AN INTERTIDAL SURVEY OF MARINE FAUNA

OF

GREAT WASS ISLAND, MAINE

BY

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Prepared for the Nature Conservancy

Summer 1979

Bigelow Laboratory Technical Report No. ~~1-80~~ 5, 1980

ACKNOWLEDGEMENTS

I would like to thank Peter F. Larsen for being an integral part of all phases of this study; Dr. Larry Spencer of Plymouth State College and his daughter for their help with the sampling; Ann Rivers for her help sorting and identifying sedimentary samples; Robert Burns, a warden for the Department of Marine Resources, for his patience, skill and help in sampling "The Pond"; Spencer Apollonio, Commissioner of the Department of Marine Resources for allowing us to use his employees and boat; Charlotte Woodward of the Department of Conservation for letting us wash the samples at the public boat facility and Peter Larsen's dog, Tay, whose nose and white tipped tail was invaluable in finding our way back from sampling sites at dusk. John Beal is appreciated for letting us rent his cabin, and Dr. Robert Vadas and students provided interesting discussions, moral support and entertainment.

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INTRODUCTION

Great Wass Island is located in cold temperate waters of the western North Atlantic Ocean. Characteristic assemblages of marine invertebrates (animals without backbones) inhabit this region which is commonly called the boreal zone. The boreal zone extends from Cape Cod to Labrador. The principal center of these assemblages of invertebrates occur in this region. Temperature is the principal controlling factor in determining species distributions. The waters of this region are warmer than those in the arctic yet cooler and less seasonally variable than those south of Cape Cod.

The purpose of the present survey is to document and characterize the invertebrate fauna in and around the Great Wass Island preserve. The intertidal shores (between high and low tide) were examined (see Figure 1) as well as the semi-enclosed subtidal area known as "The Pond" (Site 19). Fish present in the intertidal zone are also included in the survey. This report represents a summary of data collected at Great Wass Island. Complete data are available from the author.

The intertidal zone is principally bedrock ranging from very low slopes on the eastern shore (between Sites 4 and 5) to vertical or nearly vertical bluffs (20-30 meters high) on the southern shore (between Sites 7 and 9 and near Site 12). Boulder areas are interspersed in between bedrock areas (e.g. Sites 6, 11 and 14). Cobble and gravel areas are found in the high intertidal zone of some shores. Mudflats are present in Sites 1 and 16 and around the shore of "The Pond" (Site 19). A sand flat was present at Site 20.

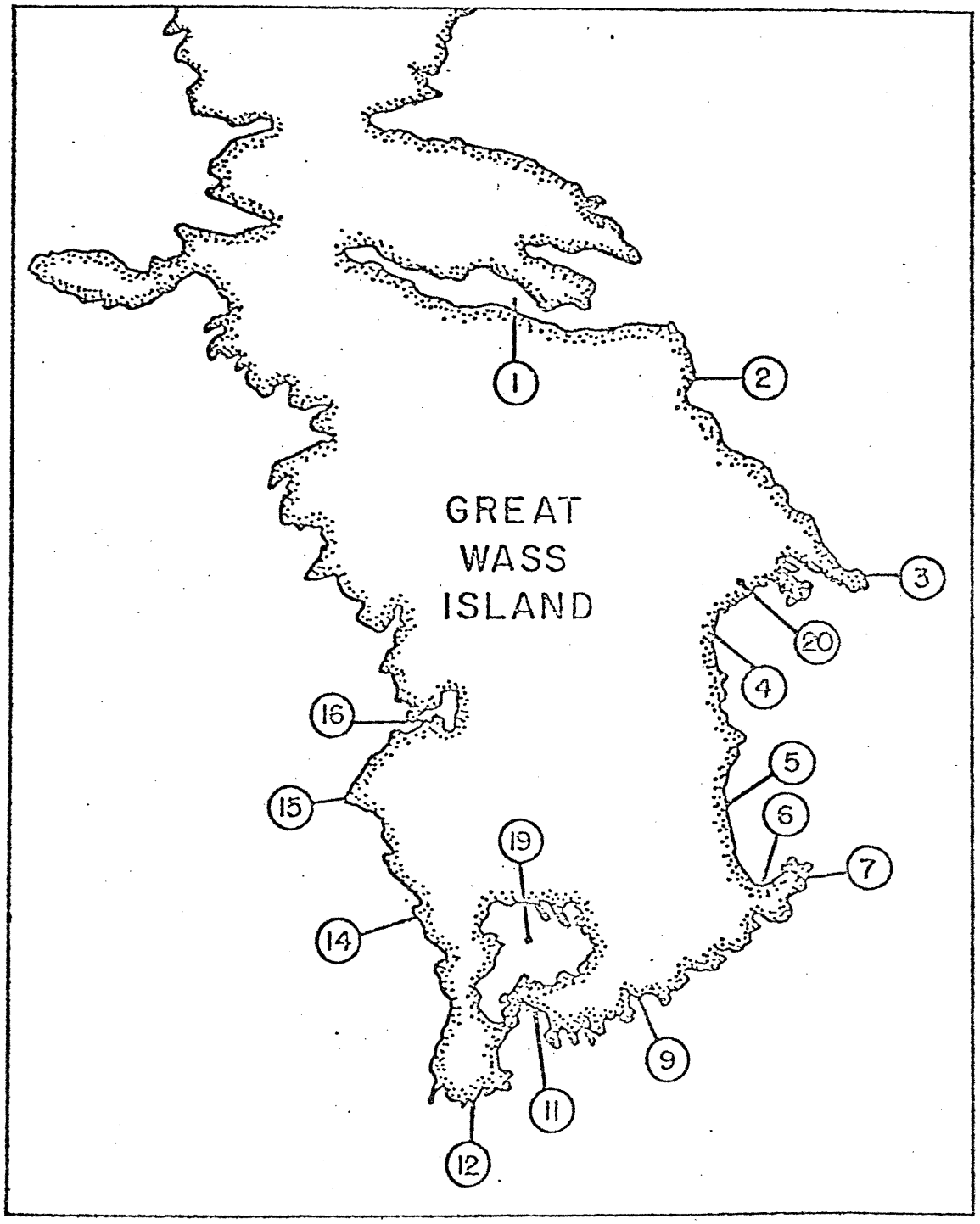

Figure 1. Sites sampled at Great Wass Island.

