Identification of candidate sites for declaration as aquatic reserves for the conservation of rocky intertidal communities in the Hawkesbury Shelf and Batemans Shelf Bioregions

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EXECUTIVE SUMMARY

1. Over recent decades, rock intertidal communities in NSW have been subjected to increasing levels of human-induced disturbance via the collection of organisms for bait and food,

2. In 1993, Intertidal Protected Areas (IPAs) were introduced by NSW Fisheries to protect selected shores from bait harvesting and the collection of animals for food,

3. The Sydney IPAs were opportunistically chosen with considerable emphasis on accessibility and local council involvement in enforcement issues, and less emphasis was placed in biodiversity conservation,

4. The efficacy of the Sydney IPAs was reviewed approximately eighteen months ago and their objectives and enforcement were identified as problems for resolution,

5. To enable IPAs to conform to the National Reserve System of Marine Protected Areas it was decided to declare all future IPAs as Aquatic Reserves to ensure their permanent status,

6. Criteria for identifying sites for declaration as IPAs were developed by modifying the criteria developed for the National Reserve System of Marine Protected Areas,

7. Nine quantifiable indicators covering "representativeness", "comprehensiveness", "naturalness" and "ecological importance" were developed for the identification criteria,

8. A site identification protocol consisting of 3 steps: (1) Mapping, (2) Habitat Assessment and (3) Biodiversity Assessment, was developed to enable the identification criteria to be used in a consistent manner in any of the IMCRA bioregions in NSW,

9. The site identification protocol also required the development of rapid assessment techniques that could be applied under field situations and at a range of sites,

10. A case study using 70 sites nominated by regional advisory committees, was carried out to examine the efficacy of the IPA identification criteria and to identify candidate sites for consideration as IPAs,

11. As the sites had been nominated the strategic mapping step of the site identification protocol was not carried out. This was recognised as an important step, but that it should be carried out as part of a subsequent Gap Analysis,

12. Twenty-five wave-exposed sites (rock platforms) were identified for habitat assessment distributed across the Hawkesbury Shelf (6 sites), Batemans Shelf (17 sites) and Twofold Shelf (2 sites) bioregions,

13. Five physical habitats: (1) Platform, (2) Crevice, (3) Rockpool, (4) Boulder areas and (5) Cobble areas were evident across the 25 sites sampled,

14. Five sites in the Hawkesbury Shelf bioregion, 7 sites in the Batemans Shelf bioregion and 1 site in the Twofold Shelf bioregion were sampled for biodiversity. Nine of these sites had 4 or 5 habitats present, and the remaining 4 sites had only 3 habitats present. The sampling also enabled an examination of possible relationships between the number of habitats and the number of species,

15. A total of 190 species comprising 40 algal species and 150 animal species was found across the 5 sites in the Hawkesbury Shelf bioregion,

16. A total of 194 species comprising 42 algal species and 152 animal species was found across the 7 sites in the Batemans Shelf bioregion,

17. Almost 50% fewer species were found at the sites with only 3 habitats present in the Hawkesbury Shelf and Batemans Shelf bioregions,

18. The numbers of species present were positively correlated with the numbers of habitats present at sites in the Hawkesbury Shelf and Batemans Shelf bioregions,

19. Between 78% and 90% of the species present at sites in the Hawkesbury Shelf and Batemans Shelf bioregions were associated with the platform and cobble habitats,

20. Length-frequency distributions for particular species and maximum and minimum sizes of a range of other animals showed that all the sites sampled had recruits and sexually mature (adult) individuals present. Consequently, all sites were acting as "sources" of larvae and "sinks" of recruits: which is considered to be a key requirement for a Marine Protected Area,

21. The organisms occurring in the Hawkesbury Shelf and Batemans Shelf bioregions were placed in 6 feeding types based on previously documented dietary information,

22. The indicators of "representativeness" showed that if Toowoon Point, Tudibaring Head and Brickyard Point were declared IPAs they would contribute greatly to the protection of habitat diversity (80 - 100%) and species diversity (71 - 76%) within the Hawkesbury Shelf bioregion. Similarly, if Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head were declared IPAs, they would also contribute greatly to the protection of habitat diversity (80 - 100%) and species diversity (63 - 79%) within Batemans Shelf bioregion,

23. The indicators of "comprehensiveness" showed that IPAs located at Toowoon Point, Tudibaring Head and Brickyard Point would include 100% of the physical habitats and 94% of the total diversity of rocky intertidal organisms in the Hawkesbury Shelf bioregion.

Similarly, an IPA system based on Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head would include 100% of the physical habitats and 96% of the species diversity in the Batemans Shelf bioregion,

24. The indicator of "naturalness" showed that the sites in the Hawkesbury Shelf bioregion were mainly located next to land zoned for residential or commercial purposes, whereas the sites in the Batemans Shelf bioregion were mainly located adjacent to reserves or National Parks,

25. Indicators of "ecological importance" showed that IPAs located at Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion) and Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion) would: act as a "source" of larvae and a "sink" for recruits; have a diversity of species with various life-history stages; have a range of species at various trophic levels; and have a diversity of species with a range of feeding-types,

26. The study recommends that Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion), and Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion) be considered as candidates for selection as IPAs and declared as Aquatic Reserves,

27. The study also recommends that Gap Analyses are undertaken in the Hawkesbury Shelf and Batemans Shelf bioregions to identify any shortfalls in a representative system of IPAs, and in doing so, attention must be given to rocky shores in wave-protected (estuarine) areas.

1.0 INTRODUCTION

1.1 BACKGROUND

With almost 80% of Australia's population living within 50km of the coastline and increases in leisure time and cultural diversity (Yapp 1986), intertidal shores have faced increasing pressure from bait collectors and human foragers (Underwood & Kennelly 1990, Kingsford *et al.* 1991, Underwood 1993). The collection of bait species such as cunjevoi *Pyura stolonifera* and the red bait crab *Plagusia chabrus*, together with the collection of many other intertidal species for food, has led to habitat disturbance and a reduction in the reproductive output of many species (Catterall & Poiner 1987, Fairweather 1991). This is a result of the selective harvesting techniques of foragers who target the larger, more fecund individuals of a population in the first instance (Moreno *et al.* 1984, Hockey & Bosman 1986, Moreno *et al.* 1986, Oliva & Castilla 1986, Sharpe & Keough 1998). Over time, individuals in a population tend to become smaller and reproductive output is reduced.

Intertidal communities are often subjected to a variety of other human activities, each of which can have adverse impacts. The effects of trampling, while acknowledged by terrestrial management agencies as being particularly harmful (Liddle 1975), have only recently been identified as an issue for consideration in the management of intertidal areas in Australia (Povey & Keough 1991, Keough & Quinn 1998), the United States (Brosnan & Crumrine 1994) and South Africa (Bally & Griffiths 1989). Results from studies investigating the impact of general recreational use of the rocky intertidal region in Australia (Underwood & Kennelly 1990, Kingsford *et al.* 1991, Underwood 1993), and the effects of intertidal shellfish collection (Underwood 1993, Keough *et al.* 1993, Sharpe & Keough 1998) have led to concerns over the future of intertidal habitats. These concerns have reinforced the need for responsible environment management of the rocky intertidal regions to mitigate the impacts of these activities and enable ecologically sustainable use of this community.

In 1991, community concern over the level of harvesting in the rocky intertidal regions in the Sydney metropolitan area prompted NSW Fisheries to consider options for managing these communities. The management recognised that members of the rocky intertidal community interact with one another and therefore conservation of individual species would require the protection of the whole community. A three-pronged approach was taken and included: (1) revising the bag and size limits for intertidal species, (2) restricting the methods of harvesting intertidal invertebrates to protect habitat, and (3) introducing Intertidal Protected Areas (IPAs) in which the collection of invertebrates was prohibited (Anon, 1991).

Rocky Intertidal Protected Areas (IPAs)

Intertidal Protected Areas were introduced in the Sydney metropolitan area by NSW Fisheries in July 1993 as a trial means of protecting selected rocky intertidal habitats from harvesting. These protected areas are designated as fishing closures of finite duration under the Fisheries Management Act. IPAs extend from the mean high water mark to ten (10) metres horizontally seaward of mean low water and apply to discrete areas of the coast. The collection of intertidal invertebrates including the tunicate *Pyura stolonifera* is prohibited in IPAs. Recreational fishing is permitted in IPAs provided anglers bring their bait to the site.
The main objectives of IPAs are:-

1. to protect intertidal habitat, biodiversity and structure, and

2. to provide biological reservoirs of breeding individuals.

The Sydney IPAs were opportunistically chosen on the basis of a combination of criteria, with considerable emphasis on accessibility and the willingness of some local councils to be involved in enforcement issues. Biodiversity was not the only or indeed the main selection criterion. However,

the conservation of biodiversity is the main focus of revised criteria used in this study (see later).

The success and/or failure of the Sydney IPAs was reviewed approximately 18 months ago (e.g. Chapman & Underwood 1997). It was concluded that one of the problems was lack of enforcement. Another critical problem was that their original objectives were not clear nor fully focused on biodiversity conservation. The objectives of the Sydney IPAs was then clarified with a prime focus on biodiversity conservation which fits with the Coastal Policy highlighting that intertidal areas are under-represented in the National Representative System of Marine Protected Areas (NRSMPA). To enable them to conform with the NRSMPA it was decided to make them permanent and declare IPAs as Aquatic Reserves. This approach would ensure that the concept of IPAs as temporary fishing closures would cease.

Scientific and anecdotal evidence suggested that harvesting of intertidal invertebrates was not confined to the Sydney metropolitan area, but occurred in many regional locations especially those locations that were within driving distance of Sydney or were popular holiday destinations (Kingsford *et al.* 1991). In response, NSW Fisheries commenced an investigation to identify the need for further IPAs along the coast of NSW. The investigation was limited to the coast between Port Stephens and Eden and encompassed the following IMCRA bioregions; Hawkesbury Shelf and Batemans Shelf (IMCRA Technical Group, 1998). This report summarises the results of these investigations and identifies additional sites between Port Stephens and Eden for declaration as IPAs.

1.2 AIMS OF THE STUDY

This study provides an opportunity to use a case study to:

(1) Develop identification criteria for Intertidal Protected Areas by modifying the NRSMPA identification criteria,

(2) Identify quantifiable indicators for the identification criteria,

(3) Develop an assessment protocol for decision-making,

(4) Use a " case study" to assess the appropriateness of the identification criteria, their associated indicators and the assessment protocol,

(5) Make recommendations concerning the future use of the identification criteria, the assessment protocol and associated indicators,

(6) Identify sites that are viable candidates for nomination as Intertidal Protected Areas in the Hawkesbury Shelf and Batemans Shelf bioregions,

(7) Make recommendations for the further development of a state-wide assessment of intertidal areas.

2.0 DEVELOPMENT OF IDENTIFICATION CRITERIA FOR ROCKY INTERTIDAL PROTECTED AREAS (IPAs) IN NSW

2.1 IDENTIFICATION CRITERIA FOR THE NRSMPA

The identification criteria for establishing a National Representative System of Marine Protected Areas (NRSMPA - ANZECC, 1998) were modelled on the generic criteria used by various countries (see reviews by McNeill 1994, Salm & Price 1995, Thackway 1996) and the criteria developed by the IUCN for the identification and selection of marine protected areas (Kelleher & Kenchington 1992). The criteria (Table 1) cover many attributes which are still under debate with respect to their application and weighting. The collection of pertinent information (e.g. Edgar *et al.* 1997) is clearly the best way to apply the identification criteria for MPAs. In the absence of relevant information (site-specific and question-specific) the identification process will become essentially "Delphic" in approach (Belbin 1993, Wilson 1995, Yurick 1995 for further details). This may well become the only means by which sites can be identified as data on Australia's marine biological communities are almost absent for many locations around the continent (for details see reviews of Fairweather 1990, Fairweather and Quinn 1995).

2.2 IDENTIFICATION CRITERIA FOR (IPAs) IN NSW

A set of identification criteria (Table 2) was developed for establishing rocky Intertidal Protected Areas in NSW by adapting the criteria developed for the NRSMPA (ANZECC, 1998). As the primary role of MPAs is to protect biodiversity, it was important to ensure that the resultant IPA criteria would:

(1) focus on biodiversity,
(2) maintain the overall intent of the NRSMPA criteria,
(3) be appropriate at the smaller spatial scale, and
(4) be quantifiable and enable discrimination among all the possible sites within a given bioregion.

Table 1. Identification criteria adopted as part of the strategic plan of action for establishing the National Representative System of Marine Protected Areas (NRSMPA) by the ANZECC Task Force on Marine Protected Areas (ANZECC, 1998).

Quality	Details
Representativeness	• Will the area represent one or more ecosystems within an IMCRA bioregion, and to what degree, • Will the area add to the representativeness of the NRSMPA and to what degree.
Comprehensiveness	• Does the area add to the coverage of the full range of ecosystems recognised at an appropriate scale within and across each bioregion, • Does the area add to the comprehensiveness of the NRSMPA.
Biogeographic Importance	• Does the area capture important biogeographic qualities.
Naturalness	• How much has the area been protected from, or not been subjected to, human-induced change.
Ecological Importance	• Does the area contribute to the maintenance of essential ecological processes or life-support systems, • Does the area contain habitat for rare or endangered species, • Does the area preserve genetic diversity i.e. is diverse or abundant in species, • Does the area contain areas on which species or other systems are dependent e.g. contain nursery or juvenile areas or feeding, breeding or resting sites for migratory species, • Does the area contain one or more areas which are a biologically functional, self-sustaining ecological unit.
International or National Importance	• Is the area rated, or have the potential to be listed, on the World or National Heritage List or declared as a Biosphere Reserve or subject to an international or national conservation agreement.
Uniqueness	• Does the area contain unique species, populations, communities or ecosystems, • Does the area contain unique or unusual geographic features.
Productivity	• Do the species, populations or communities of the area have a high natural biological productivity.
Vulnerability Assessment	• Are the ecosystems and/or communities vulnerable to natural processes.

2.2.1 REPRESENTATIVENESS

Representativeness is "the extent to which an area selected for inclusion in a reserve system is capable of reflecting the known biological diversity and ecological patterns and processes of the ecological community or ecosystem concerned" (Commonwealth of Australia, 1996).

Given that: (1) each site is part of an ecosystem, (2) there is a predetermined focus on the rocky intertidal community (i.e. one particular biological community), and (3) that these protected areas, when declared, would likely cover less than 5 kilometres of coastline, the representativeness of any particular site will be examined in two ways.

Will the site represent one or more habitats within the rocky intertidal region, and to what degree?

Representativeness at a small spatial scale (i.e. at a particular site), will be examined at the level of physical habitats within a given site within an IMCRA bioregion. The indicators quantified will be:

(1) the number of physical habitats present at a site, and

(2) the number of habitats present at a site as a proportion of the number of habitats in the entire bioregion.

The respective null hypotheses would be that:

(1) there are no differences in the number of habitats present at all rocky intertidal sites in the bioregion, and

(2) there are no differences in the proportional representation of habitats among all the rocky intertidal sites in the bioregion.

Will the site add to the representativeness of the rocky intertidal region within the IMCRA bioregion?

Representativeness at a larger spatial scale (i.e. at a bioregional level), will be examined by comparing the species diversity at a given site compared to that for the entire bioregion. The indicator quantified will be:

(1) the number of species present at a given site relative to the species present in the entire bioregion (expressed as a percentage).

The null hypothesis would be that:

(1) there are no differences in proportional representation of species among all the rocky intertidal sites in the bioregion.

Table 2. Identification criteria and indicators developed for establishing rocky Intertidal Protected Areas in NSW. Note criteria adapted from those developed for establishing a National Representative System of Marine Protected Areas (ANZECC, 1998).

IDENTIFICATION CRITERIA	QUANTIFIABLE INDICATORS
Representativeness	
• Will the site represent the habitats within the rocky intertidal region, and to what degree.	• The number of habitats present at a given site. • The number of habitats present at a site relative to the number of habitats in the bioregion.
• Will the site add to the representativeness of the rocky intertidal region within the IMCRA bioregion.	• The number of species present at the site relative to the species present in the entire bioregion.
Comprehensiveness	
• Does the site add to the coverage of the full range of habitats in the rocky intertidal region in each bioregion.	• The number of habitats present in a system of IPAs compared to the total number in each bioregion. • The number of species present in a system of IPAs compared to the total number in each bioregion.
Naturalness	
• How much has the site been protected from, or not been subjected to, human-induced change.	• The types of human usage of the intertidal region and adjacent land.
Ecological Importance	
• Does the site contribute to the maintenance of essential ecological processes or life-support systems and is the site a biologically functional, self-sustaining ecological unit.	• Presence of species in various trophic levels and a diversity of feeding modes. • Presence of recruits, juveniles and reproductively mature individuals of the organisms.
• Does the site preserve genetic diversity i.e. is there a diversity of species and are individual species abundant.	• The numbers of species present at the site and their abundance.

When assessing the habitats present across all sites within a bioregion, it is possible that the types of habitats present will differ among sites, but the number of habitats will not. In the unlikely

event that this occurs, differentiation among sites within the bioregion will need to rely on the estimates of species diversity from all the sites sampled.

As stated above, the species list (fauna and flora) for a bioregion was generated by pooling the species lists from all the individual sites sampled within the bioregion. A bioregional species list could also have been generated from taxonomic and biogeographic accounts. However, this was not done because taxonomic collections are: (1) often incomplete (i.e. species remain undescribed), (2) not based on an appropriate sampling regime and are frequently biased towards particular sampling locations (e.g. urban centres and/or the location of particular studies), (3) often undergoing revision, (4) only partially entered onto computer databases, and (5) biased because of the selective nature of the sampling equipment used. Moreover, a species list generated from taxonomic and biogeographic accounts would also include species that would not have been sampled using the techniques adopted in a logistically constrained survey. Finally, it is unlikely that it will ever be possible to identify all the species (i.e. the "absolute" numbers of fauna and flora) within a given community because of the inefficiencies inherent in sampling a spatially and temporally dynamic environment.

Clearly, it is important to be aware of the "absolute" (likely) number of species that could be found in the rocky intertidal regions within a given bioregion as this will enable an estimate of the proportion of species actually quantified in a survey. It is also necessary to be aware of the species not sampled and the habitats they utilise because it is likely that the species not sampled will be present if their preferred habitat is present (in sufficient amounts) in a system of protected areas.

Finally, it is important to be mindful of the species that are conspicuously absent from the community because these data may be more informative and lead to better, more conclusive outcomes.

2.2.2 COMPREHENSIVENESS

Comprehensiveness is "the degree to which the full range of ecological communities and their biological diversity are incorporated within reserves" (Commonwealth of Australia, 1996). In the case of the rocky intertidal community, this principle requires that a system of protected areas incorporates the full range of habitats present and their associated species within a given bioregion.

Does the site add to the coverage of the full range of habitats in the rocky intertidal region within each bioregion?

The indicators quantified will be:

(1) the number of habitats present in a system of IPAs compared to the total number in each bioregion (expressed as a percentage), and

(2) the number of species present in a system of IPAs compared to the total number in each bioregion (expressed as a percentage).

The respective null hypotheses would be that:

(1) the proportional representation of habitats in a system of IPAs in a bioregion is less than one, and

(2) the proportional representation of all species (fauna and flora) in a system of IPAs in the bioregion is less than one.

Note that both null hypotheses are 1-tailed because there can only be one alternative hypothesis in each case, that is, that the proportional representation of habitats/species (respectively) in a system

of IPAs in a bioregion is equal to one. While it may be possible to document all the physical habitats present, it is unlikely that all the species would be identified for all the reasons discussed previously (see Section 2.2.1.1). Consequently, it is likely that the total number of species derived from the sampling would be used to test the latter null hypothesis.

2.2.3 NATURALNESS

The "naturalness" of any given site will depend on: (1) the nature and frequency of human usage of the adjacent land, and (2) the nature and frequency of human usage of the intertidal region. The human usage of the adjacent land is readily quantifiable on a single visit to the site. Quantifying the nature and frequency of human usage of intertidal region requires replicated sampling in space and time (for details see Underwood & Kennelly 1990, Kingsford *et al.* 1991, Underwood 1993) to account for the variation in the timing of activities and changes in human behaviour.

How much has the site been protected from, or not been subjected to, human-induced change?

The indicator quantified will be the human usage of the adjacent land. However, any obvious human activities observed during site inspections and sampling trips will also be noted for use in the selection process.

2.2.4 ECOLOGICAL IMPORTANCE

A biologically functional, self-sustaining ecological unit would be expected to exhibit a diversity of species with various life-history stages, a range of species in various trophic levels, and the presence of a diversity of feeding-types. There are several key ecological processes that have been identified as necessary for the maintenance of the organisms comprising rocky intertidal communities. Of prime importance are reproduction, larval dispersal, settlement and recruitment, predation (including grazing), growth, and competition for space and/or food (Underwood and Denley 1984). With the exception of larval dispersal, evidence of the occurrence of all the other important processes should be gleaned from any given rocky intertidal site. However, as larval dispersal occurs in the water column, it is not possible to document its occurrence when sampling a rocky intertidal shore. Nevertheless, it is an extremely important ecological process as the larval dispersive phase is responsible for much of the spatial and temporal fluctuations in the recruitment and subsequent abundance of intertidal organisms (Underwood and Denley 1984, Underwood and Fairweather, 1989). Furthermore, a larval dispersive phase enables sites that have suffered a local extinction of species to be recolonised. This has prompted several authors (e.g. Carr and Reed 1993, Allison *et al.* 1998, Roberts 1998) to emphasise the need for marine protected areas to act as a "source" and a "sink" of recruits as this will maximise the potential of a protected area to maintain biodiversity within and beyond its boundaries. However, it will be possible to document the results of the larval dispersal via the presence of new recruits in size-frequency distributions.

Does the site contribute to the maintenance of essential ecological processes or life-support systems and is the site a biologically functional, self-sustaining ecological unit?

With the above in mind the indicators quantified will be:

(1) the presence of a range of organisms in various trophic levels,

(2) the presence of a diversity of feeding types, and

(3) the presence of various life-history stages (e.g. recruits, juveniles and reproductively mature individuals) of the organisms at the site.

In practical terms, the different "life-history stages" will be identified by documenting the size of individuals of representative species at the sites in each bioregion.

The respective null hypotheses would be that:

(1) there are no differences in the number of organisms in the various trophic levels present among all the sites in the bioregion,

(2) there are no differences in the number of organisms in the various feeding-types present among all the sites in the bioregion, and

(3) there are no differences in the size of individuals of representative species among all the sites in the bioregion.

Falsification of these null hypotheses in favour of alternatives may occur given the results of previous studies in the rocky intertidal regions in NSW (see references throughout this report). Moreover, the sites that exhibit a greater diversity of species in various trophic levels, feeding-types and life-history stages will likely make a greater contribution to a system of IPAs than would any of the remaining sites.

Does the site preserve genetic diversity i.e. is there a diversity of species and are individual species abundant?

To ensure genetic diversity there should be a diversity of species and an abundance of individual species. Consequently, the indicator quantified will be:

(1) the number of species present at a given site within a bioregion.

The null hypotheses would be that:

(1) there are no differences in the number species present among all the sites in the bioregion.

Similarly, it is likely that species richness will differ among sites (i.e. falsifying the null hypothesis) and those sites exhibiting greater diversity will obviously make a greater contribution to a system of IPAs than would the remaining sites.

