Characterisation of sublittoral habitats of Brier Island/Digby Neck Ecologically and Biologically Significant Area: Part I Overview and survey methods.

Background

Brier Island and Digby Neck has been recognised as an Ecologically and Biologically Significant Area (EBSA) (Buzeta, 2014). It was also one of four marine areas within the Bay of Fundy recognised by Parks Canada as of national significance (Parks Canada, 1975). The area has been recommended as a potential Marine Protected area (MPA) because it is representative of important outer Bay of Fundy features, has significant marine mammal and bird diversity and is considered to have high benthic diversity (Buzeta 2014; MCBI 1999). However, the benthic marine life in the area remains poorly known with only one major survey having been carried out (MacKay, 1977).

The area offshore of Brier Island has recently been identified (from historical surveys and species distribution modelling) as having one of the most significant concentrations of sponges in the Maritimes Region (Kenchington et al., 2016) and due to the tidal and topographic conditions the sponges inshore are also likely to be rich. However, little empirical work has been done on sponge biodiversity around Brier Island, with many of the trawl surveys used for the density analysis not being identified to species level and only four species identified from the inshore baseline transect survey (MacKay, 1977). As very little is known about sponges of the Bay of Fundy species cannot current be identified visually, therefore much biodiversity information about this important functional group is lost.

Location

Brier Island is situated at the south-west tip of Nova Scotia (Figure 1). It is the outermost island in a projection comprising Digby Neck, Long Island and Brier Island. The island is around 7.1 km long and 2.7 km wide. Sublittorally ledges extend to the south-west, terminating in Gull Rock and to the north-west. The island is formed of north mountain basalt and has steep basalt cliffs, around 30 m in height on its south shore.

Oceanographic and climatic conditions

The topography around the island results in waters being swept up over the shoals to the north and south and through Grand Passage (MacKay 1977). Currents around Brier Island are strong and can reach speeds of 5-6 knots in Grand Passage. Highly saline marine water flows into the Bay of Fundy along the Nova Scotian shore carrying abundant zooplankton (Mills & Laviolette, 2011). Tidal mixing and strong currents result in adjacent water masses being virtually isothermal from top to bottom (Gran and Braarud 1935, Hachey and Bailey 1952, Greenberg 1984, Brown and Gaskin 1986) and sea temperatures near Brier Island vary little annually and often do not exceed 7°C (Bailey 1954, Petrie *et al.* 1996). The area has the highest mean air temperature in January (about -2°C) anywhere in the Maritime Provinces, the smallest mean annual temperature range (about 16°C), smallest mean daily temperature range (≤ 8°C) except for parts of Prince Edward Island, the mildest extreme low temperature (about -14°C), and the longest frost-free period (more than 160 days) (Mills 1970). The moderate climate and the large (5-6m) tidal range results in organisms that are only found subtidally in other areas of the Bay of Fundy being found intertidally (Mills & Laviolette, 2011). The area has very clear water conditions and underwater visibility regularly exceeds 10m (MacKay, 1977). Consequently algae are abundant down to 20m or more.

Sublittoral Habitats

MacKay (1977) records the following main sublittoral habitat types:

1) North-west ledge. Extensive ledge system lying to the north of Brier Island, much of which with a depth of <3m C.D. Dominated by kelps and other algae as well as associated invertebrate species.

2) Northern entrance to Grand Passage. Bedrock and boulder with some scoured sand and cobble patches on the sea bed. Dominated by kelps and other algae.

3) Westport Shore. Gently sloping mixed substrate shore. Some areas of eelgrass.

4) The south-east coast. Steep bedrock with abundant large kelp and diverse invertebrate communities on holdfasts.

5) South-west ledge. Not surveyed due to weather conditions but expected to be similar to north-west ledge.