METHODS

Fifteen sites were examined in the Great Wass Island preserve during the summer of 1979 (Figure 1). Eleven sites were intertidal rocky shore, three were intertidal flats (two mud and one sand) and one was subtidal unconsolidated bottom or flat. Proposed sampling sites were chosen by Dr. Robert Vadas at the University of Maine with intent of giving a thorough coverage of the intertidal habitats represented in and adjacent to the preserve. We varied his design by adding a subtidal site in "the Pond" (Site 19, Figure 1) and a sand flat (Site 20, Figure 1), consolidating the closely spaced sites (6 and 7, Figure 1), and dropping four of his sites (8, 13, 17 and 18). Two of the proposed sites (17 and 18) were out of the preserve and upon brief examination appeared to have low species diversity. Site 8 was inaccessible because the intertidal zone was vertical (i.e. cliff). Site 10 was included qualitatively in "the Pond" species list and Site 13 was omitted due to combined constraints of time and weather (i.e. waves).

After an initial examination it was determined that a qualitative survey of the rocky shore habitat would yield the most meaningful results. The original plan had been to do percent cover but the rocky shores of Great Wass Island are dominated by algae. Therefore, in most areas percent cover of invertebrates would be relatively low. Relative abundance using the definitions (Table 1) outlined in Critical Areas Planning Report No. 55 (Doggett *et al*, 1978) was noted. Any animal which could not be readily identified

Table 1. Definition of relative abundance terms.

Dominant	extremely abundant and visually obvious.
Common	readily found with just a cursory examination.
Uncommon	not readily found with a cursory examination, but present regularly enough so more than one individual can be located after a relatively thorough search.
Infrequently found	very few individuals, if any, are found after a relatively thorough search.

in the field was collected and returned to the laboratory.

Two (Sites 1 and 16) of the intertidal flats were sampled quantitatively using a 0.031 m ($1/32m^2$) quadrat to a depth of 15 cm. The subtidal samples were taken with a ponar grab ($0.044m^2$). The grab did not work properly; therefore, the abundances of individuals would represent a low estimate of actual abundances. All quantitative samples were sieved through a 1 mm mesh screen. The intertidal sand flat (Site 20, Figure 1) was sampled qualitatively because of the distance one would have to transport samples was excessive. All samples were preserved in 70% ethyl alcohol.

The samples were collected and sites examined during two one week trips in June and July, during the lowest tides of the month. Sampling dates and tidal heights (relative to mean low tide) are given in Table 2. Three sites (6/7, 11, and 14) which appeared to be very diverse were chosen to be re-examined in September for seasonal changes. The weather (fog, rain and waves) hampered the sampling operation to some extent. In September the shorter days were a problem since the length of time one could sample during low tide was limited by darkness.

In determining the most important species in a group of stations, a simple rank analysis (as used in ranking the top 20 football teams) was used to reduce the influence in abundance rankings of species which occur in moderate numbers at a large number of stations. By using a rank analysis, oten called a bioindex, elements of both abundance and frequency of occurrence can be incorporated into one measure. The five-point system as used here assigns five points to the

Table 2. Sampling dates and tidal heights (relative to mean low tide) for sites at Great Wass Island (1979).

Site (see Figure 1)	Date	Tidal Height
1	6/13	-0.3
2	7/13	-1.7
3	6/11	-0.1
4	7/12	-1.8
5	7/12	-1.8
6/7	6/10	0.1
6/7 revisited	9/8	-1.8
9	7/10	-0.5
11	6/13	-1.4
11 revisited	9/9	-1.6
12	6/9	0.3
14	7/11	-0.7
14 revisited	9/8	-1.9
15	6/12	-0.2
16	6/14	-1.4
19	6/14	9.5 high tide
20	7/11	-1.7

to the most abundant species at a given station, four points to the next most abundant, and so on to the fifth most abundant. When the scores of the 5 most abundant species (from each station) are added from all stations, the ranking which is produced is corrected for species that populate limited areas densely.

ROCKY SHORES

The most obvious difference between the rocky intertidal zone of Great Wass Island and other rocky shores in Maine is the lack of a barnacle zone. The barnacle zone is one of the most characteristic features of exposed rocky shores in boreal waters. Although barnacles are common at every rocky shore site, the barnacle zone is undeveloped on the eastern (Sites 3,4,5 and 6/7) and southern (Sites 9,11,12 and 14) exposures. Site 15 is the only area which has a barnacle zone which would be considered to be typical of Maine's rocky shores. A patchy barnacle zone is present at site 2. The reasons for the lack of a barnacle zone are unknown; however, the zone was more developed along the less exposed shores (in the area of Sites 15 and 2). Possibly some factor related to exposure is responsible for this anomaly.

Another characteristic feature of exposed rocky shores in Maine is a mussel mat in the lower intertidal zone. The mat is composed of dense populations of juvenile mussels under which live a variety of animals including hairworms (nematodes) aquatic earthworms (oligochaetes) and scud (amphipods). The only mussel mat present at the rocky shore sites at Great Wass Island is at Site 2. However, at this site the mussels are adults inhabiting a few localized areas. Possibly the wave action is too great or too frequent to allow mussel mats to develop.