3.0 PROTOCOL USED FOR IDENTIFICATION OF CANDIDATE IPA SITES

3.1 BACKGROUND

This study provides an opportunity to evaluate a possible approach that might be utilised for identifying rocky Intertidal Protected Areas along the entire NSW coast. The decision-making process will involve a protocol (Fig. 1) which is aimed at refining the list of possible sites in a stepwise manner. These steps are: (1) Site Identification, (2) Habitat Assessment, and (3) Biodiversity Assessment. The protocol also aims to maximise the use of limited funds by ensuring that the majority of the biological sampling is carried out at the sites with numerous habitats.

3.2 SITE IDENTIFICATION

In setting up a system of representative intertidal protected areas in each bioregion it would be necessary to identify all rocky intertidal sites. This would probably be best achieved by mapping the location of all sites (Fig. 1) by using a combination of 1 : 25,000 topographic maps and small-scale navigation charts. This step was not carried out in the following case study as numerous sites had been nominated by a series of advisory committees (see 4.1.1).

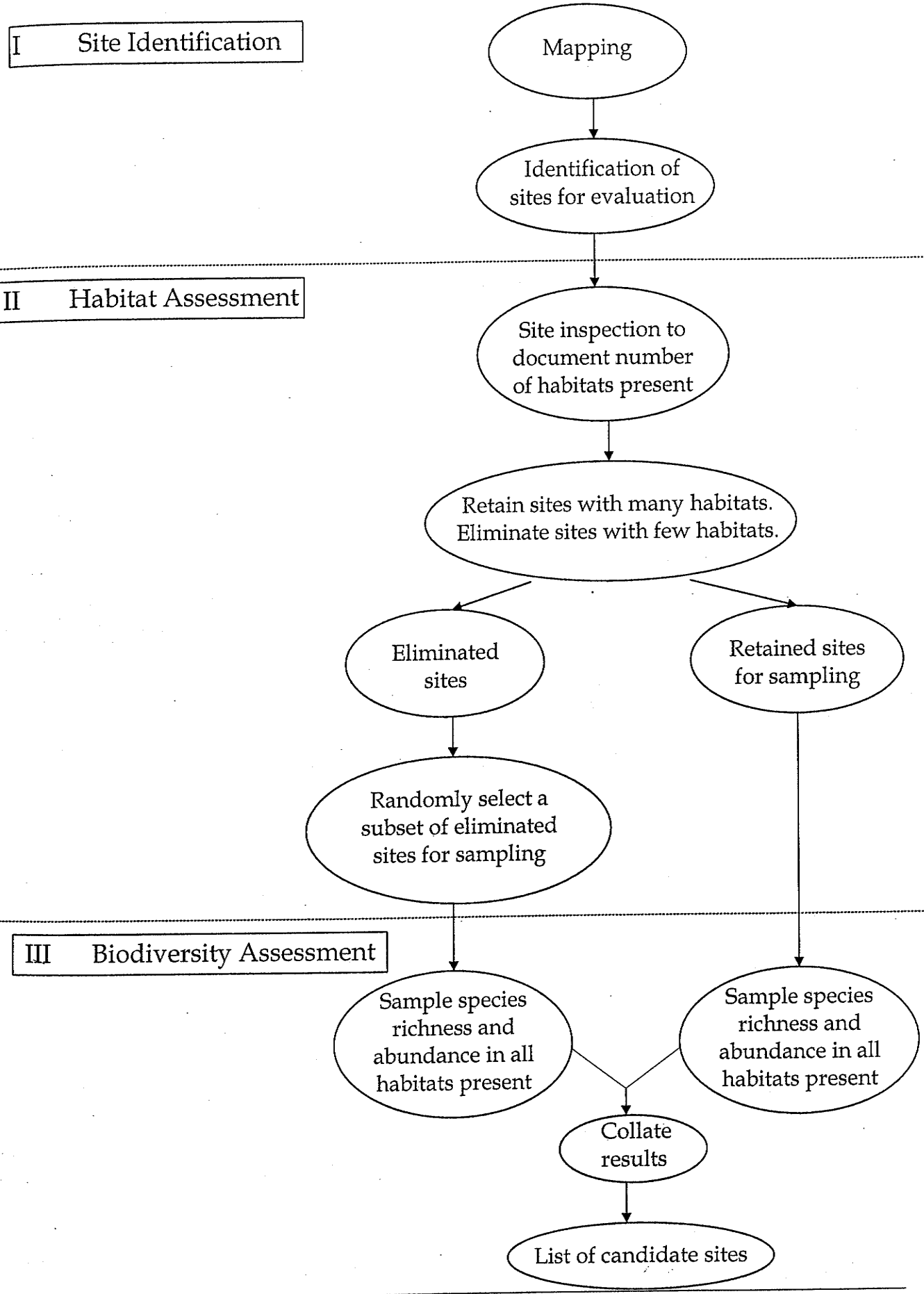
3.3 HABITAT ASSESSMENT

This second step will necessitate that all sites in each bioregion are visited to identify the habitats present (Fig. 1). These visits will also enable relevant information on aspects of future management to be obtained. The resulting data will be used to; (1) identify those sites with numerous habitats to be sampled in the "Biodiversity Assessment" (see section 3.4) and, (2) eliminate those sites with few habitats. This step is based on the untested (albeit reasonable) assumption that a greater number of habitats will yield a greater number of species. However, it is possible that the assumption of a positive correlation between habitat diversity and species richness is erroneous and thus eliminating sites with few habitats would be fraught with problems. Consequently, a number of eliminated sites (i.e. sites with few habitats) should be chosen, at random, and added to the list of sites to undergo a "Biodiversity Assessment." This procedural check should enable the significance of possible correlations between species richness and habitat diversity to be tested. The case study involving sites in the Hawkesbury Shelf and Batemans Shelf bioregions will commence with this step.

3.4 BIODIVERSITY ASSESSMENT

The third step requires that all selected sites (i.e. sites with numerous habitats and the eliminated sites chosen at random) are sampled in a consistent manner (Fig. 1 and see Section 4 for details of sampling). While step 2 (i.e the "Habitat Assessment") enables the number of sites to be sampled to be reduced, it is possible that the number of sites identified might still be large. Consequently, it will be necessary to use sampling techniques (see Section 4.3.2) that will permit a rapid assessment whilst simultaneously enabling the indicators derived from the identification criteria to be quantified.

Figure 1. Flow diagram summarising the steps in the protocol for identifying candidate IPA sites.



3.5 GAP ANALYSIS

The aim of gap analysis (Burley 1988, Scott *et al.* 1988 1991) is to identify any significant omissions in a reserve system: in this case IPAs. The data used in a gap analysis may be a combination of location data, species richness data, distributional data, and distributional information on rare and/or endangered species (Belbin 1993). Protocols and/or mechanisms for the implementation of gap analysis are not well established, but several approaches have been suggested by Kirkpatrick (1983), DeVelice *et al.* (1988), Margules *et al.* (1988), Faith and Norris (1989), and Belbin (1993).

Following completion of this study, it will be important to carry out a gap analysis for the Hawkesbury Shelf and Batemans Shelf bioregions so that any shortfalls in the system of IPAs are identified. To do so will require that existing rocky intertidal Aquatic Reserves and IPAs in the Hawkesbury Shelf and Batemans Shelf bioregions are mapped along with all the remaining rocky intertidal sites. It will be important to pay particular attention to sheltered rocky intertidal shores as they have not been included in this study and little is known about the spatial and temporal dynamics of their biological communities (Fairweather, 1990, and Underwood and Chapman, 1998 for an example).

3.6 LIMITATIONS OF THE APPROACH

Previous studies (see references in Section 4.2.1) have documented substantial temporal variation in the patterns of abundance of the organisms inhabiting the rocky intertidal regions. Therefore, patterns of abundance documented on a single occasion may differ quite markedly from second and subsequent occasions, and especially if the period of time between sampling events is large. For this reason analyses of the abundance of organisms are not utilised in this study. More importantly, decisions concerning the nomination of a site as an IPA based on a single sampling event might not be valid if the organisms present on the shore disappear prior to the site's declaration as an IPA. To overcome this problem, length-frequency distributions for a range of organisms were examined to evaluate whether populations would, in the absence of demonstrable human-induced perturbations (e.g. an oil-spill), persist for several years into the future. Moreover, the collection of this information would not cause an additional impost to the rapid assessment process because length-frequency data would need to be collected to document whether a site was acting as "source" and/or "sink," i.e. whether reproduction and recruitment were occurring.

4.0 CASE STUDY - AN ASSESSMENT OF NOMINATED ROCKY INTERTIDAL SITES

4. 1 SITE IDENTIFICATION

4.1.1 BACKGROUND

In November 1994, NSW Fisheries established five Regional Intertidal Protected Area Advisory Committees to recommend possible locations for IPAs on the central and southern coasts of New South Wales. The committees were convened at Port Stephens, Newcastle, Gosford, Wollongong and Moruya. A broad spectrum of stakeholders (Table 3) served on these committees and this ensured that a wide variety of views were expressed. The regional committees nominated 70 sites for consideration as IPAs. This list of sites included rocky intertidal and soft-bottom intertidal regions.

Table 3. List of participating stakeholder groups in the Regional Intertidal Protected Area Advisory Committees.

Participating Stakeholder Groups	
Local Angling Clubs	Commercial Fishermen
Ethnic Community	Oyster Farmers Association
Aboriginal Land Councils	Coastwatchers Association
Private Citizens	NSW Fishing Federation
National Parks and Wildlife Service	Recreational Fishing Federation
Local Government	Maritime Services Board
Tertiary Institutions	Dept. of School Education
Dept. of Land and Water Conservation	

4.1.2 MATERIALS AND METHODS

The list of 70 nominated sites was used as a basis for further investigations by NSW Fisheries. Initially these sites were allocated to their respective bioregion (IMCRA, 1998), then they were divided into those that were predominantly rocky intertidal communities and those that were principally soft-bottom communities.

4.1.3 RESULTS

Exposed rocky intertidal communities were evident at 25 of the 70 sites nominated by the regional IPA advisory committees. Of these, 6 sites were located in the Hawkesbury Shelf bioregion, a further 17 sites were in Batemans Shelf bioregion, and the remaining 2 sites were in the Twofold bioregion (Table 4).

Table 4. List of rocky intertidal sites nominated for further assessment as Intertidal Protected Areas.

	BIOREGION		
	Hawkesbury Shelf	**Batemans Shelf**	**Twofold Shelf**
NOMINATED SITE	Nobby's Head Toowoon Point Yumbool Point Tudibaring Head Green Point Brickyard Point	Bass Point Cathedral Rocks Bombo Head Cudmirrah N R Inyadda Point Preservation Point Ulladulla Head Warden Head Bawley Point Wasp Head Observation Head Mossy Point Toragy Point Tuross Head Dalmeny Wagonga Head Cuttagee Point	Tathra Head Short Point

4.1.4 DISCUSSION

The 25 rocky intertidal sites (Table 4) nominated by the five regional IPA advisory committees were identified using a "Delphic" process (Burley 1988, Scott *et al.* 1988 1991, Wilson 1995, Yurick 1995). There are important deficiencies in the Delphic approach and these include personal biases and an uneven knowledge of the participants (Edgar *et al.* 1997). It also ignores the need to map all the sites in each bioregion. However, these sites were considered to be important by the stakeholders. Given this background it was decided to use these sites to examine the veracity of the Habitat and Biodiversity Assessment steps in the Identification Protocol. Consequently, each site will be visited to identify the habitats present.

Finally, it will be necessary to carry out a Gap Analysis once this study has been completed. To do so will require the information generated by mapping the rocky intertidal sites in the Hawkesbury Shelf and Batemans Shelf bioregions. When all the sites have been mapped, the site identification protocol would then be re-examined and refined if required.

4.2 HABITAT ASSESSMENT

4.2.1 INTRODUCTION

The geomorphology of rocky shores can vary quite markedly and this is due to the interaction of rock-type, bed formations, jointing, differential rates of weathering and erosion, and the degree of exposure to the predominant SE swell (Trenamen & Short 1987) over long periods of time. The resulting rocky intertidal regions are a mosaic of physical habitats which can be further modified by the plant and animal communities present.

Previous research on rocky platforms (e.g. Creese 1980ab 1981, Underwood 1981, Underwood & Denley 1984, O'Donnell 1986, Underwood & Chapman 1989, Otway 1989 1994), in rock pools (e.g. Worthington & Fairweather 1989, Astles 1993, Arrontes & Underwood 1991, Underwood & Skilleter 1996), in cobble areas (e.g. McGuinness 1987 1988, Smith & Otway 1996) along the NSW coast has shown that while the organisms occupying these habitats often overlap, there are also particular species that are restricted to only one or two of these habitats. These observations suggest that the overall number of species for any given shore will increase with the increasing number of habitats. This relationship can be readily shown using data from the early descriptive studies of the rocky intertidal fauna and flora at sites such as Long Reef (e.g. Pope, 1943). While there have been the inevitable changes to the taxonomy of the organisms, the use of data from these early studies is extremely advantageous because they were carried out prior to demonstrable human disturbances (via trampling and/or the harvesting of organisms for bait or food) that have become common over recent decades.

It is clearly not possible to sample the biodiversity at all 25 nominated sites given the constraints (financial, logistical and temporal) placed on the project. Instead, documenting the number of habitats (e.g. platforms, rock pools, boulder areas, etc.) occurring at each of the 25 sites on the basis that there was a relationship between species richness and habitat diversity was considered feasible. Using this approach it should be possible to predict which sites should have greater biodiversity. This would also enable the number of sites to be sampled for biodiversity to be reduced to a logistically practical number.

4.2.2 MATERIALS AND METHODS

The 25 sites (Table 4) were visited over a two-month period in January and February, 1998 and the habitats present at each shore were recorded. To maximise the cost-effectiveness of these site inspections, information concerning the possible management of these sites (e.g. access, signage, enforcement patrols, etc.) was also obtained through direct observations and meetings with local Fisheries Officers. This latter information will be considered when finally selecting the sites for declaration as IPAs.

4.2.3 RESULTS

At least five different physical habitats including: (1) platforms, (2) crevices, (3) rock pools, (4) boulder areas (i.e. rocks with diameters exceeding 1.0 m), and (5) cobble areas (i.e. rocks with diameters 100 mm - 1.0 m) were recognisable across the 25 sites. Five habitats were present in the Hawkesbury Shelf bioregion (Table 5), but not at all sites. The five habitats were only present at Toowoon Point and Tudibaring Head. Brickyard Point, had 4 of the 5 habitats with the "Boulder" habitat absent. The remaining 3 sites (Nobby's Head, Yumbool Point and Green Point) only had 3 habitats present with the "Boulder" and "Cobble" habitats absent.

Table 5. Summary of the habitats occurring at the 6 nominated sites in the Hawkesbury Shelf Bioregion.

NOMINATED SITE	HABITAT				
	Platform	**Crevice**	**Rock pool**	**Boulder**	**Cobble**
Nobby's Head	Present	Present	Present		
Toowoon Point	Present	Present	Present	Present	Present
Yumbool Point	Present	Present	Present		
Tudibaring Head	Present	Present	Present	Present	Present
Green Point	Present	Present	Present		
Brickyard Point	Present	Present	Present		Present

The same 5 physical habitats were also present across the 17 nominated sites in the Batemans Shelf bioregion (Table 6). However, the five habitats were only present at Inyadda Point, Preservation Point and Warden Head. A further two sites: Bombo Head and Wagonga Head had 4 of the 5 habitats present with the "Boulder" habitat absent at both shores. The remaining 12 sites only had 3 or fewer habitats present.

Table 6. Summary of the habitats occurring at the 17 nominated sites in the Batemans Shelf Bioregion (NR denotes Nature Reserve).

NOMINATED SITE	HABITAT				
	Platform	Crevice	Rock pool	Boulder	Cobble
Bass Point	Present	Present	Present		
Cathedral Rocks	Present	Present	Present		
Bombo Head	Present	Present	Present		Present
Cudmirrah N R	Present				
Inyadda Point	Present	Present	Present	Present	Present
Preservation Point	Present	Present	Present	Present	Present
Ulladulla Head	Present	Present	Present		
Warden Head	Present	Present	Present	Present	Present
Bawley Point	Present	Present			
Wasp Head	Present	Present	Present		
Observation Head	Present	Present			
Mossy Point		Present	Present	Present	
Toragy Point				Present	
Tuross Head			Present	Present	
Dalmeny Head		Present	Present		
Wagonga Head	Present	Present	Present		Present
Cuttagee Point		Present	Present		

Only 4 of the physical habitats were present across the 2 nominated sites (Tathra Head and Short Point) in the Twofold Shelf bioregion (Table 7). The boulder habitat was absent at Short Point, whereas extensive platforms, boulders and cobble areas were absent from Tathra Head.

Table 7. Summary of the habitats occurring at the 2 nominated sites in the Twofold Shelf Bioregion.

NOMINATED SITE	HABITAT				
	Platform	Crevice	Rock pool	Boulder	Cobble
Tathra Head		Present	Present		
Short Point	Present	Present	Present		Present

4.2.4 DISCUSSION

Five different physical habitats comprising: (1) platforms, (2) crevices, (3) rock pools, (4) boulder areas, and (5) cobble areas were recognisable across the 6, 17 and 2 sites in the Hawkesbury Shelf, Batemans Shelf and Twofold Shelf Bioregions, respectively. It is important to note that size-ranges of boulders (i.e. rocks with diameters exceeding 1.0 m) and cobbles (i.e. rocks with diameters 100 mm - 1.0 m) reflect the range in sizes of the rocks comprising these habitats. These size-ranges differ from those used in sedimentary petrology as cobbles refer to rocks 64 mm - 256 mm in diameter and boulders are rocks exceeding 256 mm in diameter (Folk 1974).

The sites across the Hawkesbury Shelf and Batemans Shelf bioregions exhibited a range of rock types. Sandstone (e.g. Toowoon Point and Tudibaring Head) and shale (e.g. Brickyard Point) dominated the shores observed in the Hawkesbury Shelf bioregion. Shores in the Batemans Shelf bioregion were more varied in composition and included basalt (e.g. Bombo Head, Inyadda Point), sandstone (e.g. Preservation Point) and Shale (e.g. Warden Head). The different substrata produced obvious differences within a given habitat. For example, sandstone or shale cobbles were generally "sheet-like," whereas basalt cobbles were "egg-shaped" with much smoother surfaces. Moreover, the basalt cobbles had greater depth and weight for a given size compared to the sandstone and shale cobbles. Additionally, the basalt platforms were generally steeper at their seaward margins and this appeared to be a reflection of the characteristic columns formed during the cooling of this igneous rock. The weathering and erosion of these columns in more wave-exposed areas also produced net-like patterns of interconnected crevices.

It was unclear whether the differences in rock-type were translated into differences in biodiversity because the biological communities appeared similar on shores with different rock-types. While rock-type may not appear to be important in relation to species diversity, there are a few studies (e.g. Caffey 1985, McGuinness and Underwood 1986, Otway 1989) that indicate that rock-type may contribute more to patterns of abundance than is realised at present. For example, the recruitment of algae can be affected by the rock-type as significantly greater amounts of ephemeral algae (e.g. *Ulva lactuca*) recruit onto sandstone compared to shale in the low-shore areas (Otway 1989) and in cobble areas (McGuinness and Underwood 1986). Moreover, Caffey (1982) has shown that rock-type had no consistent effect on the settlement and recruitment of the surf barnacle *Tesseropora rosea*. Unfortunately, it is not clear whether rock-type affects species richness. However,

it should be possible to examine whether there is any correlative evidence for differences in species diversity across the sites with different rock-types by using the data gathered during the biodiversity assessment (see section 4.3).

In selecting the shores for Biodiversity Assessment, it was apparent that the 25 sites could be separated into 2 categories: (1) those shores with 4 or 5 habitats, and (2) those shores with 3 or fewer habitats. With this mind all the sites with 3 or fewer habitats were eliminated. However, 4 of sites eliminated were then chosen, at random, for sampling to enable a procedural check and permit an examination of possible correlations between the number of habitats and species diversity. The sites selected for Biodiversity Assessment within the Hawkesbury Shelf and Batemans Shelf bioregions are given in Table 8. Short Point in the Twofold Shelf bioregion was also included to assess the change in species richness across the bioregional boundary. In doing so, the data from Short Point was compared with the most southerly site in the Batemans Shelf bioregion (i.e. Wagonga Head - Table 8).

Table 8. Sites selected for biodiversity assessment. Abbreviation of site name is in brackets.

	BIOREGION		
	Hawkesbury Shelf	**Batemans Shelf**	**Twofold Shelf**
SITE SELECTED FOR BIODIVERSITY ASSESSMENT	Toowoon Point (Too) Tudibaring Head (Tud) Brickyard Point (Bri)	Bombo Head (Bom Inyadda Point (Iny) Preservation Point (Pre) Warden Head (War Wagonga Head (Wag)	Short Point (Sho)
SITE SELECTED FOR PROCEDURAL CHECK	Nobby's Head (Nob) Yumbool Point (Yum)	Bass Point (Bas) Wasp Head (Was)	

4.3 BIODIVERSITY ASSESSMENT

4.3.1 INTRODUCTION

A description of the organisms inhabiting the rocky intertidal regions along the coast of NSW is covered in a revision of Dakin's (1952) study entitled "Australian Seashores". The rocky intertidal community in NSW has been the subject of much research over the past two decades. Unfortunately, much of this work has been carried out at the major urban centres or at locations dictated by the location of major government studies (e.g. the Dept. of Defence study of Jervis Bay - CSIRO 1994, Underwood and Chapman 1998). Furthermore, while the taxonomy of the more obvious animals is well known, the same cannot be said for: (1) small, mobile organisms (e.g. polychaetes, amphipods and isopods), many of the filamentous red and brown algae (e.g. *Ectocarpus* spp. and *Polysiphonia* spp.), and the rare organisms. Moreover, sampling the filamentous algae, infaunal and mobile species can often consume large amounts of time and could not be undertaken within the scope of the present study. Finally, little is known about the spatial and temporal fluctuations in abundance of the organisms at the sites selected for an assessment of biodiversity.

4.3.2 MATERIALS AND METHODS

4.3.2.1 SAMPLING SITES

The locations of the 13 sites selected for biodiversity assessment are shown in Figure 2 and the abbreviations used in subsequent figures are presented in Table 8. These sites were sampled using the methods described below in the months of March to June. The methods reflect the need to obtain a rapid assessment of the fauna and flora living in the 5 major habitats identified during the habitat assessment.

4.3.2.2 SPECIES RICHNESS

The limited amount of time available to sample all the habitats present at a site prevented the use of detailed sampling techniques developed for rock pools (Astles 1993) and cobble areas (McGuinness 1987 1988). Consequently, a range of alternative techniques was used and these are described below.

Platform

Previous studies have clearly identified a range of habitats on rocky platforms. These include: (1) a high-shore area dominated by littorinid snails, (2) wave-exposed, mid-shore areas occupied by barnacles and limpets, (3) sheltered, mid-shore areas dominated by barnacles and grazing snails such as *Nerita atramentosa, Bembicium nanum* and *Austrocochlea constricta,* (4) low-shore areas dominated by the encrusting tubeworm *Galeolaria caespitosa,* and (5) a low-shore algal community with a range of animals including solitary ascidians (*Pyura stolonifera*) and macro-algal grazing chitons (e.g. *Onithochiton quercinus* and *Plaxiphora albida*).