Species

Limited survey work has been carried out in the area. Invertebrate species recorded by MacKay (1977) are listed in Appendix 1. As their methodology involved recording only conspicuous species with no sampling to confirm identifications the number of species is likely to have been significantly under-recorded. The biodiversity of groups which are hard to identify *in situ* such as Bryozoa (no named species listed) and Porifera (only four named species recorded) is likely to have been particularly under-estimated.

Some algal survey work has been carried out in the area: Edelstein et al. (1970) recorded 187 species from the adjacent Digby Neck Peninsula, although only a single trip was made to Brier Island. A summary was also provided in Wilson et al. (1979). Research on the algae of Brier Island is currently being carried out by Professor David Garbary (St Francis Xavier University) and his current species list is provided in Appendix 2 – this is original unpublished research data and not for reproduction.

Survey methodology

A diver-based survey of sublittoral habitat and species will be conducted to validate and revise historical information on invertebrate and macroalgal species assemblages (Edelstein et al. (1970); MacKay 1977). The initial investigation will employ a baseline 'roving-diver' survey on as many as 38 target stations surrounding Brier Island and its nearby ledges (Figure 1). A list of priority regions (Table 1; Figure 1) has been selected based on featured species and habitats identified within the literature and through personal communication with current researchers in this area.

This roving-diver survey will collect semi-quantitative information on habitat and species presence using a SACFOR abundance scale (Appendix 3). This scale and some of the substrate terminology are based on the UK Marine Nature Conservation Review recording scheme (see http://jncc.defra.gov.uk/page-2683 and http://jncc.defra.gov.uk/pdf/mncrform.pdf for guidance notes) with substrate categories and algal cover definitions based on habitat and species inventory protocols employed by DFO Aquatic Resources Research and Assessment Division in British Columbia (methods obtained from Domique Bureau). Wide angle photography will be used to document sites and macro photography to document species. Specimens of invertebrates and algae will be taken and preserved to confirm identifications. Tissue samples will be taken of sponges, these will be collected in numbered bags to ensure they can be matched with photographs post-dive. Following the survey a site record form will be completed (Appendix 4) and photos will be organised using Adobe Lightroom. Algal samples will be identified by David Garbary (Professor at St. Francis Xavier University) and invertebrates by staff from the Atlantic Reference Centre. Invertebrate specimens will be place in the Atlantic Reference Centre museum. The baseline information collected during