Aside from the differences noted above, rocky shores of Great Wass Island have a suite of species which are typical of rocky shores of Maine. Eighteen taxa were found at all rocky shore sites sampled on Great Wass Island (Table 3). Common names, principal location

Table 3. Taxa found at all rocky shore sites sampled at Great Wass Island.

TAXA	COMMON NAME	LOCATION IN INTER-TIDAL ZONE	RELATIVE ABUNDANCE
Halichondria panicea	crumb of bread sponge	mid to low (principally in tide pools)	uncommon to common
Nematoda	roundworm or hairworm	mid to low	uncommon to dominant (patchy)
Acmaea testudinalis	tortoiseshell limpet	mid to low	uncommon to dominant
Buccinum undatum	waved welk	low	uncommon
Lacuna vincta	chink shell	low (principally on algae in tide pools)	uncommon to common
Littorina littorea	common periwinkle	mid to low	common to dominant
Littorina obtusata	smooth periwinkle	mid (low to a lesser extent)	uncommon to common
Littorina saxatilis	rough periwinkle	high	uncommon to common
Nucella (Thais) lapillus	dogwinkle	mid to low	uncommon to common
Modiolus modiolus	horse mussel	mid to low	uncommon to common
Mytilus edulis	blue mussel	mid to low	uncommon to common (dominant in patches at Site 2)

Table 3. (Continued).

TAXA	COMMON NAME	LOCATION IN INTER-TIDAL ZONE	RELATIVE ABUNDANCE
Lepidonotus squamatus	twelve-scaled worm	low (principally in kelp holdfasts)	uncommon to common
Oligochaeta	aquatic earthworm	mid to low	uncommon to dominant (patchy)
Balanus balanoides	barnacle	high to low	uncommon to dominant (patchy)
Gammarellus angulosus	scud	mid to low (principally in tide pools)	uncommon to dominant
Hyale nilssoni	beach flea	high	uncommon to common
Asterias sp.	asteriid sea star	low	uncommon to common (dominant at Site 14)
Henricia sp.	blood star	low (principally in tidepools)	infrequently found to common

in the intertidal zone and relative abundance are also given in Table 3. With the exception of *Nucella lapillus, Gammarellus angulosus, Hyale nilssoni, Henricia* spp. and *Buccinum undatum,* all of these species were found at all rocky shore sites sampled along the entire coast of Maine in a previous study (see Doggett *et al,* 1978). *Nucella lapillus, Gammarellus angulosus* and *Hyale nilssoni* were present at all but one of the twelve sites sampled by Doggett *et al* (1978). Although *Henricia* spp. is not as regularly found along the coast of Maine (see Doggett *et al,* 1978) as at Great Wass Island, it is considered to be a widely distributed and relatively common rocky shore inhabitant of Maine. *Buccinum undatum* was not found at any of the rocky intertidal sites sampled by Doggett *et al* (1978). This species is more commonly found on shallow subtidal bottoms than in the intertidal zone.

The garland hydroid (*Sertularia pumila*) was the only species which was found at all sites sampled by Doggett *et al* (1978) which was not found at all sites at Great Wass Island. However, this species was present at all but two sites (6/7 and 11) on Great Wass Island. Other species which occur regularly in coastal Maine samples (Doggett *et al,* 1978) and at Great Wass Island are nemertean worms, encrusting and erect bryozoans, the red chiton (*Tonicella ruber* which is mislabelled as *Tonicella marmorea* in Doggett *et al,* 1978), the jingle shell (*Anomia simplex*), the arctic rock borer (*Hiatella arctica*), the scuds or amphipods (*Ampithoe* sp. and *Gammarus oceanicus*), the rock crab (*Cancer irroratus*), the green crab (*Carcinus maenas*), the daisy brittlestar (*Ophiopholis aculeata*) and the sea

urchin (*Strongylocentrotus droebachiensis*). The little shore isopod (*Jaera* spp.) and the spingtail (*Anurida maritima*) were more common at other rocky intertidal sites than at Great Wass Island. Anenomes, hard tube worms (*Spirorbis borealis*), fifteen scaled worms (*Harmothoe imbricata*), two polychaetes (*Naineris quadricuspida* and *Nereis pelagica*), mites, isopods (*Idotea phosphorea*), sea cucumbers (*Cucumaria frondosa*), hermit crabs (*Pagurus acadianus*) sea grapes (*Molgula* spp.) and the rock eel (*Pholis gunnellus*) were more common and regularly found at Great Wass Island than along the rest of the Maine coast (see Doggett *et al*, 1978). Ascidians or sea grapes may have been more common because of the timing of the sampling (i.e. later in the summer than previous sampling.

One hundred and twenty four species (Appendix I) were found at the rocky intertidal sites sampled at Great Wass Island (Figure 1). Numbers of species found at a single site (see Appendix I) varied from a low of 38 at Site 12 to a high of 68 at Sites 11 and 14 (see Figure 1.) Site 12 has an almost vertical intertidal zone with a few tidepools while Sites 11 and 14 have numerous tidepools, crevices and boulders under and around which live numerous species. The mean number of species per site is 53.5. This number is high when compared to number of species per site taken on other rocky shores along the coast of Maine (Doggett *et al*, 1978) using similar methods. In the Critical Areas study the mean number of species per site was 32.2 and the range was from 19 to 42.

Few seasonal differences between summer and fall were apparent. Ascidians were much more common while isopods (*Idotea phosphorea*)

and rock eels (*Pholis gunnellus*) were less abundant in the fall. All other species appeared to be in similar abundances and locations as they had been in the summer.