The fauna and flora on the platform were sampled using visual and photographic techniques. Where possible, each habitat on the platform was sampled at 3 locations approximately 50 - 100 m apart. At each location, 4 randomly-placed 0.25 m^2 quadrats were photographed and then the presence of all fauna and flora recorded.

Crevices

Crevices were defined as cracks in the rock with a minimum depth of 20 cm. In reality, a large majority of the crevices exceeded 50 cm in depth. Organisms living in crevices were identified *in situ* and a species list compiled. No attempt was made to sample their abundances owing to the restricted amount of time available for sampling. However, the small-scale variation in the species

living in crevices within a site and among 3 similar sites was estimated by sampling 4 replicate 50 cm lengths of crevice at each site.

Rock pools

The fauna and flora present in four replicate rock pools was recorded, where possible, at each of 3 replicate sites. Furthermore, preliminary sampling had indicated that a period of 5 minutes was the minimum amount of time required to identify at least 90% of the species present in rock pools with complex bathymetry. Consequently, to ensure comparable data each individual rock pool was sampled using a timed search of five minutes duration and only rock pools 30 - 100 cm in depth were sampled.

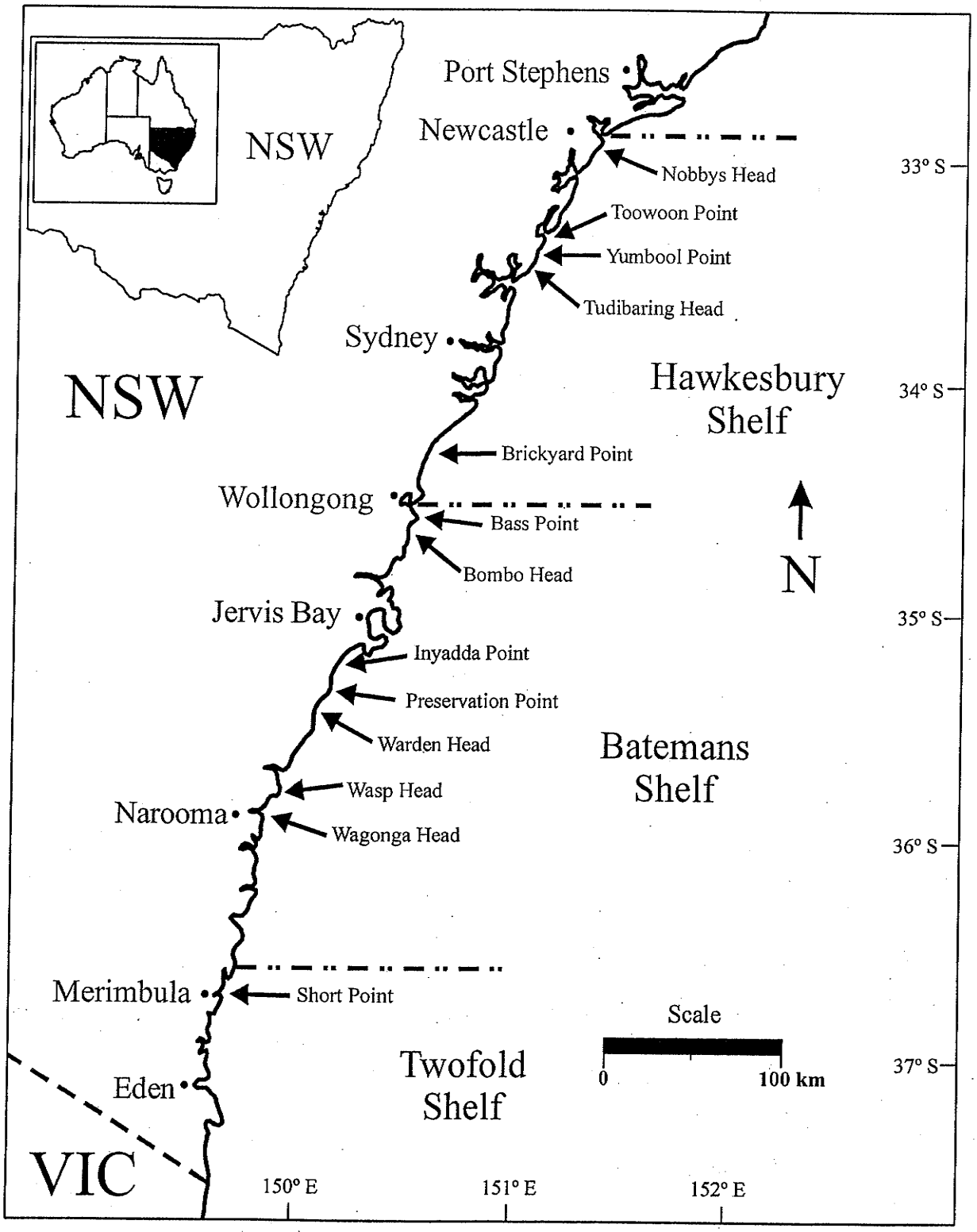
Boulder Areas

Timed searches, each of 5 minutes duration per replicate, were used to identify the fauna and flora in boulder habitats at 3 replicate locations (where possible) within a shore. At each site, the undersides of boulders (with maximal lengths of 2 - 4 m) enclosed within 4 replicate areas of 5 m x 5m were sampled.

Cobble Areas

A list of the fauna and flora inhabiting cobble areas was compiled from a one-hour search of the habitat. Cobbles of varying sizes (30 - 100 cm in diameter) were always sampled in a consistent manner. This involved the recording of the fauna and flora present in three strata comprising: (1) the top of the cobble, (2) the underside of the cobble, and (3) the sediments (mainly shell fragments and occasionally some sand) underlying the cobble. The overall species list was generated by combining the species present in all three strata for all the cobbles examined in the timed search. Finally, it is important to note that extensive cobble areas (i.e. 5 x 5 m or greater in area) were generally only present at one location (often in an embayment at the northern end of the platform) and thus it was not possible to sample at replicate locations.

Figure 2. Map showing the location of the 13 sites selected for sampling as part of the biodiversity assessment for a system of Intertidal Protected Areas in the Hawkesbury Shelf and Batemans Shelf bioregions of NSW. Note one site (Short Point) in the Twofold Shelf bioregion was sampled to assess the degree of change in species richness from the Batemans Shelf bioregion.



4.3.2.3 SIZE OF ANIMALS

Where possible, the population size-structures of 5 gastropods and the solitary ascidian *Pyura stolonifera* were obtained at 3 locations at each site. The size of *Pyura stolonifera* was estimated using the mean of the maximum and minimum diameters of the tunic at the level of the siphons (for further details see Otway 1989). The maximum and minimum sizes of a variety of other animals were also recorded at each shore. All measurements were taken to the nearest millimetre using vernier calipers.

The length-frequency data and the size-ranges (maximum and minimum sizes) were then used to indicate whether the sites were acting as "sources" (of larvae) and "sinks" (for new recruits). To assist with the interpretation of these data, studies documenting the size at sexual maturity, the size of 1 year-old individuals and longevity were reviewed and the relevant information summarised.

4.3.2.4 TROPHIC LEVELS AND FEEDING-TYPES

The organisms were assigned to trophic levels and 7 feeding-types (i.e. primary producers, grazers, predators, filter feeders, detrital feeders, omnivores, unknown) based on a review of published dietary studies. Where direct information was not available, the diets of similar species were used to assign a feeding type.

4.3.2.5 DATA PROCESSING

The total number of species (fauna and flora combined) occurring in the platform, crevice, rock pool and boulder habitats were quantified by combining the species lists from all replicate locations at each site. These individual lists were then combined to give an estimated of the total number of species (fauna and flora combined) for a site. The total numbers of species (fauna and flora combined) occurring in the Hawkesbury Shelf and Batemans Shelf bioregions were estimated by combining the species lists all the sites within the respective bioregion.

4.3.3 RESULTS

4.3.3.1 SPECIES RICHNESS

A total of 214 species comprising 43 algal species of algae and 171 animal species (Appendix 1) was found across all 13 sites sampled. The 5 sites in the Hawkesbury Shelf bioregion yielded a total of 190 species comprising 40 algal species and 150 animal species (Table 9), whereas the 7 sites in the Batemans Shelf bioregion yielded a total of 194 species comprising 42 algal species and 152 animal species (Table 10).

The total number of species combined across all 5 habitats also varied across the 13 sites sampled in the Hawkesbury Shelf, Batemans Shelf and Twofold Shelf bioregions (Fig. 3a). The variation in species richness at any given site (see Appendix 2 for species present at each of the 13 sites sampled) appeared to correlate with the number of physical habitats present at the shore (Fig. 3b). For example, there was a total of 72 species present across 3 habitats (i.e. platform, crevices and rock pools) at Nobby's Head and Yumbool Point, whereas Toowoon Point and Tudibaring Head had respectively, 135 and 144 species arising from all 5 habitats. This pattern was assessed by examining

the statistical significance of the correlations between the total number of species and habitats present for: (1) the sites in the Hawkesbury Shelf bioregion, (2) the sites in the Batemans Shelf bioregion, and (3) all 13 sites sampled.

The correlations between the total number of species and number of habitats for the Hawkesbury Shelf bioregion, Batemans Shelf bioregion and all sites sampled were all significant (Fig. 4, all $P < 0.05$, $r = 0.91$, 0.81 and 0.83, respectively) indicating that biodiversity increased with an increase in the number of habitats present at a site.

The total number of species present in each of the five habitats (i.e. platforms, crevices, rock pools, boulders and cobble areas) varied within and among sites. Despite this, when the cumulative percent increase in species richness was calculated across the five habitats (ordered as above) two clear results emerged and examples of these are illustrated for 3 sites in each bioregion in Figures 5 and 6. First, there was a substantial overlap in species composition and diversity across the platform, crevice, rock pool and boulder habitats. Second, the presence of a cobble habitat at a site resulted in a marked increase in the total number of species. Moreover, these patterns were consistent across the Hawkesbury Shelf and Batemans Shelf bioregions. In the Hawkesbury Shelf bioregion, the presence of a cobble habitat at Toowoon Point, Tudibaring Head and Brickyard Point (Fig. 5) resulted in increases in species richness of 39%, 43% and 40%, respectively. Similarly, the presence of a cobble habitat at Inyadda Point, Preservation Point and Warden Head in the Batemans Shelf bioregion (Fig. 6) resulted in increases in species richness of 33%, 33% and 39%, respectively.

To examine whether differences in species occurred at sites with different rock-types (see section 4.2.4) the means and ranges in species richness were documented from each of two sites with platforms composed of sandstone, shale and basalt. The sites used were Tudibaring Head and Preservation Point (Sandstone, mean = 133.5, range = 123 - 144, Fig. 3), Brickyard Point and Warden Head (Shale, mean = 146.5, range = 139 - 154, Fig. 3), and Bombo Head and Inyadda Point (Basalt, mean = 137, range = 136 - 138, Fig. 3). This comparison showed that no obvious differences were apparent as the range in numbers of species found at the sites composed of sandstone, shale and basalt overlapped.

Table 9. List of species in the Hawkesbury Shelf bioregion.

CHLOROPHYTA (Green algae)
Bryopsis sp.
Caulerpa filiformis
Chaetomorpha darwinii
Cladophora sp.
Codium fragile
Codium lucasii
Enteromorpha intestinalis
Ulva lactuca

PHAEOPHYTA (Brown algae)
Colpomenia sinuosa
Dictyota dichotoma
Dilophus marginatus
Ecklonia radiata
Ectocarpus sp
Hildenbrandia prototypus
Hormosira banksii
Lobophora variegata
Leathesia difformis
Padina fraseri
Petalonia
Ralfsia sp.
Sargassum 1
Sargassum 2
Splanchnidium rugosum
Zonaria sp

RHODOPHYTA (Red algae)
Amphiroa anceps
Champia compressa
Corallina officinalis
Gelidium pusillum
Gigartina sp
Gracilaria sp
Laurencia sp
Martensia
Melobesia
Neogoniolithon sp
Peyssonnelia
Polysiphonia sp
Porolithon
Porphyra sp
Pterocladia capillacea
Rhodymenia australis

PORIFERA (Sponges)
Haliclona sp.
Tethya corticata

CNIDARIA
Anemones
Actinia tenebrosa
Actinia australis
Anthothoe albocincta
Cnidopus verater
Phlyctenanthus australis
Corals
Culicia quinaria

PLATYHELMINTHES (Flat worms)
Callioplana marginata
Notoplana australis

NEMERTA (Nemerteans)
Baseodiscus hemprichii

ANNELIDA (Segmented Worms)
Australonereis ehlersi
Diopatra dentata
Eulaeospira convexis
Eurythoe complanata
Filograna implexa
Galeolaria caespitosa
Galeolaria hystrix
Hydroides elegans
Idanthyrsus pennatus
Janua pseudocorrugata
Lepidonotus bowerbankii
Lepidonotus melanogrammus
Nereid sp.
Sabellastarte indica
Serpula vermicularis
Terebella sp.

SIPUNCULA (Sipunculids)
Phascolosoma noduliferum

ARTHROPODA
Crabs
Cyclograpsus audouinii
Leptograpsus variegatus
Naxia tumida
Ozius truncatus
Plagusia chabrus
Hermit Crabs
Dardanus setifer
Paguristes squasmosus
Pagurus lacertosus
Pagurus sinuatus

ARTHROPODA Continued
Shrimps
Alope australis
Alpheus euphrosyne
Alpheus stenuus
Rhynchocinetes rugulosus
Barnacles
Austrobalanus imperator
Austromegabalanus nigrescens
Balanus variegatus
Catomerus polymerus
Chamaesipho columna
Chamaesipho tasmanica
Chthamalus antennatus
Ibla quadrivalvis
Tesseropora rosea
Tetraclitella purpurascens

MOLLUSCA
Chitons
Acanthochiton granostriatus
Callistochiton antiquus
Chiton jugosus
Chiton pelliserpentis
Cryptoplax mystica
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton variegatus
Ischnochiton versicolor
Onithochiton quercinus
Plaxiphora albida
Gastropods
Agnewia tritoniformis
Amblychilepas nigrita
Australium tentoriforme
Austrocochlea concamerata
Austrocochlea constricta
Bembicium nanum
Cabestana spengleri
Canthradella picturata
Cellana tramoserica
Charonia rubicunda
Conus papilliferus
Cypraea caputserpentis
Dentimitrella
Diodora lineata
Gena impertusa
Granata imbricata

Table 9 continued.

MOLLUSCA Continued
Gastropods
Haliotis ruber
Hinea brasiliana
Limatula strangei
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Nassarius particeps
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoacmaea petterdi
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Scutus antipodes
Thias orbita
Tugali parmaphoidea
Turbo militaris
Turbo torquatus
Turbo undulatus
Pulmonates
Kerguelenella sp
Siphonaria denticulata
Siphonaria virgulata
Sea hares
Dolabella
Dolabrifera dolabrifera
Sea slugs
Austraeolis ornata
Berthellina citrina
Onchidella patelloides
Bi-valves
Chlamys lividus
Lima nimbifer
Ostrea angasi
Pinctada
Saccostrea cucullata
Trichomya hirsuta
Cephalopods
Hapalochlena maculosa
Bubble-shells
Bullina lineata
Hydatina physis

BRYZOA (Bryzoans)
Bugula avicularia
Bugula neritina
Membranipora membranacea
Phidolopora avicularia
Schizoporella errata
Tricellaria porteri
Watersipora arcuata

ECHINODERMATA
Starfish
Allostichaster polyplax
Astrostole insularis
Coscinasterias calamaria
Coscinasterias muricata
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Brittle stars
Clarkcoma pulchra
Ophiocoma dentata
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Urchins
Centrostephanus rodgersii
Heliocidaris erythrogramma
Holopneustes pycnotilus
Phyllacanthus parvispinus
Holothurians
Leptosynapta dolabrifera
Stichopus mollis

CHORDATA
Ascidians
Herdmania momus
Pyura gibbosa gibbosa
Pyura stolonifera
Compound Ascidians
Botrylloides leachi
Eudistoma prolifera
Sidneoides tamaramae
Symplegma oceania

Table 10. List of species in the Batemans Shelf bioregion.

CHLOROPHYTA (Green algae)
Caulerpa filiformis
Chaetomorpha darwinii
Cladophora sp.
Codium fragile
Codium lucasii
Enteromorpha intestinalis
Ulva lactuca

PHAEOPHYTA (Brown algae)
Colpomenia sinuosa
Cystophora sp.
Dictyota dichotoma
Dilophus marginatus
Ecklonia radiata
Ectocarpus sp
Hildenbrandia prototypus
Hormosira banksii
Leathesia difformis
Lobophora variegata
Padina fraseri
Petalonia fascia
Phyllospora comosa
Ralfsia sp.
Sargassum verruculosum
Sargassum vestitum
Sargassum fallax
Splanchnidium rugosum

RHODOPHYTA (Red algae)
Amphiroa anceps
Champia compressa
Corallina officinalis
Gelidium pusillum
Gigartina sp
Gracilaria sp
Laurencia sp
Martensia
Melobesia
Neogoniolithon sp
Peyssonnelia
Polysiphonia sp.
Porolithon
Porphyra sp
Pterocladia capillacea
Rhodymenia australis
Zonaria sp

PORIFERA (Sponges)
Haliclona sp.
Tethya corticata

CNIDARIA
Anemones
Actinia tenebrosa
Actinia australis
Anthothoe albocincta
Cnidopus verater
Oulactis muscosa
Phlyctenanthus australis
Corals
Culicia quinaria

PLATYHELMINTHES (Flat worms)
Callioplana marginata
Notoplana australis
Thysanozoon sp.

NEMERTA (Nemerteans)
Baseodiscus hemprichii

ANNELIDA (Segmented Worms)
Australonereis ehlersi
Diopatra dentata
Eulaeospira convexis
Eurythoe complanata
Filograna implexa
Galeolaria caespitosa
Galeolaria hystrix
Hydroides elegans
Idanthyrsus pennatus
Janua pseudocorrugata
Lepidonotus melanogrammus
Nereid sp.
Sabellastarte indica
Serpula vermicularis
Terebella sp.

SIPUNCULA (Sipunculids)
Phascolosoma noduliferum

ARTHROPODA
Crabs
Cyclograpsus audouinii
Leptograpsus variegatus
Naxia tumida
Ozius truncatus
Palaemon serenus
Plagusia chabrus
Plagusia chabrus
Hermit Crabs
Dardanus setifer
Paguristes squasmosus
Pagurus lacertosus
Shrimps
Alope australis
Alpheus euphrosyne
Alpheus stenuus
Rhynchocinetes rugulosus
Barnacles
Austrobalanus imperator
Austromegabalanus nigrescens
Balanus variegatus
Catomerus polymerus
Chamaesipho columna
Chamaesipho tasmanica
Chthamalus antennatus
Epopella simplex
Ibla quadrivalvis
Tesseropora rosea
Tetraclitella purpurascens

MOLLUSCA
Chitons
Acanthochiton granostriatus
Callistochiton antiquus
Chiton jugosus
Chiton pelliserpentis
Cryptoplax mystica
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton variegatus
Ischnochiton versicolor
Onithochiton quercinus
Plaxiphora albida

Table 10 continued.

MOLLUSCA Continued
Gastropods
Agnewia tritoniformis
Amblychilepas nigrita
Australium tentoriforme
Austrocochlea concamerata
Austrocochlea constricta
Bembicium nanum
Cabestana spengleri
Canthradella picturata
Cellana tramoserica
Charonia rubicunda
Cominella lineolata
Conus anemone
Conus papilliferus
Cypraea caputserpentis
Dentimitrella
Diodora lineata
Gena impertusa
Granata imbricata
Haliotis ruber
Hinea brasiliana
Mitra carbonaria
Moneta annulus
Montfortula rugosa
Morula marginalba
Nassarius particeps
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoacmaea petterdi
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida Mufria
Phaisantrochus eximius
Pyrazus sp.
Scutus antipodes
Thias orbita
Tugali parmaphoidea
Turbo torquatus
Turbo undulatus
Umbraculum sinicum
Pulmonates
Kerguelenella sp
Siphonaria denticulata
Siphonaria virgulata

MOLLUSCA Continued
Sea hares
Aplysia dactylomela
Dolabella
Dolabrifera dolabrifera
Sea slugs
Berthellina citrina
Glossodoris atromarginata
Nudibranch 1
Pleurobranchus hilli
Bi-valves
Chlamys lividus
Onchidella patelloides
Ostrea angasi
Saccostrea cucullata
Saccostrea glomerata
Trichomya hirsuta
Cephalopods
Hapalochlena maculosa
Octopus cyaneus

BRYZOA (Bryzoans)
Membranipora membranacea
Phidolopora avicularia
Schizoporella errata
Tricellaria porteri
Watersipora arcuata

ECHINODERMATA
Starfish
Allostichaster polyplax
Astrostole insularis
Coscinasterias calamaria
Coscinasterias muricata
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Brittle stars
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Urchins
Centrostephanus rodgersii
Heliocidaris erythrogramma
Holopneustes pycnotilus
Phyllacanthus parvispinus

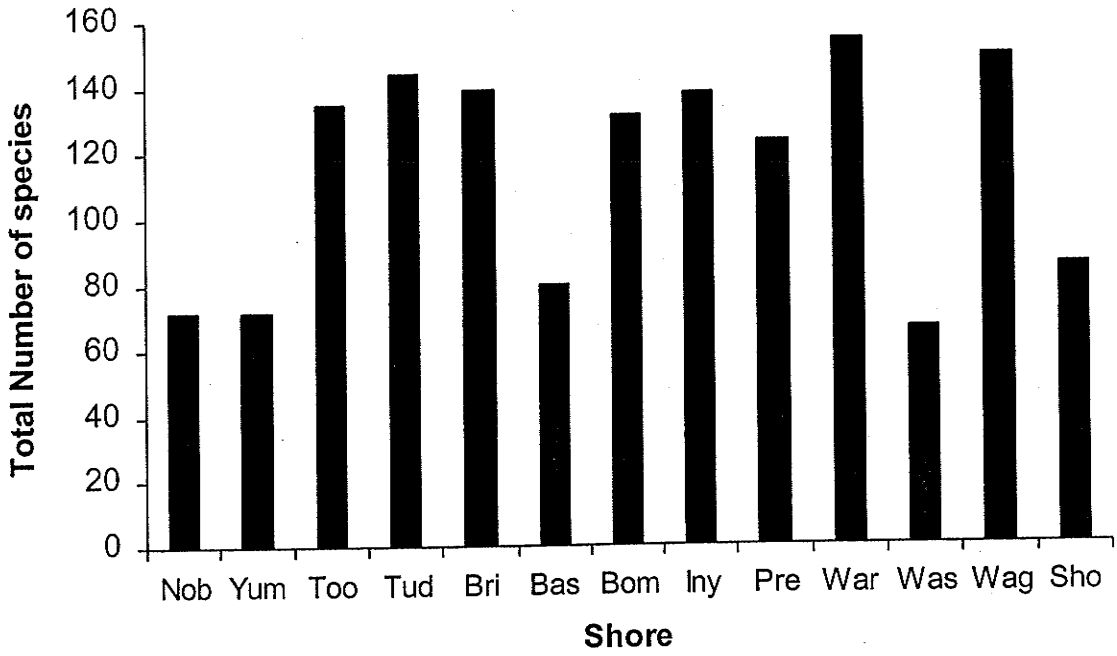
ECHINODERMATA Continued
Holothurians
Chiridota gigas
Leptosynapta dolabrifera
Stichopus mollis

HEMICHORDATA
Balanoglossus australiensis

CHORDATA
Ascidians
Herdmania momus
Pyura gibbosa gibbosa
Pyura stolonifera
Compound Ascidians
Botrylloides leachi
Symplegma oceania

Figure 3. Species and habitat diversity at the 13 sites sampled as part of the Biodiversity Assessment. (A) Species richness at each site, and (B) Habitat diversity at each site.

