each VEC. Results vary by method but show a moderate degree of consistency. Winter Cove, Reef Harbour, James Bay, and Russell Island have the same relative rank position and vulnerability category in each method. Richardson Bay, Russell Island, and Beaumont have a low VEC Vulnerability with each method. VEC vulnerability covers a wide range from little to no vulnerability (e.g. Beaumont) to high vulnerability (e.g. Winter Cove ranked highest by both methods). Not all sites investigated in this assessment had sensitive resources present when videotaped for this study. This conclusion is based solely on the present condition and ecological community at this site. No attempt has been made to determine if the present ecological communities are stable and have been continuously present over the last several decades or longer.

Conclusions and Recommendations

This study documented the present distribution of three species potentially vulnerable to anchoring in the 13 main anchorages in GINPR. Additional monitoring of theses sites is recommended to measure the effectiveness of any approach to adaptively manage and protect sensitive resources while allowing visitor experience opportunities to continue at these sites.

There is a high likelihood of anchoring or mooring impacts to GINPR eelgrass meadows due to: 1) shared preference of eelgrass plants and boaters for shallow, protected waters with soft bottoms; 2) peak abundance of plants and boaters during the summer season; 3) lack of mooring facilities at most GINPR anchorages where eelgrass is present; 4) traditional moorings located within eelgrass meadows at Reef Harbour and Sidney Spit; 5) lack of anchoring/mooring exclusion zones to protect sensitive resources like eelgrass; 6) eelgrass occurrence in 11 of 13 anchorages; 7) clumped distribution of eelgrass relative to other VECs; and 8) largest surface area coverage by far of the VECs. Therefore the greatest opportunity to reduce or eliminate impacts to vulnerable sensitive resources in GINPR would be to focus on activities that impact eelgrass meadows. Results from nearby jurisdictions such as the San Juan Islands, indicate that investment of efforts to protect eelgrass, such as voluntary no anchoring areas, are paying off and damaged meadows can recover in a matter of years after the impact source is decreased or eliminated.

There is a moderate likelihood of anchoring or mooring impacts to sea pens in GINPR anchorages due to: 1) presence in six of 13 anchorages; 2) presence year round; 3) moderate overlap with areas of preferred anchoring; 4) moderately dense distribution across the seabed; 5) cyclic colonial behaviour where about ¼ of the colony is exposed above the sediments at a time. Deeper water species such as White Sea pen (*Virgularia sp*.), are not likely to be impacted due to boater preference for shallow, closer to shore anchorages that reduce wind exposure and facilitate trips ashore. Sidney Spit, Bennett Bay, Winter Cove, and James Bay have the largest areas of bottom habitat covered in sea pens. The large Orange sea pen (*Ptilosarcus gurneyi*) colony in the portion of Bennett Bay near the channel between Campbell Point and Georgeson Island is unlikely to be impacted by anchoring as this site is more exposed to wind and has higher current velocities. Skippers typically prefer anchoring or mooring their craft in sites like Sidney Spit that have little to no current, and less wind exposure. The sea pens at Sidney Spit and James Bay are therefore considered to be more vulnerable to anchoring impacts than those at Bennett Bay.

There is a low likelihood of anchoring or mooring impacts to sea anemones in GINPR anchorages because: 1) they are the least abundant VEC in terms of number of anchorages (n=5) where they are present; 2) the amount of substrate area where they are present (approximately one tenth the total area of eelgrass, and one fifth area of sea pens); and 3) are the most sparsely distributed VEC across the substrate where they do occur. These differences support the view that VEC vulnerability based on encounter rates with anchor or mooring tackle would be ranked low for sea anemones (sparse distribution of solitary animals; and smallest surface area coverage). The northern portion of the Russell Island anchorage has the largest occurrence of sea anemones found in this study. This is the deepest part of the study area (approximately 10-20 m), most exposed to wind and currents, and furthest from shore. As most skippers prefer anchoring close to shore in the most protected waters available, the likelihood of anchoring occurring in the deeper waters where anemone are present is further reduced. It is therefore reasonable to conclude that likelihood of anchoring impacting sea anemones is low.

Nearshore marine ecology is very complex and can be heavily influenced from a wide variety of land based and marine based activities. Since Parks Canada has limited control over many of these activities, it should focus on activities for which it has mandated responsibility and control. Management of recreational boating activities, to provide high quality visitor experiences while protecting resources, should be a key focus in the GINPR management plan.

Although a structured methodology was used to derive the VEC vulnerability scores and rankings, the results are not intended to fully represent the relative vulnerability of sensitive seabed in the various study anchorages. The results should therefore be used as guidance only, and not be the sole factor used to prioritize management interventions or further investigations. Levels of anchoring activity must also be taken into account as it is a key factor influencing the probability of impact occurrence to sensitive seabed. Boat use data is beyond the scope of this study but is a key data gap requiring attention in order to effectively assess anchoring impacts and then determine how to manage them.

Key Recommendations:

1. Fill Key Data Gaps
    - Undertake a quantitative boat use study to record and analyse actual levels of mooring and anchoring taking place.
    - Assess if all viable GINPR anchorages have been identified. If new areas are identified, map sensitive habitats as per this study.
    - Assess impacts of anchoring on submerged cultural resources.

2. Manage for Protection of Sensitive Habitats and Species
   Opportunities exist to improve management of anchoring and mooring activities in GINPR by:

    - Installing conservation moorings at priority anchorage sites to protect vulnerable species or habitat (E.g. protect eelgrass by installing mooring buoys in Princess Bay; expanding mooring fields at Sidney Spit and Reef Harbour; and/or converting existing chain moorings to conservation moorings).
    - Instituting a policy for mandatory use of moorings where they are present and available;
    - Developing and implementing an anchoring best practices code for areas where anchoring is permitted;
    - Involving and educating the public and stakeholders in these initiatives, and on the importance of low impact anchoring and mooring methods. VEC conservation would be enhanced if the value of these resources was better understood by boaters. Parks Canada should develop communication products to clearly communicate these values.
    - Voluntary anchor exclusion zones have been used in other jurisdictions to prevent anchoring damage to sensitive resources, especially seagrass meadows. This management technique has been effective in the nearby San Juan Islands of Washington State. The program helped accomplish two very important outcomes: firstly, it increased resource protection; and secondly, it enhanced public understanding of the importance of eelgrass meadows in the ecology of nearshore areas, their vulnerability to anchoring, and the need to protect them. Gulf Islands National Park Reserve may wish to explore options for voluntary anchoring exclusion zones at select locations within the park.
    - Assessing the need/viability/desirability for sensitive seabed restoration at existing anchorages.

Preliminary Assessment of the Status of Subtidal Habitat at Thirteen Anchorages within Gulf Islands National Park Reserve of Canada

PURPOSE AND NEED

Gulf Islands National Park Reserve of Canada (GINPR) lies in the Strait of Georgia on Canada's Pacific coast between the cities of Victoria and Vancouver. The park is part of an archipelago, the Gulf Islands, which still retain a pastoral ambiance despite their close proximity to large urban centres. GINPR was created in 2003 from a combination of purchased private properties, and crown lands transferred to Canada from the Province of British Columbia. Many of the transferred BC crown lands were previously protected areas in the BC Provincial Parks system (e.g. Cabbage Island, Portland Island). There is a well established and long standing use of these sites by recreational boaters as the Gulf Islands offer some of the safest and most scenic marine waters in Canada. Large numbers of sail and power boats use these waters each year. The climate is mild enough for committed boaters to operate year round. Use levels vary widely with the seasons. Anchorages are generally well protected, and most heavily used from May through October with a peak of use in July and August. Mooring buoys are available at three (Sidney Spit; Beaumont; Reef Harbour) of the thirteen anchorages assessed in this study. Consequently, anchoring is required at a majority of the anchorages within GINPR. Large yacht clubs are located in nearby Vancouver (e.g. Royal Vancouver), Victoria (Royal Victoria), and Sidney, BC. Boaters from Washington State (Seattle-Puget Sound; Olympic Peninsula; San Juan Islands) also make regular use of these waters.

Since its establishment, GINPR has been guided by Interim Management Guidelines. The process to develop the Park's first management plan is currently underway. Management of boat anchoring and mooring is an important issue to be discussed during plan development. In August 2010, Wayne Bourque, Superintendent of Gulf Islands National Park Reserve, approached resource conservation staff in the Vancouver office of the Western and Northern Service Centre (W&NSC) with a request to conduct an investigation into the condition of benthic habitats in the most heavily used anchoring areas in the park. The intent of the work was to map and describe the existing benthic habitat in each anchorage area, identify resources or species likely to be sensitive to anchoring and mooring activities, and to provide recommendations to help inform discussions with the public and boating stakeholders during the management planning process. Deliverables included underwater videotape coverage of benthic (bottom) areas in the study anchorages, and a series of reports presenting study methods, results, and recommendations. This work is consistent with direction from the Gulf Islands National Park Reserve Interim Management Guidelines[4] (2006).

USE OF THIS REPORT

Study Scope

This study was:

- ✓ A preliminary investigation of benthic (bottom substrate) habitats at thirteen (13) popular anchorages within GINPR;

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[4] Section 7.1.4 (Boating) of the GINPR Interim Management Guidelines (2006) lists the following management actions:

1. Conduct or support research to identify sensitive marine areas.
2. Evaluate the impact of current mooring and anchoring sites and practices on the marine environment, and work with the marine community to seek solutions for any negative effects.
3. Work with partners to conduct or support initial research regarding the carrying capacity of key marine use areas within the park in order to provide information for the Park Management Plan.
4. If information indicates that mooring buoys or anchoring are causing significant impact to the marine environment, work cooperatively with the yachting and marine communities to determine possible alternative locations or solutions.

- ✓ A record of the types of substrates, habitat types and organisms at these sites based on analysis of underwater video transects through these sites;
- ✓ A literature search on types of valued ecosystem components in northeast Pacific Ocean nearshore habitats, and impacts of recreational boat anchoring and mooring on these habitats;
- ✓ A series of reports documenting the methods, analysis, results, discussion of results, and recommendations for next steps or further investigation for the study sites.

This study was not:

- × A detailed cause-effect investigation of the impacts of recreational boat mooring and anchoring on marine resources at these sites;
- × An assessment of the effects of all recreational boating activities (e.g. fuelling; waste management) upon marine resources at these sites.

Organization of This Document

Several reports and map series were created as part of this work. Results of various reports are briefly summarized in the body of this main report. Supporting reports are appended. Documents have been organised as shown in Table 1.

METHODOLOGY

Geographic Scope

The geographic scope for this study was thirteen anchorages within Gulf Islands National Park Reserve in British Columbia's Gulf Islands. Relative locations of the anchorages within the Gulf Islands archipelago are shown on Figure 1. Characteristics and site amenities for each anchorage are briefly summarized in Table 2.

Summary of Assessment Methodology

A team of W&NSC staff comprised of Tomas Tomascik (Senior Marine Advisor), Cliff Robinson (Marine Ecologist), and Steve Oates (Environmental Assessment Scientist) met to discuss the project, and develop a methodology for undertaking the necessary field work. In discussion with GINPR staff, a set of 13 candidate anchorage areas was selected based on existing anchoring patterns from observations from GINPR operations staff and managers.

Study area boundaries for each site were refined based on feedback from GINPR staff to focus effort on areas within each anchorage that receive the majority of use by the boating public. A GINPR boat was rigged to collect geo-referenced underwater video survey transects. Transect data was recorded onto videotape with a standard definition video equipped remotely operated underwater vehicle (ROV), or a towed underwater video camera tethered to the boat. Portions of the videotapes were reviewed to determine the types and extent of marine habitats and species present in the study sites. A habitat classification scheme was then developed based on preliminary viewing of the tapes in combination with results of a review of marine classification systems. All videotape coverage was then analysed, the results saved in a relational database, and then entered into an Arc Map geographical information system (GIS). This provided comprehensive data on the spatial extent and distribution of seabed habitats and their associated species. Sensitive resources were then identified based on: 1) their relative presence in the study sites; 2) a literature review on anchoring effects; and 3) expert opinion. Additional details on study methodology and results of this portion of the study are provided in the reports in Appendices Volume 1: Supporting Reports

Appendix 1	Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Methods & Definitions
Appendix 2	Metadata for the Subtidal Habitat Assessment for Gulf Islands National Park Reserve
Appendix 3	Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Results

At this point in the study, the following maps were created for each anchorage: Video transect coverage, Substrate, Eelgrass, Sea anemones, Sea pens, Algae, Invertebrate coverage, and Garbage. The content of these maps is briefly described in Table 1, and more fully described in Appendix 3. Maps themselves are in Appendices Volume 2: Maps.

Table 1 Document Organization

<table>
<tr><th>Item</th><th>Location</th><th colspan="2">Content</th></tr>
<tr><td>Main Report: Preliminary Assessment of the Status of Marine Resources at Thirteen Popular Anchorages within Gulf Islands National Park Reserve of Canada.</td><td></td><td colspan="2">Narrative report with study methods, environmental setting, impact analysis, valued ecosystem component (VEC) identification and evaluation, VEC vulnerability to anchoring and mooring, conclusions and recommendations, and detailed references by topic.</td></tr>
<tr><td>Supporting Report: Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Methods & Definitions.</td><td>Appendices Volume 1: Supporting Reports

Appendix 1</td><td colspan="2">This document describes the methodology and definitions used during the video collection and analysis portion of the Gulf Island National Park Reserve anchorage study.</td></tr>
<tr><td>Supporting Report: Metadata for the Subtidal Habitat Assessment for Gulf Islands National Park Reserve.</td><td>Appendix 2</td><td colspan="2">This report documents the marine classification and database categories used during the video analysis, data capture, and data analysis portions of the Gulf Island National Park Reserve anchorage study. Report content includes: attribute definitions and catalogues, finalized datasets, GIS data layers and maps, raw data, and data filing systems.</td></tr>
<tr><td>Supporting Report: Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Results.</td><td>Appendix 3</td><td colspan="2">This report documents results of the video analysis undertaken for the subtidal habitat assessment project in Gulf Islands National Park Reserve. Results for each study site are briefly summarised in the narrative of the report, and supported by a series of maps ranging from Video transect coverage, to Garbage.</td></tr>
<tr><td rowspan="12">Map series for each of the 13 study sites.</td><td rowspan="12">Appendices Volume 2: Maps</td><td>Map</td><td>Description</td></tr>
<tr><td>Video transect coverage</td><td>Maps show the location of all video transects with useable footage for each anchorage (i.e. view plane of camera shows bottom habitat).</td></tr>
<tr><td>Substrate</td><td>Maps depict all of the dominant substrate types encountered during videotape transect analysis.</td></tr>
<tr><td>Eelgrass</td><td>Valued Ecosystem Component (VEC): Maps show the locations of Eelgrass (Zostera marina) meadows in all anchorages where they occur.</td></tr>
<tr><td>Sea anemones</td><td>Valued Ecosystem Component (VEC): Maps show the locations of sea anemones encountered during videotape transect analysis.</td></tr>
<tr><td>Sea pens</td><td>Valued Ecosystem Component (VEC): Maps show the locations of all sea pens encountered during videotape transect analysis.</td></tr>
<tr><td>Algae</td><td>Maps show the coverage of all the algae encountered during videotape transect analysis.</td></tr>
<tr><td>Invertebrate coverage</td><td>Maps depict invertebrates encountered during videotape transect analysis that are not considered to be sensitive.</td></tr>
<tr><td>Garbage</td><td>Maps show locations and description of all objects encountered during videotape transect analysis considered as human generated garbage.</td></tr>
<tr><td>Seabed Sensitivity</td><td>Maps depict the coverage of all the biotic categories defined as being sensitive to anchoring including the 3 VECs (eelgrass, sea pens, and sea anemones).</td></tr>
<tr><td>Anchoring suitability</td><td>Maps show areas of medium or high anchoring suitability based on 3 criteria: depths $\leq$ 20 m, substrate holding power, and garbage cluster presence as an indicator of past use.</td></tr>
<tr><td>VEC Vulnerability</td><td>Maps show the degree of overlap of valued ecosystem components (eelgrass, sea pens, and sea anemones) and garbage. In the absence of detailed boat use data, garbage presence is used as an indicator of preferred or highly used sites within individual anchorage areas.</td></tr>
</table>