INTERTIDAL FLATS

The species found in the intertidal flats of Great Wass Island are generally found in flats throughout the state of Maine. The weighted relative abundance (see Methods) of invertebrates found at Three Falls Cove (Site 16) and the Mud Hole (Site 1) are given in Tables 4 and 5, respectively. Many of the same species are found on both lists, and of the species which ranked higher than 10 only one species (*Eteone longa*) is not found in similar abundances at both sites. Oligochaetes (aquatic earthworms); the amphipod, *Corophium volutator*; the baltic clam, *Macoma balthica*; the sand worm, *Nereis virens*; and the soft shell clam, *Mya arenaria* are all important and abundant components of flats in Maine.

Three Falls Cove is more diverse than the Mud Hole, 40 vs 19 species (Appendix I). The ledge areas which create the falls at Three Falls Cove harbor a variety of species and create enough water flow to sustain beds of mussels. At the Mud Hole there is only one falls area where abundant mussel beds are also found. A number of the species at Three Falls Cove are probably washed on to the flats from the many neighboring ledge areas.

Mean numbers of species per station of the two Great Wass Island mud flats is low when compared to other mudflats in Maine (Table 6). Possibly, the samples taken at Great Wass are not large enough or replicated enough for a valid comparison. However, the only other samples taken in eastern Maine also had low numbers of species.

Mean numbers of individuals per m^2 are within the range represented at other mud flats in Maine (Table 6). At the two Great Wass flats mean numbers of individuals per m^2 compare closely, while mean numbers of species reflects the higher diversity at Three Falls Cove.

Table 4. Rank Score Analysis for Three Falls Cove

(Highest possible score 55)

Taxa	Score
Oligochaeta	52.00
Eteone longa	18.70
Corophium volutator	16.50
Nematoda	14.50
Nereis virens	12.83
Mya arenaria	12.33
Mytilus edulis	9.20
Paraonis gracilis	4.00
Streblospio benedicti	3.50
Aglaophamus sp.	3.00
Aricidea jeffreysii	3.00
Gammarus oceanicus	3.00
Polydora sp.	2.50
Macoma balthica	2.33
Acmaea testudinalis	2.00
Jaera sp.	1.00
Edotea triloba	0.50
Clymenella torquata	0.50
Nephtys caeca	0.20
Eteone flava	0.20
Littorina littorea	0.20

Table 5. Rank Score Analysis of the Mud Hole

(highest possible score 60)

Taxa	Score
Corophium volutator	52.00
Oligochaeta	43.50
Nematoda	23.50
Nereis virens	16.50
Mya arenaria	11.08
Ceratopogonidae	8.00
Streblospio benedicti	6.50
Aglaophamus sp.	5.75
Eteone longa	4.33
Macoma balthica	1.83
Exogone hebes	1.50
Nephtys picta	1.50
Tharyx acutus	0.75
Unidentified Mysid	0.75
Nephtys caeca	0.50

Table 6. Comparison between mean numbers of species per station and mean numbers of individuals per m^2 in mud flats at Great Wass Island and other mud flats in Maine.

Site	Numbers of Species per station		Numbers of Individuals per m^2	
	mean	range	mean	range
Great Wass Island-Total	7.3	3-14	3818	256-7872
Mud Hole (Site 1)	5.8	4-7	3680	288-6944
Three Falls Cove (Site 16)	9.0	3-14	3968	256-7872
Other Maine Sites-Total	17.5	6-30	7345	404-52392
Kittery	18.4	15-22	1050	624-1632
Casco Bay	19.1	13-26	5552	404-19920
Boothbay Harbor	18.8	14-21	4946	648-10380
East Friendship	21.3	16-30	22322	2404-52392
Addison	9.1	6-11	2069	1448-3232

The sand flat, although inadequately sampled (qualitative) contained many species which are typically found on sand flats, such as the bamboo worm, *Clymenella torquata;* the soft shell clam, *Mya arenaria;* and the sand shrimp, *Crangon septemspinosa.* The only species found in obvious abundance (from fecal mounds) which is not as commonly found on other flats in Maine was the lugworm (*Arenicola marina*).

SUBTIDAL UNCONSOLIDATED BOTTOM, "THE POND"

Since few subtidal samples have been taken in eastern Maine, it is difficult to determine whether or not the fauna found in "The Pond" is unusual compared to the subtidal fauna of the region. Therefore, it is intended that these data document the existence and relative abundance of the species present (Appendix I and Table 5, respectively).

The mean numbers of individuals per m^2 in "The Pond" is high (mean 2498, range 318-7273) in comparison to the only other similar study at similar depths in Maine, in the Sheepscot estuary (Larsen, 1979). In the Sheepscot the mean number of individuals per m^2 was 771, (range 113-6,789). The higher density, even though the sampling was inadequate, may be due to the fact the "The Pond" has dense eelgrass beds. Mean number of species per station, however, was much lower at Great Wass Island than in the Sheepscot estuary, 7.7 (range 4-11) vs. 19.4 (range 12-27) respectively. Sampling deficiencies may explain this difference.

Table 7. Rank Score Analysis for "The Pond"

(Highest possible score 50)

Taxa	Score
Oligochaeta	45.00
Pontogenia inermis	29.00
Corophium bonelli	16.50
Aglaophamus sp.	15.00
Phoxocephalus holbolli	10.75
Nereis virens	7.63
Nematoda	5.50
Exogone hebes	4.50
Calliopus laeviusculus	3.63
Edotea triloba	3.50
Scolecolepides viridis	3.00
Mysis mixta	1.50
Harmothoe imbricata	1.50
Nemertea	1.00
Lacuna vincta	1.00
Nephtys incisa	0.75
Nephtys squamosa	0.25
Polydora ligni	0.25
Macoma balthica	0.13
Littorina littorea	0.13
Mya arenaria	0.13
?Scolelepis squamata	0.13
Phyllodoce maculata	0.13
Pholoe minuta	0.13

SIGNIFICANT FAUNAL SPECIES AND SITES

A number of species collected at Great Wass Island are considered to be significant because they are infrequently found in the intertidal zone, particularly in regions west of Mount Desert. None of the significant species occur on the flats. They include the following:

Species	Common Name
Tealia felina	Silver spotted anenome
Terebratulina septentrionalis	Northern lamp shell
Ishnochiton albus	White Chiton
Buccinum undatum	Waved welk
Margarites groenlandicus	Pearly top shell
Puncturella noachina	Linne's puncturella (limpet)
Skeneopsis planorbis	Gastropod
Velutina laevigata	Gastropod
Ancula gibbosa	Nudibranch
Coryphella rufibranchialis	Red gilled nudibranch
Lamellidoris aspera	Dorid nudibranch
Lamellidoris fusca	Dusky dorid nudibranch
Lamellidoris muricata	Muricate dorid nudibranch
Crenella glandula	Glandular bean mussel
Musculus niger	Black musculus (mussellike)
Amphitrite cirrata	Terebellid worm
Potamilla reniformis	Sabellid worm
Lepas anatifera	Goose necked barnacle
Mysis mixta	Mysid shrimp
Neomysis americana	Mysid shrimp
Hyas araneus	Toad (or spider) crab
Pagurus arcuatus	Hairy hermit crab
Amphiopholis squamta	Dwarf brittle star
Boltenia ovifera	Stalked sea squirt
Halocynthia pyriformis	Sea peach
Neoliparis atlanticus	Sea snail (fish)
Ulvaria subbifurcata	Radiated shanny (fish)

The pearly top shell (*Margarites helincinus*), the maned nudibranch (*Aeolida papillosa*), the bushy backed nudibranch (*Dendronotus frondosa*), the lentil sea spider (*Anoplodactylus lentus*), the white synapta sea cucumber (*Leptosynapta tenuis*) and the blood drop sea squirt (*Dendradea carnea*), are also of interest, although they are more commonly found at other locations than the species listed above.

Some of the species are significant because of their unusual body forms, color or beauty. The silver spotted anenome, the northern lamp shell, pearly top shells, the nudibranchs, the anenome-like terebellid and sabellid worms, the stalked and blood drop sea squirt, the peach and the poly-wog like sea snail are examples. Others are of particular interest because they are either more abundant or occur more regularly than at most other rocky shores on the coast of Maine. These species include the white chiton, the waved welk, the dorid nudibranch (*Lamellidoris aspera*), the terrebellid worm, toad crabs, and dwarf brittle stars. The only other sites on Maine's rocky shores which have comparable numbers and variety of significant species occurs in Cobscook Bay, particularly at Crow Neck.

The northern lamp shell (*Terebratulina septentrionalis*) is of particular interest because it is a representative of a group which peaked in abundance and diversity 400 million years ago in the Devonian era. Of the 200 genera which lived then only few species remain on the Atlantic coast of North America. Brachiopods have been supplemented by more specialized benthic invertebrates, principally bivalve molluscs. (Gosner, 1971). The only place outside the Quody region that brachiopods have been found intertidally is at Great Wass Island (Site II). Because of the presence of brachiopods, the Critical Areas Program of Maine intends to register the site as a critical area (H. Tyler, Maine State Planning Office, personal communication).

Although all rocky sites have a relatively high diversity (see Rocky Shores), two sites, 11 and 14 have a particularly high diversity (see Appendix I). These sites also harbor many of the significant species listed above.

The unusual large size of some invertebrate species was also noted. At Sites 3, 12 and 14 (Figure 1), the periwinkle *Littorina Littorea* was particularly large and at Site 14, the starfish, *Asterias vulgaris* was larger than other populations of this species. Abnormally large species also occur in Cobscook Bay. The large size may be due to a number of factors including slower growth to maturity because of low temperatures, extremely good feeding conditions and parasitism (C. Scheaffer, University of Connecticut, personal communication).

FACTORS INFLUENCING FAUNAL DISTRIBUTION AND DIVERSITY

All animals living in the intertidal zone, with the exception of mites, spiders and insects are of marine origin. In order to live in this zone their particular physical requirements (water, temperature, salinity, etc.) must be met. The physical requirments of invertebrates vary by species. The threat of dessication or drying out is the biggest problem for intertidal invertebrates. Generally, those species living higher in the intertidal zone are more adapted to the stress of being out of the sea for longer periods of time than those species living in the lower part of the zone. More species can adapt to stresses of the lower intertidal zone than higher intertidal levels. Hence, the greatest intertidal diversity occurs in the low intertidal zone.

The following discussion outlines physical factors which are influential in determining the number of species (species diversity) which inhabit the intertidal zone, principally the lower intertidal zone. The way in which these factors effect species diversity and allow for the unusual occurrence of subtidal organisms in the intertidal zone of Great Wass Island is discussed.

Substrate heterogeneity is an important factor controlling species diversity. Boulders, crevices, cracks and tidepools provide protection from being washed away by waves or consumed by predators. These irregular surfaces retain water when the tide is out so that the individual animal is exposed to fewer extremes in temperature, salinity and available moisture. The importance of substrate heterogeneity to species diversity is demonstrated by the results of the present study. Sites 6/7, 11 and 14 have many boulders

and tidepools and have the highest number of species. Site 12 has little substrate heterogeneity and the lowest number of species for rocky shore sites sampled (see Appendix I and Figure 1).

Other factors which may be important in determining the number of species which can inhabit the southern shores of Great Wass Island (Sites 12 and 9) are slope and wave action. The steeper the slope the faster the rocks will drain and animals present will be subject to dessication. Site 12 had the steepest slope of the areas sampled, followed by Site 9. Most of the area along the south shore of Great Wass Island is vertical or nearly vertical and therefore would be expected to have a low species diversity. Also, wave action and surge along this nearly vertical shore may be too extreme to allow many species to live.