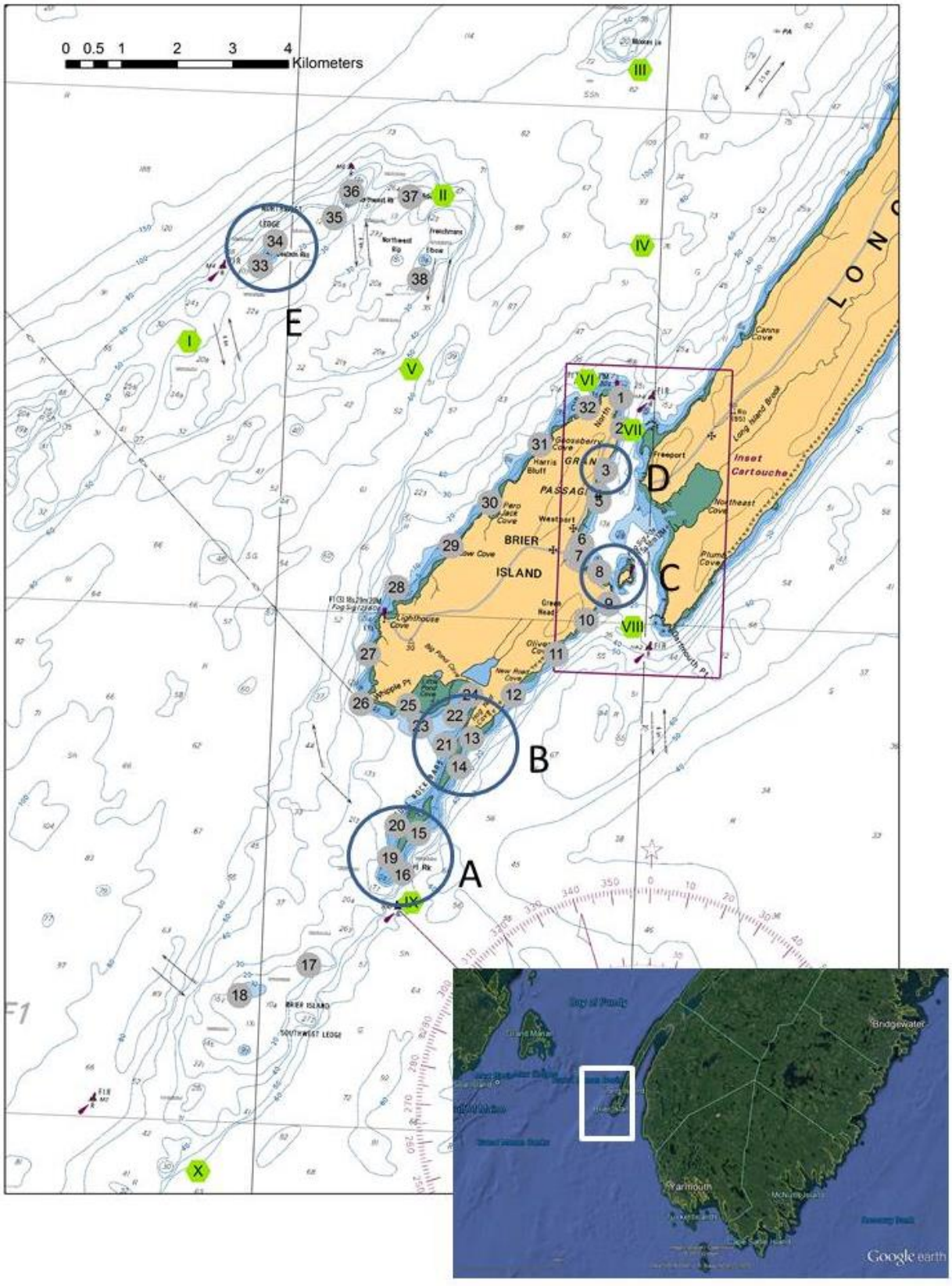
the initial assessment will be used to customise a quantitative survey method for the Brier Island area.

New physical oceanographic information will be recorded at each dive location in order to quantify water quality conditions considered to support the diversity of species in this area. Parameters will include temperature, salinity, depth, turbidity (NTU), and chlorophyll (RFU) using either a YSI multi-parameter water quality sonde at dive depth, or castaway vertical profiler. In addition, vertical profiles of salinity and temperature will be collected at depths of up to 60m for ten historical stations (Figure 1) to offer a quantifiable reassessment of oceanographic mixing in the surrounding area.

Table 1 - Target survey sites (see Figure 1 for locations).

Site name	Figure 1 Marker	Area	Features/species	Source
Gull Rock	A	South-west	Sponges (*Haliclona oculata*)	MacKay 1977
MacKay site 8.	8	Grand Passage	Zostera bed.	MacKay 1977
MacKay site 3	3	Grand Passage	*Cerianthus borealis*	MacKay 1977
Peter's Island	C	Between Brier and Long Islands	Branching and encrusting sponges	Scott Leslie
Cliffs below Brier Island Lodge	D	North-eastern coast	Grooved rock which might be good for sponges	Scott Leslie
North-west ledge	E	North-west of Brier (exposed)	'incised with little protective "canyons" that may be good spots for sponges and other sessile species. I remember a fair number of anemones (mostly northern red). '	Scott Leslie
Green Island	B	Southern Tip of Brier	Algae. Shore survey at LW (David Garbary) and sublittoral survey.	David Garbary

Figure 1 - Sampling locations at Brier Island. Sampling sites from MacKay (1977) indicated by grey circles. Target areas A-E (see Table 1) indicated by blue circles. Oceanographic sampling sites I-X in green circles. Inset location of Brier Island.