A.



B.

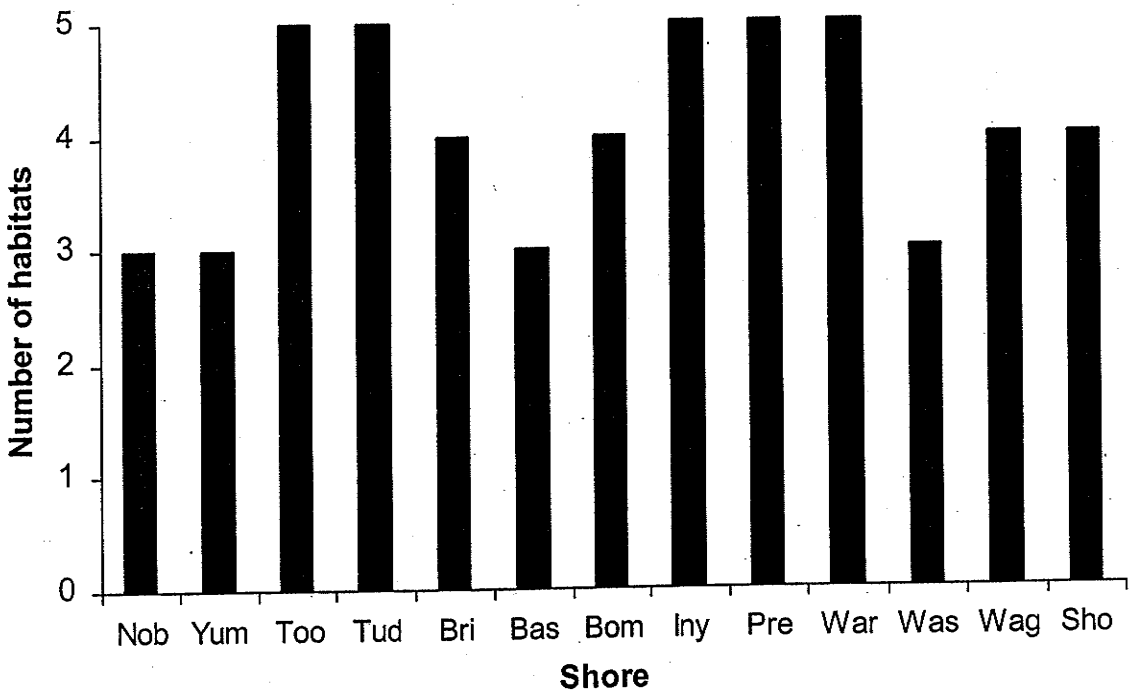


Figure 4. Correlations between the total number of species and number of habitats for the Hawkesbury Shelf bioregion, Batemans Shelf

bioregion and all sites sampled as part of the Biodiversity Assessment.

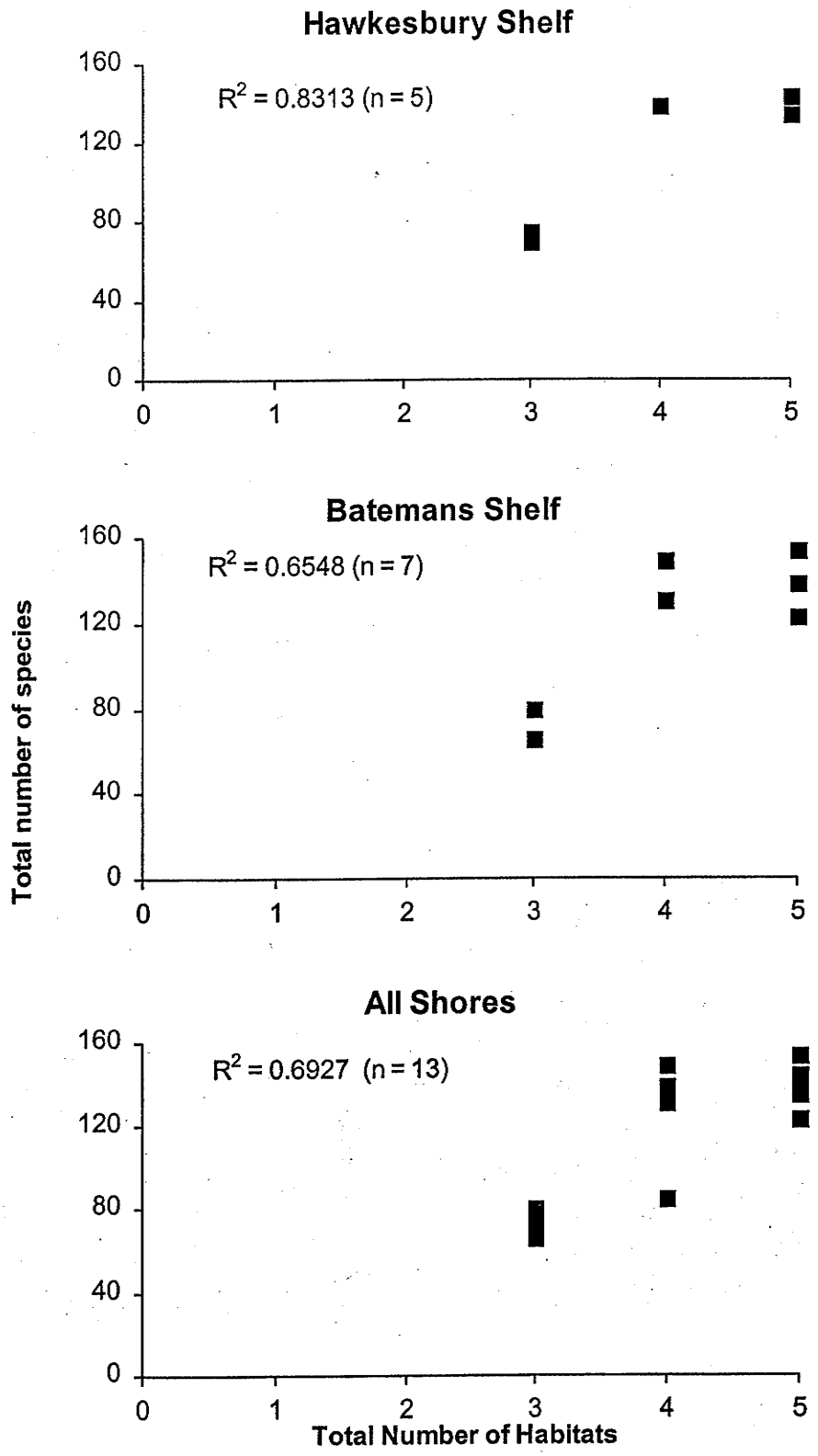


Figure 5. Cumulative percent increase in the number of species across the 5 habitats (i.e. platforms, crevices, rock pools, boulders and cobble areas) for 3 sites in the Hawkesbury Shelf bioregion.

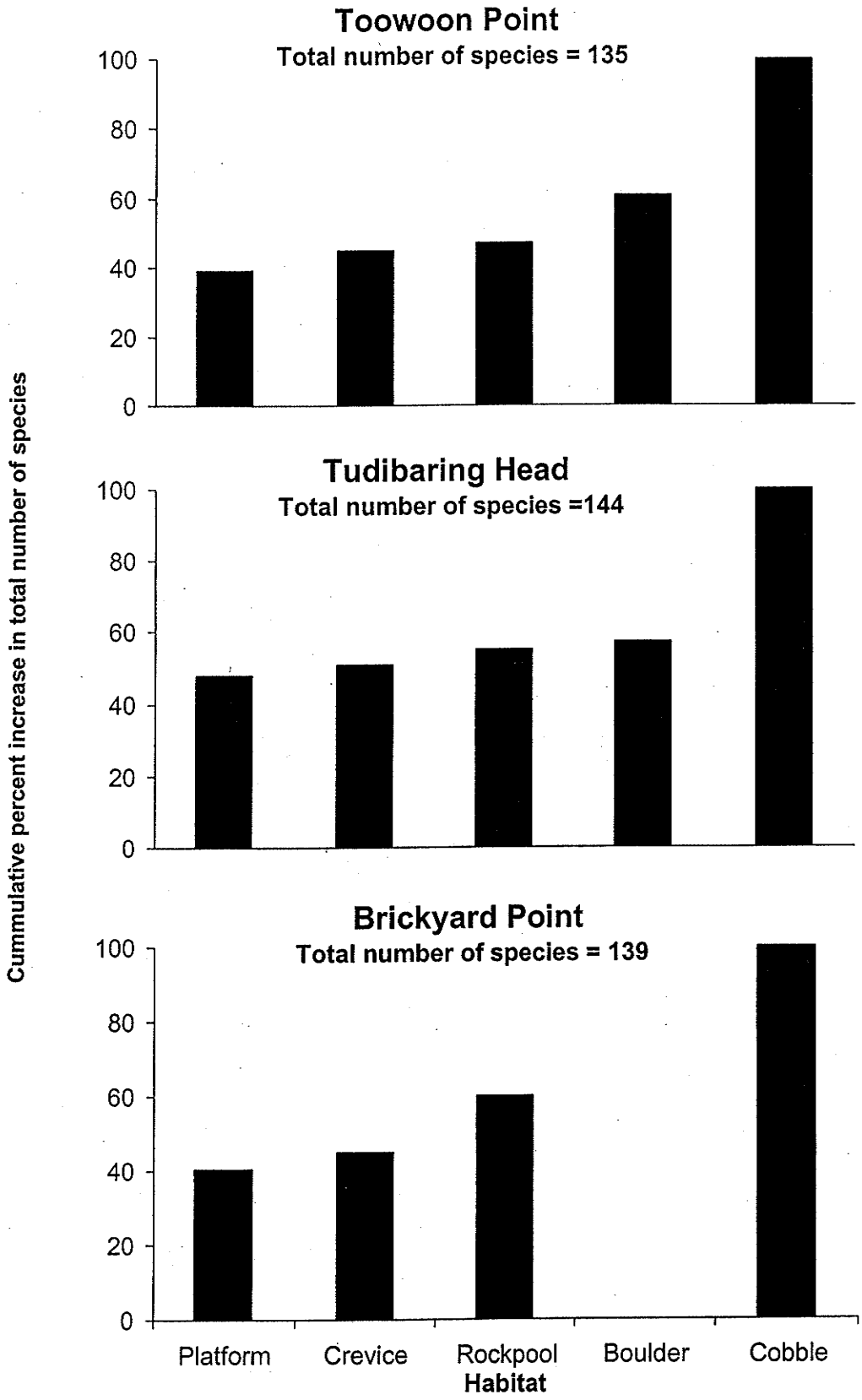
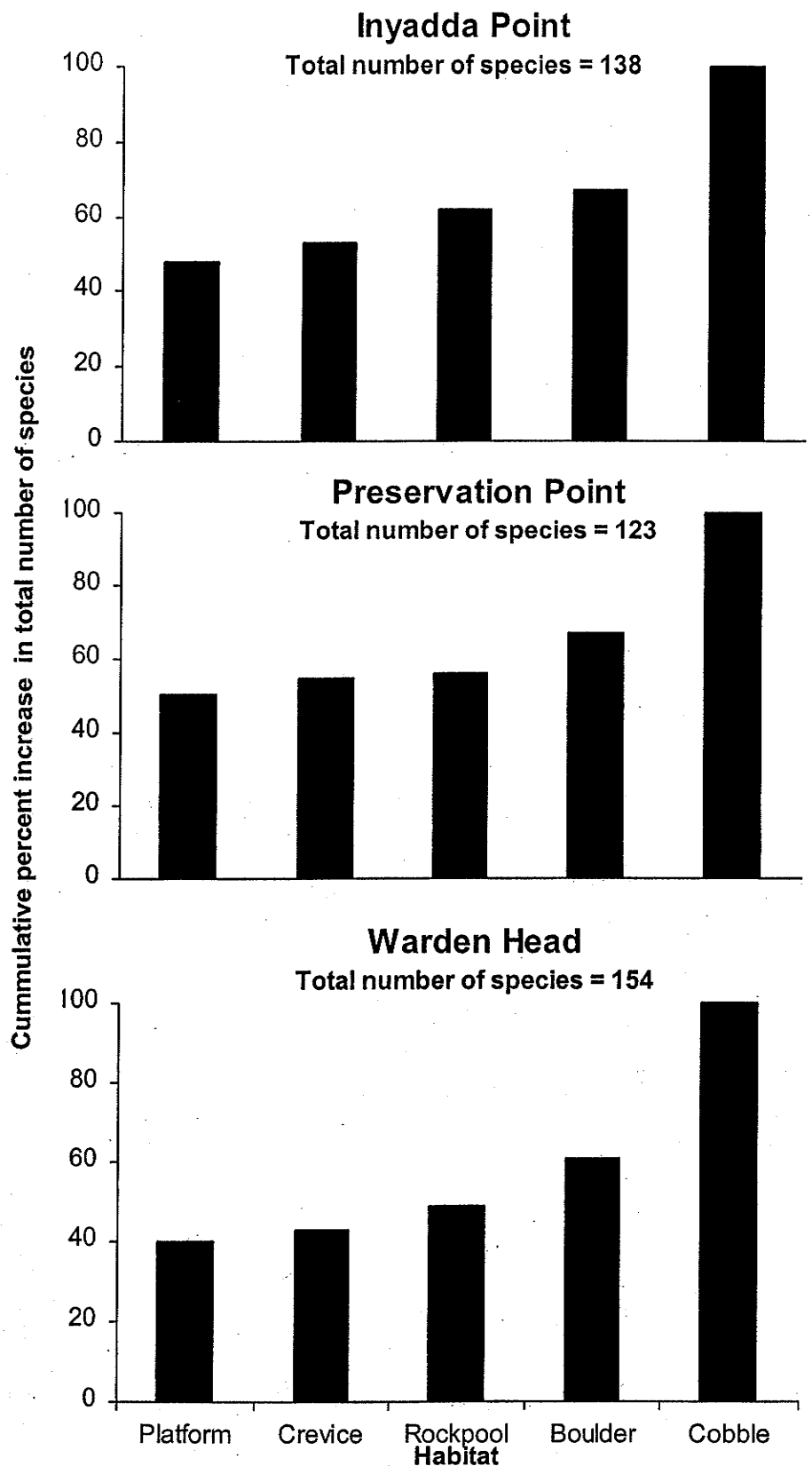


Figure 6. Cumulative percent increase in the number of species across the 5 habitats (i.e. platforms, crevices, rock pools, boulders and cobble areas) for 3 sites in the Batemans Shelf bioregion.



4.3.3.2 SIZE OF ANIMALS

Size-frequency distributions of *Nerita atramentosa, Bembicium nanum, Austrocochlea constricta* and *Montfortula rugosa* are plotted for 3 randomly-chosen locations within each of 2 sites in the Hawkesbury Shelf and Batemans Shelf bioregions (Figs. 7 - 20) to provide examples of the results obtained at the various sites in both bioregions. It was not possible to obtain length-frequency distributions for *Montfortula rugosa* at Toowoon Point (Hawkesbury Shelf bioregion) and Warden Head (Batemans Shelf bioregion) because of rough seas and a moderate swell (i.e. 2 - 3 m). Size-frequency distributions of *Pyura stolonifera* pooled across locations within each shore (Fig. 21) are presented for Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion), and for Inyadda Head and Warden Head (Batemans Shelf bioregion) to provide examples of the results obtained. *Pyura stolonifera* were notably absent from the low-shore regions at Yumbool Point (Hawkesbury Shelf bioregion). Similarly, size-frequency distributions of *Cellana tramoserica* (pooled across locations within each shore) are plotted for 1 site in each of the 3 bioregions (i.e. Tudibaring Head, Bass Point and Short Point, respectively - Fig. 22).

These figures show that individuals of all 6 species ranged in size from small to large at Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion), and Inyadda Head and Warden Head (Batemans Shelf bioregion). There was also clear evidence of size/age cohorts for particular species at some sites. For example, the size-frequency distributions of *Nerita atramentosa* at Toowoon Point (Hawkesbury Shelf bioregion) and Preservation Point (Batemans Shelf bioregion) were characterised by 3 distinct cohorts with modal sizes (pooled across the 3 randomly-chosen locations) of 5, 13 and 19 mm, and 2, 9 and 14 mm at Toowoon Point and Preservation Point, respectively.

The size-frequency distributions of the 6 species varied among shores with similar patterns occurring at some shores and quite different patterns at others. For example, the size-frequency distributions of *Nerita atramentosa* were characterised by 3 size/age cohorts at Toowoon Point, Preservation Point and Warden Head, and 2 size/age cohorts at Brickyard Point.

The size-frequency distributions of the 6 species also varied among replicate sites within a given shore. For example, smaller individuals of *Austrocochlea constricta* were absent from locations 1, 2 and 3 at Warden Head, Brickyard and Preservation Point, respectively.

Finally, the maximum and minimum sizes of various species at Toowoon Point and Brickyard Point (Table 11) and at Preservation Point and Warden Head (Table 12) clearly indicate that large and small individuals were present at these shores. This was also true of the remaining sites in the Hawkesbury Shelf and Batemans Shelf bioregions.

The results of studies documenting the size at sexual maturity, the size of 1 year-old individuals and longevity for several species are summarised in Tables 13 and 14.

Figure 7. Size-frequency distributions of *Nerita atramentosa* at 3 randomly-chosen locations at Toowoon Point (Hawkesbury Shelf bioregion).

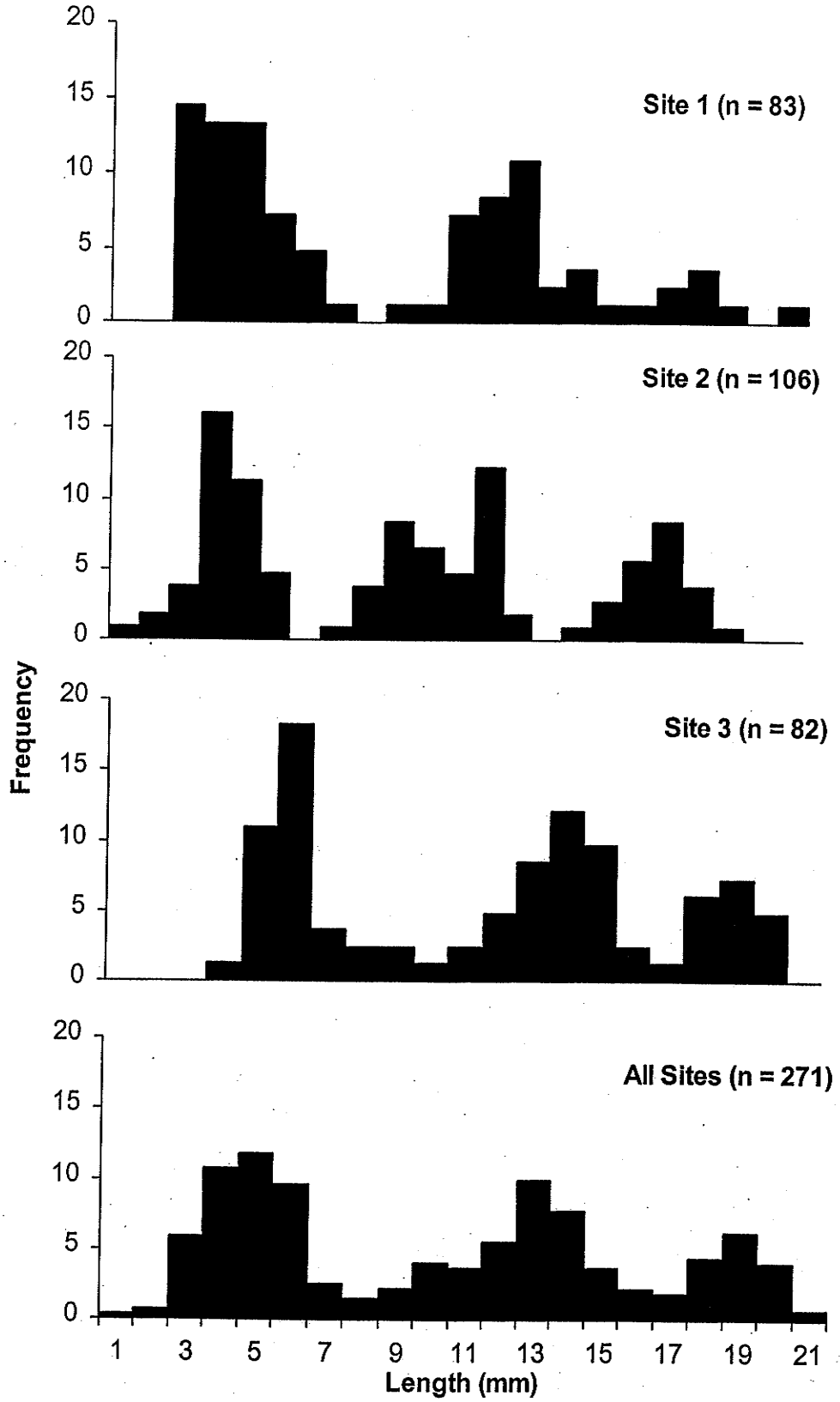


Figure 8. Size-frequency distributions of *Bembicium nanum* at 3 randomly-chosen locations at Toowoon Point (Hawkesbury Shelf bioregion).