Another important factor in determining species diversity is wave action. Waves break on the shore and wash over or splash onto intertidal elevations above the instantaneous sea level. Therefore, even when the tide is out moisture to prevent dessication is delivered by waves. This is particularly important in the low intertidal zone where waves combined with a heterogeneous substrate allows animals which normally only live in the subtidal zone to exist. The larger the waves, the more pronounced the effect. The shores of Great Wass Island are exposed to large waves and frequent wave action. The wave action may, in part, allow more diverse assemblages of animals to inhabit the shores of Great Wass Island than other Maine rocky shore sites (see Doggett *et al*, 1978).

Wave action at the level which occurs at Great Wass Island also precludes the formation of heavy winter ice. Heavy ice can suffocate intertidal organisms at low tide.

Temperature is a significant factor in determining the distribution and abundances of benthic invertebrates. The area north of Penobscot Bay has cold summer surface water temperatures (<12°C; Figure 2) and is subarctic in nature (Bousfield and Thomas, 1975). This is the only area of this type south of Labrador and is unique in the continental United States. The species present in this region reflect this unique environment. The cool summer temperatures which decrease the threat of dessication allow some of these unusual species to inhabit the low intertidal zone.

Fog, particularly during the summer, insulates intertidal organisms from dessication and allows less hardy species to live in the low intertidal zone. Eastern Maine (records are for Eastport) has three times as much fog as Portland (TRIGOM, 1973).

The large tides (range 3.5m or 11.5 ft.) at Great Wass Island may have an effect on species diversity by creating a large intertidal zone. Large areas are more diverse than small areas, because there is simply more room for biological interactions to develop.

Stress and reduced salinity (less than 30 °/oo) and increased turbidity (particles suspended in the water) may limit the number of species which can survive. The effects of these factors in the vicinity of Great Wass Island seems minimal. Localized effects of salinity reduction may be present where streams (intermittent or constant) cross the intertidal zone (e.g. Site 16, and near Site 6).

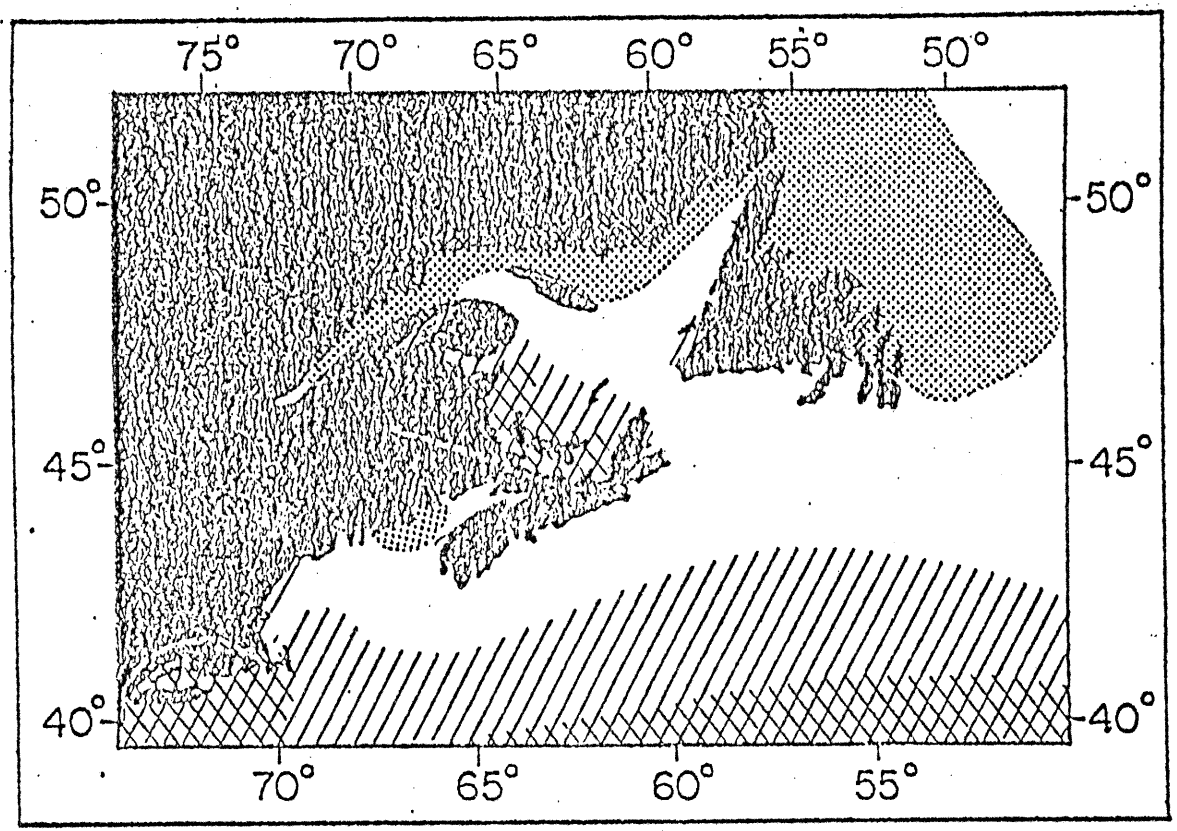

Fig. 2. - The Canadian Atlantic and northern New England Coastal Regions showing summer surface temperatures and zoogeographic zonation. Dots <12°C (subarctic). White 12-15°C (boreal). Diagonal lines 15-18°C (cool temperate). Cross-hatched >18°C (temperate or Virginian). (Modified from Bousfield and Thomas, 1975)

Factors which have an unknown effect on species distribution at Great Wass Island are currents and upwelling. Currents distribute the young of many invertebrate species. Upwelling which is believed to occur in eastern Maine brings nutrients from deeper waters of the Gulf of Maine to the surface, thus, potentially increasing productivity (e.g. increasing levels of growth of algae or phytoplankton).