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Appendix 1 – Invertebrate species recorded by MacKay (1977)

PORIFERA	ANNELIDA	*Dendronotus frondosus*	BRYOZOA
Halichondria panicea	*Amphitrite sp.*	*Hiatella arctica*	*Several species*
Haliclona oculata	*Clymenella sp.*	*Ischnochiton ruber*	BRACHIOPODA
Isodictya deichmannae	*Glycera dibranchiata*	*I. alba*	*Terebratulina septentrionalis*
Scypha ciliata	*Lepidonotus squamatus*	*Lacuna sp.*	
CNIDARIA	*Myxicola infundibulum*	*Littorina littorea*	CHORDATA
HYDROZOA	*Potamilla neglecta*	*L. obtusata*	*ASCIDIACEA*
Obelia sp.	*Spirorbis borealis*	*L. saxatilis*	*Boltenia ovifera*
Tubularia sp.	ARTHROPODA	*Lunatia heros*	
Unidentified sp.	*Balanus balanoides*	*Modiolus modiolus*	
ANTHOZOA	*Balanus balanus*	*Mya arenaria*	
Cerianthus borealis	*Cancer borealis*	*Mytilus edulis*	
Metridium senile	*Carcinus (Carcinides) maenas*	*Neptunea decemcostata*	
Tealia felina	*Gammarus oceanicus*	*Onchidoris sp.*	
Unidentified sp.	*Homarus americanus*	*Placopecten magellanicus*	
CTENOPHORA	*Isopod (? sp.)*	*Thais lapillus*	
Pleurobrachia pileus	*Pagurus sp.*	ECHINODERMATA	
RHYNCHOCOELA	*Shrimp (?sp.)*	*Asterias vulgaris*	
Lineus sp.	MOLLUSCA	*Cucumaria frondosus*	
	Acmaea testudinalis	*Henricia sanguinolenta*	
	Buccinum undatum	*Ophiopholis aculeata*	
	Coryphella sp.	*Psolus fabricii*	
		Solaster endeca	
		Strongylocentrotus droebachiensis	

Appendix 2– Algae recorded from the area recorded by Wilson (1980) and Garbary (unpublished research data, not for reproduction).