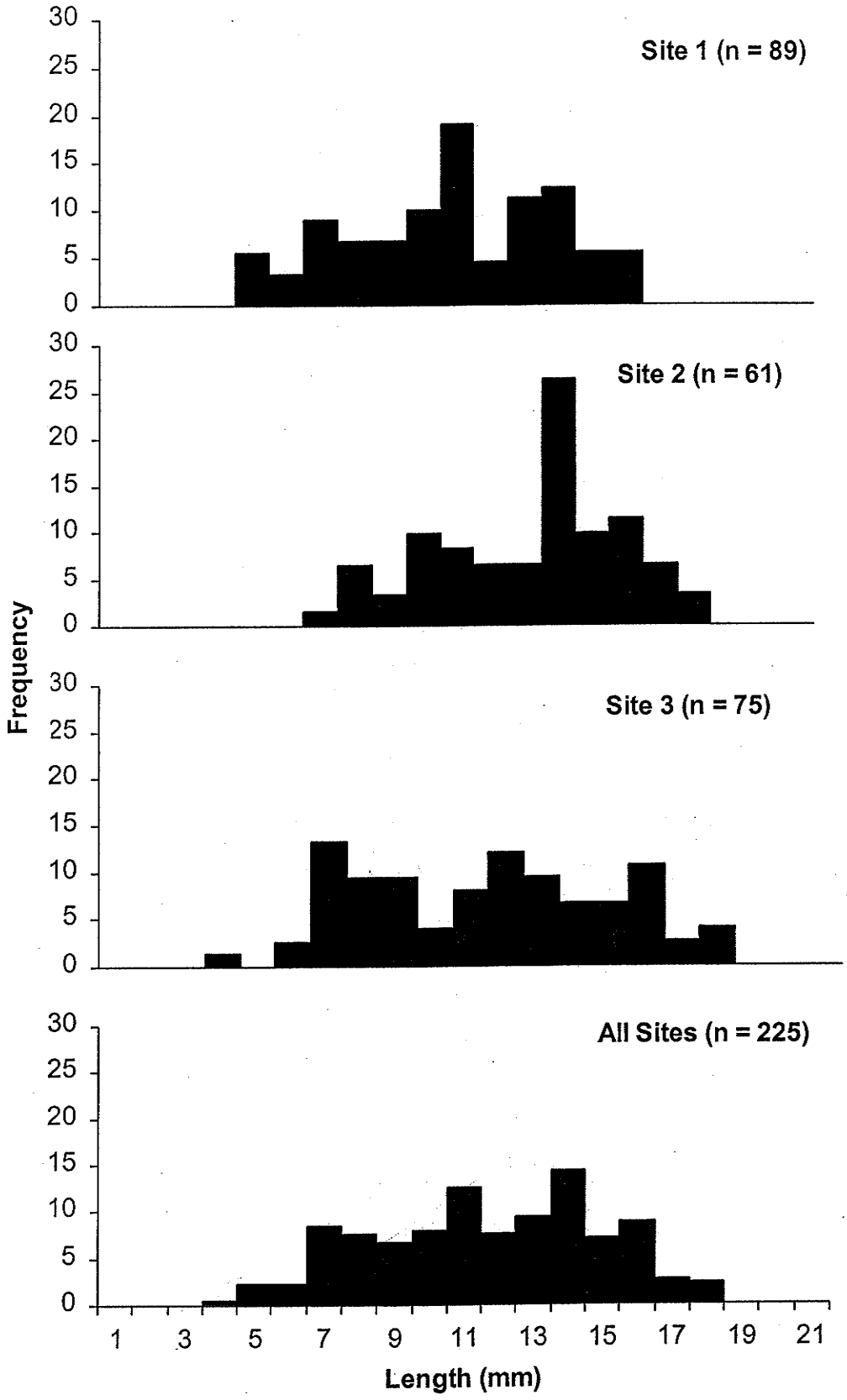


Figure 9. Size-frequency distributions of *Austrocochlea constricta* at 3 randomly-chosen locations at Toowoon Point (Hawkesbury Shelf bioregion).

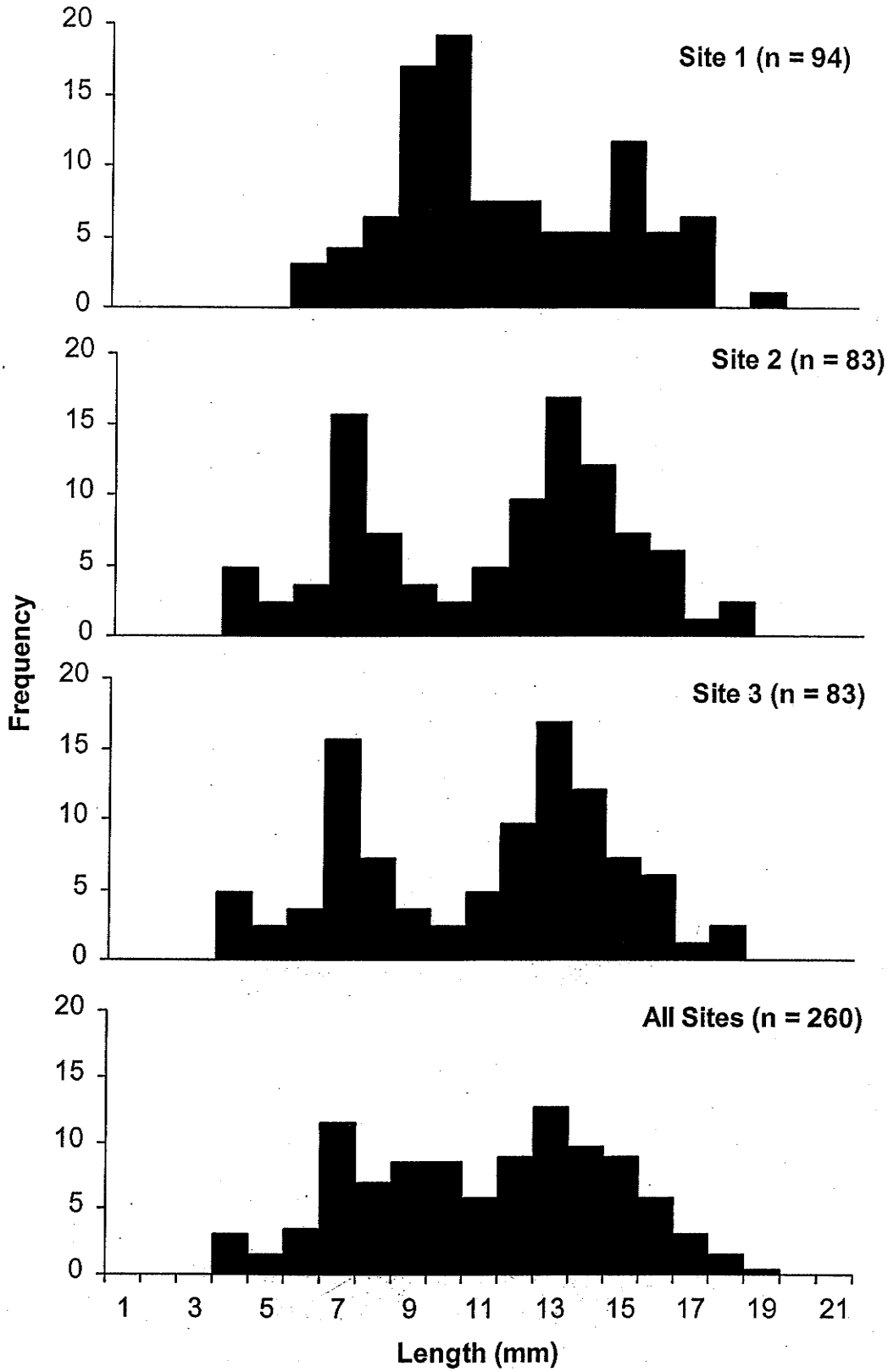


Figure 10. Size-frequency distributions of *Nerita atramentosa* at 3 randomly-chosen locations Brickyard Point (Hawkesbury Shelf bioregion).

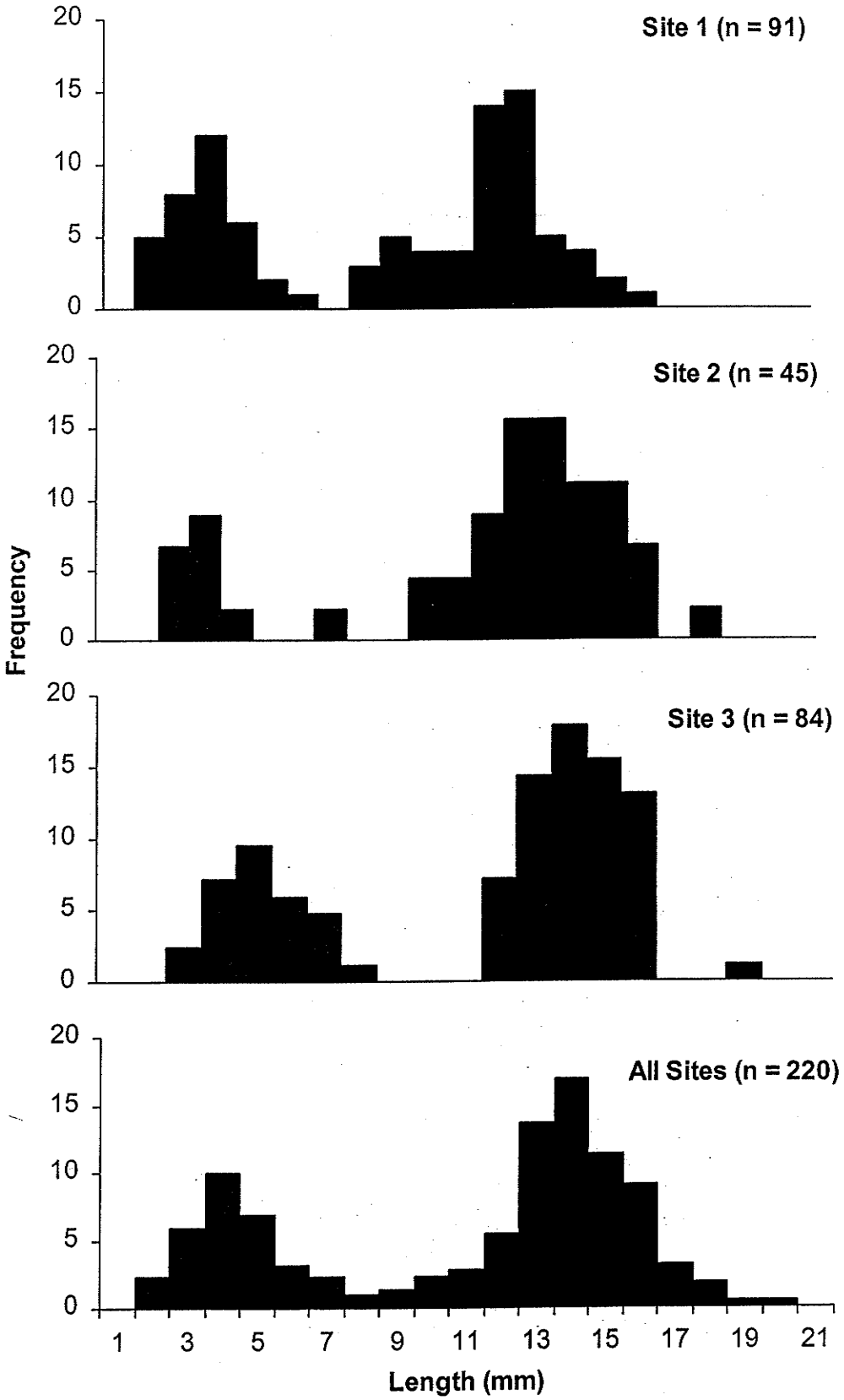


Figure 11. Size-frequency distributions of *Bembicium nanum* at 3 randomly-

chosen locations at Brickyard Point (Hawkesbury Shelf bioregion).

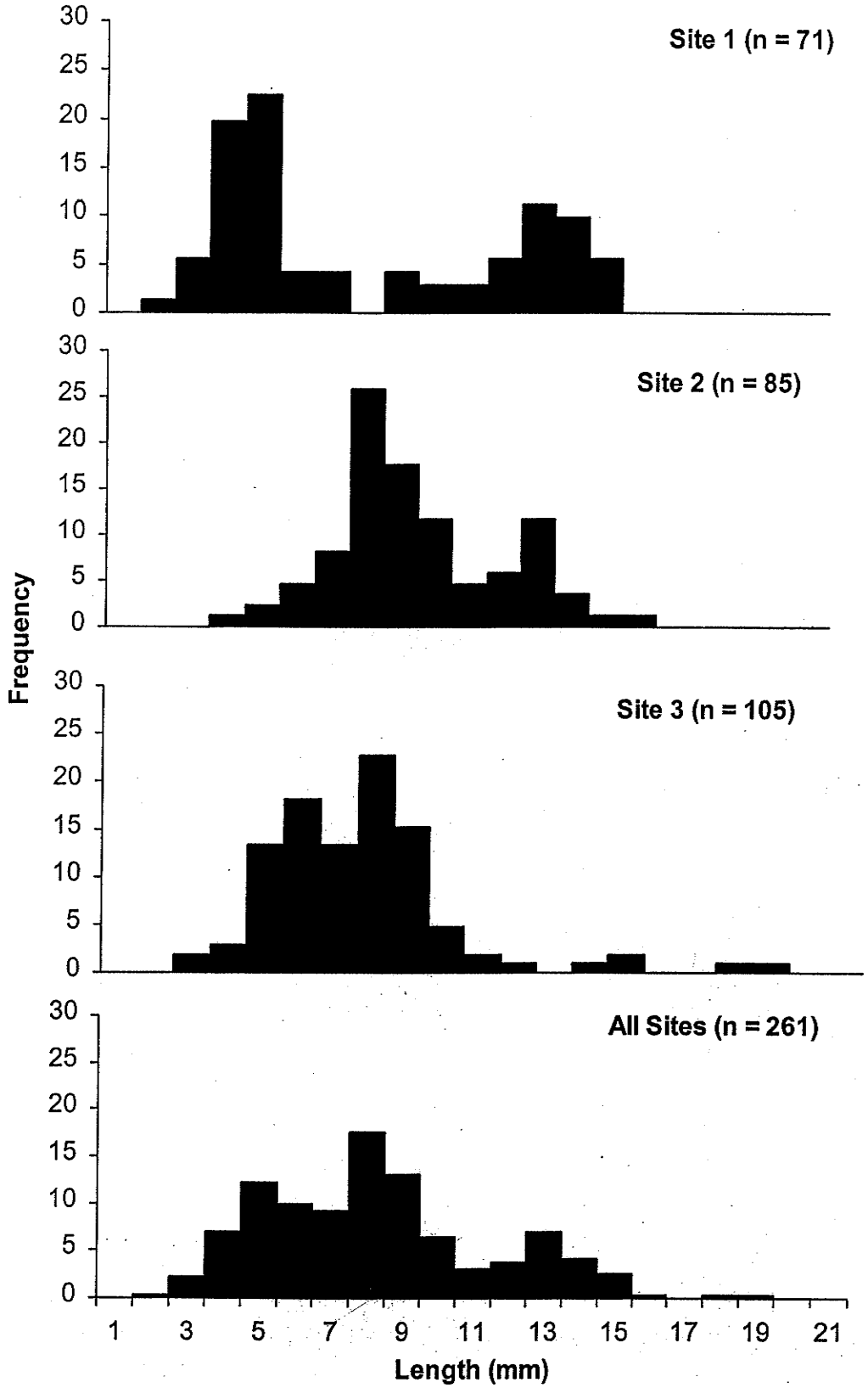


Figure 12. Size-frequency distributions of *Austrocochlea constricta* at 3 randomly-chosen locations at Brickyard Point (Hawkesbury Shelf bioregion).

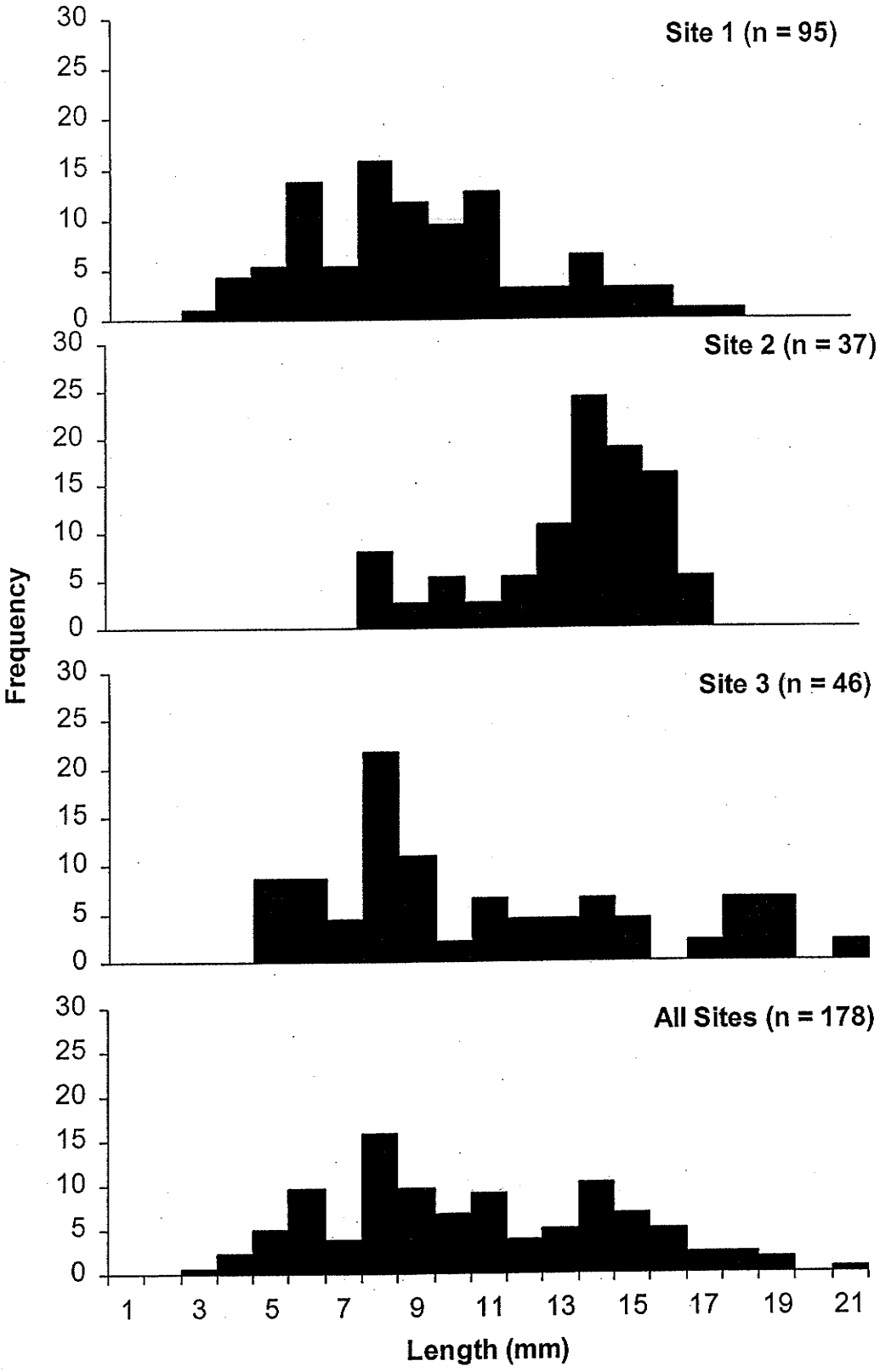


Figure 13. Size-frequency distributions of *Montfortula rugosa* at 3 randomly-chosen locations at Brickyard Point (Hawkesbury Shelf bioregion).

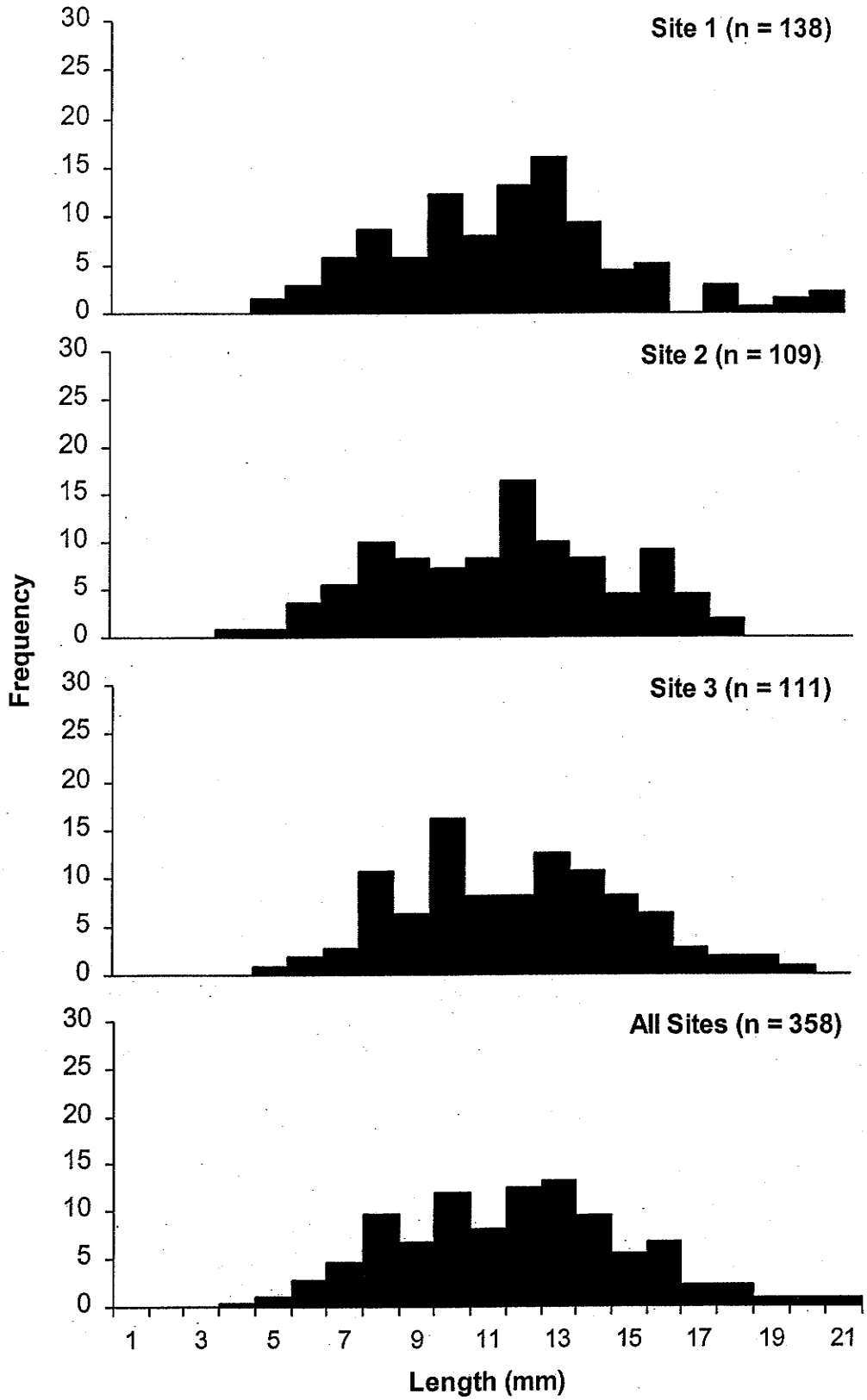


Figure 14. Size-frequency distributions of *Nerita atramentosa* at 3 randomly-chosen locations at Preservation Point (Batemans Shelf bioregion).