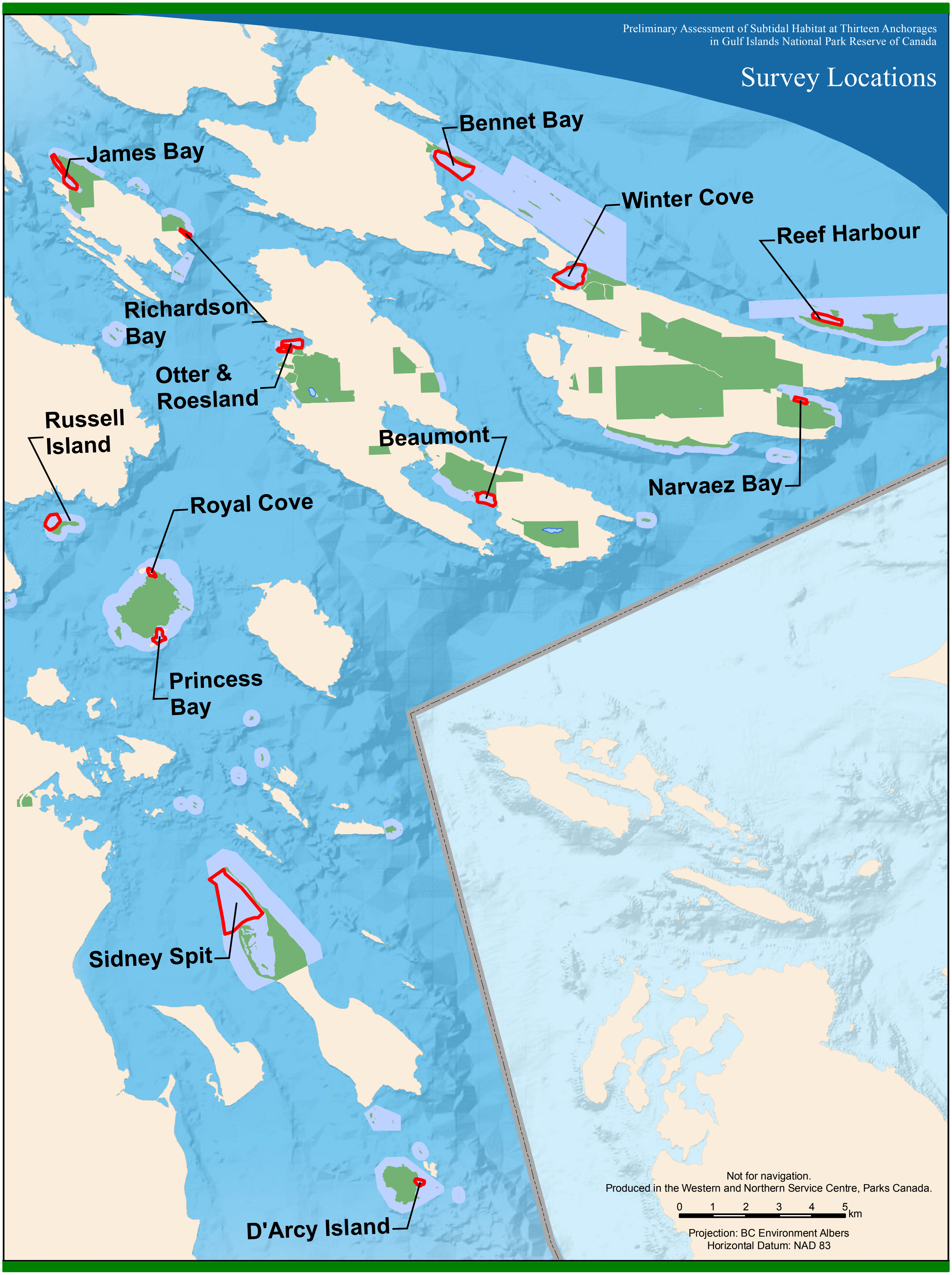
Preliminary Assessment of Subtidal Habitat at Thirteen Anchorages
in Gulf Islands National Park Reserve of Canada
Survey Locations
Bennet Bay
James Bay
Winter Cove
Reef Harbour
Richardson Bay
Otter & Roesland
Russell Island
Beaumont
Narvaez Bay
Royal Cove
Princess Bay
Sidney Spit
D'Arcy Island
Not for navigation.
Produced in the Western and Northern Service Centre, Parks Canada.
0 1 2 3 4 5 km
Projection: BC Environment Albers
Horizontal Datum: NAD 83

Table 2 Summary of Anchorage Site Characteristics and Amenities

Site Name	Location	Overview of Site Characteristics and Amenities
Beaumont	South Pender Island	Large and very popular anchorage which receives heavy use during peak summer periods. Good anchor holding power in soft bottom sediments throughout the site. Exposed to S winds. Site amenities include 15 mooring buoys; sandy beach; campground with 11 campsites; day use area with picnic sites and pit toilets; access to Mount Norman hiking trail, a popular trail and viewpoint. Canada Customs point of entry, pub, and marina located nearby at Poets Cove Resort in Bedwell Harbour. Sidney North Saanich Yacht Club provides information to boaters from a marine host float in the bay during summer months.
Bennett Bay	Mayne Island	Located on the SE tip of Mayne Island, Bennett Bay has a sand beach for shore landings; relatively pristine waterfront; remnant old growth forest; walking trail to viewpoint at Campbell Point; and pit toilets. This is a popular launch spot for kayakers exploring Tumbo, Cabbage, and Saturna Islands. The site is somewhat exposed to SE winds, as well as wind and current in the passage between Campbell Point and Georgeson Island. Generally used as a temporary day anchorage or in settled conditions. No Parks Canada marine facilities are present.
D'Arcy Island	D'Arcy Island	The main anchorage area is on the south side of D'Arcy Island. Long history of First Nations use of the island, and more recently as a leper colony in late 1800s to early 1900s. Site amenities include 7 campsites; picnic tables; and pit toilets. Anchorage quite exposed to winds from Haro Strait, in particular from the SE. Generally used as a day anchorage in settled conditions.
James Bay	Prevost Island	On the northern tip of Prevost Island on Trincomali Channel. Boat accessible only. Gravel beach landing in James Bay and nearby open camping in former fruit orchard area, make this site popular with kayakers. Well sheltered from all except NW winds.
Narvaez Bay	Saturna Island	Located on the SE tip of Saturna Island, Narvaez Bay provides a large anchoring area. Most users anchor in the most protected portion of the site at Little Bay near the site of a former homestead. Anchorage somewhat exposed to E winds. Excellent trail network leads to Echo Bay, and a loop trail to Monarch Head viewpoint. Site amenities include a landing beach; 7 campsites; picnic site; and toilets.
Russell Island	Russell Island	A large sheltered anchorage on the NW end (lee side) of the island, with a landing float and shore ramp; hiking trails; and historic buildings (house and sheds) from Hawaiian (Kanaka) settlers of the late 1800s. Somewhat exposed to NW and E winds as well as BC Ferries vessel wake. Beautiful white shell swimming beach on NW tip of island. One to two knot current.
Otter Bay & Roesland	North Pender Island	Large anchoring area in Otter Bay with good holding on mud bottom. The site is protected from SE winds but somewhat exposed to westerlies and BC Ferries vessel wake. Ella Bay, the small bay south of Roe Islet on the Roesland property, provides similar anchoring conditions to those in Otter Bay. Amenities at these sites include a dingy dock; washrooms; beach access; park office; picnic area; trail and viewpoint on Roe Islet; and museum.
Princess Bay	Portland (aka Princess Margaret Island)	Princess Bay is a popular, well protected summer anchorage. A dock provides boater access to Portland Island trails and facilities. As the bay opens to the south, sustained south winds can result in swell large enough to cause concern to anchored boats. A well developed network of cross island and perimeter trails is in place. The dock provides direct access to the trail network. The Royal Victoria Yacht Club provides information to boaters from a marine host float in the bay during summer months.
Reef Harbour	Between Tumbo and Cabbage Islands	A popular anchorage between Tumbo Island (to the south), and Cabbage Island (to the north) with good holding ground. Somewhat exposed to winds from Strait of Georgia, as well as NW winds. Best used in settled, calm conditions. Amenities include 10 mooring buoys; 5 campsites on Cabbage Island; composting toilets; and a loop trail, picnic site, and pit toilets on Tumbo Island.
Richardson Bay (aka Portlock Point)	Prevost Island	Infrequently used anchorage sheltered from NW winds but somewhat exposed to S winds and wake from BC Ferries vessels. No marine or shore facilities are present other than the 1895 Portlock Point Lighthouse.
Royal Cove	Portland Island	Popular anchorage with good holding power on soft bottom but somewhat exposed to BC Ferries vessel wake. Stern ties are available for use when anchorage is busy. Amenities include dingy dock, excellent network of perimeter and cross island trails, access to nearby swimming beach, stern ties, 6 campsites at Arbutus Point, and a composting toilet.
Sidney Spit	Sidney Island	Highly popular, large anchorage with good holding on sandy bottom. Exposed to NW and SW winds. One to two knot current often present. Amenities include 21 mooring buoys; trail network; composting toilets; 26 campsites; group campsite; potable water; sandy swim beaches; anchoring area; and picnic shelters. Site is in close proximity to marinas and services at Sidney, BC.
Winter Cove	Saturna Island	Large, very well protected anchorage between NW tip Saturna Island and Samuel Island to the north. Good anchoring in mud throughout the cove. Exposed to NW winds and shallow areas with drying reefs/rocks. No mooring buoys available. Shore amenities include a good landing beach; dingy dock; well developed trail system; viewpoint of strong tidal currents on flood tide at Boat Passage; picnic site; and pit toilets. Very high level of marine use as host site for Saturna Island Lamb Barbeque held each year over a summer weekend. One to two knot current present.

Sources:

1. Parks Canada Website http://www.pc.gc.ca/pn-np/bc/gulf/carte-map-nfl.aspx
2. Gulf Islands National Park Reserve Hiking and Camping Map/Brochure http://www.pc.gc.ca/pn-np/bc/gulf/~/media/pn-np/bc/gulf/pdf/2011-randonnee-hiking_e.ashx
3. Best Anchorages of the Inside Passage. Anne Vipond and William Kelly. 1st Edition. Ocean Cruise Guides. 2006.

The next step was to generate seabed sensitivity maps for each anchorage by visually interpolating transects data for each VEC (Eelgrass, Orange sea pens, and sea anemones) into polygons. An anchoring suitability map was then derived for each anchorage by combining information on substrates suitable for anchoring, occurrence of water depth ≤ 20m, and the presence of garbage on the seabed (as an indicator of past use derived from underwater videotaping). The final step was to combine the content of the seabed sensitivity and anchoring suitability maps to identify and quantify the degree of overlap between anchoring activities and VECs. The resulting VEC Vulnerability map series shows the potential for direct interaction between sensitive benthic habitat (as represented by the 3 VECs), and boat anchoring and mooring activities.

Data Gaps / Uncertainty

Several data gaps became apparent as the study progressed. These gaps introduce potential sources of uncertainty when predicting the impacts of anchoring and mooring on marine benthic habitat. The degree of uncertainty varies by the factor under consideration. For example, very little is known about the potential for anchoring or mooring activities to adversely impact sea anemone communities, while more is known about impacts to sea pen communities, and much more is known about the impacts to eelgrass meadows.

Other data gaps identified while conducting this assessment include:

- Lack of detailed, quantitative information on boat use patterns (distribution, frequency, duration, vessel type, percent anchoring versus mooring, number of anchors deployed per vessel, seasonal use pattern).
- Potential impacts of boating anchoring on submerged cultural resources.
- Historical distribution and abundance of sensitive benthic habitats in these anchorages.
- Eelgrass is a perennial plant with maximum growth in summer, and that typically partially dies back in fall in the northeast Pacific. Inventory and survey work done in winter, such as was done in this study, may therefore under represent the spatial extent of Eelgrass meadows within the anchorages.
- No information was collected on subtidal habitats in areas adjacent to the 13 study anchorages. This may become an important data gap to address if a decision is made to establish voluntary no anchoring exclusion areas within some of the existing GINPR anchorages.
- Incomplete video coverage and data analysis for Sidney Spit anchorage. Eelgrass data is available for the whole anchorage, but data for other marine species and garbage occurrence is only available from the western portion of the study site where video taping was conducted.

ENVIRONMENTAL SETTING

Physiographic Setting

Gulf Islands National Park Reserve is located in the Georgia Depression, a large shallow basin stretching from southeast Vancouver Island to the Fraser River lowlands (Fraser River delta and estuary, and Fraser Valley) in Vancouver's lower mainland. The Gulf Islands and Strait of Georgia occupy the central portion of the depression. Physiography of the area has been heavily influenced by tectonic forces such as coastal subduction[5] and mountain building at plate margins, as well as glaciation. During the Pleistocene, large glaciers from eastern Vancouver Island and the west coast of the BC mainland coalesced into one large mass that flowed south through Puget Sound and Juan de Fuca Strait. Glacial erosion created a deep depression into which large thick deposits of morainal rocks, sands, and silts were deposited during glacial retreat. These materials have been redistributed over time by gravity, wind and water to produce the mixture and distribution of surficial features we see today. The Strait of Georgia has many small to very small islands and islets. Saltspring Island is the largest Gulf Island at 183 km^2, and D'Arcy among the smallest at less than 1 km^2. Most of the Gulf Islands have bedrock geology, although a few such as Sidney, are wholly composed of glacially deposited sand and gravel (Demarchi 2011).

[5] The Strait of Georgia is part of the Cascadia subduction zone, the name given to the boundary between the oceanic plate and the North American continental plate. The Cascadia subduction zone runs from Northern Vancouver Island to northern California. As the oceanic plate expands and moves eastward, it is forced beneath the continental plate where they meet, the so called subduction zone.

Study Process

Identify candidate study sites

↓

Staff review and feedback

↓

Final study site selection

↓

Record underwater video transcects

↓

Preliminary quick scan of video tapes

↓

Select classification categories

↓

Analyse video tapes

↓

Record results in database & GIS

↓

Produce preliminary results tables and maps

↓

Interpolate sensitive species transects into polygons to create Seabed Sensitivity map series

↓

Develop Anchoring Suitability map series

↓

Overlay Anchoring Suitability and Seabed Sensitivity maps

↓

Produce VEC Vulnerability map series

Literature Review: video methods and marine classification schemes

Literature Review: species and ecosystem sensitivities to anchoring and mooring

Reports and Maps

Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Methods and Definitions
Prepared for Parks Canada
By Matthew Drake, May 2011
(Appendices Volume 1)

Metadata for the Subtidal Habitat Assessment for Gulf Islands National Park Reserve
Prepared for Parks Canada
By Matthew Drake, May 2011
(Appendices Volume 1)

Subtidal Habitat Assessment for Gulf Islands National Park Reserve: Results
Prepared for Parks Canada
By Matthew Drake, May 2011
(Appendices Volume 1)

Preliminary Assessment of Subtidal Habitat at Thirteen Anchorages within Gulf Islands National Park Reserve of Canada

Appendices Volume 2: Maps

Oceanographic Setting

Three major factors influence oceanographic processes, and ultimately sensitive habitats, in the southern Strait of Georgia (SSG) in summer (May-Aug): 1) Fraser River discharge; 2) Northwesterly winds; and 3) strong mixed, mainly semi-diurnal tides[6]. The SSG is considered a large semi-enclosed basin with an estuarine circulation pattern. In this system the freshwater discharge of the Fraser River flows towards the Vancouver Island continental shelf which induces a return deepwater flow of salt water drawn from the continental slope via the Straits of Juan De Fuca. The surface flowing Fraser River plume extends across the southern Strait and pushes up against the outer southern Gulf Islands (e.g., Mayne and Tumbo), and it is clearly visible as warmer (red) water in the satellite image in Figure 3. The main features of the Fraser plume that influence the area are low salinities, higher water temperatures, and inputs of nitrates (the latter of which are limiting in marine systems). The deep inward returning oceanic flow in Juan de Fuca Straits consists of cold, high salinity oceanic water and contributes to the renewal of SSG deeper waters by re-oxygenation and replenishment of nutrients (LeBlond 1983).

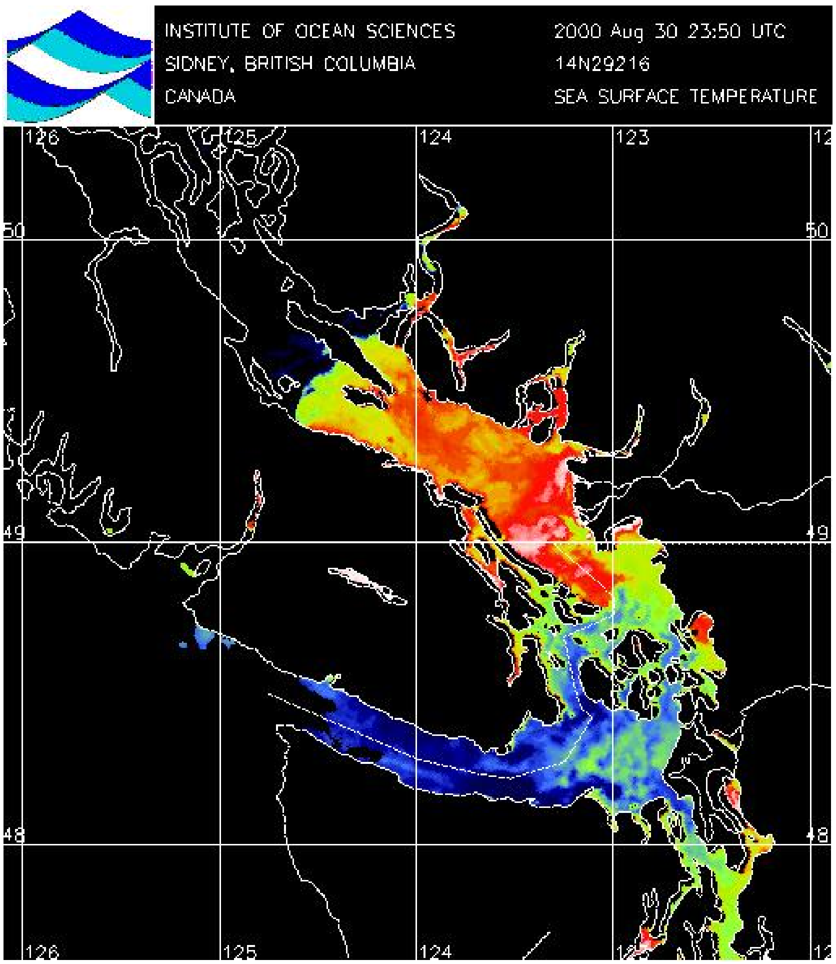

Figure 3
Sea surface temperatures in the Strait of Georgia and Juan de Fuca Strait, August 2000. Red indicates warm water, blue colder. Most of the GINPRC lies in the mixing area. The influence of the Fraser River is clearly visible (red).

The combined actions of river runoff, wind and tides lead to temporally and spatially varying patterns of current and water properties in the SSG. The interior of the southern Gulf Islands is bounded from the SSG by several well-defined tidal passages (Dodd's Narrows, Active Pass, and Porlier Pass). The tidal passages are narrow and shallow, and are the site of strong topographic upwelling, where deep waters are brought to the surface (LeBlond 1983). These tidal passes 'isolate' the interior Gulf Islands from strong surface freshwater influence. Hence, the waters within the southern Gulf Islands tend to be less influenced by freshwater driven estuarine circulation or tidal currents and more so by regional winds, coastline and bottom topographic effects (Thomson 1981). Figure 4 shows areas of high tidal current velocity in the water column as orangey red, and slow moving waters as blue-green. As expected, the anchoring areas examined in this study are in regions of low tidal speed.