Rhodophyta

Acrochaetium alariae, Acrochaetium microscopicum, Acrochaetium secundatum, Ahfeltia plicata, Antithamnion cruciatum (incl A.amer & A. plumula), Antithamnionella floccosum, Bangia atropurpurea, Bonnemaisonia hamifera, Callithamnion tetragonum, Callithamnon corymbosum, Callophyllis cristata, Ceramium deslongchampii, Ceramium elegans, Ceramium secundatum or virgatum? (incl. C. elegans?), Ceramium virgatum, Ceramium strictum, Champia parvula, Chondrus crispus, Choreocolax polysiphoniae, Choreocolax rabenhorstii, Clathromorphum circumscriptum, Clathromorphus compactum, Coccotylus truncates, Colaconema daviesii, Colaconema saviana, Corallina officinalis, Cruoria arctica, Cystoclonium purpureum, Dasya baillouviana, Devalarea ramentacium, Dumontia incrassate, Erythrodermis traillii (=Phyllophora traillii), Erythrotrichia carnea, Fimbrifolium dichotomum (=Rhodophyllis dichotoma), Gelidium crinale, Gloiosiphonia capillaris, Goniotrichum alsidii, Gymnogongrus crenulatus, Haemescharia hennedyi (Petrocelis hennedyi), Halosacciocolax kjellmanii, Halosacciocolax lundii, Harveyella mirabilis, Hildenbrandia rubra, Hydrolithon farinosa (Melobesia), Leptophytum foecundum, Leptophytum leave, Lithophyllum corallinae, Lithophyllum orbiculatum, Lithothamnion glaciale, Lomentaria orcadensis, Mastocarpus stellatus, Membranoptera fabriciana, Meiodiscus spetsbergensis, Melanothamnus harvyi (=Polysiphonia harvyi), Melobesia membranacea, Membranoptera alata, Odonthalia dentate, Palmaria palmate, Peyssonnelia rosenvingii, Phycodrys rubens, Phyllophora pseudoceranoides, Phymatolithon laevigatum, Phymatolithon lamii (=P. rugulosum), Phymatolithon lenormandii, Plumaria elegans, Pneophyllum confervicola (Melobesia lejolisii), Polyides rotunda, Polyostea arctica (=Polysiphonia arctica), Polysiphonia brodaei, Polysipphonia elongata (=flexicaulis in Edelstein??), Polysiphonia fibrillose, Polysiphonia fucoides (=Polysiphonia nigrescens), Polysiphonia stricta (=Polysiphonia urceolata), Polysipnoia flexicaulis, Porphyra linearis, Porphyra umbilicalis, Porphyra sp. (mid shore epiphyte), Porphyrropsis coccinea, Ptilota serrata, Pyropia leucosticta (=Porphyra leucosticta), Rhodochorton purpureum, Rhodomela confervoides, Rhodomela lycopodioides, Rhodophysema elegans, Rhodophysema georgii, Rubrointrusa membranacea (171), Scagelia pylaisaei, Scinaia forcellata, Solieria filiformis (=Soliera tenera), Spermothamnion repens, Spyridia filamentosa, Titanoserma pustulatum (=Dermatolithon), Tsengia bairdii (Platoma bairdii), Vertebrata lanosa, Wildemania miniata (=Porphyra miniata)

Chlorophyta

Acrosiphonia arcta (Spongom arcta), Acrosiphonia sonderi (=Spongom sonderi), Acrosiphonia spinescens (=Spongom spinescens), Blidingia chaedefaudii, Blidingia marginata, Blidingia minima, Bolbocoleon piliferum, Bryopsis hypnoides, Capsosiphon fulvescens, Chaetomorpha aerea, Chaetomorpha ligustica (=Rhizo. tortuosum), Chaetomorpha linum, Chaetomorpha melagonium, Chaetomorpha picquotiana (=C. atrovirens), Chlorochytrium cohnii, Chlorochytrium dermatocolax, Cladophora albida, Cladophora glomerata (=C. capillaris), Cladophora laetevirens, Cladophora rupestris, Cladophora sericea, Derbesia marina, Epicladia flustrae (=Entocladia flustrae), Eugomontia saccculata, Gayralia (=Ulvaria oxysperma), Gomontia polyrhiza, Halochlorococcum moorei (=Chlorochytrium moorei), Kornmannia leptoderma, Monostroma grevillei, Ochlochaete hystrix var. ferox (=Ochlochaete ferox), Percursaria percursa, Prasiola crispa, Prasiola stipitata, Protomonostroma undulatun, Pseudendoclonium fucicolum (=Pseudopringsheimia fucicola), Pseudendoclonium marinum (=Pseudendoclonium submarinum), Pseudoprinsheimia confluens, Pseudothrix groenlandica (=Entero. groenlandica), Rhizoclonium riparium, Spongomorpha aeruginosa, Stichococcus marinus, Ulothrix flacca, Ulothrix laetevirens, Ulothrix speciosa (=Urospora

speciosa), Ulothrix subflaccida, Ulothrix tenuissima (=Ulothrix pseudoflacca), Ulva clathata (=Enteromorpha clathrata), Ulva compressa (=Enteromorpha compressa), Ulva flexuosa (=Entero. flexuosa), Ulva intestinalis (=Entero. intestinalis), Ulva lactuca, Ulva linza (=Entero linza), Ulva prolifera (=Entero prolifera), Ulva rigida, Ulvaria obscura, Ulvella parasitica (=Acrochaete parasitica), Ulvella repens (=Acrochaete repens), Ulvella repens (=Pilinia endophytica), Ulvella scutata (=Pringsheimiella scutata), Ulvella viridis (=Entocladia viridis), Ulvella wittrockii (=Ectochaete wittrockii), Urospora penicilliformis, Urospora wormskoldii