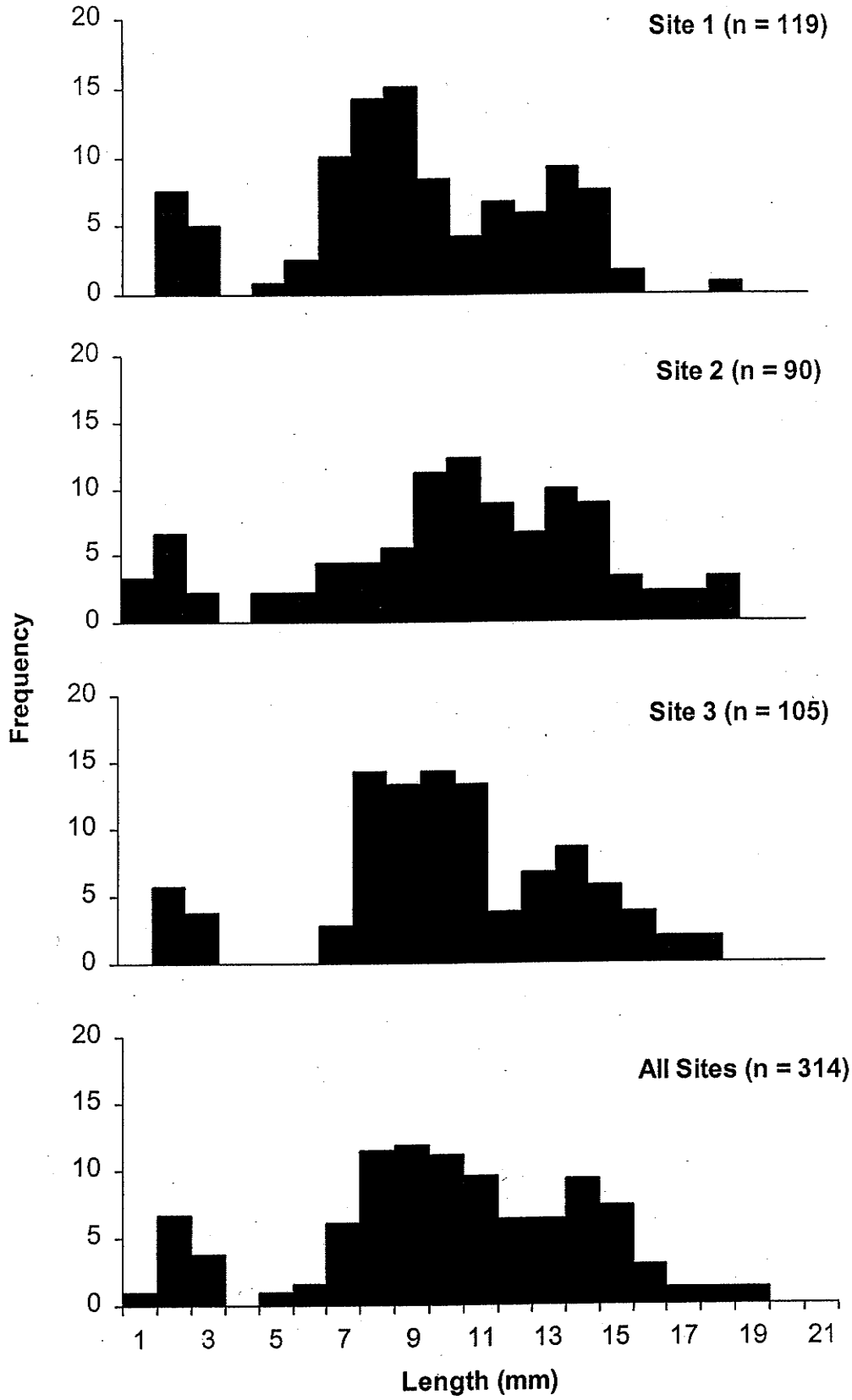


Figure 15. Size-frequency distributions of *Bembicium nanum* at 3 randomly-chosen locations at Preservation Point (Batemans Shelf bioregion).

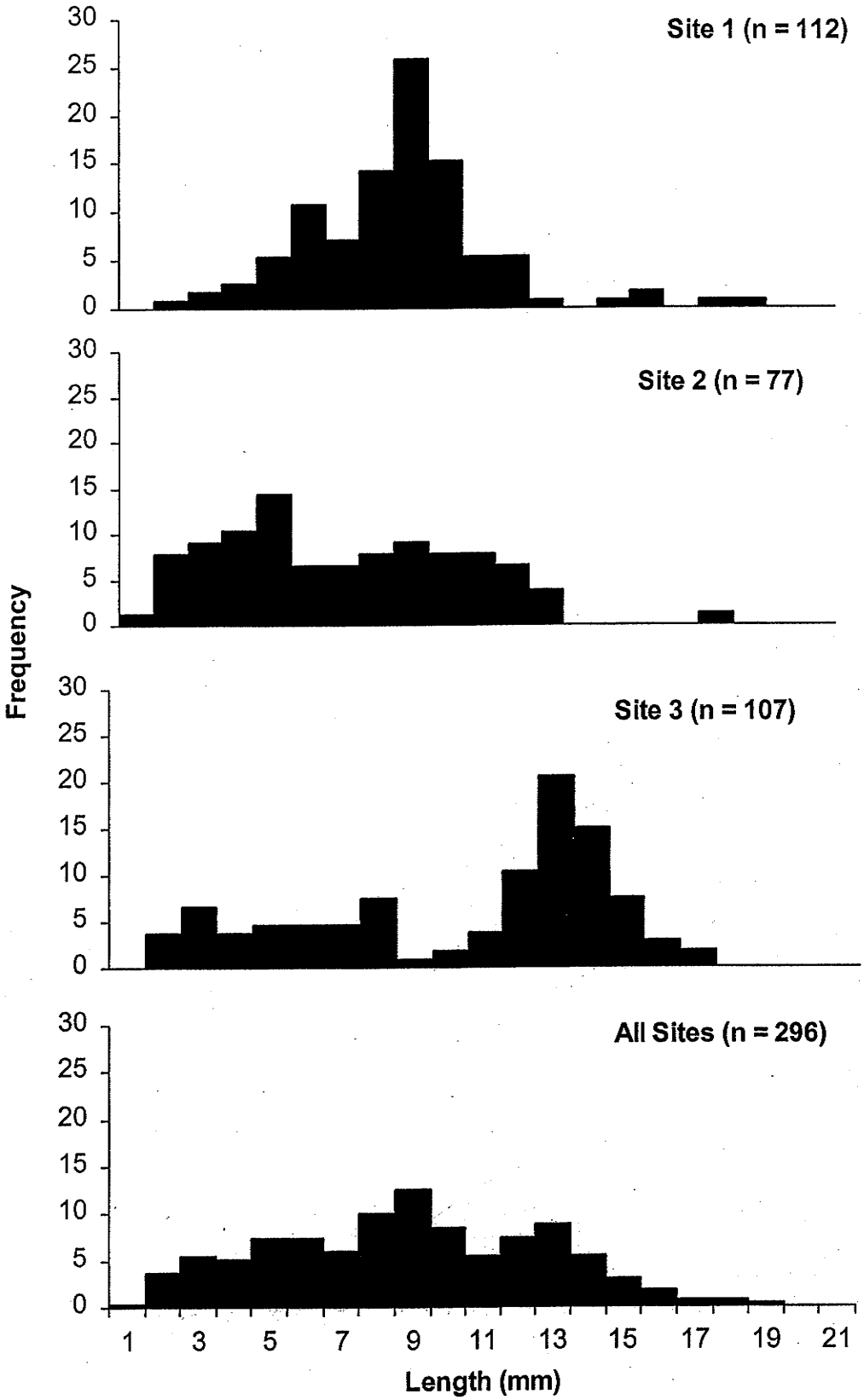


Figure 16. Size-frequency distributions of *Austrocochlea constricta* at 3 randomly-chosen locations Preservation Point (Batemans Shelf bioregion).

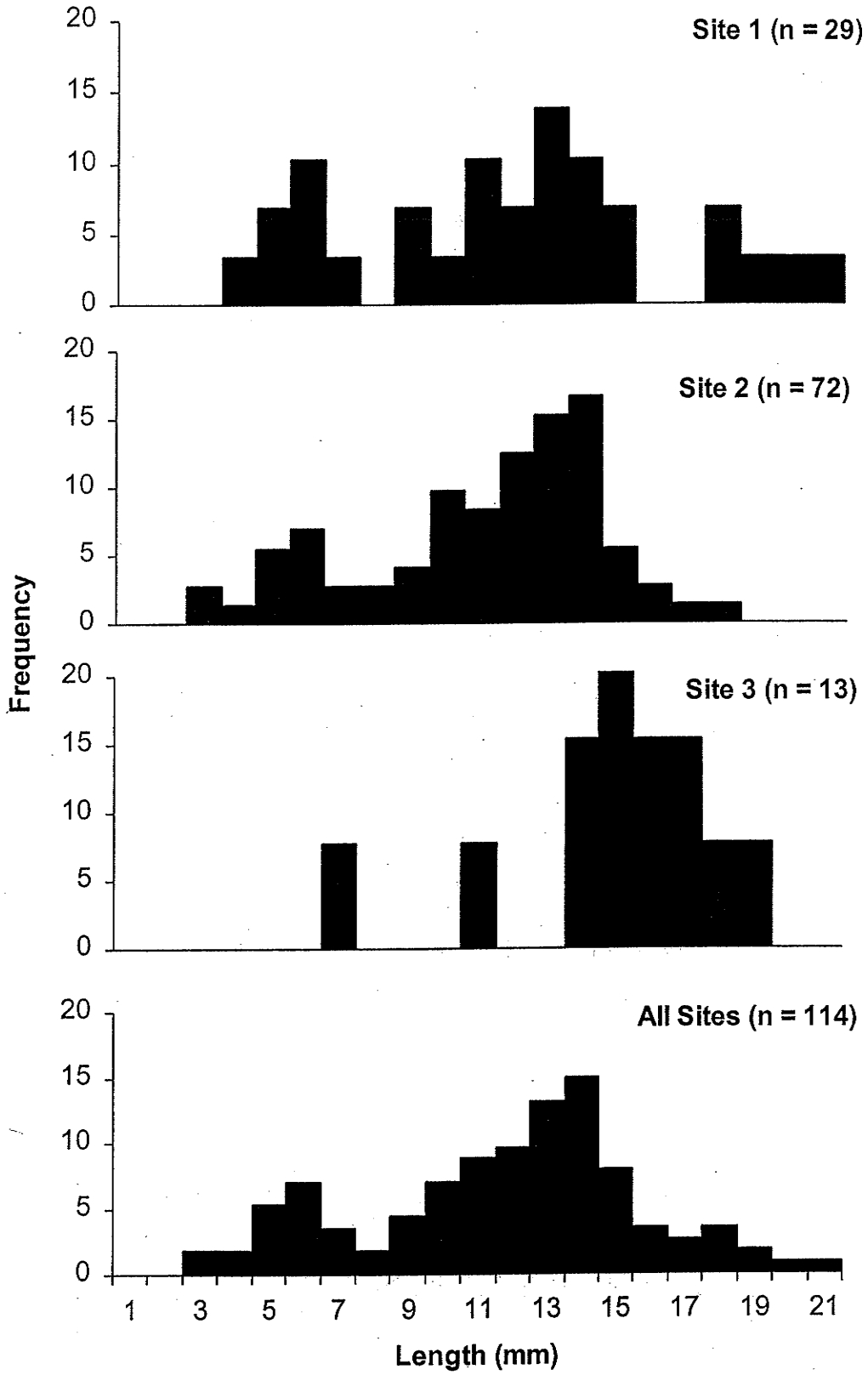


Figure 17. Size-frequency distributions of *Montfortula rugosa* at 3 randomly-chosen locations at Preservation Point (Batemans Shelf bioregion).

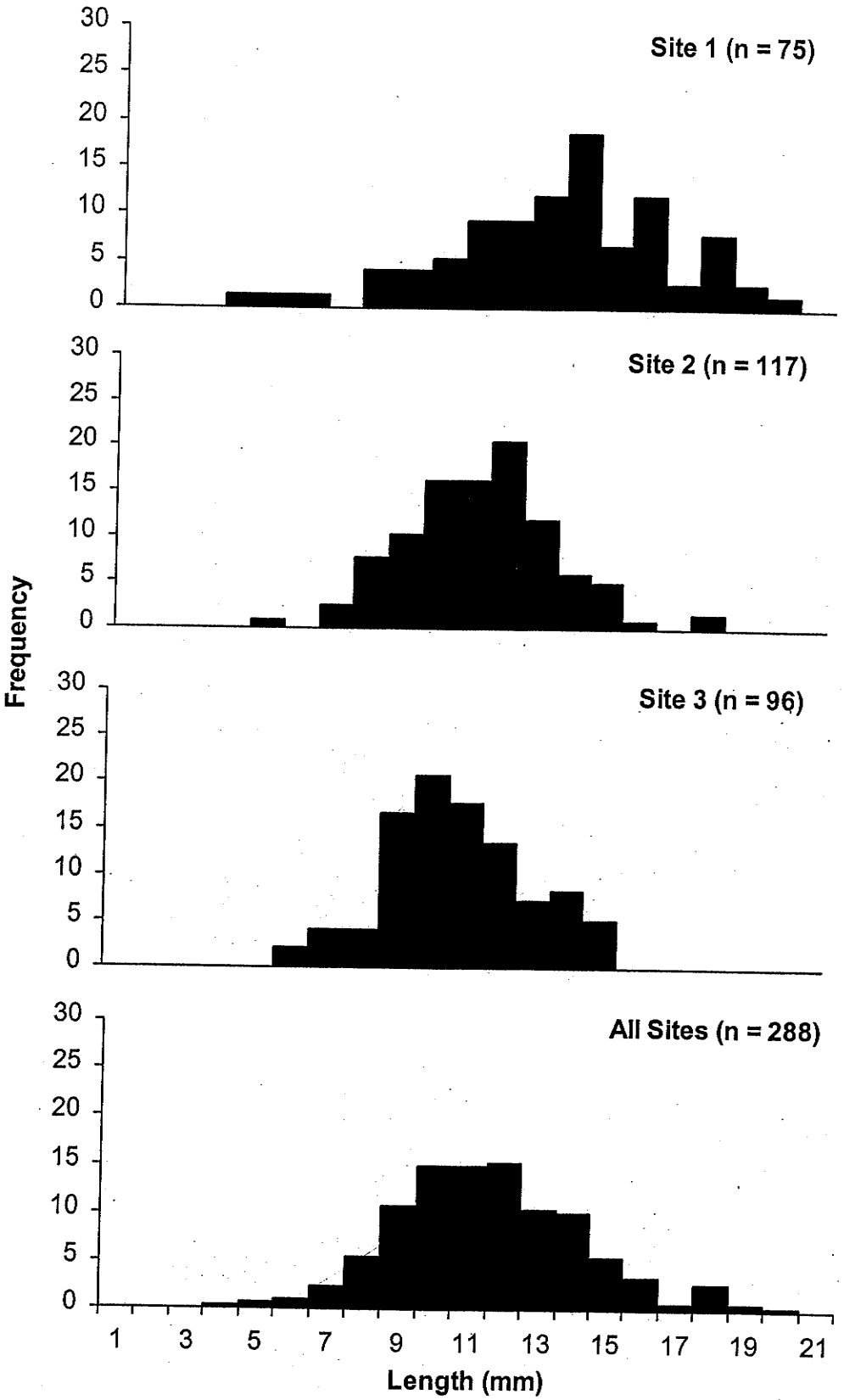


Figure 18. Size-frequency distributions of *Nerita atramentosa* at 3 randomly-chosen locations at Warden Head (Batemans Shelf bioregion).

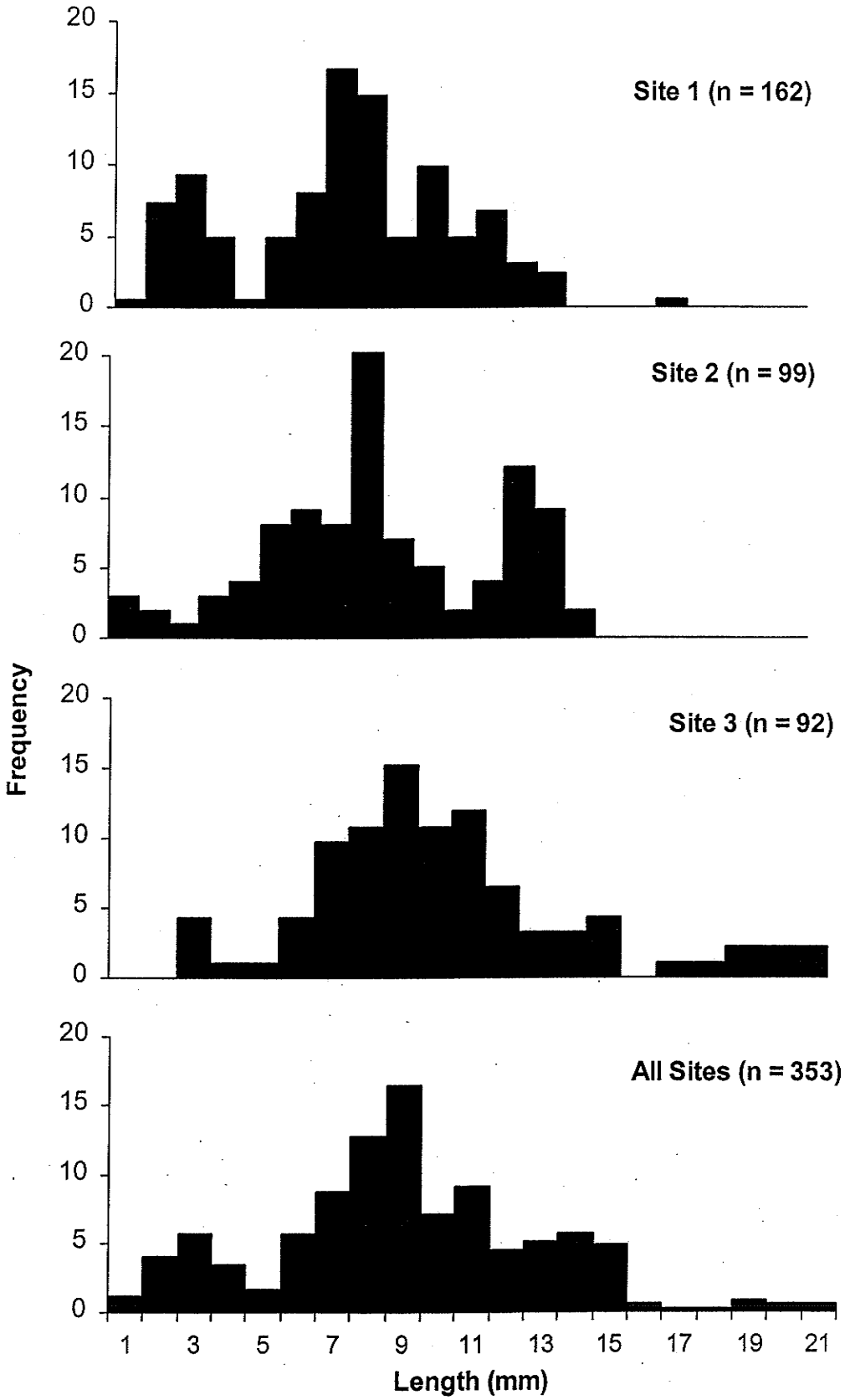


Figure 19. Size-frequency distributions of *Bembicium nanum* at 3 randomly-chosen locations at Warden Head (Batemans Shelf bioregion).

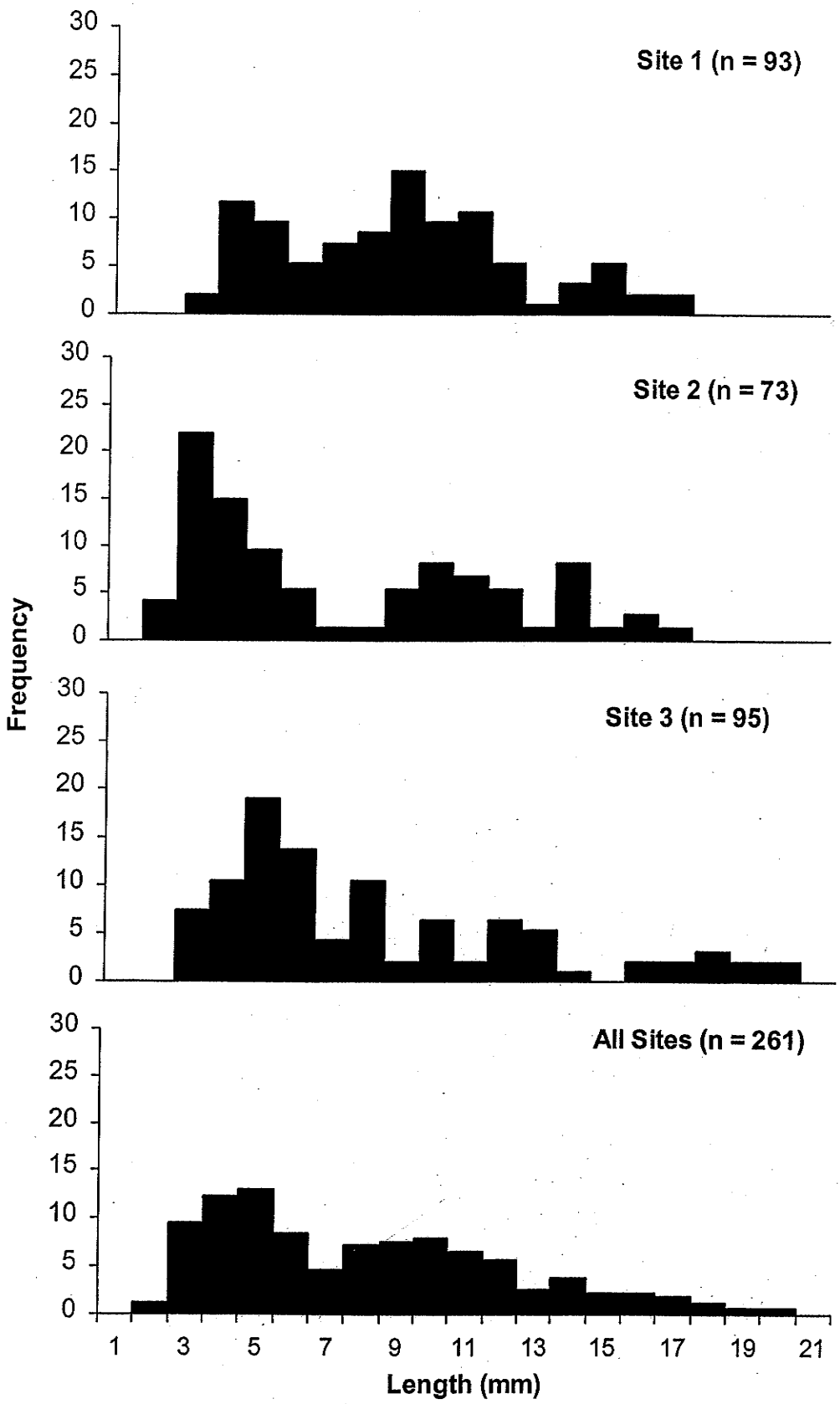


Figure 20. Size-frequency distributions of *Austrocochlea constricta* at 3 randomly-chosen locations at Warden Head (Batemans Shelf bioregion).