[6] Mixed semidiurnal tides exhibit differences in tidal elevation between successive high tide levels, and between successive low tide levels. This is known as diurnal inequality. In the SSG the tide pattern is always, Higher High Water, Higher Low Water, Lower High Water, Lower Low Water (Thompson 1981).

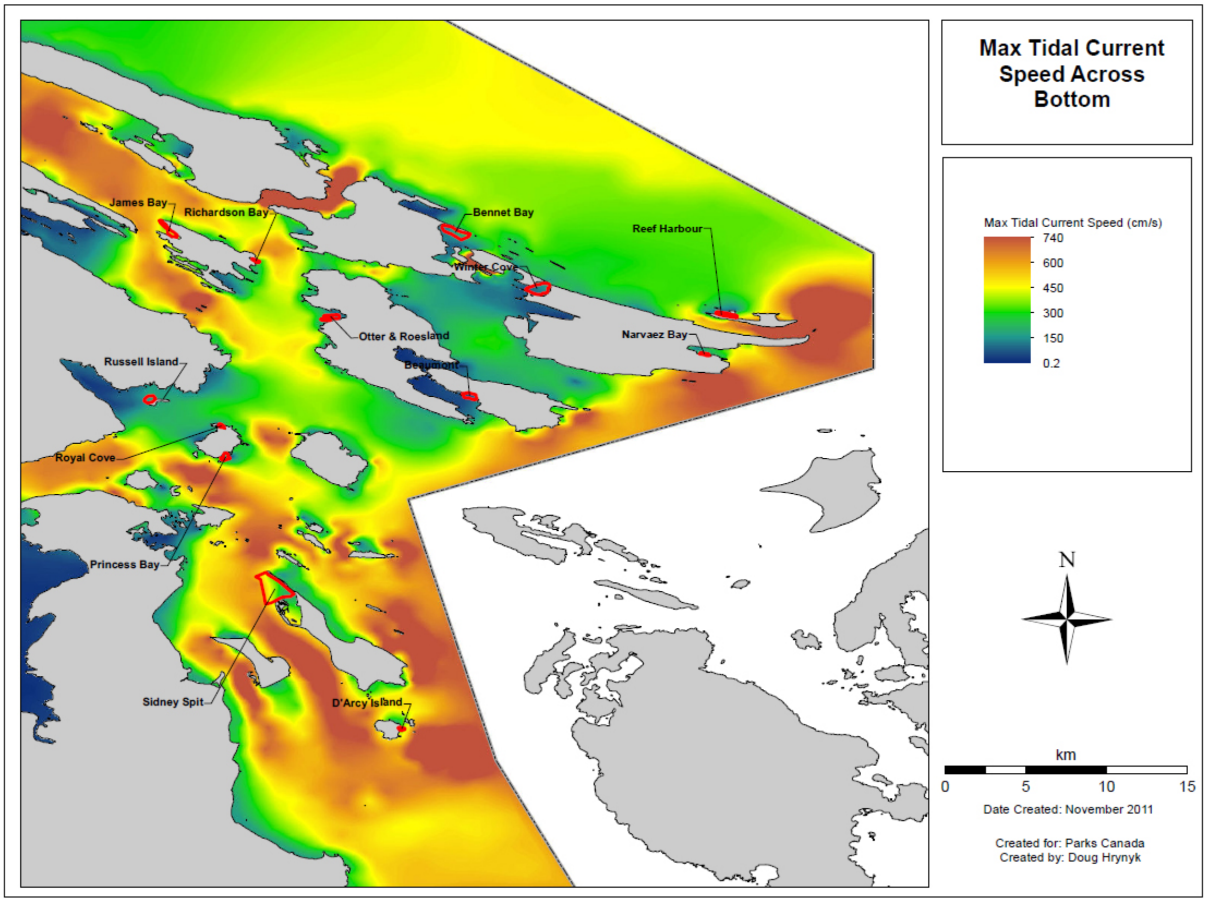

Figure 4
Mid water column tidal velocities[7].

The dominant regional and generalized wind direction in British Columbia is from the northwest in the summer (associated with North Pacific High Pressure system off California) and from the southeast in winter (associated with the Aleutian Low off southern Alaska). Within this regional context, Georgia basin winds tend to move in one direction, then back in the opposite direction. When a weather system moves south across Vancouver Island, winds are drawn up the Strait from the southeast (e.g., out of Puget Sound), channel through Haro Strait into Swanson Channel, and eventually funnel into the southern SSG. The San Juan Islands provide some leeward protection to south Pender and Saturna islands. At any time of the year, when a small ridge of high pressure develops over the Fraser Valley and along the Cascade Mountains, a pushed wind develops that is stronger along the Vancouver Island side than the mainland side. These northwest winds blow down the Strait of Georgia and turn through the Gulf and San Juan Islands into Juan de Fuca Strait as northeasterlies.

Coastal and Ocean Resources Incorporated, an environmental consulting company from Victoria British Columbia, has developed a coastal habitat mapping and classification known as ShoreZone. It uses spatially referenced aerial photography of intertidal and nearshore environments. The system enables estimation of shoreline exposure to wind and waves from observations of biotic assemblages in the intertidal zone. Intertidal species generally have very specific energy tolerance ranges (e.g., eelgrass prefers low exposure levels). By carefully noting key indicator species and assemblages, the wave exposure of each shore unit along a length of coast can be estimated.

[7] Tidal velocity values shown were derived from a 3-dimensional, triangular-grid, barotrophic finite element model known as FUNDY5SP. It is an extension of the FUNDY5 model described in Forman et al. (2008).

ShoreZone results for the Southern Strait of Georgia indicate four Biological Wave Exposure categories:

- Semi-Exposed: wave fetch in the range of 50 km to 500 km.
- Semi-Protected: wave fetch between 10 and 50 km.
- Protected: wave fetch less than 10 km.
- Very Protected: wave fetch less than 1 km.

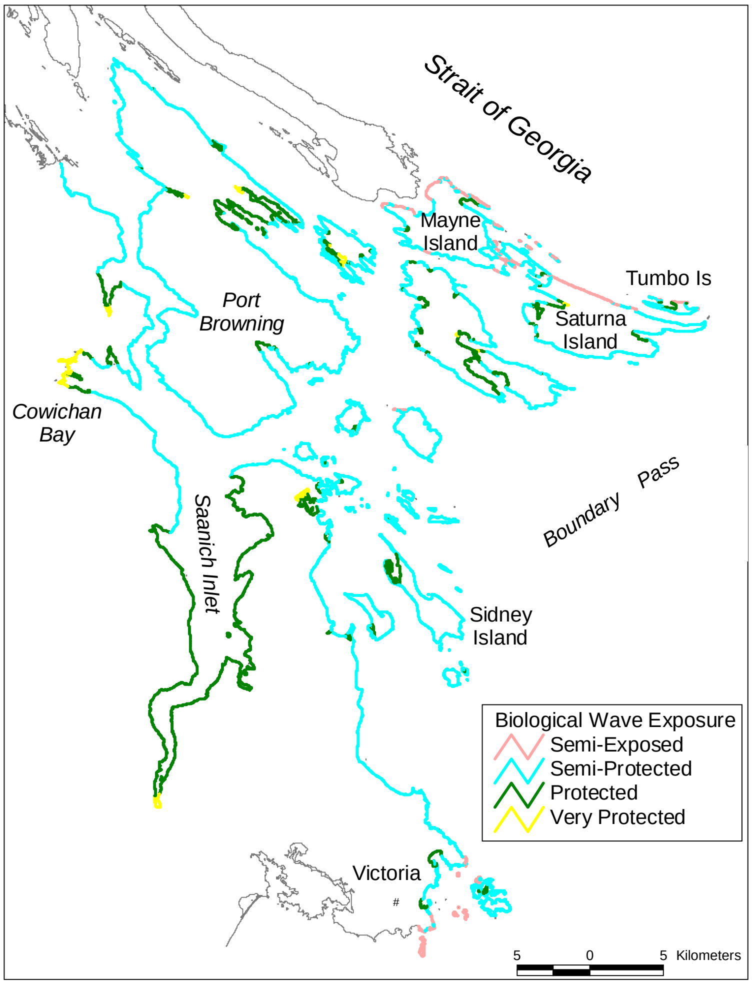

Figure 5
Wave exposure estimated by Coastal and Ocean Resources Inc. ShoreZone system from observations of key indicator species and assemblages (Coastal and Ocean Resources Inc. 2005).

As Figure 5 shows, the majority of the southern Gulf Islands have low-energy shoreline: 68% is classified as semi-protected exposure, 25% as protected, and 3% as very protected. The small semi-exposed areas on the figure are those sections open to the larger fetches in the Straits of Juan de Fuca, and Georgia. Some narrow wind protected passages such as Active Pass, have higher than expected biological wave exposure rankings. In these locations, the higher energy levels are related to high current energies during maximal tidal flows, rather than greater wind exposure. The 13 GINPR anchor study sites are all in the Semi-Protected (majority), and Protected categories.

Natural Resources Canada has developed a system to derive sediment classes using high resolution (< 5m) acoustic backscatter data from multi-beam imagery collected in waters > 40m deep in the SSG. Although no direct relationship exists between backscatter amplitude and surficial sediment type, backscatter data can be cautiously used to classify sediment sizes. For angles of incidence > 20°, there is a correspondence between backscatter strength and surficial sediment roughness. This correlation can be used for cursory mapping and sediment identification. Based on the limited area of interpreted acoustic backscatter for the southern Gulf Islands, the distribution and extent of 8 substrate classes are shown in Figure 6. The predominate seabed substrate for Otter Bay, Narvaez Bay, Richardson Bay, Sidney Spit and Beaumont is a combination of sand and mud. Russell, D'Arcy, Royal Cove, Princess Bay, and Reef Harbour anchorages are mainly surrounded by rocky type substrates. Acoustic backscatter data is not available for Winter Cove, Bennett Bay, and James Bay at the present time.

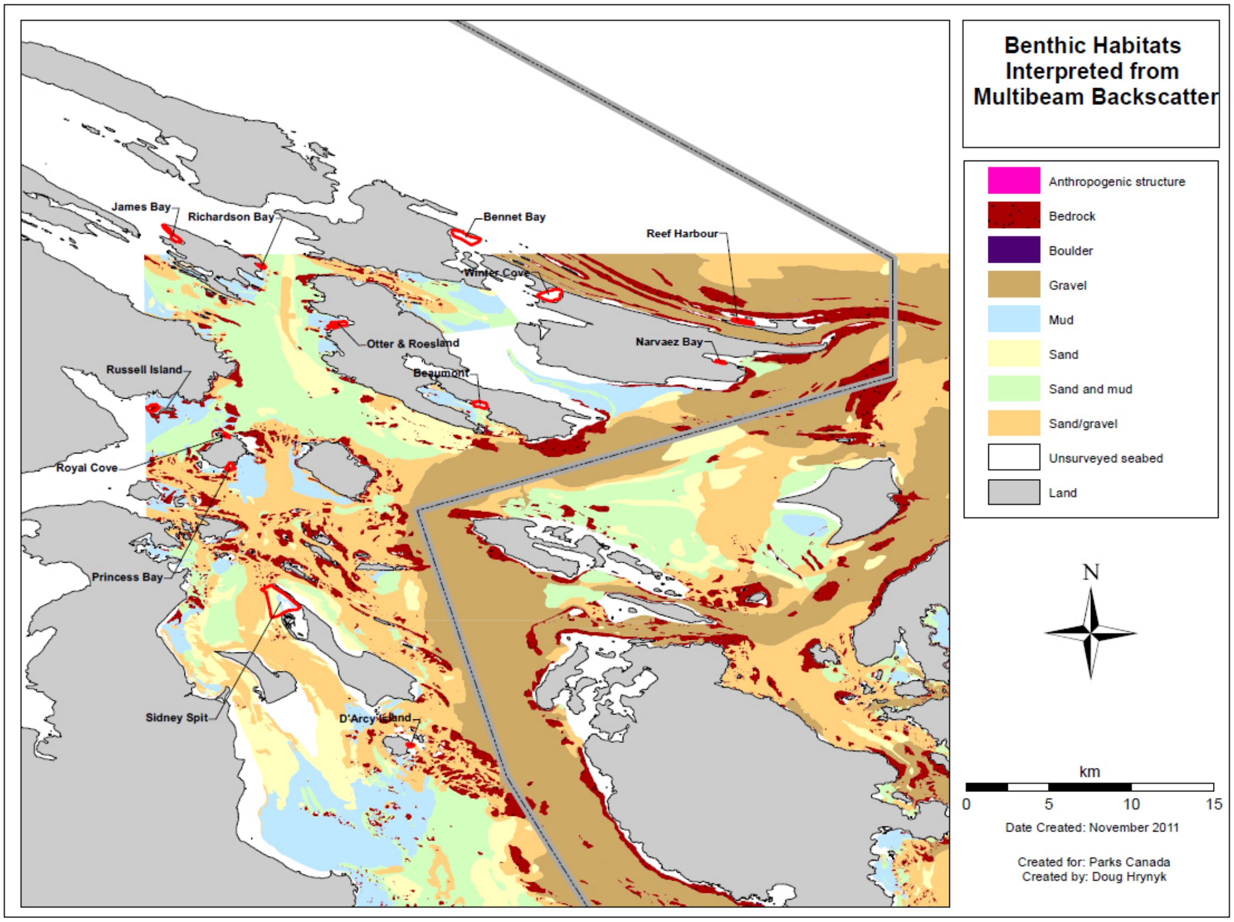

Figure 6
Benthic Habitat Surficial Sediment Classes Interpreted from Multibeam Backscatter

SENSITIVE ECOSYSTEM MAPPING RESULTS

Table 3 lists anchorage study site sizes (area in hectares), and the percent coverage by each VEC, and garbage. Anchorage size varies considerably from Sidney Spit at 1.39 km^2 (139 hectares[8]) on the large side, to tiny Richardson Bay at just 0.03 km^2 (3 hectares). This broad range influences the relative occurrence of VECs both in terms of presence/absence (larger habitat area = higher probability of presence of a wider variety of VECs), and quantity (larger area of benthic habitat covered) where VECs do occur. The series of figures below Table 3 displays the same information in an alternate, more visual format.

In general, eelgrass was the most widely distributed VEC, being found in 11 of 13 anchorages. Four of thirteen anchorages had fairly large eelgrass meadows with areas > 50,000 m^2. Two anchorages, Beaumont and Russell Island, had no eelgrass present, but had the highest surface area of anemones of the 13 study sites. The largest, dense patches of Orange sea pens were found at Bennett Bay, James Bay, Sidney Spit and Winter Cove. Otter Bay and Richardson had small areas of sparse Orange sea pens.

Maps showing occurrences of sensitive ecosystems and garbage for each study site are in Appendices Volume 2: Maps.

[8] One square kilometre (km^2) = 100 hectares or 1,000,000 m^2

Table 3 Study Site Areas, and percent coverage by VECs and Garbage

Anchorage		VEC Occurrence						Garbage Occurrence
Anchorage Study Site	Study Site Area (hectares)	Eelgrass coverage m^2	Eelgrass coverage %	Sea pen coverage m^2	Sea pen coverage %	Sea anemones coverage m^2	Sea anemones % coverage	Garbage % coverage
Sidney Spit	138.6	327,035	24	143,415	10	0	0	19
Winter Cove	44.1	251,810	57	72,241	16	0	0	33
Bennett Bay	43.2	23, 577	5	114,414	27	0	0	11
James Bay	18.0	6,549	4	65,613	37	18,830	10	29
Reef Harbour	15.0	58,799	39	0	0	0	0	34
D'Arcy	4.1	15,035	37	0	0	0	0	0
Princess Bay	9.3	46,684	50	0	0	0	0	23
Otter Bay	15.7	5,640	4	19,941	13	0	0	11
Richardson Bay	3.0	3,609	12	2,318	8	597	2	0
Narvaez	4.3	1,602	4	0	0	10,356	24	35
Royal Cove	3.5	202	1	0	0	0	0	52
Russell	14.6	0	0	0	0	46,174	32	16
Beaumont	16.4	0	0	0	0	12,292	8	79
Total	329.61	740,542		417,942		88,250		