Phaeophyceae

Acrothrix novae-angliae, Agarum cribrosum, Alaria esculenta, Ascophyllum nodosum, Asperococcus fistulosus, Chorda filum, Chordaria flagelliformis, Cladosiphon zosterae, Coilodesme bulligera, Colpomenia peregrine, Desmarestia aculeate, Desmarestia viridis, Desmotrichum undulatum, Dictyosiphon chordariae, Dictyosiphon eckmannii, Dictyosiphon foeniculaceus, Dictyosiphon macounii, Ectocarpus fasiculatus, Ectocarpus penicillatus, Ectocarpus siliculosus, Elachisa chondrii, Elachista fucicola, Elachista lubrica, Entonema alariae?, Entonema polycladum, Eudesme virescens, Fucus distichus, Fucus edentates, Fucus evanescens, Fucus serratus, Fucus spiralis, Fucus vesiculosus, Halopteris scoparia, Halosiphon tomentosum, Haplospora globosa, Hecatonema terminale (previously maculans), Hincksia granulosa, Isthmoplea sphaerophora, Laminaria digitata, Laminariocolax aecioides, Laminariocolax tomentosoides, Leathesia difformis, Leptonematella fasciculate, Litosiphon laminariae (Streblonema oligosporum), Melanosiphon intestinalis, Microspongium globosum, Microspongium immersum (Streblonema imm), Microsyphar polysiphoniae, Microsyphar porphyrae, Myriocladia lovenii, Myrionema corunnae, Myrionema magnusii, Myrionema strangulans, Myriotrichia clavaeformis, Petalonia fascia, Petalonia zosterifolia, Petroderma maculiforme, Pseudolithoderma extensum, Punctaria latifolia, Punctaria plantaginea, Pylaiella littoralis, Ralfsia fungiformis, Ralfsia pussila, Ralfsia verrucosa, Saccharina latissima , Sacchorriza dermatodea, Scytosiphon dotyi, Scytosiphon lomentaria , Scytosphon complanatus, Sorapion kjellmannii, Sphacelaia radicans, Sphacelaria arctica, Sphacelaria Britannica, Sphacelaria cirrhosa, Sphacelaria furcigera, Sphacelaria fusca, Sphacelaria plumose, Sphacelaria sp., Sphaerotrichia divaricate, Spongonema tomentosum, Stictyosiphon griffithsianus, Stictyosiphon soriferus, Strangularia clavata (Ralfsia bornetii), Streblonema chordariae, Streblonema fasiculatum, Streblonema infestans (Endodictyon infestans), Streblonema parasiticum, Tilopteris mertensii, Ulonema rhizophorum

Appendix 3 – MNCR SACFOR Abundance Scale

	Growth form		Size of individuals/colonies					
% cover	Crust/meadow	Massive/Turf	<1cm	1-3 cm	3-15 cm	>15 cm	Density	
>80%	S		S				>1/0.001 m^2 (1x1 cm)	>10,000 / m^2
40-79%	A	S	A	S			1-9/0.001 m^2	1000-9999 / m^2
20-39%	C	A	C	A	S		1-9 / 0.01 m^2 (10 x 10 cm)	100-999 / m^2
10-19%	F	C	F	C	A	S	1-9 / 0.1 m^2	10-99 / m^2
5-9%	O	F	O	F	C	A	1-9 / m^2	
1-5% or density	R	O	R	O	F	C	1-9 / 10m^2 (3.16 x 3.16 m)	
<1% or density		R		R	O	F	1-9 / 100 m^2 (10 x 10 m)	
					R	O	1-9 / 1000 m^2 (31.6 x 31.6 m)	
						R	<1/1000 m^2	