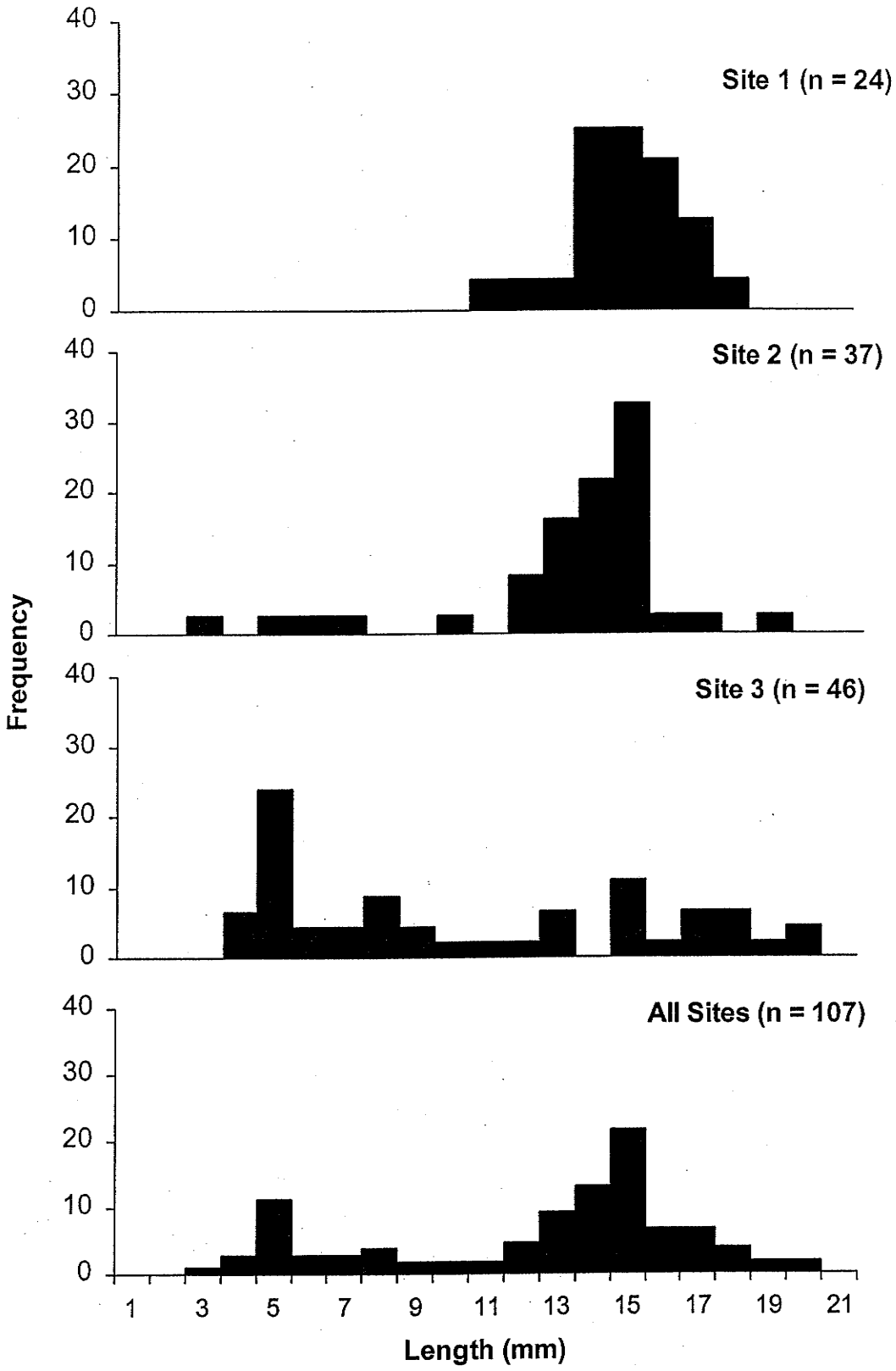


Figure 21. Size-frequency distributions of *Pyura stolonifera* at Toowoon Point,

Brickyard Point (Hawkesbury Shelf bioregion) and Preservation Point and Warden Head (Batemans Shelf bioregion).

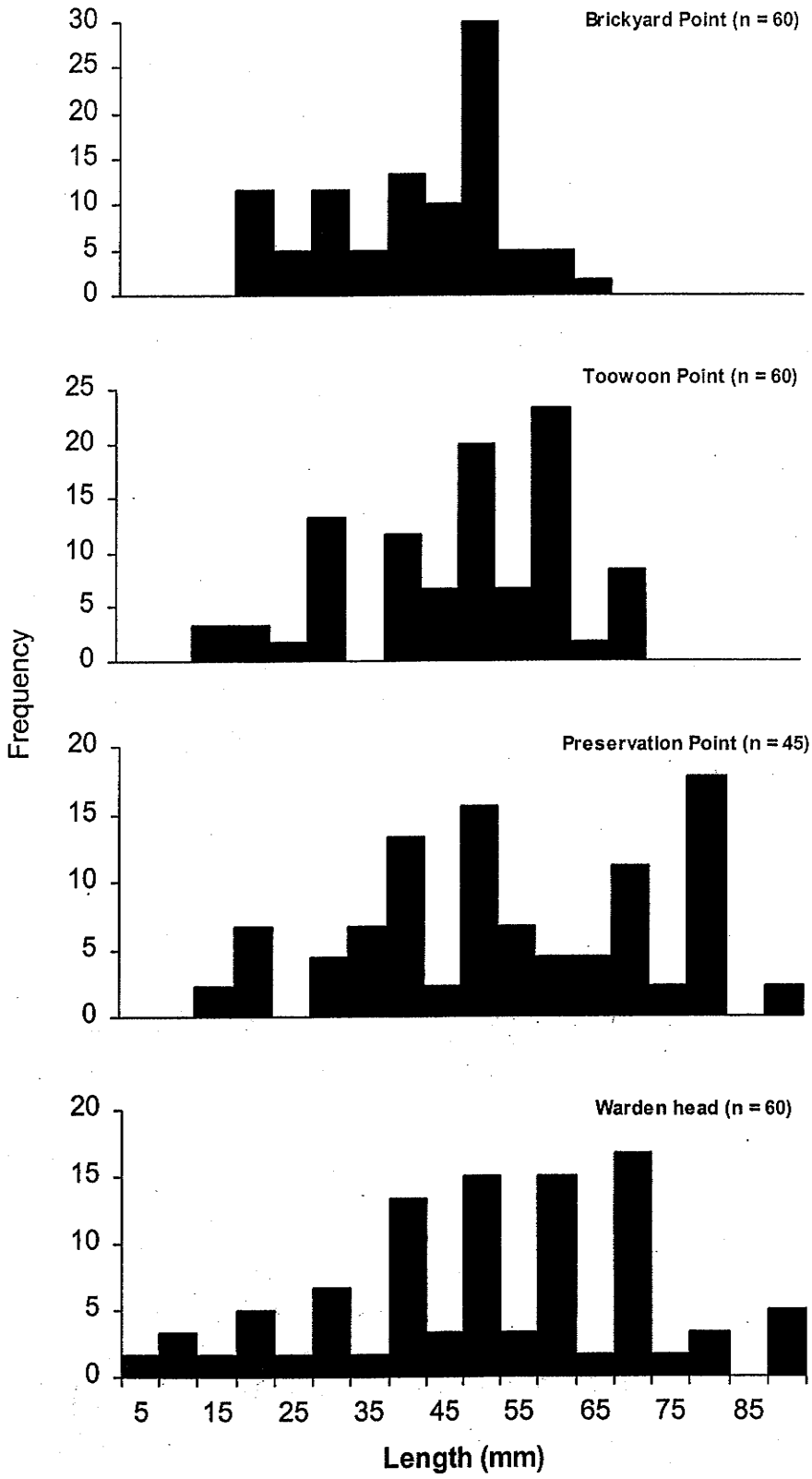


Figure 22. Size-frequency distributions of *Cellana tramoserica* at Tudibaring Head (Hawkesbury Shelf bioregion), Bass Point (Batemans Shelf bioregion) and Short Point (Twofold Shelf bioregion).

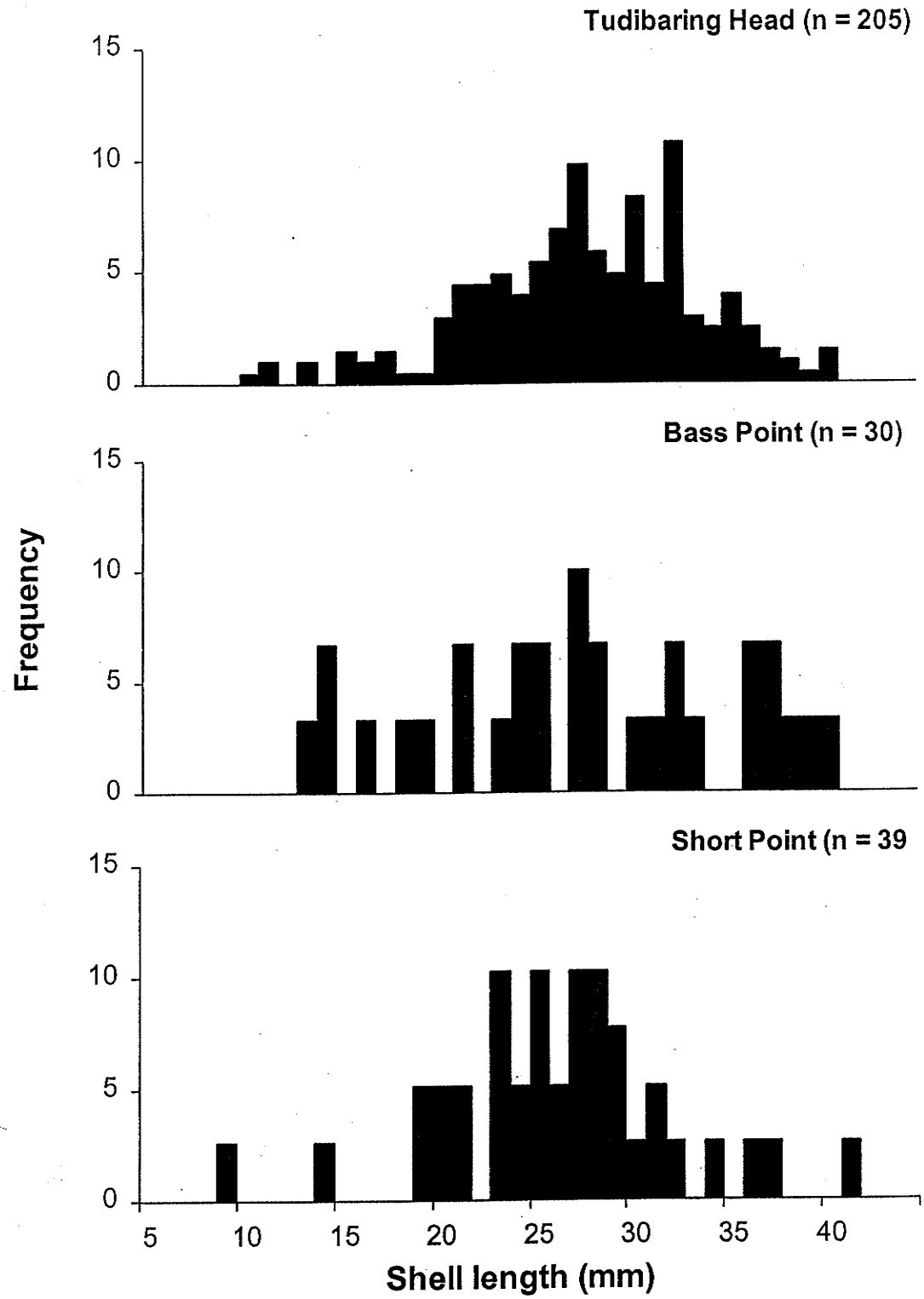


Table 11. Minimum and maximum sizes of various organisms at Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion).

SPECIES	VARIABLE USED TO ESTIMATE SIZE	TOOWOON POINT		BRICKYARD POINT	
		Min (mm)	Max (mm)	Min (mm)	Max (mm)
Chitons					
Chiton pelliserpentis	Width of shell IV	4	19	4	18
Onithochiton quercinus	"	3	20	3	20
Plaxiphora albida	"	4	23	3	25
Ischnochiton australis	"	3	29	4	27
Gastropods					
Cellana tramoserica	Length of shell	6	38	5	40
Nerita atramentosa	"	1	21	2	21
Bembicium nanum	"	4	18	2	19
Austrocochlea constricta	"	4	19	3	21
Montfortula rugosa	"	4	20	4	21
Scutus antipodes	"	5	67	6	60
Turbo undulatus	Shell breadth	7	40	5	37
Pulmonate limpets					
Siphonaria denticulata	Length of shell	5	23	6	25
Siphonaria virgulata	"	4	12	4	10
Solitary Ascidian					
Pyura stolonifera	Diameter of tunic	15	90	20	110

Table 12. Minimum and maximum sizes of various organisms at Preservation Point and Warden Head (Batemans Shelf bioregion).

SPECIES	VARIABLE USED TO ESTIMATE SIZE	PRESERVATION POINT		WARDEN HEAD	
		Min (mm)	Max (mm)	Min (mm)	Max (mm)
Chitons					
Chiton pelliserpentis	Width of shell IV	4	16	4	15
Onithochiton quercinus	"	4	19	3	21
Plaxiphora albida	"	3	24	4	26
Ischnochiton australis	"	4	25	4	26
Gastropods					
Cellana tramoserica	Length of shell	5	36	5	39
Nerita atramentosa	"	1	19	2	21
Bembicium nanum	"	1	19	2	19
Austrocochlea constricta	"	3	21	3	21
Montfortula rugosa	"	4	20	4	21
Scutus antipodes	"	6	65	7	58
Turbo undulatus	Shell Breadth	5	35	6	36
Pulmonate limpets					
Siphonaria denticulata	Length of shell	5	22	5	23
Siphonaria virgulata	"	4	10	4	11
Solitary Ascidian					
Pyura stolonifera	Diameter of tunic	20	80	20	100

Table 13. Size at sexual maturity of chitons, gastropods, pulmonate limpets and a solitary ascidian as documented in previous studies in the intertidal regions. SW, width of shell-plate IV; BL, body length; SL, shell length; SB, shell breadth; SD, siphonal distance.

SPECIES	SIZE AT SEXUAL MATURITY (mm)	REFERENCE
Chitons		
Chiton pelliserpentis	5 - 9 (SW)	Otway 1989
Onithochiton quercinus	6 - 9 (SW)	Otway 1989, 1994
Plaxiphora albida	7 - 10 (SW)	Otway 1989, 1994
Ischnochiton australis	34 (BL)	Currie 1994
Gastropods		
Cellana tramoserica	12 (SL)	Underwood, 1975
Nerita atramentosa	13 (SL)	Underwood 1974, 1975
Bembicium nanum	11 (SB)	Underwood 1974, 1975
Austrocochlea constricta	16 (SL)	Underwood 1974, 1975
Montfortula rugosa	12 (SL)	Creese 1980b
Turbo undulatus	24 - 32 (SB)	Underwood 1974
Pulmonate limpets		
Siphonaria denticulata	12 (SL)	Creese 1980a
Siphonaria virgulata	12 (SL)	Creese 1980a
Solitary Ascidian		
Pyura stolonifera	25 (SD)	Fairweather 1991

Table 14. Summary of studies documenting the size of 1 year-old individuals and longevity for several species found at sites in the Hawkesbury Shelf, Batemans Shelf and Twofold Shelf bioregions.

SPECIES	SIZE WHEN 1 YEAR OLD (mm)	LONGEVITY (years)	REFERENCE
Chitons			
Chiton pelliserpentis	5	4 +	Otway 1989
Onithochiton quercinus	6	4 +	Otway 1989 1994
Plaxiphora albida	6	5 +	Otway 1989 1994
Gastropods			
Cellana tramoserica	17	3 +	Underwood 1975
Nerita atramentosa	8	3 - 5.5	Underwood 1975
Bembicium nanum	6	4 - 8	Underwood 1975
Montfortula rugosa	9	12	Creese 1981
Pulmonate limpets			
Siphonaria denticulata	9	6 +	Creese 1981
Siphonaria virgulata	12	2 - 3	Creese 1981

4.3.3.3 TROPHIC LEVELS AND FEEDING-TYPES

The species found across the Hawkesbury Shelf, Batemans Shelf and Twofold Shelf bioregions were assigned to the 7 feeding-types (i.e. primary producers, grazers, predators, filter feeders, detrital feeders, omnivores and unknown). The numbers of species in each feeding-type were summed and these resulting data showed patterns that were consistent across the 2 bioregions (Table 15).

Approximately twice as many grazers, predators, filter feeders and omnivores (on average) were present at the sites with 4 or 5 habitats in the Hawkesbury Shelf bioregion (i.e. Toowoon Point, Tudibaring Head and Brickyard Point) and in the Batemans Shelf bioregion (i.e. Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head). Moreover, active detrital feeders were also only observed at the sites with 4 or 5 habitats.

Table 15. Total number of species in each of the feeding-types in the Hawkesbury Shelf and Batemans Shelf bioregions. Number of species: the total number of species (fauna and flora) across all main habitats. Feeding types: Al, Algae (primary producer); Gr, grazer; Pr, predator; FF, filter feeder; De, detrital feeder, Om, omnivore; Un; unknown. Asterisk denotes site originally eliminated, but then included for sampling by random selection.

BIOREGION	Number of Species in each Feeding Type						
Site	Al	Gr	Pr	FF	De	Om	Un
Hawkesbury Shelf							
Nobby's Head *	26	18	13	11	0	1	3
Toowoon Point	28	38	23	30	7	2	7
Yumbool Point *	20	21	11	11	0	1	8
Tudibaring Head	25	46	28	26	9	2	8
Brickyard Point	32	42	20	31	8	2	4
Batemans Shelf							
Bass Point *	23	23	10	12	0	1	11
Bombo Head	28	37	24	29	4	2	7
Inyadda Point	33	37	22	31	7	2	6
Preservation Point	28	34	20	29	6	2	6
Warden Head	31	43	29	37	8	2	4
Wasp Head *	18	21	13	13	0	1	1
Wagonga Head	27	46	30	24	8	2	11

4.3.4 DISCUSSION

4.3.4.1 SPECIES RICHNESS

Species diversity in the Hawkesbury Shelf and Batemans Shelf bioregions was positively correlated with the number of habitats present at a given site. These significant correlations support the initial assumptions and approach taken in the Site Identification Protocol. While the rock pool, crevice and boulder habitats were partly responsible for further increases in the numbers of species, proportionally greater increases in species richness occurred at sites where cobble habitats were present. In summary, it was apparent that between 78 - 90% (Hawkesbury Shelf) and 79 - 86% (Batemans Shelf) of the species present occurred in the platform and cobble habitats combined. This suggests that in identifying sites as IPAs, it will be important to identify sites that have platform and cobble habitats as a priority. If these same sites also have rock pool, crevice and boulder habitats present, then the potential to protect habitat and species diversity will be maximised.

Given that Wagonga Head (Batemans Shelf bioregion) and Short Point (Twofold Shelf bioregion) were separated by approximately 100 km, it was expected that the species occurring in comparable habitats (i.e. rock platform, crevices and rock pools) would be demonstrably different. While 93 and 64 species (fauna and flora combined) occurred respectively at Wagonga Head and Short Point, 59 species were common to both shores. It is not clear whether the observed differences are real. As stated previously, the survey was not replicated in time and thus any observed differences may be the result of short-term temporal changes between the different sampling dates.

4.3.4.2 SIZE OF ANIMALS

The length-frequency distributions of *Nerita atramentosa, Bembicium nanum, Austrocochlea constricta* and *Montfortula rugosa* from Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion), and Preservation Point and Warden Head (Batemans Shelf bioregion) together with the information on size at sexual maturity (Table 13) show that the populations on these shores have reproductively mature individuals present. However, the proportions of sexually mature individuals differed among species and shores (Table 16).

The length-frequency distributions of *Nerita atramentosa, Bembicium nanum, Austrocochlea constricta* and *Montfortula rugosa* also show that small individuals were also present on the shores sampled. Moreover, comparison of the size of the smallest individual present (Table 16) with the sizes of one year old individuals (Table 14) clearly shows that the smallest individuals present at Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion), and Preservation Point and Warden Head (Batemans Shelf bioregion) were all less than one year old. This provides irrefutable evidence that recruitment must have occurred within the past year at these shores. Similar results were also evident at the other sites sampled in the Hawkesbury Shelf and Batemans Shelf bioregions.

Similar patterns emerged when the maximum and minimum sizes of a range of other organisms (Tables 11 and 12) were compared with information on size at sexual maturity (Table 13) and size at one year of age (Table 14). These comparisons showed that newly recruited individuals and sexually mature individuals of a range of other species were present at the sites sampled. For example, the range of sizes of the chitons *Chiton pelliserpentis, Onithochiton quercinus* and *Plaxiphora albida* at Toowoon Point and Brickyard Point (Hawkesbury Shelf bioregion), and Preservation Point and Warden Head (Batemans Shelf bioregion) included individuals less one year old and individuals that would have been sexually mature (Tables 11 - 14). Similar results were also evident for the pulmonate limpets *Siphonaria denticulata and S. virgulata* (Tables 11 - 14), the true limpet *Cellana tramoserica* (Fig. 22 and Tables 11 - 14), and the solitary ascidian *Pyura stolonifera* (Fig. 21 and Tables 11 - 14).

Finally, the previously documented estimates of longevity of various species, together with the fact that recruitment of these species is occurring suggests that the intertidal populations present at sites in the Hawkesbury Shelf and Batemans Shelf bioregions should persist for some time into future.

4.3.4.3 TROPHIC LEVELS AND FEEDING-TYPES

The results of the feeding-types analysis suggested that the food webs at Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion), and at Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion) would be more complex than those at sites with fewer habitats and species.

Table 16. Size of smallest individuals in population and percentage of population that is of a sexually mature size as determined from previous studies (see Table 13).

BIOREGION SITE Species	SIZE OF SMALLEST INDIVIDUAL IN POPULATION (mm)	PERCENT OF POPULATION OF SEXUALLY MATURE SIZE
HAWKESBURY SHELF		
Toowoon Point		
Nerita atramentosa	1	42.1
Bembicium nanum	4	64.4
Austrocochlea constricta	4	10.4
Brickyard Point		
Nerita atramentosa	2	57.7
Bembicium nanum	2	23.0
Austrocochlea constricta	3	11.8
Montfortula rugosa	4	52.8
BATEMANS SHELF		
Preservation Point		
Nerita atramentosa	1	29.6
Bembicium nanum	1	33.4
Austrocochlea constricta	3	13.2
Montfortula rugosa	4	49.3
Warden Head		
Nerita atramentosa	1	20.4
Bembicium nanum	2	26.1
Austrocochlea constricta	3	20.6

5.0 OVERVIEW AND CONCLUSIONS

5.1 PRELUDE

The results of the habitat and biodiversity assessments are now summarised. In doing so, the indicators of Representativeness, Comprehensiveness, Naturalness and Ecological Importance are compared across all the sites within the Hawkesbury Shelf and Batemans Shelf bioregions with the aim of identifying those sites that would contribute most to a representative system of intertidal protected areas within each bioregion. It is important to note that these conclusions are based on limited data because only 5 sites in the Hawkesbury Shelf bioregion and 7 sites in the Batemans Shelf bioregion were sampled. In addition, it is likely that the overall number of species for a given bioregion would increase with a greater number of sites sampled.

5.2 REPRESENTATIVENESS

Recall that "representativeness" is defined as "the extent to which an area selected for inclusion in a reserve system is capable of reflecting the known biological diversity and ecological patterns and processes of the ecological community or ecosystem concerned" (Commonwealth of Australia, 1996). The three key indicators developed to quantify the "representativeness" of a site for the identification of a system of Intertidal Protected Areas were:

(1) the number of physical habitats present at a given site,

(2) the number of habitats present at a site relative to the number of habitats in the entire bioregion (expressed as a percentage), and

(3) the number of species present at a given site relative to the species present in the entire bioregion (expressed as a percentage).

These three indicators are documented (Table 17) for the sites subjected to a biodiversity assessment in Hawkesbury Shelf and Batemans Shelf bioregions. The habitat assessment showed that 5 different physical habitats (i.e. platforms, crevices, rock pools, boulder areas and cobble areas) were present across the 6 and 17 sites in Hawkesbury Shelf and Batemans Shelf, respectively. The biodiversity assessment showed that there were 190 and 194 species were observed across the sites sampled in the Hawkesbury Shelf and Batemans Shelf, respectively.