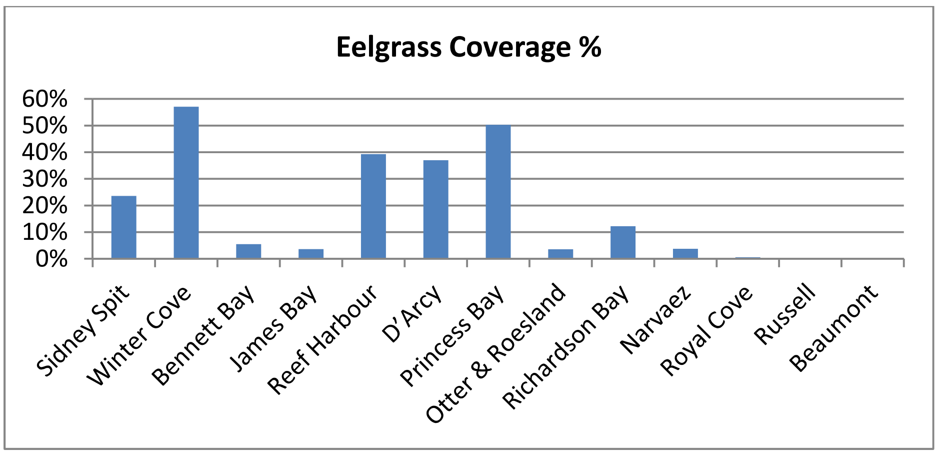

Figure 7 Eelgrass percent coverage at GINPR anchorage study sites

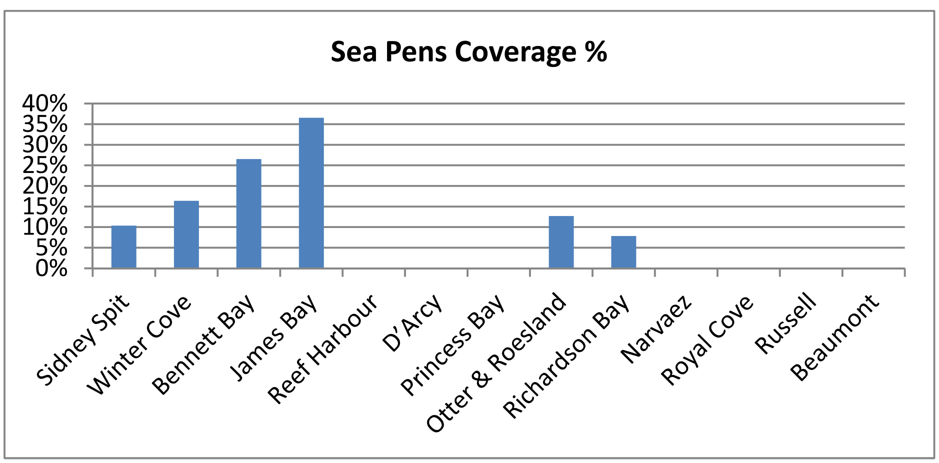

Figure 8 Sea Pens percent coverage at GINPR anchorage study sites

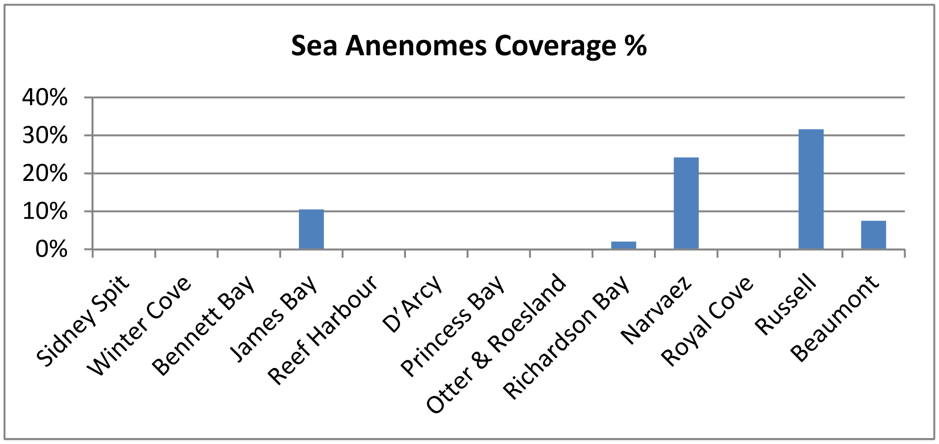

Figure 9 Sea Anemone percent coverage at GINPR anchorage study sites

Videotape analysis of the underwater survey transects indicated garbage is present in about one tenth of Bennett Bay, and Otter Bay & Roesland; ¼ of Sidney Spit, and Princess Bay; ⅓ of the anchorage area at Winter Cove, James Bay, Reef Harbour, and Narvaez Bay; ½ of Royal Cove; and ¾ at Beaumont. No garbage was noted at D'Arcy Island or Richardson Bay. Note that garbage on the seabed, sea pen and sea anemone coverage shown in Table 3 and Figures 8, 9, and 10 will underestimate actual occurrences for Sidney Spit as only the western portion of the anchorage was videotaped for this study, but the complete study area was used when calculating percent coverage.

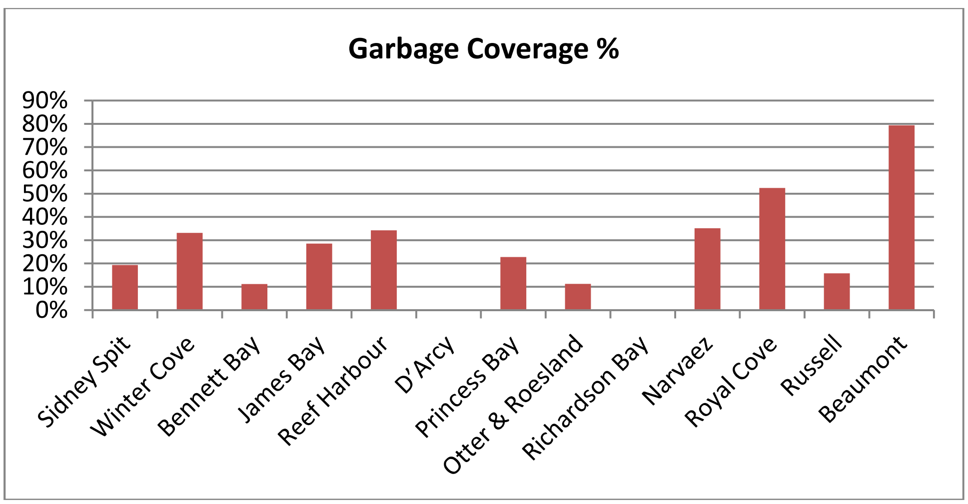

Figure 10 Percentage of Anchorage with Garbage Present

IMPACT ANALYSIS

The impact analysis was based on the results of the sensitive ecosystem mapping from video transects, and the literature review on impacts of boating on nearshore environments. The focus of the literature review was to gain insights into the sensitivity of the nearshore organisms identified in the videotapes, to recreational boating activities, and more specifically mooring and anchoring. Sensitivity was assessed based on methods widely in use in impact assessment, but that have undergone refinement for the Marine Life Information Network (MarLIN), a comprehensive marine resource management and impact assessment program in the United Kingdom. The rationale and methods are briefly outlined in the following section.

Sensitivity Assessment Rationale (adopted from MarLIN: Tyler-Walters, H. & Hiscock, K. 2005)

Assessing the sensitivity of species

"The assessment process involves judging the intolerance of a species to change in an external factor arising from human activities or natural events. The rationale then assesses the likely recoverability of the species following cessation on the human activity or natural event. Intolerance and recoverability are then combined to provide a meaningful assessment of their overall sensitivity to environmental change."

Sensitivity Assessment Definitions:

'Intolerance' is the susceptibility of a habitat, community, or species to damage, or death, from an external factor. Intolerance must be assessed relative to specified change in a specific environmental factor.

'Recoverability' is the ability of a habitat, community, or species to return to a state close to that which existed before the activity or event caused change.

'Sensitivity' is dependent on the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery. For example, a "highly sensitive" species or habitat is one that is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, "high" intolerance) and is expected to recover only over a very long period of time, (10 to 25 years: 'low' recoverability). Intolerance, and hence sensitivity, must be assessed relative to a specified change in a specific environmental factor.

(Source: Tyler-Walters, H. & Hiscock, K. 2005)

Steps in Sensitivity Assessment:

Collate the best available scientific information required to describe the biology and likely sensitivity of the species using the resources of the World Wide Web, the expertise of departmental marine biologists, and colleagues from academia and other government agencies.

Assess the intolerance of the species to change in environmental factors likely to result from the activity (anchoring and mooring). Species intolerance was assessed with respect to the forecast magnitude and duration of change for the environmental factors expected to be involved.

Assess the recoverability of the species. The likely recoverability of a species from disturbance or damage is dependent on its ability to regenerate, regrow, recruit or recolonize, depending on the extent of damage incurred and hence its intolerance. The recoverability of a species is assessed against evidence of recruitment, recolonization or recovery (e.g. after environmental impact or experimental manipulation in the field) and/or key information on the reproductive biology, habitat preferences and distribution of the species.

(Source: Tyler-Walters, H. & Hiscock, K. 2005)

Best Available Scientific Information

The approach used in the GINPR Anchorage study was consistent with the methods described above. It involved an extensive literature review; preliminary viewing of videotapes to determine species and communities present in the area; additional literature review on species ecology; sensitivity to anchoring and mooring; and resilience to impacts; and marine science and management expertise of the investigation team members and associated colleagues.

Intolerance assessment

The assessment only considered environmental factors likely to be relevant to the activities associated with recreational boat anchoring and mooring. Literature reviews were therefore focussed on environmental factors such as substratum loss, smothering, increased suspended sediment, changes in turbidity, abrasion and physical disturbance to the VECs in general, and related to boating where such information was available. Chemical factors such as hydrocarbons, and biological factors such as introduction of non-native species, were not considered in this assessment. Table 4 illustrates how broad the range of possible environmental factors may be when undertaking sensitivity assessments.

Table 4
Range of Environmental Factors for which Intolerance can be assessed

Physical factors	
	Substratum loss
	Smothering
	Suspended sediment
	Desiccation
	Changes in emergence regime
	Changes in water flow rate
	Changes in temperature
	Changes in turbidity
	Changes in wave exposure
	Noise
	Visual presence
	Abrasion and physical disturbance
	Displacement
Chemical factors	
	Synthetic compounds
	Heavy metals
	Hydrocarbons
	Radionuclides
	Changes in nutrient levels
	Changes in salinity
	Changes in oxygenation
Biological factors	
	Introduction of microbial pathogens
	Introduction of non-native species
	Selective extraction of this species
	Selective extraction of other species

Recoverability Assessment

Assessment of a VEC's ability to recover after being impacted was based on literature review results and expert opinion.

Valued Ecosystem Components

A wide range of plant and animal species make use of nearshore habitats on a seasonal or year round basis. Many of these species are sensitive to land and marine based human activities. The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) is a large scale marine restoration initiative that has been underway since 2001. The Puget Sound nearshore[9] covers a broad area which includes the San Juan Islands that lie directly south and east of British Columbia's Gulf Islands. Given the high degree of similarity in the Puget Sound and Gulf Island marine and terrestrial environments, the valued ecosystem components (VECs) identified and assessed in the Puget Sound studies, are considered to be highly relevant to the Gulf Islands. Studies undertaken in the PSNERP process invested considerable effort identifying, evaluating, and describing nine VECs. These range from single mobile species such as the Great Blue Heron, and Killer Whale, to important community forming plants such as eelgrass, and seaweeds such as kelp. A series of Puget Sound reports document both the methods used to evaluate and select VECs, as well as detailed information on the ecology and sensitivity of individual VECs. See in particular, "Valuing Puget Sound's Valued Ecosystem Components" (Leschine, T.M., and A.W. Petersen. 2007) and "Kelp and Eelgrass in Puget Sound" (Mumford, T.F. 2007).

Since the GINPR anchorage study focused on benthic habitats in popular anchorages, it made sense to choose species or communities that are resident year round and most sensitive to the anchoring and mooring activities associated with recreational boating in the park. After an initial review of the anchorage study videotapes, and an extensive review of published and grey literature, Eelgrass Meadows, Sea Pens, and Sea Anemones, were selected as the three VECs for the GINPR study. Supporting rationale for these selections is described in greater detail in the next section of this report. Potential interactions between individual VECs and recreational boat anchoring/mooring activities are more fully described in the Impact Analysis section of the report.

Candidate VECs considered but not selected for the GINPR study are more fully documented in the Methods & Definitions report (see Appendix 1). They included:

- Mounding Infaunal Animals
- Kelp
- Sea Urchins
- Bivalves
- Articulated Coralline Algae

The three VECs that were selected for further assessment, (seagrass, sea pens, sea anemones), are described in greater detail in the following section.

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[9] The Puget Sound nearshore is defined as that area of marine and estuarine shoreline extending approximately 2,500 miles from the Canadian border, throughout Puget Sound and out the Strait of Juan de Fuca to Neah Bay. http://www.pugetsoundnearshore.org/what.htm

Seagrass Meadows

Eelgrass is a common name for *Zostera marina*, one of five seagrass species found in British Columbia's nearshore waters. Its range extends along the west coast of the North American from Alaska to Mexico (Orth et al. 1994). Seagrasses are a functional grouping of vascular flowering plants that have adapted to the protected nearshore soft bottom marine environments of most of the world's continents. Eelgrass meadows form significant coastal habitats in British Columbia's coastal region, extending from intertidal to shallow subtidal along protected coastlines, estuaries, and shallow embayments (Harbo 1999).

Why Seagrass was selected as a Valued Ecosystem Component (VEC)

These seed-bearing plants are well known components of temperate climate intertidal communities, often forming large meadows under optimal conditions. They are recognized for their ability to help stabilize coastline sediments, and to provide food and shelter for a host of marine organisms, many of which are of high value to humans. The ecological role of seagrass meadows has long been recognized as they represent areas of high primary productivity, as well as areas of high value ecosystem services (McRoy & McMillan 1977; Orth et al. 2006). Seagrass meadows support a complex nearshore food web through the secondary production of invertebrates associated with epiphytes (animals or algae growing on seagrass blades), as well as through export of organic matter that feeds into the detrital pathway of adjacent ecosystems (e.g., mudflats). Throughout their range seagrass meadows are considered as important feeding and nursery grounds for many economically and ecologically important marine finfish (e.g., rockfish) and shellfish species (e.g., Dungeness crab), and as feeding areas for birds (e.g., Brant Geese) (Thayer et al. 1975, Murphey & Fonseca 1995).

Figure 11
Eelgrass meadow *(Zostera marina)* in Bennett Bay , GINPR. March 17, 2011.

Seagrasses provide a wide range of functional roles, such as regulating water column dissolved oxygen, modifying their physical and chemical environments and reducing suspended sediments loads in the water column. They also are an integral component of shallow-water nutrient recycling processes. The shallow seagrass roots and rhizome systems have an important role in binding and stabilizing bottom sediments, and seagrass leaves baffle currents and waves, thus protecting coastlines from erosion (Fonseca 1989, Fonseca et al. 1982).
Eelgrass was chosen as an VEC because of its regular occurrence in GINPR waters; known cause-effect relationships between anchoring and seagrass impacts; importance to nearshore community structure and species; sensitivity to disturbance; and availability of large amounts of knowledge regarding ecology, stressors, and restoration relative to other potential VECs.

Seagrass stressors

The morphology and life history traits of Eelgrass, including its occurrence in coastal waters that are subject to frequent environmental disturbances, explain to a large extent why Eelgrass meadows are considered as sensitive shallow-water marine systems (Frost et al. 1999). Both natural and anthropogenic disturbances that alter water quality and clarity, as well as physical damage through storms and human impacts are responsible for the loss and fragmentation of Eelgrass habitats (Short & Wyllie-Echeverria 1996, Frost et al. 1999). Changes in sea level, wave exposure, tides, salinity, temperature, light levels, nutrients, atmospheric CO_2 and UV radiation can alter Eelgrass distribution, productivity and community composition. As coastal populations grow, the potential for human activities to disturb nearshore habitats, such as Eelgrass meadows, will increase. Threats which intensify with increased levels of coastal development include: 1) mechanical damage from dredging and boating activities as well as the construction of ports and marinas; 2) decreased light levels from higher turbidity and shading from docks; 3) eutrophication from agricultural or urban runoff, and sewage outfalls; 4) increased water temperatures from the discharge of heated waste water; and 5) disrupted faunal communities initiated by unsustainable fishing practices. Habitat fragmentation and increased epiphyte loads often result from these impacts and may jeopardize the continued survival of Eelgrass meadows. Changes in eelgrass distribution and structure may have profound implications for other flora and fauna, as well as nearshore geomorphology and biogeochemical cycles (Short & Neckles 1999). Recent observations in the San Juan Islands (Wyllie-Echeverria, S., et al. 2003) indicate that within a span of two years significant intertidal portions of many eelgrass meadows were completely lost, suggesting that Eelgrass meadows may offer an early warning system to a number of natural and anthropogenic threats as they respond rapidly to changing environmental conditions. Eelgrass is one of the few marine species that offers such a complete attribute package for acting as an indicator of coastal ecosystem health. By monitoring the status of Eelgrass meadows early detection of coastal environmental degradation can be made before irreparable losses occur (Short et al. 2006). Insufficient information is available at present to conclude if the eelgrass meadows in the GINPR study sites are stable, increasing, or decreasing in extent.

Seagrass vulnerability to recreational boat anchoring or mooring

The general morphology and life history traits of eelgrass make it highly susceptible to physical damage resulting from both natural (e.g., storm generated waves) and anthropogenic (e.g., boat anchoring) disturbances. Seagrass plants are herbaceous (soft bodied) so very vulnerable to abrasion or mechanical impacts. The physical impact of anchors hitting plants and anchoring substrate may result in leaf shearing or crushing. Dragging of anchors when setting or retrieving anchors, or loosing holding power because of poor anchor setup or stormy conditions, can damage or cut meristems[10] and rhizomes[11], or uproot plants. Seagrasses are shallow rooted plants, typically rooting within the top 20 cm of sediment (Fonseca 1992). This makes them particularly susceptible to a wide range of activities that may disturb surface sediments including, anchoring, digging, dragging, dredging, and powerboat wash in shallow waters. Seagrasses exhibit a strong seasonal growth pattern in temperate regions such as the Gulf Islands. Peak summer growing season for eelgrass coincides with peak levels of vessel use and anchoring activities. Seagrasses can reproduce sexually, by releasing seeds into the water column, or by vegetative (asexual) means such as rhizome growth. Sexual reproduction in eelgrass species is poorly understood for some species. It is known however that sexual reproduction is the predominant means by which new seagrass colonies or patches are established (Duarte, C.M. 2006). Vegetative (asexual) reproduction is the primary method by which seagrasses reproduce to maintain or expand existing meadows. Asexual reproduction includes rhizome growth and subsequent sprouting of new shoots (primary method), or much less frequently, transport of seagrass plants or plant fragments to suitable habitat (Duarte, C.M. 2006). Average rhizome growth rates for *Zostera marina*, the primary species present in GINPR, is 26 cm per year (Marba and Duarte 1998).