MANAGEMENT RECOMMENDATIONS

Presently there appears to be nothing threatening invertebrate populations of Great Wass Island. When the public becomes aware of the variety and unusual occurrences of intertidal invertebrates present, they may be a possibility that overcollecting could occur. Collection of these significant species should be discouraged. It is also recommended that Sites 11 and 14 be designated as Critical Areas by the Maine Critical Areas Program because of the high diversity of species present.

Harvesting of clams and worms disrupts the invertebrates living in the flats. The extent of this disruption is unknown and should be examined. Until this examination of disruption takes place, harvesting should be discouraged. Since none of the unusual species found at Great Wass Island occur in the flats, a ban on the harvesting of clams and worms would have no effect on populations of these unusual species.

Harvesting of periwinkles (*Littorina littorea*) has an unknown effect on other invertebrate species. Periwinkles graze on algae and keep rocks cleaned so that other types of algae (e.g. *Chondrus crispus* or Irish moss) can become established. These other algae (e.g. Irish moss) provide protection or substrate for some intertidal invertebrates.

The role of periwinkles in relation to other rocky shore inhabitants is unknown and should be studied. Although periwinkles are extremely abundant at some sites (e.g. Site 11), it would take a relatively short time to deplete this resource through commercial harvesting. The recovery time of periwinkle populations is also unknown. Because of its potentially close links with other less common rocky shore inhabitants the harvesting of periwinkles should be banned.

Harvesting of seaweed (Irish moss *Chrondrus crispus* and rockweeds *Ascophyllum* and *Fucus*) should also be banned. When seaweeds are harvested the animals in and around the algae are disrupted or destroyed. The removal of kelp (*Laminaria* sp.) would be particularly destructive because of the wide variety of species which inhabit their holdfasts.

The most pressing problem at Great Wass Island is the potential destruction of terrestrial vegetation on and along the paths. The quickest route to most of the intertidal sites of interest is via the paths. Therefore, as more interest develops in the intertidal fauna of the preserve, more destruction of terrestrial vegetation will occur. The paths need to be upgraded so that visitors will follow them and avoid stepping on vegetation in the process of avoiding bogs and wet spots.

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APPENDIX

I

Species List for Great Wass Island

Appendix I

Species List For Great Wass Island

(Numbers indicate sites sampled as indicated on Figure .)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Phylum Porifera														
Halichondria panicea	x	x	x	x	x	x	x	x	x	x				
Leucosolenia botryoides				x		x								
Scypha ciliata	x						x							
Unidentified Porifera		x				x								
Phylum Cnidaria														
?Bunodactis stella		x		x		x	x							
Metridium senile	x							x	x					x
Sertularia pumila	x	x	x	x		x		x	x	x				
Tealia felina		x												
Unidentified Anenome,A	x	x			x			x	x			x		
Unidentified Hydrozoan	x		x			x			x					
Phylum Platyhelminthes														
Notoplana atomata		x	x				x							
Unidentified Platyhelminthes									x					

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Phylum Rhynchocoela														
Lineus ruber		x	x	x	x	x	x		x					
Unidentified Nemertea	x		x		x		x	x	x					x
Phylum Aschelminthes														
Class Nematoda	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Phylum Bryozoa														
Electra pilosa						x				x				
Flustrellida hispida	x	x		x	x	x		x	x	x				
Membranipora sp.				x			x							
Unidentified encrusting Bryozoa	x		x	x	x		x		x	x				
Unidentified erect Bryozoa	x	x			x		x							
Phylum Brachiopoda														
Terebratulina septentrionalis							x							
Phylum Mollusca														
Class Polyplacophora														
Ischnochiton albus				x	x		x							
Tonicella ruber	x	x	x	x	x	x	x	x	x					

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Class Gastropoda														
Acmaea testudinalis	x	x	x	x	x	x	x	x	x	x		x		
Buccinum undatum	x	x	x	x	x	x	x	x	x	x				
Hydrobia sp.												x		
Lacuna vincta	x	x	x	x	x	x	x	x	x	x		x	x	x
Littorina littorea	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Littorina obtusata	x	x	x	x	x	x	x	x	x	x		x		
Littorina saxatilis	x	x	x	x	x	x	x	x	x	x				
Margarites groenlandicus			x	x	x	x	x							
Margarites helincinus			x	x	x			x	x	x				
Nucella (Thais) lapillus	x	x	x	x	x	x	x	x	x	x				
Onoba aculeus		x		x	x		x	x	x	x				
Puncturella noachina				x	x									
Skeneopsis planorbis			x		x									x
Velutina laevigata						x								
Subclass Opisthobranchia														
Aeolida papillosa									x					
Ancula gibbosa	x					x								

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Coryphella rufibranchialis					x									
Dendronotus frondosus	x		x		x		x		x					
Lamellidoris aspera	x		x	x	x	x	x	x	x	x				
Lamellidoris fusca										x				
Lamellidoris muricata				x										
Unidentified Nudibranch	x		x			x			x					
Class Bivalva														
Anomia aculeata			x				x							
Anomia simplex	x	x	x		x	x	x		x	x				
Crenella glandula							x							
Hiatella arctica		x			x	x	x	x	x	x				
Macoma balthica											x	x		x
Modiolus modiolus	x	x	x	x	x	x	x	x	x	x			x	
Musculus niger	x								x					
Mya arenania	x	x									x	x	x	x
Mytilus edulis	x	x	x	x	x	x	x	x	x	x	x	x	x	
Class Cephalopoda														
Illex illecebrosus												(x)*		