Use of the MNCR SACFOR abundance scales

The MNCR cover/density scales adopted from 1990 provide a unified system for recording the abundance of marine benthic flora and fauna in biological surveys. The following notes should be read before their use:

1. Whenever an attached species covers the substratum and percentage cover can be estimated, that scale should be used in preference to the density scale.
2. Use the massive/turf percentage cover scale for all species, excepting those given under crust/meadow.
3. Where two or more layers exist, for instance foliose algae overgrowing crustose algae, total percentage cover can be over 100% and abundance grade will reflect this.
4. Percentage cover of littoral species, particularly the fucoid algae, must be estimated when the tide is out.
5. Use quadrats as reference frames for counting, particularly when density is borderline between two of the scale.
6. Some extrapolation of the scales may be necessary to estimate abundance for restricted habitats such as rockpools.
7. The species (as listed above) take precedence over their actual size in deciding which scale to use.
8. When species (such as those associated with algae, hydroid and bryozoan turf or on rocks and shells) are incidentally collected (i.e. collected with other species that were superficially collected for identification) and no meaningful abundance can be assigned to them, they should be noted as present (P).

Appendix 4

Brier Island Dive Survey Form		**Dive no:**
Site Name:		
General Location:		
Position:	**Derived from:**	
Date of dive:		
Start time:	**Duration:**	**Temp:**
Exposure of site: extremely exposed; very exposed; exposed; mod exposed; sheltered; v sheltered; extremely sheltered		
Max tidal stream: >6k; 3-6k; 1-3k; <1k; negligible		
Max depth:	**Min depth:**	**Correction to Chart Datum:**
Diver names		
Camera 1 (type/photo nos)		
Camera 2 (type/photos nos)		
Specimens taken (type/numbers)		
Site Summary: main features (plant/animal cover types, substrate), unusual species/features/human activities/impacts		
Sketch of site - include seabed profile, sketch map of position, main habitats (link to 1,2,3 described below).		

Appendix 4

Habitat description: Depth range, substrate, dominant species

Habitat 1:

Habitat 2:

Habitat 3:

	Habitat		
Depth (m)	**1**	**2**	**3**
Upper (SL)			
Lower (SL)			
Upper (CD)			
Lower (CD)			

	Habitat		
Substrate (%)	1	2	3
Bedrock			
Boulders - larger than basketball			
Cobbles - fist to basketball sized			
Pebbles - 1cm to fist sized			
Gravel - 2mm-1cm			
Sand <2mm			
Mud			
Shell gravel			
Shell whole or chunks			
Other (state)			

	Habitat		
	1	**2**	**3**
Algal Cover (%)			
Kelps			
Turf species (<30cm high)			

	Habitat		
Rock features (1-5)	**1**	**2**	**3**
Relief (even-rugged)			
Texture (smooth-pitted)			
Stability (stable-mobile)			
Scour (none-scoured)			
Silt (none-heavy)			
Fissure > 10mm (none-many)			
Crevice <10mm (none-many)			
(rounded to angular)			
Sediment features (1-5)			
Firmness (firm-soft)			
Stability (stable-mobile)			
Sorting (well-poor)			
Sediment features (tick)			
Mounds/casts			
Burrows/Holes			
Waves >10cm			
Ripples <10cm			

Appendix 4

Species List. Abundance to be recorded using SACFOR scale (**S**uper Abundant, **A**bundant, **C**ommon, **F**requent, **O**ccasional, **R**are)

If subsequently identified from a photo or specimen record as **P**resent.

	Habitat					Habitat			
	1	**2**	**3**			**1**	**2**	**3**	
Sponges					**Echinoderms**				
					Ascidians				
Cnidarians: hydroids/anemones/corals									
					Fishes				
Worms									
					Algae				
Crustaceans									
Molluscs									
					Other/continuations				
Bryozoans									