Soft Sedimentary Environments (Sea pens and Sea anemones)

Marine sedimentary environments cover over 80% of the ocean floor creating a multitude of habitats which support a wide variety of organisms ranging from bacteria to bottom-feeding whales (Lenihan and Micheli, 2001). Soft sediments are a mixture of inorganic particles, organic particles, and pore-water. As in the water column, life in soft bottom fluid sedimentary environments is defined in three dimensions. The physical and chemical character of soft bottom environments is determined by the underlying geology, basin morphology, and associated physical, chemical, and biological processes. Soft bottom environments are often dynamic and when perturbed can easily change from erosional to depositional and back in response to changes in sediment balance. The unstable nature of the sediment requires organisms to be physiologically flexible to succeed in this environment. The inhabiting organisms play a key role in altering their habitat. Diatoms and seagrasses can be effective in binding mud particles together, while burrowing infauna (i.e., organisms that live in or burrow through the sediments) have the opposite effect and tend to destabilize the sediment with their burrowing and feeding activities. One of the most characteristic features of soft bottom communities is that individual abundance, biomass, and species diversity and composition fluctuate widely in both space and time (Lenihan and Micheli, 2001).

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[10] Meristem - tissue from which new cells are formed, as at the tip of a stem or root. Meristem tissue plays a key role in the asexual reproductive ecology of eelgrass through clonal growth. A new eelgrass shoot consists of a leaf bundle, roots, and section of rhizome or branched rhizomes. Rhizomes grow in length and branch from cells produced by the apical (at the tip) meristem (Duarte et al 2006).

[11] Rhizome - horizontal, underground plant stem capable of producing the shoot and root systems of a new plant. This capability allows the parent plant to propagate vegetatively or asexually (Encyclopedia Britannica Online, s. v. "rhizome," accessed December 09, 2011, http://www.britannica.com/EBchecked/topic/501483/rhizome).

The distribution of organisms in soft bottom environments was originally thought to be controlled by sediment size and stability. Although the picture now appears to be more complex, the nature of the sediment is still considered an important factor for infaunal organisms. While organisms in soft bottom environments of the deeper parts of the ocean are supported mainly by pelagic production and by detritus originating from other coastal habitats, animals in shallow water depths graze on micro- and macrobenthic algae. Most of the surface sediments in the shallow water habitats in this study are covered by a layer of benthic unicellular and filamentous algae as well as some macrophytes (e.g., kelps and green algae). Organic material derived from allochthonous sources (i.e., from a source outside the marine ecosystem) accumulates in the sediments creating a food source for both the infauna and epifauna[12] (Peterson and Quammen, 1982). The infauna of soft bottom environments live buried in the sand or mud, most emerging only very rarely. For infauna, the ability to move around within the sediment enables then to avoid direct competition with neighbours, and escape predation by benthic feeders or other burrowers. Soft bottom environments are also home to mobile epifauna, such as crabs and fish, which move in and out with the tide and feed in adjacent shallow-water habitats.

Nearshore soft bottom benthic communities in the Gulf Islands are dominated by polychaetes (worms), crustaceans (e.g., amphipods, isopods, etc.), echinoderms (e.g., sand dollars) and molluscs (e.g., burrowing bivalves). These organisms can be classified based on their trophic status as deposit feeders, filter and suspension feeders, opportunists and scavengers, or predators. These groups can also be classified into two key groups, namely sediment stabilizers and sediment destabilizers. Sediment stabilizers, in addition to the plants like the seagrasses, include various invertebrate tube builders which at high densities stabilize large areas of the sea bottom. Two of the most visible invertebrate stabilizers in the study areas are the Orange Sea Pen *(Ptilosarcus gurneyi),* and the Tube-dwelling sea anemone *(Pachycerianthus fimbriatus).*

Soft bottom benthic communities are often dismissed as unproductive, and their key role in ecological processes is seldom recognized even though they provide important ecological goods and services. Soft bottom environments and their associated biological communities support a number of economically important invertebrate fisheries, such as crabs, shrimps and bivalves. Furthermore, soft bottom benthic communities recycle nutrients, detoxify pollutants and are vital trophic links in nearshore ecosystems (Lenihan and Micheli, 2001). Past research has clearly demonstrated that these communities provide key energy pathways in the marine nearshore ecosystems (Grembeier et al. 1988; Graf et al. 1992).

Physical disturbance in soft sediment environments is known to disrupt the sediment structure and lead to major shifts in community structure of resident biota due to death or emigration. Physical disruption of benthic communities by various human activities, such as bottom trawling for example, has been linked to reduced biomass and production, as well as major shifts in community composition from crustacean, mollusc and echinoderm dominated communities to more opportunistic polychaete worms (Kaiser et al. 2000; Jennings et al. 2001). For example, Herbert et al. 2009 demonstrated abundance of the benthic amphipod *(Corophium volutator),* an important bird prey species, was significantly reduced in areas affected by physical damage from mooring buoy chains. In a recent study, Tyler-Walters et al. (2009) have suggested that a majority of soft bottom species examined in their study were adversely affected by physical disturbance (e.g., mobile fishing gear), and that species' (and thus biotope[13]) sensitivity to disturbance was dependent on their ability to recover.

Sea Pens

The Orange sea pen *(Ptilosarcus gurneyi)* is a close relative of corals. While they appear solitary, an individual Ptilosarcus is actually a colony made up of many polyps. Unlike their coral cousins, sea pen polyps have eight tentacles, as would be expected from a species belonging to Subclass Octocorallia. Sea pens are unique among the octocorals, since their polyps have specialized to perform certain functions like feeding or reproduction. They are sessile organisms, living burrowed in wide variety of soft-bottom sediments. They are not fastened to the

[12] Epifauna refers to benthic or bottom dwelling animals that live on the surface of the bottom substrate rather than within the substrate.

[13] Biotope is a concept used to describe areas of uniform environmental conditions that support specific assemblages or communities of plants and animals.

substrate, and some species are capable of locomotion. Sea pens are generally found in coastal waters from the shallow subtidal to depths of about 300 m. In certain areas dominated by plains of soft mud and/or sand deposits, Orange sea pens can be very abundant, reaching densities of 30 individuals/m^2 (Birkeland 1974). Birkeland also found that at any one time, only about 26% of the Orange sea pen population was exposed above the substrate, the rest being buried in sediments to a depth of 30 cm or more. They alternately expand for feeding and contract into the sand, most likely to escape predation. Birkeland (1974) found that when contracted into the sediment they are less likely to be attacked by their predators.

Where they are abundant, sea pens play an important trophic role in coastal food webs. They are suspension-feeding animals feeding on a wide variety of suspended organic particles ranging from detritus to larvae and other zooplankton. In turn, they support an assortment of benthic predators. Juvenile sea pens are consumed mainly by nudibranch (sea slug) species. As sea pens grow in size they become an important prey for several species of seastars. The Spiny red star *(Hippasteria spinosa),* feeds almost exclusively on Orange sea pens, and is rarely found outside of sea pen gardens (Birkeland 1974).

Why Sea Pens were selected as a Valued Ecosystem Component (VEC)

Orange sea pens were found in over half of the 13 anchorage sites assessed in this study. Birkeland (1974) termed the Orange sea pen a “key-industry species” since it supports at least seven predator species in Puget Sound.

Sea Pen stressors and vulnerability to recreational boat anchoring or mooring

Very little work has been done on this group of benthic organisms with respect to their sensitivity to physical disturbance. Tyler-Walters et al. 2009 found slow growing, erect species such as sea pens to be sensitive to physical disturbance and exhibit slow recoverability. Low recovery rates may be a function of Orange sea pens’ life history strategy, reflecting its spatially unpredictable and clumped recruitment (Birkeland 1974). In their 2009 study assessing sensitivity of species to physical disturbance, Tyler-Walters et al ranked sea pen sensitivity from Moderate to High. This ranking implies that sea pens can be very adversely affected by an external physical disturbance arising from either anthropogenic activities or natural events and is expected to take a long time (10 to 25 years) to recover. Probability of impact occurrence to orange sea pens may be reduced by their behaviour as only about 25% of the colony is exposed above the substrate at once (Birkeland 1974). The remaining three-quarters of the colony are buried within the sediments, often to a depth of 30 cm (1 foot) or more, a depth likely to provide protection from anchoring activities. This behaviour is likely to provide protection to a majority of the sea pens in an area where anchoring takes place as the probability of encountering anchoring tackle is reduced. Even if anchors are deployed in dense sea pen beds, they are not likely to penetrate the substrate as much as 30 cm. As with the other two VECs, exposed sea pens are vulnerable to impacts from anchors dropped onto the substrate, and to anchor or mooring chains as they move about the bottom. Sea pens have soft tissues that offer no resistance to these mechanical impacts. They also have little to no mobility, so likely can’t move rapidly enough to avoid anchors or anchoring tackle that is travelling quickly across benthic habitat. However an experimental study found that sea pens were quite resilient to being smothered,

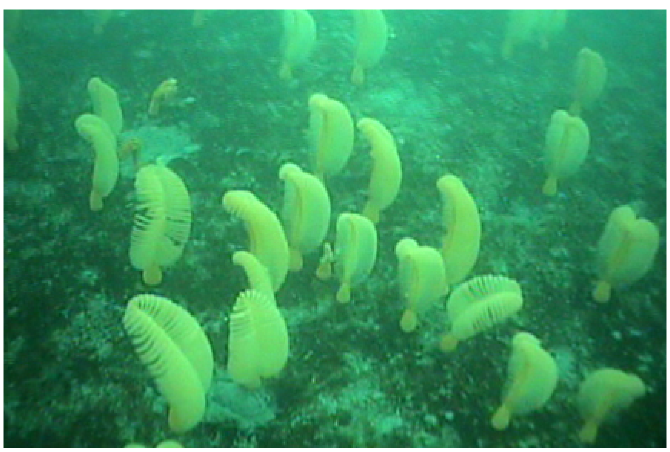

Figure 12
Dense bed of Orange sea pens *(Ptilosarcus gurneyi)*, at Bennett Bay, GINPR. March 17, 2011.

dragged or uprooted by creels[14] moving at a moderate speed (Kinnear et al., 1996). All three sea pen species in that study proved able to re-anchor themselves provided the basal peduncle[15] remained in contact with the sediment surface, and mortality rates following experimental creel disturbance were very low.

Sea Anemones

Tube-dwelling sea anemones (*Pachycerianthus fimbriatus)* inhabit soft-bottom environments from the shallow subtidal to depths of 30 m or more in sheltered coastal waters. It is commonly found in soft muddy environments (e.g., sheltered bays and harbours) and sometimes in fine sandy areas. Its distribution ranges from Southern Alaska to Baja California. Their common name is derived from their ability to build a tube in which they live burrowed in soft sediments (sand or mud), with only their oral disc and tentacles exposed. One key characteristic feature that separates *Pachycerianthus* from other tube-dwelling sea anemones is that their tube is raised above the surface sediment layer by several centimeters. It has two rings of slender tentacles. *Pachycerianthus* creates its tube by releasing threads of a special type of nematocysts called 'ptychocysts', which are then woven into a fibrous tube consisting of stinging cells that serve to protect the sea anemones from predators. The tube may be up to 60 cm in length. When attacked the whole animal withdraws into the protective tube. The Giant nudibranch *(Dendronotus iris)* is its only predator. Unlike other predators that usually fully consume and kill their prey, *Dendronotus* never kills the *Pachycerianthus*, it just eats the tentacles allowing the anemone to regenerate after the attack.

Why Sea anemones were selected as a Valued Ecosystem Component (VEC)

Sea anemones are present in some study sites, and like sea pens, have little to no mobility, and soft body tissue that offers little to no resistance to mechanical impacts from anchoring or mooring tackle.

Figure 13
Plumose sea anemones *(Metridium farcimen)*, at Russell Island, GINPR. December 1, 2010.

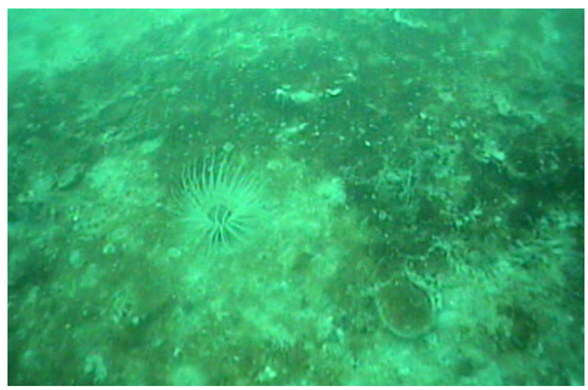

Figure 14
Tube-dwelling sea anemone *(Pachycerianthus fimbriatus)*, GINPR.

Sea anemone stressors and vulnerability to recreational boat anchoring or mooring

Very little work has been done on sea anemones with respect to their sensitivity to physical disturbance. However, it is likely that this relatively fast growing burrowing species will be less sensitive to physical disturbance and will exhibit higher recoverability when compared to sea pens (Tyler-Walters et al. 2009). In their 2009 study, assessing sensitivity of species to physical disturbance, they ranked tube-dwelling anemone *(Cerianthus lloydii)* sensitivity as Low. This rating implies that this group of benthic organisms can be adversely affected by physical disturbance, either anthropogenic or natural, but is expected to recover in a relatively short period of time (i.e., within 2 to 10 years) depending on the degree of damage (Tyler-Walters et al. 2009). The literature review found no studies that directly assessed the impacts of boat anchoring or mooring on sea anemone species. It is reasonable to conclude

[14] Creel – Term for type of trap placed on the bottom of a water body to catch lobster, crab or other benthic organisms. Also know as pots, or traps, they typically are constructed of a supporting wooden, metal or plastic frame, covered in open mesh fabric, and are approximately 20cm wide by 75cm long.

[15] Peduncle – basal widening of body which acts as a root or base when buried in soft sediments, and anchors the organism in the substrate.

that based on their soft bodied physiology, occurrence in shallow subtidal soft bottom sediments, and immobility, that some sea anemones would be damaged or killed in areas where anchors are set, dragged, and retrieved. Low sensitivity in these organisms is in part due to their solitary nature, which lowers the probability of encounters with an anchor relative to clumped organisms such as sea pens or eelgrass.

VEC Conservation Status

The British Columbia Conservation Data Centre on-line BC Species and Ecosystems Explorer was searched to determine if Eelgrass *(Zostera marina),* Orange sea pens, or sea anemones have a legal conservation status in British Columbia or Canada. Search results are presented in Table 5. Results indicate none of the VECs are considered to be at risk, nor have a legal conservation status in British Columbia or Canada at the present time, or are on a species at risk candidate list.

Table 5 Conservation Status of VECs

<table>
<tr><th>Species / Group</th><th>Provincial Status</th><th>BC List</th><th>National Status</th><th>COSEWIC Status</th><th>SARA Listed</th></tr>
<tr><td>Zostera marina</td><td>S5 (Oct 2001) Secure—Common, widespread, and abundant in the nation or state/province</td><td>Yellow (all species not on the Red or Blue lists, but tracked by the CDC; they are not considered to be at risk).</td><td>4 - Secure (2010)</td><td>Not at risk</td><td>No</td></tr>
<tr><td>Sea pens</td><td colspan="5">No matches could be found for your specified Search Criteria.

Search Criteria
Search Type: Plants & Animals AND Species Name (Include Synonyms): Scientific Name like PTILOSARCUS*GUERNEYI OR English Name like PTILOSARCUS*GUERNEYI
Sort Order: Scientific Name Ascending
Plants & Animals Search Results (0 records)</td></tr>
<tr><td>Sea anemones</td><td colspan="5">No matches could be found for your specified Search Criteria

Search Criteria
Search Type: Animal AND Species Name (Include Synonyms): Scientific Name like ANEMONE OR English Name like ANEMONE
Sort Order: Scientific Name Ascending
Animals Search Results (0 records)
No matches could be found for your specified Search Criteria</td></tr>
<tr><td colspan="6">Description of Conservation Status Categories and Classifications

Provincial Conservation Status
Provincial Ranks apply to a species' or ecological community's conservation status in British Columbia. The number in parenthesis is the year the rank was last reviewed. The ranks have the following meaning:

X = presumed extirpated
H = possibly extirpated
1 = critically imperilled
2 = imperilled
3 = special concern, vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.
NA = not applicable
NR = unranked
U = unrankable

B.C. List Status
Species are assigned to provincial lists depending on their Provincial Conservation Status. Yellow: Includes species that are apparently secure and not at risk of extinction.

COSEWIC Ranks
Each COSEWIC (Committee On the Status of Endangered Species In Canada) rank is followed by the date that the rank was last reviewed.

SARA Status
Each SARA (Species At Risk Act) status consists of the SARA Schedule followed by the SARA Status code and may be followed by the date that the rank was last reviewed. NOT AT RISK: A species that has been evaluated and found to be not at risk.</td></tr>
</table>

Source: B.C. Conservation Data Centre. 2011. Species Summary: Zostera marina. B.C. Ministry of Environment. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Oct 19, 2011).

IMPACT SOURCES AFFECTING BENTHIC HABITAT

Marine ecosystems are very complex structurally (habitat) and functionally (processes). A wide range of marine and land based activities influence marine ecosystems, particularly nearshore regions. These land - sea interactions increase the complexity of nearshore ecology and management. Pollution, for example, affects marine areas around the world. Seventy-seven percent of this comes from land-based sources, with only 23% coming from marine-based sources (European Confederation of Nautical Industries. 2009). Marine-based sources can be further broken down into 12% from marine transport (predominantly commercial shipping), 10% ocean dumping, and 1 oil exploration and production. The relative contribution of recreational boating is very small at 1 percent. This example illustrates both the complexity of marine environments, and the relative large influence land-based activities can have upon marine resources. An assessment of a full suite of impact sources affecting coastal marine resources is well beyond the scope of the present study. Recognising, assessing, and managing land-marine linkages is a key component of many coastal ecosystem restoration programs.

Recreational Boating Activities

Despite the relatively small contribution of recreational boating to marine pollution, a wide range of recreational boating activities do generate environmental impacts. These too can be broken down into land based activities such as boat building, storage, transport, maintenance and repair; and on the water activities such as motoring, anchoring, and managing wastes. Table 6 summarises how various types of on the water boating activities can impact marine resources.