*washed in

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Phylum Annelida														
Class Polychaeta														
Aglaophamus sp.											x	x		x
Ampharetidae	x	x					x							
Ampharete sp.				x										
Amphitrite cirrata	x	x	x	x	x	x	x		x	x				
Amphitrite johnstoni					x					x				
Arenicola marina												x	x	x
Aricidea jeffreysii												x		
Capitella capitata							x		x			x		
Cirratulus cirratus		x							x	x				
Clymenella torquata												x	x	
Driloneris longa														x
Eteone flava												x		
Eteone lactea														
Eteone longa											x	x		
Eulalia viridis									x					
Eumida sanguinea	x	x							x					

Appendix I (Continued)

	Intertidal Rocky Habitat											Intertidal Flat			Subtidal Flat
	2	3	4	5	6/	7	9	11	12	14	15	1	16	20	19
Eusyllis lamelligera													x		
Exogone hebes												x	x		x
Fabricia sabella			x					x		x					
Glycera dibranchiata								x							
Harmothoe imbricata	x		x	x	x	x		x		x					x
Lepidonotus squamatus	x	x	x	x	x	x		x	x	x	x				
Naineris quadricuspida	x	x	x	x	x					x			x		
Nephtys caeca												x	x		
Nephtys ciliata								x		x		x			
Nephtys incisa															x
Nephtys picta												x	x		
Nephtys squamosa															x
Nereis pelagica	x	x	x	x				x	x	x	x				
Nereis virens												x	x	x	x
Ophelina acuminata															x
Paraonis gracilis													x		
Pholoe minuta					x										x

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Phyllodoce sp.	x													
Phyllodoce maculata			x		x			x	x					x
Polycirrus phosphoreus		x					x							
Polydora sp.												x		
Polydora ligni														x
Potamilla reniformis	x				x							x		
Sabella crassicornis			x							x				
Scoecolepides vindis													x	x
?*Scolelepis squamata*														x
Spio setosa												x	x	
Spirorbis borealis	x	x	x	x	x	x	x		x	x				
Spirorbis spirillum						x	x							
Streblospio benedicti											x	x		x
Tharyx acutus											x			
Unidentified Polychaete												x		

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Class Oligochaeta	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Phylum Sipunculida		x		x	x									
Phylum Arthopoda														
Subphylum Pycnogonida														
Anoplodactylus lentus									x					
Class Arachnida														
Order Acari	x	x			x	x	x	x		x			x	
Order Araneae				x										
Subphylum Mandibulata														
Class Crustacea														
Subclass Cirripedia														
Balanus balanoides	x	x	x	x	x	x	x	x	x	x	x	x	x	
Lepas anatifera			(x)*											
Subclass Malacostraca														
Order Isopoda														
Edotea triloba												x		x
Idotea phosphorea		x	x	x	x	x			x					
Jaera spp.		x					x		x	x		x	x	
Order Amphipoda														

*washed in

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Ampithoe longimana	x	x	x	x	x	x		x	x					
Ampithoe rubricata					x									
Calliopus laeviusculus														x
Corophium bonelli	x		x	x			x							x
Corophium volutator											x	x		x
Eulimnogammarus obtusatus		x					x		x	x			x	
Gammarellus angulosus	x	x	x	x	x	x	x	x	x	x				
Gammarus annulatus													x	
Gammarus lawrencianus												x		
Gammarus oceanicus		x	x		x			x	x					
Hyale nilssoni	x	x	x	x	x	x	x	x	x	x		x		
Maera danae							x							
Marinogammarus sp.							x							
Marinogammarus finmarchicus													x	
Microdeutopus ?anomalus									x					
Orchestia platensis								x						
Orchomonella minuta														x
Phoxocephalus holbolli														x

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Pontogenia inermis							x	x	x					x
Unciola irrorata			x		x									
Unidentified Amphipod									x			x		
Suborder Caprellidea														
Caprella sp.			x											
Order Mysidacea														
Mysis mixta														x
Neomysis americana							x							
Unidentified Mysid											x			
Order Decapoda														
Cancer irrotatus	x	x		x	x		x	x	x	x				
Carcinus maenas	x	x	x	x	x	x	x		x	x		x		
Crangon septemspinosa													x	x
Hyas araneus						x	x	x						
Pagarus acadianus	x	x	x	x	x		x		x	x				
Pagurus arcuatus		x								x				
Pagurus longicarpus							x							
Class Insecta														
Anurida maritima													x	

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Ceratopogonidae	x										x			
Chironomid larva	x				x									
Dipteran larva													x	
Phylum Echinodermata														
Class Holothuroidea														
Cucumaria frondosa	x	x	x		x		x		x	x				
Leptosynapta tenuis					x									
Class Echinodea														
Strongylocentrotus droebachiensis	x	x	x		x	x	x	x	x					
Class Stelleroidea														
Subclass Asteroidea														
Asterias sp. (juvenile)	x	x	x	x	x	x	x	x	x					
Asterias forbesii									x					
Asterias vulgaris									x					
Henricia spp.	x	x	x	x	x	x	x	x	x	x				
Subclass Ophiuroidea														
Amphiopholis squamata				x			x							x
Ophiopholis aculeata				x	x	x		x						

Appendix I (Continued)

	Intertidal Rocky Habitat										Intertidal Flat			Subtidal Flat
	2	3	4	5	6/7	9	11	12	14	15	1	16	20	19
Phylum Chordata														
Class Ascidiacea														
Boltenia ovifera									x					
Dendrodea carnea				x	x									
Halocynthia pyriformis									x					
Molgula spp.		x		x	x	x	x		x					
Unidentified Ascideans	x	x					x		x	x				
Class Osteichtyes														
Neoliparis atlanticus			x				x							
Pholis gunnellus	x	x	x		x	x	x		x					
Ulvaria subbifurcata						x								
Number of species per site	54	55	52	50	63	45	68	38	68	42	19	40	23	34

Total Number of Species 165

Number of Intertidal Rocky Habitat Species 124

" " Intertidal Flat Species 55

" " Subtidal Flat Species 34