Table 6 Summary of Recreational Boating Activities Affecting Nearshore Benthic Habitat

Boating Activity	Environmental Impact
Anchoring	All stages of anchoring (Anchor setting; anchor dragging; boat swinging; and anchor release and retrieval); have the potential to erode surface sediments, re-suspend and redistribute particles; and make direct physical contact to or damage organisms and benthic habitat. Increased turbidity via sediment re-suspension, reduces habitat quality for seagrass and other species dependant on high light levels in the nearshore water column.
Mooring	Initial habitat loss/alteration on installation of mooring anchor, the extent of which depends on type of anchor assembly used: concrete blocks vs. helical screw anchors or mushroom anchors). Traditional moorings with chains in contact with bottom sediment can result in erosion of surface sediments, similar to that listed above under anchoring. Halo dead zones around chain moorings are well documented and occur from vessels and moorings swinging in response to tides, winds, and currents. Conservation moorings with buoyant rode instead of heavy chain rode, can significantly reduce or eliminate these types of impacts.
Hydrocarbon Use	Motorized vessels release engine emission hydrocarbons into the water and air. Transfer and use of fuels, oils, lubricants, solvents and cleaner residues from exposed vessel surfaces to receiving waters may adversely affect water quality, sensitive habitats, aquatic organisms. Bilge pumped into receiving waters typically contains a complex mixture of fuel, lubricants, and solvents. Fuel spills may occur from leaking tanks or while transferring hydrocarbons to/from tanks or fuel pumps. Other than spills, most are chronic small scale inputs. Best practices are readily available to minimise effects.
Liquid Waste Management	Grey water is likely to be produced onboard on vessels equipped with a galley and head. Grey water typically contains domestic detergents used for dishwashing; personal hygiene products such as soap, shampoo and shower gel; and boat cleaning and maintenance products. Resulting grey water solutions are a mixture of salts, fat, and chemical active agents from detergents. Some vessels have holding tanks so grey water can be disposed of upon return to port versus when at anchor, or underway.
Sewage Management	Discharging raw or partially treated sewage into nearshore waters may threaten the health of both the coastal environment, and the people that use it. Nutrients and pathogens in human waste can result in blooms of harmful algae, or spread of infectious diseases among humans who come into direct contact with wastes. They may also contaminate local harvestable foods such as shellfish, and fish. Some vessels have holding tanks so sewage can be disposed of when back at port versus when at anchor, or underway. Boaters should be encouraged to use shore based toilet facilities when convenient and available, or to use holding tanks and dispose of sewage at pump out facilities back at port.
Solid Waste Management	While a vessel is in use materials can be accidentally or intentionally lost overboard. Garbage generated onboard is very similar in composition to that produced when at home. It typically consists of product packaging, empty containers, food wastes, and broken or unusable items. Recycling programs are available onshore in many locations, including some marinas. Boaters should be encouraged to return to shore with all materials they set out with, and make use of onshore recycling and waste disposal facilities.
Vessel Grounding and Propeller Scarring	In shallow nearshore environments, propellers can deliberately or accidentally make contact with the bottom resulting in damage to the substrate, resident animals, or the vessels propulsion system. Bottom type plays a large role in determining if the vessel, substrate, or both, will be damaged. The Florida Keys contain large areas of seagrass rooted in shallow, sandy sediments. Very high levels of boat use occur year round in the warm southern Florida climate. Consequently many eelgrass meadows have been extensively damaged from propeller scarring. In contrast, many areas within the gulf islands have bedrock outcroppings. Local boater's therefore diligently attempt to avoid any vessel contact with the bottom as vessel damage is likely to result. For these reasons, propeller scarring is not considered to be a significant impact source in the present assessment of GINPR anchorages.

Source: European Confederation of Nautical Industries. 2009. Nautical Activities: What Impact on the Environment? A Life Cycle Approach for "Clear Blue" Boating. Second Edition.

Recreational Boating Activities Included in this Assessment: Anchoring and Mooring

Despite the relatively small impact contribution of recreational boating relative to other sources, there is potential for significant impacts from some activities such as anchoring in eelgrass meadows or mooring boats in sites with sensitive benthic communities using traditional moorings with heavy anchor blocks and chains.

Types of use

For the purposes of the present study, recreational boating activities can be summarised as shallow sub-tidal, near-shore anchoring or mooring of motorised and non-motorised pleasure craft, with a predominant late spring to mid fall use pattern. A decision was made to scope the study narrowly to consider only anchoring and mooring effects upon sensitive receptors likely to be present in the most popular and heavily used anchorages within GINPR. Potential interactions between these activities and the VECs are discussed below.

Level of use

No attempt is made to assess if levels of boat use are decreasing, stable, or increasing. The limited amount of boat use data available for GINPR (Leatherbarrow 2006; Gray 2008) indicates a short intense summer boating season coincident with the warmest and calmest weather conditions of the year, and the main growing season for eelgrass plants. There is a low level of use year round, with increasing use through April, May and early June, peak use late June through Sept Labour Day Weekend, and declining use through September and October back to low winter use levels.

Anchoring Impact Pathways

Anchors

All anchors work by embedding themselves into the substrate. This requires that the surface sediments are penetrated to make way for the plough, arms or body of the anchor. Anchors till the surface sediments as they are dragged across the bottom while being set, or if failing while under load. If sensitive species such as eelgrass are present in the area through which the anchor is moving, the anchor can uproot plants, rip through rhizomes, and expose plants to additional erosion at the margin of the furrow left after the anchor has travelled through. Anchor retrieval causes similar impacts. Impacts are greatest where the anchor is forcefully ripped from the substrate as in this case it will need to travel through a longer section of substrate in order to break free than if it was pulled straight up. Boat operators should therefore be encouraged to motor up the anchor line so they can retrieve the anchor from directly overhead to minimise damage to benthic substrate while retrieving anchors.

Anchor ground tackle or chains

As a general rule, shallow anchorages require relatively longer scope[16]than deeper anchorages. This implies that in shallow nearshore anchorages such as those in the GINPR study sites, longer scope and hence a proportionately longer rode (section of metal anchor chain, or anchor chain and nylon line combination) will be in contact with the substrate, relative to one used in deeper waters. This increases the probability of damage to sensitive resources due to a longer rode being used as a greater length of anchor bottom tackle is in contact with the benthic substrate. Several factors may cause anchor dragging, or ultimately failure, with the anchor being ripped from the substrate. Anchors often drag in areas with poor holding power such as thin sand layers overlying flat rock surfaces, or soft mud, hard sands, or boulders. Dragging and failure may also be attributed to a poor or inefficient anchor design, or insufficient scope for the water depth and weather conditions. Wind exposure is also a key factor in dragging or failure. Vessel windage[17] influences how much force wind exerts on a vessel. On average power boats have greater windage that sail boats of a similar length due to the streamlined hull design of sailing vessels (Poiraud, A., Achim Ginsberg-Klemmt, Erika Ginsberg-Klemmt. 2008).

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[16] Scope – term used to describe the ratio between the amount of rode (anchor ground tackle and line attaching anchor to boat, typically metal chain, or chain and nylon line combination) attached to an anchor, and the depth of the water column at the anchor site. For example: a scope of 3:1 in 5 metres of water would mean the rode would be 15 m in length.

[17] Windage - force created on an object by friction when there is relative movement between air and the object. When used in the nautical context it means how vessel area and shape affect the amount of force exerted on it by wind. Source: Wikipedia. http://en.wikipedia.org/wiki/Windage (accessed December 20, 2011).

Figure 15
Anchor chains on sandy eelgrass bottom at Studland Bay, Dorset, UK.
Photo copyright of Steve Trewhella, used by permission.

Anchor chains regularly move across the bottom as vessels swing in wind, current, or with changing tides. This movement can shear, crush or uproot plants such as eelgrass, and may also erode small channels in the sediments like those visible in Figure 15. A scope of 3:1 usually provides sufficient holding in calm conditions or when anchorages are crowded as it limits the amount of swing room a vessel requires. As soon as conditions deteriorate, most skippers pay out more rode line to increase the scope in the hopes of obtaining additional holding power. Exposed anchorages may require scopes in the range of 7:1 to 10:1 (Poiraud, A., Achim Ginsberg-Klemmt, Erika Ginsberg-Klemmt. 2008). Beyond this point longer rode will not increase holding power. The potential for anchor tackle impacting sensitive benthic resources is related to the type and length of anchor tackle deployed, the behaviour of the vessel in waves, wind or current, and the weather conditions and sea state present while at anchor. Longer rode, and heavier weather maximise potential for anchor tackle movement and impacts to sensitive seabed resources, short scope and clam conditions minimise it.

Mooring Impact Pathways

Traditional mooring buoys consist of an anchor (mushroom anchor or large block of concrete or similar material), a length of metal chain, connecting metal chain tackle, buoyant rope or light chain, and a surface float. This style of mooring can damage sensitive resources when the chain moves across the bottom as moored vessels move against the mooring due to wind, current, or changing tide levels. The eroding action of mooring chain is particularly damaging and visible in eelgrass meadows, often leaving circular halos of denuded sediment around the anchor block. The central image in Figure 19 illustrates this well. It shows halo scars in seagrasses at the anchorage in Man-O-War Cay, Abaco, Bahamas. Conservation mooring systems have been developed to replace traditional moorings and substantially reduce or eliminate these impact sources. They are an increasingly popular means of protecting sensitive marine resources, and there are many examples of their use to protect eelgrass (Baker, J., and Evans, T. 2010).

Table 7 Comparison of Environmental Impacts of Traditional and Conservation Moorings

Impact Source	Traditional Mooring Component	Impacts	Conservation Mooring Component	Impacts
Mooring Anchor Installation	Gravity (e.g. concrete) Block	Permanent loss of habitat under anchor block(typically 1-2 m^2)	Helical screw anchor	Temporary disturbance of 20-25 cm diameter area when helical anchor screw is installed
Rode Chain Movement	Heavy Metal Chain	Erosion of surface sediments. Mechanical damage to species such as eelgrass from chain swing. Localized temporary decreased water quality (increased turbidity) and consequent reduced habitat quality for eelgrass and other species dependant on good water quality. May create halo effects from loss of plants and reworking of surface layers of benthic substrate within arc of chain.	Elastic	None. Mid water column float; or surface float, or buoyant rubber rode, or combination of these, keeps rode off of bottom at all times thereby eliminating repeated mechanical impacts with substrate associated with traditional chain or chain and nylon line rode.

Relative Vulnerability of VECs to Recreational Boat Anchoring or Mooring Activities

Vulnerability is defined by the sensitivity of the resource, the likelihood of impact occurrence, and the resiliency of the resource to recover to a pre-impact state after the impact event is complete. A resource (habitat, species, or community), is considered vulnerable when it is sensitive to an external factor, or factors, and these factors are likely to be present. Vulnerability should therefore be viewed as a measure of the degree of exposure of a receptor to a factor to which it is sensitive (Roberts, C., Smith, C., Tillin, H. Tyler-Walters, H. 2010).

Influence of Spatial and Temporal Aspects on Probability of Impact Occurrence

Likelihood of impact occurrence is influenced by several factors including the spatial extent and distribution (single sea anemone, group of sea pens, eelgrass meadow) of the organisms across the substrate (greater the surface area coverage, greater the probability of impact occurrences), the spatial extent of the impact (area of substrate affected by anchoring or mooring activity), and the spatiotemporal requirement for both the VEC and the activity to be simultaneously present. All areas within an eelgrass meadow may be vulnerable to anchoring if anchoring site selection is at the discretion of the skipper, whereas only areas within the arc of mooring buoy chains are vulnerable (McCarthy and Prelli 2007). Anchoring can impact sensitive seabed only when the anchor and bottom tackle are present. By contrast, traditional buoys can cause continuous impacts but in a discrete area within the arc of the buoy anchor chains. Buoy spacing in mooring fields is designed to allow adequate swing room and clearance between adjacent vessels. Impact occurrence should therefore be strongly related to the density of moorings in the mooring field, and somewhat independent of level of use as mooring buoy chain scour occurs even when a boat is not anchored to the buoy. Scour occurs at unoccupied buoys when tides rise and fall, or currents, waves and wind cause sufficient movement of the surface buoy to move the anchor chain across the bottom. Conservation type moorings using off-bottom mooring tackle significantly reduce or eliminate these impacts.

Table 8 VEC Coverage by Anchorage and Total Area of each VEC

Anchorage		VEC Occurrence		
Anchorage Study Site	Study Site Area m^2	Eelgrass coverage m^2	Sea pen coverage m^2	Sea anemones coverage m^2
Sidney Spit	1,385,680	327,035	143,415	0
Winter Cove	441,174	251,810	72,241	0
Bennett Bay	431,600	23, 577	114,414	0
James Bay	179,600	6,549	65,613	18,830
Reef Harbour	149,761	58,799	0	0
D'Arcy	40,648	15,035	0	0
Princess Bay	92,826	46,684	0	0
Otter Bay	157,248	5,640	19,941	0
Richardson Bay	29,520	3,609	2,318	597
Narvaez	42,780	1,602	0	10,356
Royal Cove	35,365	202	0	0
Russell	146,070	0	0	46,174
Beaumont	163,779	0	0	12,292
Total	3,296,053	740,542	417,942	88,250

Coverage figures for GINPR study anchorages were calculated in the GIS using polygon data based on interpolated transect data from earlier stages in the study process. As Table 8 illustrates, eelgrass is by far the most prevalent VEC both in terms of number of anchorages where it is present (n=11), and in total area of benthic habitat it covers. Sea pens are about half as prevalent as eelgrass in terms of area covered, and number of sites (n=6) in which they are present. Sea anemones are the least abundant organisms and are found in the fewest number of anchorages (n=5), and cover approximately one tenth the total area that eelgrass does. These differences in area covered, and density of organisms on the substrate where they do occur, support the view that VEC vulnerability based on encounter rates with anchor or mooring tackle would be ranked high for eelgrass (largest surface area and clumped, dense growth/distribution pattern), moderate (moderate surface area and clumped distribution) for sea pens, and low for sea anemones (sparse distribution and smallest surface area coverage).

Gulf Islands National Park Reserve of Canada Moorings
Traditional moorings buoys are available at three anchorages in GINPR. Sidney Spit has 21 moorings, Beaumont 15, and Reef Harbour 10. No conservation moorings have been installed in GINPR to date. Stern ties are available at a few sites such as Royal Cove, but anchoring is the main method used in most of the park anchorages. The present mooring policy at GINPR does not require mandatory use of buoys where they are present. This policy may result in some skippers choosing to anchor when moorage is available because they prefer to anchor, or wish to avoid being charged mooring fees ($9.80 a night from May 15-Sept 30th, 2011). Mooring and anchoring data for Sidney Spit and Reef Harbour (Leatherbarrow 2006) clearly shows occasions where this has occurred.

Eelgrass

There is a high likelihood of anchoring or mooring impacts to GINPR eelgrass meadows due to: 1) shared preference of eelgrass plants and boaters for shallow, protected waters with soft bottoms; 2) peak abundance of plants and boaters during the summer season; 3) lack of mooring facilities at most GINPR anchorages where eelgrass is present; 4) traditional moorings located within eelgrass meadows at Reef Harbour and Sidney Spit; 5) lack of anchoring/mooring exclusion zones to protect sensitive resources like eelgrass; 6) eelgrass occurrence in 11 of 13 anchorages; 7) eelgrass has a dense, clumped distribution relative to other VECs; and 8) largest surface area coverage by far of the VECs (Table 8). The mechanism of effects is well documented and understood: (anchor set, drag, retrieval, anchor/mooring chain scour). Scouring effects can also increase turbidity in the water column, decreasing available light to adjacent plants. Although individual anchoring impacts to eelgrass beds may seem insignificant, the cumulative impact of repeated anchoring can be significant. The structure of eelgrass meadows is more complex than casual observation would suggest. They are dynamic systems comprised of many clonal plants growing in close proximity. Meadow maintenance or expansion is based on the ability of clonal plants to grow and establish new clones by vegetative or sexual means, as fast as, or faster than, the forces that work to work to stress, remove or kill plants from the system (Duarte, C.M. 2006). Anchors retrieved from eelgrass meadows typically have eelgrass plants attached to them when pulled from the water. While the scope of these impacts may seem small on an individual basis, collectively it can have a significant impact to the structure (density, patchiness) and long term viability of the meadow. Eelgrass is somewhat resilient but requires several years to recover after areas are lost to anchoring or other mortality sources. If the rate at which plants are lost due to mooring chain movement or anchoring exceeds recruitment from rhizome growth or establishment of new plants from seed, the meadow condition will erode over time. If these conditions persist, the meadow will eventually disappear.

Figure 16
Anchor placed in seagrass meadow. Source: Government of Bermuda, Department of Conservation Services.

Figure 17
Recently retrieved anchor with ensnared eelgrass. Source: Orcas Issues Website Newsletter http://orcasissues.com/

Sea Pens

There is a moderate likelihood of anchoring or mooring impacts to sea pens in GINPR anchorages due to: 1) presence in six of 13 anchorages; 2) presence year round; 3) moderate overlap with areas of preferred anchoring; 4) moderately dense distribution across the seabed; 5) cyclic colonial behaviour where about ¼ of the colony is exposed above the sediments at a time. Deeper water species such as White Sea pen *(Virgularia sp.)*, are not likely to be impacted due to boater preference for shallow, closer to shore anchorages that reduce wind exposure and facilitate trips ashore. Sidney Spit, Bennett Bay, Winter Cove, and James Bay have the largest areas of bottom habitat covered in sea pens. The large Orange sea pen *(Ptilosarcus gurneyi)* colony in the portion of Bennett Bay near the channel between Campbell Point and Georgeson Island is unlikely to be impacted by anchoring as this site is more exposed to wind and has higher current velocities. Skippers prefer to anchor or moor their craft in sites like Sidney Spit that have little to no current, and less wind exposure. The sea pens at Sidney Spit and James Bay are therefore considered to be more vulnerable to anchoring impacts than those at Bennett Bay.

Sea Anemones

There is a low likelihood of anchoring or mooring impacts to sea anemones in GINPR anchorages because they are least abundant VEC in terms of number of anchorages (n=5) where they are present; the amount of substrate area where they are present (approximately one tenth the total area of eelgrass, and one fifth area of sea pens); and are the most sparsely distributed organisms across the substrate where they do occur. These differences support the view that VEC vulnerability based on encounter rates with anchor or mooring tackle would be ranked low for sea anemones (sparse distribution of solitary animals; and smallest surface area coverage). The northern portion of the Russell Island anchorage has the largest occurrence of sea anemones found in this study. This is the deepest part of the study area (approximately 10-20 m), most exposed to wind and currents, and furthest from shore. As most skippers prefer anchoring close to shore in the most protected waters available, the likelihood of anchoring occurring in the deeper waters where anemone are present is further reduced. It is therefore reasonable to conclude that likelihood of anchoring impacting sea anemones is low.

VEC VULNERABILITY RANKING BY ANCHORAGE

In order to make a relative comparison of VEC occurrence and potential vulnerability at individual anchorages, percent cover for VECs was calculated for each study anchorage. The working assumption is that VEC vulnerability is influenced by VEC presence, abundance (in this case percent of benthic coverage), and anchoring and mooring activities within VEC occurrences. Following this logic, sites with more VECs, and higher percentages of surface area covered in VECs, are more vulnerable to impacts per unit of anchoring and mooring activities.

Since valued ecosystem component vulnerability could not be directly measured in the field, an approach was developed where the relative vulnerability of VECs could be inferred from their presence in areas likely to receive the highest levels of anchoring and mooring use. Two things are required in order for impacts to occur: 1) a sensitive receptor, in this case the 3 VECs; and 2) activities with the potential to negatively affect these receptors, in this case anchoring or mooring of recreational boats. If either element is missing, there will be no impacts to the receptor (VEC) attributable to that activity (anchoring/mooring). The method used to determine vulnerability relied on presence of suitable anchoring substrate, and preferred water depths (≤ 20m). The first step in the process involved making VEC polygons from transect data. Then anchoring g suitability maps were prepared using the criteria listed above. Results are displayed on an Anchoring Suitability map for each anchorage (Appendices Volume 2). The VEC Vulnerability map series illustrates the degree of overlap of suitable anchorage area and VEC occurrences. None of these methods provides absolute data on vulnerability so should be used a guidance only when assessing actions and priorities for management of anchoring and mooring at these GINPR sites.

Table 9 lists anchoring site rankings based on presence of the three VECs thought to be sensitive to anchoring: Eelgrass , Sea Pens , and Sea Anemones. The first ranking column for each VEC indicates a sites rank relative to other sites in the study. For example, Winter Cove was ranked first for Eelgrass as it had the greatest percent area (57%) occupied by eelgrass. Sites were assigned the same rank for instances where more than one site had the exact same percent cover value. James Bay, Narvaez Bay and Otter Bay were all assigned an eelgrass rank of 7 as they all had 4% eelgrass coverage. The weighted ranks (WTD) columns multiply the percent cover rank score with a factor representing the relative sensitivity[18] of each VEC to anchoring. Eelgrass was considered most sensitive and weighted using a factor of one (1). Sea pens were considered next most sensitive and given a ranking factor of one half (0.5), while sea anemones were given a ranking factor of one tenth (0.1). This implies that eelgrass is twice as sensitive to anchoring as sea pens and about 10 times more sensitive than anemones. Sea pens are considered 5 times more sensitive to anchoring than anemones. The total WTD rank score column is the sum of the weighted rank scores for all 3 VECs at each anchorage. VEC Vulnerability categories of low, moderate and high were chosen based on the range (3.0 to 13.9), and distribution of the total weighted rank scores. Category ranges were defined as:

- high (ranges from lowest possible score of 1.6 to 7.5)
- moderate (ranges from 7.6 to 10.0)
- low (ranges from 10.1 to maximum possible score)

Although in reality there is a continuum of vulnerability from low to high rather than discrete defined categories, the categories help conceptualize the relative vulnerability of the VECs at the different anchorages.

Table 9 VEC Vulnerability Rankings Based on Percent Coverage by Anchorage

Anchoring area	Eelgrass			Sea Pens			Sea Anemones			Total WTD rank score	VEC Vulnerability Category
	% cover	rank	Wtd rank	% cover	rank	Wtd rank	% cover	rank	Wtd rank		
Winter Cove	57	1	1	16	3	1.5	0	5	0.5	3.0	High
Princess Bay	50	2	2	0	6	3	0	5	0.5	5.5	High
Reef Harbour	39	3	3	0	6	3	0	5	0.5	6.5	High
Bennett Bay	5	6	6	27	2	1	0	5	0.5	7.5	High
James Bay	4	7	7	37	1	0.5	10	3	0.3	7.8	Moderate
Sidney Spit[19]	24	5	5	10	5	2.5	0	5	0.5	8.0	Moderate
D'Arcy Island	37	4	4	0	7	3.5	0	5	0.5	8.0	Moderate
Otter Bay	4	7	7	13	4	2	0	5	0.5	9.5	Moderate
Narvaez Bay	4	7	7	0	7	3.5	24	2	0.2	10.7	Low
Richardson Bay	2	8	8	1	6	3	0	5	0.5	11.5	Low
Royal Cove	1	9	9	0	7	3.5	0	5	0.5	13.0	Low
Russell Island	0	10	10	0	7	3.5	32	1	0.1	13.6	Low
Beaumont	0	10	10	0	7	3.5	8	4	0.4	13.9	Low

[18] Sensitivity was determined based on results of published and grey literature, personal observations during fieldwork, and expert opinion.

[19] Interpreting Sidney Spit Results

The occurrence of sea pens, sea anemones, and garbage at Sidney Spit may be under represented for the following reasons: 1) videotape transect coverage focused on the western portion of the study site; 2) transect spacing was wider relative to other study sites as Sidney Spit was a very large study area compared to the others; 3) presence of mooring buoys in the shallower eastern side of the site posed an entanglement risk for the towed video camera equipment so these areas were not traversed; and 4) eelgrass coverage was available for the eastern half of the anchorage from air photo interpretation supported by ground truthing by GINPR staff in 2010. Eelgrass is the only VEC for which there is occurrence data for the whole study area. Lack of occurrence data for sea pens, sea anemones, and garbage in the eastern portion of the study site is data gap in the study. For these reasons, the relative ranking of Sidney Spit may be lower than it would be if data for all VECs and garbage were available for the complete study site. This is because the whole study area was used to calculate percent coverage figures for the sea pens, sea anemones, and garbage, but occurrence data was based on the portion of the study site videotaped during the present study. Please refer to the Sidney Spit Video Coverage map in Appendices Volume 2: MAPS, for actual transect coverage within the study site.

As the results show, the ranking method is sensitive enough to not be dominated by a single high value for one VEC at a site. In the case of D'Arcy Island, it ranked highly for percent cover of eelgrass (4th highest of 13 sites), yet was ranked overall in the moderately vulnerable VEC category.

Sidney Spit, and D'Arcy Island have the same total weighted rank score (8.0) based on VEC percent coverage (Table 9). Sidney Spit is a very popular anchorage, and frequently has many vessels simultaneously anchored or moored during busy days in the summer boating season. D'Arcy Island is much less heavily used and typically used as a day anchorage when it is used. The study found one fifth (19%) of the bottom had garbage at Sidney Spit, while D'Arcy Island had no garbage at all (0%). It is assumed that garbage presence and abundance is a reasonable indicator of relative boat use levels where more garbage means more intense boat use including anchoring and mooring activities. Garbage includes items unintentionally dropped overboard, as well as items that were intentionally discarded while in the anchorage. Garbage presence at Sidney Spit and absence at D'Arcy Island is consistent with the notion that garbage occurrence can be used as an indicator of relative levels of use at the anchorage study sites. These findings support the view that resource vulnerability is likely greater at Sidney Spit than at D'Arcy Island, and reinforce that the weighted rank results should not be the sole factor used to rank sensitive seabed vulnerability.

Table 10 ranks VEC Vulnerability at each anchorage based on the amount that garbage overlaps the 3 VECs. The ranking method is the same as described above for Table 9. There is some consistency in the results between the two ranking methods:

- Winter Cove, Reef Harbour, James Bay, and Russell Island have the same relative rank position, and vulnerability category in each method;
- Richardson Bay, Russell Island, and Beaumont have a low VEC Vulnerability with each method.

Table 10 VEC Vulnerability Rankings Based on Percent Overlap of Garbage and VECs by Anchorage

Anchoring area	Eelgrass			Sea Pens			Sea Anemones			Total WTD rank score	VEC Vulnerability Category
	Garbage overlap %	rank	Wtd rank	Garbage overlap %	rank	Wtd rank	Garbage overlap %	rank	Wtd rank		
Winter Cove	43	2	2	53	2	1		4	0.4	3.4	High
Narvaez Bay	50	1	1		5	2.5	54	3	0.3	3.8	High
Reef Harbour	36	3	3		5	2.5		4	0.4	5.9	High
Royal Cove	24	4	4		5	2.5		4	0.4	6.9	High
James Bay	15	7	7	75	1	0.5	72	2	0.2	7.7	Moderate
Princess Bay	22	5	5		5	2.5		4	0.4	7.9	Moderate
Bennett Bay	20	6	6	22	4	2		4	0.4	8.4	Moderate
Sidney Spit	3	8	8	53	2	1		3	0.4	9.4	Moderate
Otter Bay		9	9	39	3	1.5		3	0.4	10.9	Low
Beaumont		9	9		5	2.5	100	1	0.1	11.6	Low
Richardson Bay		9	9		5	2.5		3	0.4	11.9	Low
Russell Island		9	9		5	2.5		3	0.4	11.9	Low
D'Arcy Island		9	9		5	2.5		3	0.4	11.9	Low

The most noteworthy change in rankings between the two methods is for Narvaez Bay and Royal Cove. These sites rank low based on VEC percent cover, but high based on overlap of garbage on VECs. Royal Cove's only VEC occurrence is a relatively small patch of eelgrass meadow covering only one percent of the site. Since Royal Cove has a large amount of garbage present (highest count of items of any study site), there is a fair amount of overlap between garbage and the eelgrass patch. Since Table 10 rankings do not take into account relative size of VEC occurrences, the relative vulnerability of the Royal Cove eelgrass is likely too high for the actual vulnerability of the resource that is present there. The alternate way to look at this finding is to conclude that the Royal Cove eelgrass is highly vulnerable as it is very small, and occurs in a site with relatively high levels of use (based on garbage presence).

In the absence of comprehensive boat use data for GINPR, garbage presence was used as an indicator of preferred anchoring locations within an anchorage site. This is based on two assumptions: 1) garbage which sinks to the bottom remains in or near the location it was initially deposited, and is not moved by bottom currents or other means; and 2) garbage was deposited from vessels while at anchor. The Anchoring suitability maps shows areas that may be suitable for anchoring or mooring vessels based on two criteria: water depth ≤ 20 m, and bottom substrate = size with good holding power (mud, silt, sand). In reality, skippers often take a broad range of factors into account when selecting preferred anchorages. These can include exposure to wind and currents; crowding; swing room; marked and unmarked hazards such as rocks awash; availability of escape routes; proximity to trails, beaches and other features of interest; quality of fishing; viewscape and other aesthetic factors; and proximity to shore campsites, picnic sites, or visitor information materials.

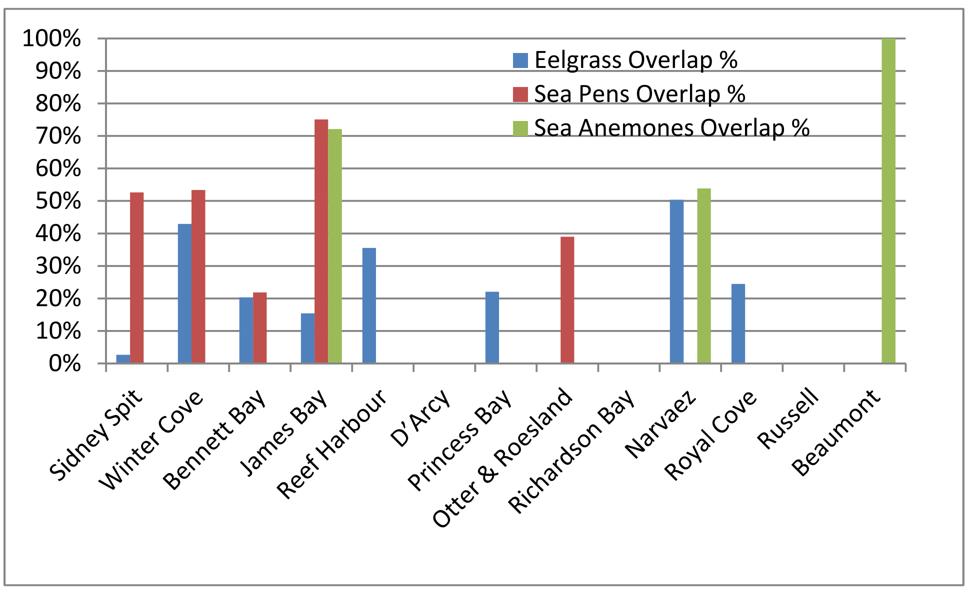

Figure 18 **Percent Overlap of Garbage on VECs by Anchorage Site**

CONCLUSIONS and RECOMMENDATIONS

No data was collected in this study to directly measure the impacts of anchoring and mooring on eelgrass meadows and other VECs within GINPR anchorages. Based on studies undertaken in other jurisdictions it is reasonable to conclude that anchoring and mooring activities have the potential to impact VECs within the 13 GINPR anchorages that were assessed. Studies in many other locations around the world have concluded that recreational boat anchoring and mooring can significantly damage seagrass meadows. The impact pathways are well known, and a variety of management measures have emerged to reduce or eliminate some of these impact sources. Anchor exclusion areas, and conservation moorings are the methods most frequently used to protect seagrass meadows worldwide.

There is a high likelihood of anchoring or mooring impacts to GINPR eelgrass meadows at the study sites due to: 1) shared preference of eelgrass plants and boaters for shallow, protected waters with soft bottoms; 2) peak abundance of plants and boaters during the summer season; 3) lack of mooring facilities at most GINPR anchorages where eelgrass is present; 4) traditional moorings located within eelgrass meadows at Reef Harbour and Sidney Spit; 5) lack of anchoring/mooring exclusion zones to protect sensitive resources like eelgrass; 6) eelgrass occurrence in 11 of 13 anchorages; 7) clumped distribution of eelgrass relative to other VECs; and 8) largest surface area coverage by far of the VECs. Therefore the greatest opportunity to reduce or eliminate impacts to vulnerable sensitive resources in GINPR would be to focus on activities that impact Eelgrass meadows. Results from nearby jurisdictions such as the San Juan Islands, indicate that investment of efforts to protect eelgrass are paying off and damaged meadows can recover in a matter of years after the impact source is decreased or eliminated.

There is a moderate likelihood of anchoring or mooring impacts to sea pens in GINPR anchorages due to: 1) presence in six of 13 anchorages; 2) presence year round; 3) moderate overlap with areas of preferred anchoring; 4) moderately dense distribution across the seabed; 5) cyclic colonial behaviour where about ¼ of the colony is exposed above the sediments at a time. Deeper water species such as White Sea pen (Virgularia sp.), are not likely to be impacted due to boater preference for shallow, closer to shore anchorages that reduce wind exposure and facilitate trips ashore. Sidney Spit, Bennett Bay, Winter Cove, and James Bay have the largest areas of bottom habitat covered in sea pens. The large Orange sea pen (Ptilosarcus gurneyi) colony in the portion of Bennett Bay near the channel between Campbell Point and Georgeson Island is unlikely to be impacted by anchoring as this site is more exposed to wind and has higher current velocities. Skippers prefer to anchor or moor their craft in sites like Sidney Spit that have little to no current, and less wind exposure. The sea pens at Sidney Spit and James Bay are therefore considered to be more vulnerable to anchoring impacts than those at Bennett Bay.

There is a low likelihood of anchoring or mooring impacts to sea anemones in GINPR anchorages because they are least abundant VEC in terms of number of anchorages (n=5) where they are present; the amount of substrate area where they are present (approximately one tenth the total area of eelgrass, and one fifth area of sea pens); and are the most sparsely distributed organisms across the substrate where they do occur. These differences support the view that VEC vulnerability based on encounter rates with anchor or mooring tackle would be ranked low for sea anemones (sparse distribution of solitary animals; and smallest surface area coverage). The northern portion of the Russell Island anchorage has the largest occurrence of sea anemones found in this study. This is the deepest part of the study area (approximately 10-20 m), most exposed to wind and currents, and furthest from shore. As most skippers prefer anchoring close to shore in the most protected waters available, the likelihood of anchoring occurring in the deeper waters where anemone are present is further reduced. It is therefore reasonable to conclude that likelihood of anchoring impacting sea anemones is low.

Valued Ecosystem Component vulnerability rankings for each study anchorage were determined by two methods: percent coverage by each VEC; and percent overlap of garbage on each VEC. Results vary by method but show a moderate degree of consistency. Winter Cove, Reef Harbour, James Bay, and Russell Island have the same relative rank position and vulnerability category in each method. Richardson Bay, Russell Island, and Beaumont have a low VEC Vulnerability with each method. VEC vulnerability covers a wide arrange from little to no vulnerability (e.g. Beaumont) to high vulnerability (e.g. Winter Cove). Not all sites investigated in this assessment had sensitive resources present when videotaped for this study. This conclusion is however based solely on the present condition and ecological community at this site. No attempt has been made to determine if the present ecological communities have been continuously present over the last 50+ years.

Although a structured methodology was used to derive the scores and rankings, the results are not intended to fully represent the relative vulnerability of sensitive seabed in the various study anchorages. The results should therefore be used as guidance only, and not be the sole factor used to prioritize management interventions or further investigations. Levels of anchoring activity must also be taken into account as it is a key factor influencing the probability of impact occurrence to sensitive seabed. Boat use data is beyond the scope of this study but is a key data gap requiring attention in order to effectively assess anchoring impacts and then manage them. A potential list of factors to consider when looking at the boat use side of the impact assessment equation is listed below. These include:

- type and number of vessels by anchorage site;
- type and number of anchors deployed;
- type of anchor ground tackle (rode chain vs. chain & nylon line mix);
- length of rode and line;
- wind conditions and exposure (more exposed site have greater probability of anchor dragging and sensitive seabed impacts);
- length of stay;
- anchor methods used during rode pull and anchor retrieval;
- overlap of anchoring with VECs;
- use of mooring buoys where/when available.

The lack of quantitative data on boat use levels and patterns within GINPR is a key data gap in the investigation of how boating activities may be impacting the nearshore environment. GINPR should consider developing a program to monitor boat usage. This is an important outstanding need as anchoring activities can directly impact sensitive communities such as eelgrass meadows. Understanding the relative contributions of anchoring upon eelgrass health and abundance would assist making informed decisions about management options (E.g. switch to mooring basin; closure). There are several local examples of this type of work available to assist in the design of a program at GINPR (Dismukes 2006; Leatherbarrow 2006).

Cause-effect relationships between anchoring and mooring, and eelgrass damage are well understood and documented in literature. There is a high likelihood that anchoring damage has been, and is occurring at GINPR, but the necessary study to confirm or refute this hypothesis was not conducted as part of this

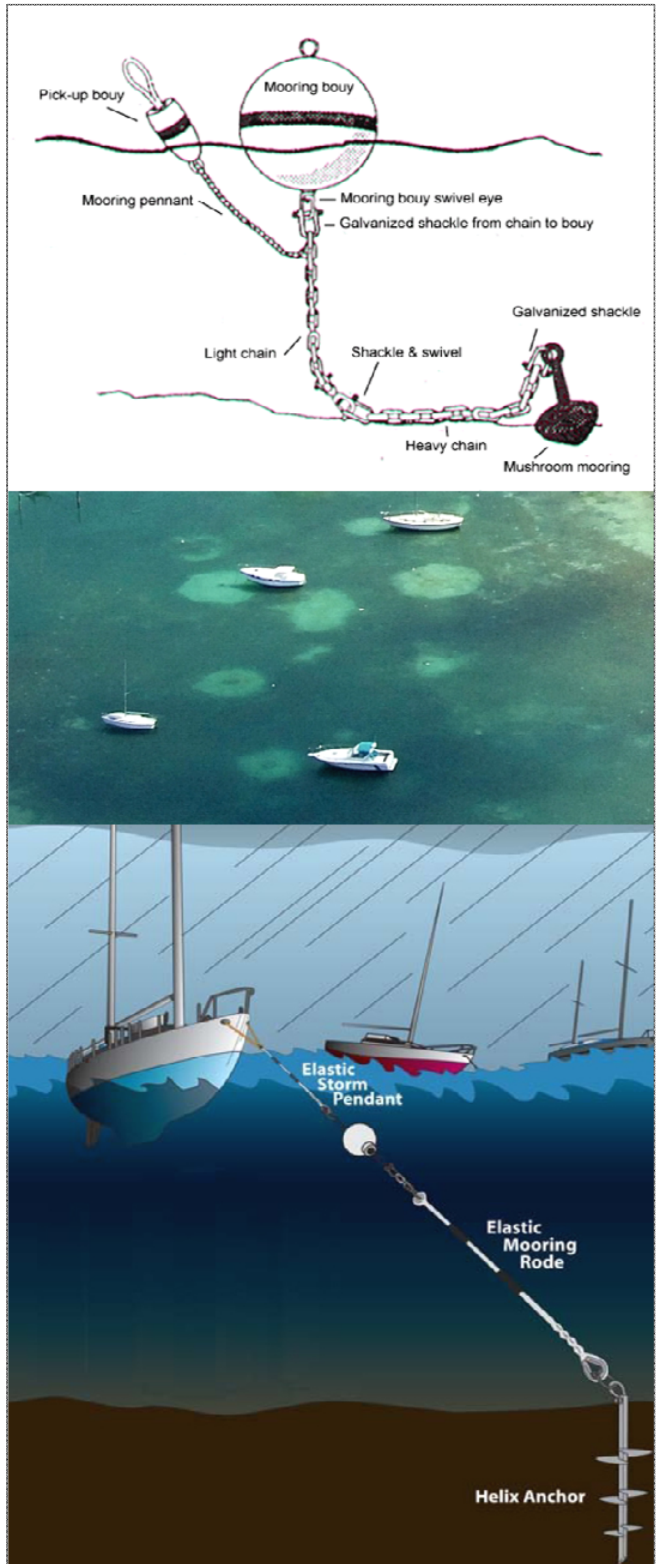

Figure 19 Impacts of traditional moorings and environmental benefits of conservation moorings. Adapted from Figure 59 in Buzzards Bay Comprehensive Conservation and Management Plan: 2011. (Buzzards Bay National Estuary Program 2011).

investigation. Sub-tidal eelgrass meadows, such as those present at Princess Bay, are a very important resource/habitat as documented in literature, and by adjacent protected areas agencies such as Washington State and US National Park Service. Conservation moorings have been shown to be effective at reducing the degree of impact from mooring activities in eelgrass meadows to tolerable levels. They have been used in many recent seagrass restoration projects where there is a clear mandate to protect and restore seagrass meadows, while continuing to allow recreational boat mooring activities to take place. Well researched and executed nearshore or vessel management programs such as Puget Sound Nearshore Ecosystem restoration Project, and the San Juan Voluntary Eelgrass Exclusion Zone Project, provide GINPR valuable examples from which to learn. Website links for these programs are listed at the end of References section of this report.

A typical conservation mooring consists of a helical screw anchor, elastic rode, buoyant floats to keep all parts off the bottom, and a surface float with moorage attachment point as depicted in the bottom portion of Figure 19. Additional examples of conservation moorings can be seen at http://www.thecoastalpassage.com/storm%20pics/mooring.pdf or http://www.hazelettmarine.com/new/ or http://new-england-marine.com/

The capital cost of conservation moorings when they first became available was quite high and in the range of 3000 to 4000 dollars per unit installed. Rising popularity of conservation moorings has lead to a more competitive market place with a wider selection of designs and suppliers to choose from, and consequent drop in unit price. Many conservation moorings are now cost competitive with traditional systems when the long working life span of conservation mooring components is factored into cost comparisons. Conservation designs reduce chafing of moorings lines and significantly lessen system loads because of the elastic properties of the material they are constructed with. Wear and tear on vessels is also reduced in wavy conditions as yawing[20] is much reduced.

The park should consider exploring the merits of mooring buoys as a management tool for protection of sensitive resources, in particular seagrass meadows. The plan should consider the present state of resources; boat use patterns and relationship to sensitive resources; an assessment of resource protection alternatives; a buoy design and installation plan with appropriate number and concentration of buoys; an education/outreach program to support the initiative; an enforcement of the mooring/anchoring rules (Mooring Buoy Planning Guide). The present mooring policy at GINPR does not require mandatory use of mooring buoys in circumstances where moorage is provided and vacant. This policy is likely to result in some boaters choosing to anchor nearby because they prefer to anchor, or wish to avoid being charged mooring fees. Mooring and anchoring data for Sidney Spit and Reef Harbour (Leatherbarrow 2006), clearly shows occasions where moorings were available while recreational boats were anchored nearby. Gulf Islands National Park Reserve should consider making use of mooring buoys mandatory when they are available. Perhaps mooring buoys should be free to use, but a fee charged for anchoring.

Key Recommendations:

1. Fill Key Data Gaps
- Undertake quantitative boat use study to record and analyse actual levels of mooring and anchoring taking place.
- Assess if all viable GINPR anchorages have been identified. If new areas are identified, map sensitive habitats as per this study.
- Assess potential for anchoring and mooring activities to damage or destroy nearshore subtidal cultural resources.

2. Manage for Protection of Sensitive Habitats and Species

Opportunities exist to improve management of anchoring and mooring activities in GINPR by:

[20] A vessel which will not hold a steady heading or direction, so swings from side to side is said to yaw. Vessels at anchor yaw due to wind or waves pushing against the hull.

- Installing conservation moorings at priority anchorage sites to protect vulnerable species or habitat (E.g. protect eelgrass by installing mooring buoys in Princess Bay, expanding mooring fields at Sidney and Reef Harbour, and/or converting existing chain moorings to conservation moorings.
- Instituting a policy for mandatory use of moorings where they are present and available;
- Developing and implementing an anchoring best practices code for areas where anchoring is permitted;
- Involving and educating the public and stakeholders in these initiatives, and on the importance of low impact anchoring and mooring methods. VEC conservation would be enhanced if the value of these resources was better understood by boaters. Parks Canada should therefore develop communication products to clearly communicate these values.
- Voluntary anchor exclusion zones have been used in other jurisdictions to prevent anchoring damage to sensitive resources, especially seagrass meadows. This management technique has been effective in the nearby San Juan Islands of Washington State. The program helps accomplish two very important outcomes: firstly, it increased resource protection; and secondly, it enhanced public understanding of the importance of eelgrass meadows in the ecology of nearshore areas, their vulnerability to anchoring, and the need to protect them. Gulf Islands National Park Reserve may wish to explore options for voluntary anchoring exclusion zones at select locations within the park.
- Assessing the need/viability/desirability for sensitive seabed restoration at existing anchorages.

Best Environmental Practices for Anchoring

The list below is a compilation of recommended practices from other marine jurisdictions.

- Carry the right gear - enough chain or chain and line to anchor in the appropriate depth.
- Always check the area before anchoring.
- Anchor in sand or mud away from seagrass and be sure your chain is clear of sensitive resources.
- Where installed, use appropriate mooring.
- Examine the area before anchoring to find the best location.
- Anchor away from fragile or sensitive areas including eelgrass meadows, bird nesting areas, Indigenous heritage sites and shipwrecks
- Anchor your boat a safe distance away from other boats
- Look out for the safety of people in the water when dropping your anchor
- If anchoring ashore, carefully place the anchor to minimise shore and coastal damage
- If anchoring overnight, anchor before nightfall and double check the swing room
- Carry enough chain and line for the depth you want to anchor in
- Use the correct anchor for your situation and environment
- Retrieve the anchor when the line is vertical
- If the anchor is caught on rocks or other solid ground, free it by hand wherever possible
- Do not force the anchor free by motoring forward
- Use only as much chain as you need to hold the vessel, without compromising safety
- Keep watch to make sure the anchor isn’t dragging
- Motor towards the anchor when hauling it in.

Nearshore marine ecology is very complex and can be heavily influenced from a wide variety of land based and marine based activities. Since Parks Canada has limited control over many of these activities, it should focus on activities for which it has mandated responsibility and control. Management of recreational boating activities, to provide high quality visitor experiences while protecting resources, should be a key focus in the GINPR management approach. There are many examples of this approach from other marine protected areas organizations.

Study results document the present status of sensitive habitats and species at the main anchorages in GINPR. Additional monitoring of theses sites is recommended to measure the effectiveness of any management approaches that are put in place, as well as natural variations in presence and abundance of sensitive habitat. Follow up of this nature is required to adaptively manage and protect sensitive resources while allowing visitors opportunities to continue boating at these sites.

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Washington State

Northwest Straits Marine Conservation Initiative (http://www.nwstraits.org)
Washington State Department of Natural Resources, Aquatic Resources Division, Nearshore Habitat Program.

Jefferson County Marine Resources Committee (http://www.jeffersonmrc.org)
Voluntary No-Anchor Eelgrass Protection Zone. A Non-Regulatory Marine Protected Area. Port Townsend Bay, Washington.

San Juan Marine Stewardship Area (http://www.sjcmrc.org)
Comprehensive program to assess and manage the marine resources of the San Juan Islands adjacent to BC Gulf Islands. Great opportunity to learn from their efforts and/or undertake similar program in BC waters as part of a coordinated effort across International borders. I.e. It's all the same ecosystem with similar patterns of use and issues.

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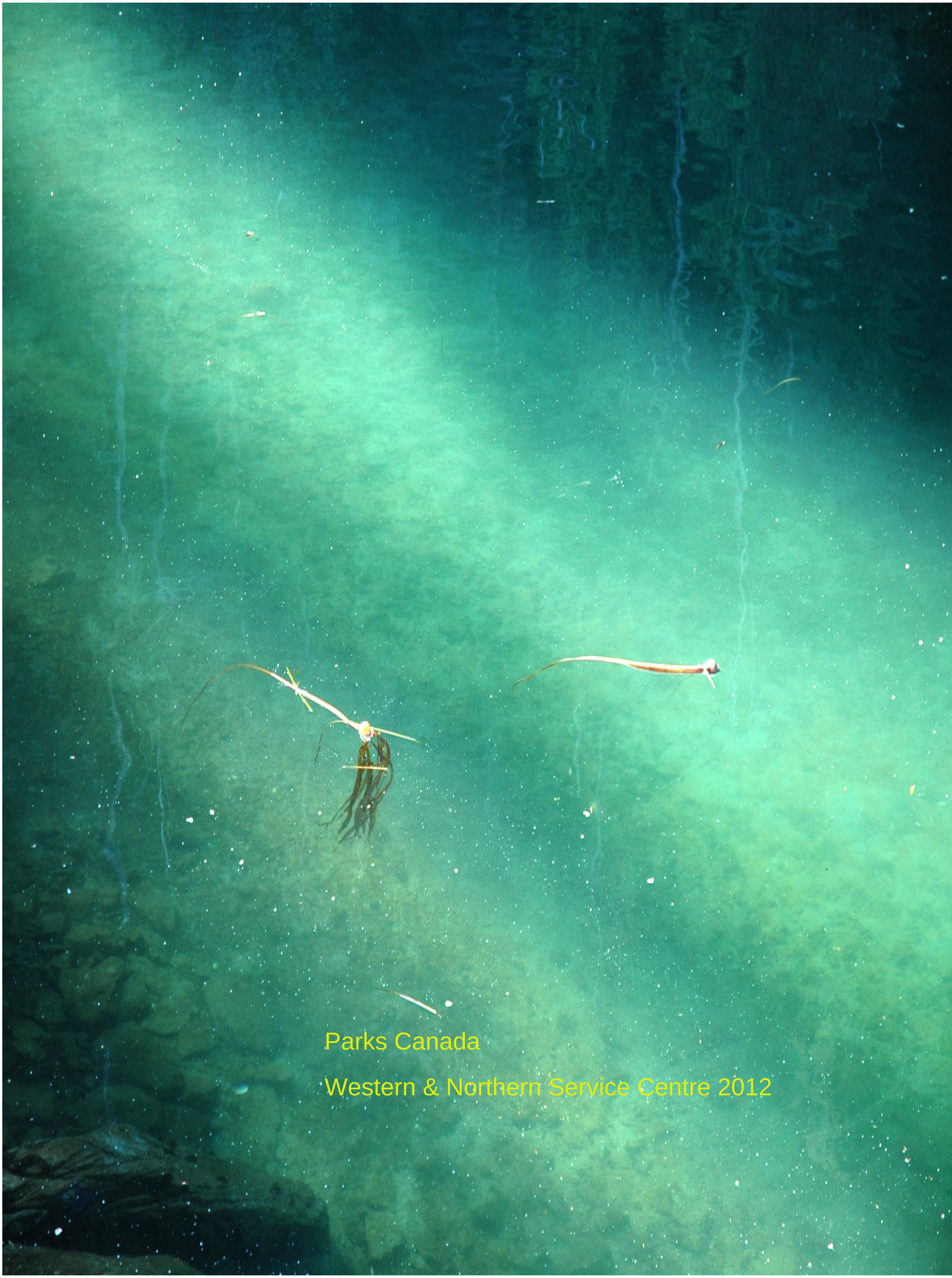
http://www.jcmrc.org/projects/project-pteelgrass.html

Puget Sound Nearshore Ecosystem Restoration Project (http://www.pugetsoundnearshore.org/index.htm)

Document list
Technical documents available from the Puget Sound Nearshore Ecosystem Restoration Project website http://www.pugetsoundnearshore.org/technical_reports.htm are listed below from most recent to oldest. The content of many of these documents would inform similar initiatives undertaken in the Gulf Islands of British Columbia.

2010-01 Principles for Strategic Conservation and Restoration
2009-01 Management Measures for Protecting and Restoring the Puget Sound Nearshore
2008-01 A Geomorphic Classification of Puget Sound Nearshore Landforms
2007-01 Orcas in Puget Sound
2007-02 Marine Riparian Vegetation Communities of Puget Sound
2007-03 Marine Forage Fishes in Puget Sound
2007-04 Beaches and Bluffs of Puget Sound and the Northern Straits
2007-05 Kelp and Eelgrass in Puget Sound
2007-06 Great Blue Herons in Puget Sound
2006-01 Coastal Habitats in Puget Sound: A Research Plan in Support of the Puget Sound Nearshore Partnership
2006-02 The Geomorphology of Puget Sound Beaches
2006-03 Conceptual Model for Assessing Restoration of Puget Sound Nearshore Ecosystems
2006-04 Native Shellfish in Nearshore Ecosystems of Washington State
2006-05 Nearshore Birds in Puget Sound
2006-06 Juvenile Pacific Salmon and the Nearshore Ecosystem of Puget Sound
2005-01 Historic Characterization of WRIA9 Shoreline Landforms
2004-01 Application of "Best Available Science" in Ecosystem Restoration: Lessons Learned from Large-Scale Restoration Efforts in the USA
2004-02 Guidance for Protection and Restoration of the Nearshore Ecosystems of Puget Sound
2004-03 Guiding Restoration Principles



Parks Canada

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