In the Hawkesbury Shelf bioregion, the indicators clearly show that if Toowoon Point, Tudibaring Head and Brickyard Point were protected areas, they would contribute to the diversity of physical habitats (i.e. 80 - 100%) and to the conservation of the biodiversity (i.e. 71.1 - 75.8%) of rocky intertidal organisms in the bioregion. Similarly, both indicators clearly show that if Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head were protected areas, they would contribute to the diversity of physical habitats (i.e. 80 - 100%) and to the conservation of the biodiversity (i.e. 63.4 - 79.4%) of rocky intertidal organisms in the Batemans Shelf bioregion.

Table 17. Estimation of the "representativeness" of the sites sampled (for Biodiversity Assessment) in the Hawkesbury Shelf and Batemans Shelf bioregions. The total number of species (fauna and flora combined) in each bioregion was estimated by combining the species lists from all sites within each bioregion. Asterisk denotes that the site was initially eliminated and then randomly chosen for sampling (see Section 3).

BIOREGION Site	NUMBER OF HABITATS PRESENT AT SITE AND THEIR PROPORTIONAL REPRESENTATION	PERCENT OF SPECIES AT SITE COMPARED TO SPECIES IN BIOREGION
Hawkesbury Shelf		
Nobby's Head *	3 (60%)	37.9
Toowoon Point	5 (100%)	71.1
Yumbool Point *	3 (60%)	37.9
Tudibaring Head	5 (100%)	75.8
Brickyard Point	4 (80%)	73.2
Batemans Shelf		
Bass Point *	3 (60%)	41.2
Bombo Head	4 (80%)	67.5
Inyadda Point	5 (100%)	71.1
Preservation Point	5 (100%)	63.4
Warden Head	5 (100%)	79.4
Wasp Head *	3 (60%)	34.0
Wagonga Head	4 (80%)	76.8

5.3 COMPREHENSIVENESS

Recall that "comprehensiveness" is defined as "the degree to which the full range of ecological communities and their biological diversity are incorporated within reserves" (Commonwealth of Australia, 1996). In the case of the rocky intertidal community, the two key indicators developed to quantify the "comprehensiveness " of a system of Intertidal Protected Areas in a given bioregion were:

(1) the number of habitats present in a system of IPAs compared to the total number in each bioregion (expressed as a percentage), and

(2) the number of species present in a system of IPAs compared to the total number in each bioregion (expressed as a percentage).

The respective null hypotheses would be that:

(1) the proportional representation of habitats in a system of IPAs in a bioregion is less than one, and

(2) the proportional representation of all species (fauna and flora) in a system of IPAs in the bioregion is less than one.

As both null hypotheses are 1-tailed there can only be one alternative hypothesis in each case, that is, that the proportional representation of habitats/species (respectively) in a system of IPAs in a bioregion is equal to one. The alternative hypotheses for habitat diversity in both bioregions will be based on a total of 5 habitats. The alternative hypotheses for species diversity in the Hawkesbury Shelf and Batemans Shelf bioregions will be based on 190 and 194 species, respectively.

The second indicator was calculated by compiling a pooled species list from the sites selected to form a system of IPAs. This species list was then calculated as the proportion (percentage) of the total number of species present in the bioregion. The greater the percentage the more comprehensive the system of protected areas will be. Theoretically, pooled species lists could be compiled for all combinations of sites and numbers of sites (i.e from 2 sites to all sites). However, this was not done because the indicators of "representativeness" (Table 17) had already identified sites with greater habitat and species diversity.

The two indicators of "comprehensiveness" are each documented (Table 18) for IPA systems in the Hawkesbury Shelf and Batemans Shelf bioregions. In the Hawkesbury Shelf bioregion, the indicators show that an IPA system based on Toowoon Point, Tudibaring Head and Brickyard Point would cover 100% of the diversity of physical habitats and 94.2% of the total diversity of rocky intertidal organisms in the bioregion. Similarly, both indicators show that an IPA system based on Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head would cover 100% of the physical habitat diversity and 95.9% of the total species diversity of rocky intertidal organisms in the Batemans Shelf bioregion.

Table 18. Estimation of the "comprehensiveness" of the system of IPAs sampled in the Hawkesbury Shelf and Batemans Shelf bioregions using the sites identified using the "representativeness" criteria (see Table 17).

BIOREGION	PERCENT OF HABITATS PRESENT IN IPA SYSTEM COMPARED TO IN BIOREGION	PERCENT OF SPECIES PRESENT IN IPA SYSTEM COMPARED TO IN BIOREGION
Hawkesbury Shelf	100.0	94.2
Batemans Shelf	100.0	95.9

When assessing the habitats present across all sites within a bioregion, it is possible that the types of habitats present will differ among sites, but the number of habitats will not. In the unlikely event that this occurs, differentiation among sites will clearly need to rely on the estimates of species diversity from all the sites sampled within the bioregion.

5.4 NATURALNESS

Recall that the "naturalness" of any given site will depend on the nature and frequency of human usage of the adjacent land, and the intertidal region. Thus, the indicator quantified during site inspections and sampling trips was:

(1) the human usage of the adjacent land.

Only one site in the Hawkesbury Shelf bioregion was located directly adjacent to a national park (Table 16). The remaining four sites were adjacent to land for commercial or residential use. It is important to note that all of the latter sites had some vacant land (i.e. crown or local government land) between the intertidal regions and the land used for residential and commercial (i.e. a caravan park) purposes. These intervening strips of land (buffers) were usually covered by natural vegetation preventing excessive soil erosion and restricting access to the intertidal region to just a few places. In contrast, six of the seven sites in the Batemans Shelf bioregion were adjacent to a national park or public reserve with natural vegetation (Table 16). The only site with residential housing adjacent to the intertidal region was Inyadda Point. However, there was an intervening strip of vacant land covered by natural vegetation between the intertidal region and the housing.

It its important to note that the degree of "naturalness" of the rocky intertidal region may be independent of the use of the adjacent land. Finally, previous studies (e.g. have shown that the organisms at most, if not all, of the sites sampled are harvested to varying degrees throughout the year.

Table 19. Estimation of the "naturalness" of the sites sampled in the Hawkesbury Shelf and Batemans Shelf bioregions. Note "naturalness" indicated by the human usage of the adjacent land.

BIOREGION Site	USE OF ADJACENT LAND
Hawkesbury Shelf	
Nobby's Head *	Residential Housing
Toowoon Point	Commercial
Yumbool Point *	National Park
Tudibaring Head	Residential Housing
Brickyard Point	Commercial/Residential Housing
Batemans Shelf	
Bass Point *	Public reserve with natural vegetation
Bombo Head	Public reserve with natural vegetation
Inyadda Point	Residential Housing
Preservation Point	Public reserve with natural vegetation
Warden Head	Public reserve with natural vegetation
Wasp Head *	National Park
Wagonga Head	Public reserve with natural vegetation

5.5 ECOLOGICAL IMPORTANCE

Recall that a biologically functional, self-sustaining rocky intertidal community would be expected to exhibit a diversity of species with various life-history stages, a range of species in various trophic levels, and the presence of a diversity of feeding-types. With this in mind the four indicators quantified were:

(1) the number of species present at a given site,

(2) the presence of a range of organisms in various trophic levels,

(3) the presence of various life-history stages (e.g. recruits, juveniles and reproductively mature individuals, of the organisms at the site, and

(4) the presence of a diversity of feeding types the number of species present at a given site.

The results of all four indicators for the sites in the Hawkesbury Shelf and Batemans Shelf bioregions are summarised in Table 20. Species richness was clearly greatest at Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion) and Bombo Head, Inyadda Head, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion). The sites with only 3 habitats present (i.e. Nobby's Head and Yumbool Point - Hawkesbury Shelf bioregion, Bass Point and Wasp Head - Batemans Shelf bioregion) had almost 50% fewer species on average.

Adults and juveniles were present at all shores sampled indicating that all the shores were acting as "sources" of larvae and "sinks" of recruits.

While at least three trophic levels were present on all shores sampled, the percentages of grazers, predators, filter feeders and omnivores were approximately 50% greater, on average, at Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion) and at Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion) compared to the remaining sites. Moreover, active detrital feeders were only observed at the former 8 sites.

An IPA system that included Toowoon Point, Tudibaring Head and Brickyard Point in the Hawkesbury Shelf bioregion, and on Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head in the Batemans Shelf bioregion would enable the protection of biologically functional, self-sustaining ecological sites. Each of the aforementioned sites is: (1) a "source" of larvae and a "sink" for recruits, (2) has a diversity of species with various life-history stages, (3) has a range of species in various trophic levels, and (4) has a diversity of species with a range of feeding-types.

Table 20. Estimation of the "ecological importance" for all the sites subjected to a biodiversity assessment in the Hawkesbury Shelf and Batemans Shelf bioregions. Number of species: the total number of species (fauna and flora) across all main habitats. Trophic levels present on the shore: 1°, primary producer; 2°, primary consumer; 3°, secondary consumer. Source and/or sink: whether recruits (R) and/or adults (A) are present on the shore. Percentage of species in each feeding types: Al, Algae (primary producer); Gr, grazer; Pr, predator; FF, filter feeder; De, detrital feeder, Om, omnivore; Un; unkown. Asterisk denotes site originally eliminated, but then included for sampling by random selection.

BIOREGION Site	Number of Species	Trophic Levels	Source and/or Sink	Percentage of Species in each Feeding Type						
				Al	Gr	Pr	FF	De	Om	Un
Hawkesbury Shelf										
Nobby's Head *	72	1°, 2°,3°	A, J	81	39	46	35	0	50	38
Toowoon Point	135	1°, 2°,3°	A, J	88	83	82	98	78	100	88
Yumbool Point *	72	1°, 2°,3°	A, J	63	46	39	35	0	50	100
Tudibaring Head	144	1°, 2°,3°	A, J	78	100	100	84	100	100	100
Brickyard Point	139	1°, 2°,3°	A, J	100	91	71	100	89	100	50
Batemans Shelf										
Bass Point *	80	1°, 2°,3°	A, J	70	50	33	12	0	50	100
Bombo Head	131	1°, 2°,3°	A, J	85	80	80	29	50	100	64
Inyadda Point	138	1°, 2°,3°	A, J	100	80	73	31	88	100	55
Preservation Point	123	1°, 2°,3°	A, J	85	74	67	29	75	100	55
Warden Head	154	1°, 2°,3°	A, J	94	93	97	37	100	100	36
Wasp Head *	66	1°, 2°,3°	A, J	55	46	43	13	0	50	82
Wagonga Head	149	1°, 2°,3°	A, J	82	100	100	24	100	100	100

6.0 RECOMMENDATIONS

It is recommended that:

1. Toowoon Point, Tudibaring Head and Brickyard Point (Hawkesbury Shelf bioregion), and Bombo Head, Inyadda Point, Preservation Point, Warden Head and Wagonga Head (Batemans Shelf bioregion) be nominated as candidates for selection as Intertidal Protected Areas and declared as Aquatic Reserves,

2. these sites be evaluated using relevant selection criteria prior to a period of community consultation and subsequent declaration,

3. Gap Analyses are undertaken in the Hawkesbury Shelf and Batemans Shelf bioregions to identify any shortfalls in the system of IPAs, and in doing so, attention must be given to rocky shores in wave-protected (estuarine) areas,

4. the Site Identification Protocol be re-examined after the gap analyses are completed in the Hawkesbury Shelf and Batemans Shelf bioregions,

5. further studies examining the effectiveness of the IPAs be undertaken, and these should include the documentation of the spatial and temporal variability of the biota.

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APPENDIX 1 - List of species recorded across all sites.

CHLOROPHYTA (Green algae)
Bryopsis sp.
Caulerpa filiformis
Chaetomorpha darwinii
Cladophora sp.
Codium fragile
Codium lucasii
Enteromorpha intestinalis
Ulva lactuca

PHAEOPHYTA (Brown algae)
Colpomenia sinuosa
Cystophora sp.
Dictyota dichotoma
Dilophus marginatus
Ecklonia radiata
Ectocarpus sp
Hildenbrandia prototypus
Hormosira banksii
Leathesia difformis
Lobophora variegata
Padina fraseri
Petalonia fascia
Phyllospora comosa
Ralfsia sp.
Sargassum verruculosum
Sargassum vestitum
Sargassum fallax
Splanchnidium rugosum
Zonaria sp

RHODOPHYTA (Red algae)
Amphiroa anceps
Champia compressa
Corallina officinalis
Gelidium pusillum
Gigartina sp
Gracilaria sp
Laurencia sp
Martensia
Melobesia
Neogoniolithon sp
Peyssonnelia
Polysiphonia sp.
Porolithon
Porphyra sp
Pterocladia capillacea
Rhodymenia australis

PORIFERA (Sponges)
Corynactis australis
Haliclona sp.
Tethya corticata

CNIDARIA
Anemones
Actinia tenebrosa
Actinia australis
Anthothoe albocincta
Cnidopus verater
Oulactis muscosa
Phlyctenanthus australis
Corals
Culicia quinaria

PLATYHELMINTHES (Flat worms)
Callioplana marginata
Notoplana australis
Thysanozoon sp.

NEMERTA (Nemerteans)
Baseodiscus hemprichii

ANNELIDA (Segmented Worms)
Australonereis ehlersi
Diopatra dentata
Eulaeospira convexis
Eurythoe complanata
Filograna implexa
Galeolaria caespitosa
Galeolaria hystrix
Hydroides elegans
Idanthyrsus pennatus
Janua pseudocorrugata
Lepidonotus bowerbankii
Lepidonotus melanogrammus
Nereid sp.
Sabellastarte indica
Sabellidae
Serpula vermicularis
Terebella sp.

SIPUNCULA (Sipunculids)
Phascolosoma noduliferum

ARTHROPODA
Crabs
Cyclograpsus audouinii
Leptograpsus variegatus
Naxia tumida
Ozius truncatus
Palaemon serenus
Plagusia chabrus
Hermit Crabs
Dardanus setifer
Paguristes squasmosus
Pagurus lacertosus
Pagurus sinuatus
Shrimps
Alope australis
Alpheus euphrosyne
Alpheus stenuus
Rhynchocinetes rugulosus
Barnacles
Austrobalanus imperator
Austromegabalanus nigrescens
Balanus variegatus
Catomerus polymerus
Chamaesipho tasmanica
Chthamalus antennatus
Epopella simplex
Ibla quadrivalvis
Tesseropora rosea
Tetraclitella purpurascens

MOLLUSCA
Chitons
Acanthochiton granostriatus
Callistochiton antiquus
Chiton jugosus
Chiton pelliserpentis
Cryptoplax mystica
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton variegatus
Ischnochiton versicolor
Onithochiton quercinus
Plaxiphora albida

MOLLUSCA Continued
Gastropods
Agnewia tritoniformis
Amblychilepas nigrita
Australium tentoriforme
Austrocochlea concamerata
Austrocochlea constricta
Bembicium nanum
Cabestana spengleri
Canthradella picturata
Cellana tramoserica
Charonia rubicunda
Cominella lineolata
Conus anemone
Conus papilliferus
Cypraea caputserpentis
Dentimitrella
Diodora lineata
Gena impertusa
Granata imbricata
Haliotis ruber
Hinea brasiliana
Mitra carbonaria
Moneta annulus
Montfortula rugosa
Morula marginalba
Nassarius particeps
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoacmaea petterdi
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Phaisantrochus eximius
Pyrazus sp.
Scutus antipodes
Septa parthenopea
Thias orbita
Tugali parmaphoidea
Turbo militaris
Turbo torquatus
Turbo undulatus
Pulmonates
Kerguelenella sp
Siphonaria denticulata
Siphonaria virgulata

MOLLUSCA Continued
Sea hares
Aplysia dactylomela
Dolabella
Dolabrifera dolabrifera
Sea slugs
Austraeolis ornata
Berthellina citrina
Glossodoris atromarginata
Nudibranch 1
Onchidella patelloides
Pleurobranchus hilli
Umbraculum sinicum
Bi-valves
Chlamys lividus
Lima nimbifer
Limatula strangei
Saccostrea cucullata
Saccostrea glomerata
Trichomya hirsuta
Ostrea angasi
Pinctada
Cephalopods
Hapalochlena maculosa
Octopus cyaneus
Bubble-shells
Bullina lineata
Hydatina physis

BRYZOA (Bryzoans)
Bugula avicularia
Bugula neritina
Membranipora membranacea
Phidolopora avicularia
Schizoporella errata
Tricellaria porteri
Watersipora arcuata

ECHINODERMATA
Starfish
Allostichaster polyplax
Astrostole insularis
Coscinasterias calamaria
Coscinasterias muricata
Patiriella gunnii
Patiriella calcar
Patiriella exigua

ECHINODERMATA Continued
Brittle stars
Clarkcoma pulchra
Ophiocoma dentata
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Urchins
Centrostephanus rodgersii
Heliocidaris erythrogramma
Holopneustes
Phyllacanthus parvispinus
Holothurians
Chiridota gigas
Leptosynapta dolabrifera
Stichopus mollis

HEMICHORDATA
Balanoglossus australiensis

CHORDATA
Ascidians
Herdmania momus
Pyura gibbosa gibbosa
Pyura stolonifera
Compound Ascidians
Botrylloides leachi
Eudistoma prolifera
Sidneoides tamaramae
Symplegma oceania

APPENDIX 2 - List of species recorded at individual sites.

Nobbys Head

Actinia tenebrosa
Agnewia tritoniformis
Amphiroa anceps
Anthothoe albocincta
Austrocochlea concamerata
Austromegabalanus nigrescens
Bembicium nanum
Cabestana spengleri
Canthradella picturata
Catomerus polymerus
Caulerpa filiformis
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Colpomenia sinuosa
Corallina officinalis
Dentimitrella
Dictyota dichotoma
Diopatra dentata
Ectocarpus sp
Enteromorpha intestinalis
Galeolaria caespitosa
Gelidium pusillum
Haliclona sp.
Hapalochlena maculosa
Holopneustes pycnotilus
Hormosira banksii
Idanthyrsus pennatus
Laurencia sp
Leathesia difformis
Martensia
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nerita atramentosa
Nodilittorina unifaciata
Nodilittorina acutispira
Onithochiton quercinus
Oulactis muscosa
Padina fraseri
Patella peroni
Patelloida latistrigata
Patelloida mufria
Patiriella calcar
Patiriella exigua
Petalonia fascia
Pinctada
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Porphyra sp
Pyura stolonifera
Ralfsia sp.
Sargassum verruculosum
Scutus antipodes
Septa parthenopea
Siphonaria denticulata
Siphonaria virgulata
Tesseropora rosea
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Turbo undulatus
Ulva lactuca
Zonaria sp

Yumbool Point

Actinia tenebrosa
Agnewia tritoniformis
Alope australis
Amphiroa anceps
Anthothoe albocincta
Aplysia dactylomela
Australium tentoriforme
Austrocochlea concamerata
Austromegabalanus nigrescens
Bembicium nanum
Catomerus polymerus
Cellana tramoserica
Chaetomorpha darwinii
Chamaesipho tasmanica
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Dardanus setifer
Dentimitrella
Dictyota dichotoma
Diopatra dentata
Ecklonia radiata
Ectocarpus sp
Enteromorpha intestinalis
Galeolaria caespitosa
Granata imbricata
Haliclona sp.
Heliocidaris erythrogramma
Hormosira banksii
Idanthyrsus pennatus
Laurencia sp
Montfortula rugosa
Morula marginalba
Naxia tumida
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Onithochiton quercinus
Oulactis muscosa
Patelloida latistrigata
Patelloida mufria
Patiriella calcar
Petalonia fascia
Phlyctenanthus australis
Plagusia chabrus
Polysiphonia sp.
Pterocladia capillacea
Ralfsia sp.
Sargassum Verruculosum
Scutus antipodes
Sidneoides tamaramae
Siphonaria denticulata
Siphonaria virgulata
Tesseropora rosea
Tethya corticata
Thias orbita
Trichomya hirsuta
Turbo undulatus
Ulva lactuca
Zonaria sp

Toowoon Point

Acanthochiton granostriatus
Actinia tenebrosa
Allostichaster polyplax
Alope australis
Alpheus euphrosyne
Alpheus stenuus
Amphiroa anceps
Amphiroa anceps
Anthothoe albocincta
Astrostole insularis
Austrobalanus imperator
Austrocochlea constricta
Balanus variegatus
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Callioplana marginata
Catomerus polymerus
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton jugosus
Chiton pelliserpentis
Chlamys lividus
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Cryptoplax mystica
Cypraea caputserpentis
Dardanus setifer
Dilophus marginatus
Diodora lineata
Diopatra dentata
Ectocarpus sp
Enteromorpha intestinalis
Eulaeospira convexis
Eulaeospira convexis
Galeolaria caespitosa
Gelidium pusillum
Gena impertusa
Gigartina sp
Gracilaria sp
Granata lmbricata
Haliclona sp.
Haliotis ruber
Heliocidaris erythrogramma
Herdmania momus
Hildenbrandia prototypus
Hinea brasiliana
Hormosira banksii
Hydroides elegans
Ibla quadrivalvis
Idanthyrsus pennatus
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton versicolor
Janua pseudocorrugata
Kerguelenella sp
Laurencia sp
Lepidonotus melanogrammus
Leptograpsus variegatus
Membranipora membranacea
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Nassarius particeps
Neogoniolithon sp
Nereid sp.
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoplana australis
Octopus cyaneus
Onchidella patelloides
Onithochiton quercinus
Ophiomyxa australis
Ophionereis schayeri
Oulactis muscosa
Ozius truncatus
Padina fraseri
Paguristes squasmosus
Patella peroni
Patelloida latistrigata
Patiriella gunnii
Patiriella calcar
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phascolosoma noduliferum
Phidolopora avicularia
Phlyctenanthus australis
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pterocladia capillacea
Pyura gibbosa gibbosa
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Rhynchocinetes rugulosus
Sabellastarte indica
Saccostrea cucullata
Sargassum verruculosum
Sargassum vestitum
Schizoporella errata
Scutus antipodes
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Splanchnidium rugosum
Stichopus mollis
Symplegma oceania
Terebella sp.
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Tricellaria porteri
Trichomya hirsuta
Tugali parmaphoidea
Turbo torquatus
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Tudibaring Head

Actinia tenebrosa
Actinia australis
Agnewia tritoniformis
Allostichaster polyplax
Alope australis
Alpheus euphrosyne
Amblychilepas nigrita
Amphiroa anceps
Anthothoe albocincta
Astrostole insularis
Australium tentoriforme
Australonereis ehlersi
Austrocochlea concamerata
Austrocochlea constricta
Baseodiscus hemprichii
Bembicium nanum
Berthellina citrina
Botrylloides leachi
Bryopsis sp.
Bugula neritina
Cabestana spengleri
Callioplana marginata
Canthradella picturata
Catomerus polymerus
Caulerpa filiformis
Cellana tramoserica
Centrostephanus rodgersii
Chamaesipho tasmanica
Champia compressa
Charonia rubicunda
Chiton jugosus
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Clarkcoma pulchra
Cnidopus verater
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Coscinasterias calamaria
Coscinasterias muricata
Cryptoplax mystica
Cyclograpsus audouinii
Cypraea caputserpentis
Dardanus setifer
Diodora lineata
Dolabella
Dolabrifera dolabrifera
Ectocarpus sp
Enteromorpha intestinalis
Eulaeospira convexis
Eurythoe complanata
Filograna implexa
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena impertusa
Granata imbricata
Haliclona sp.
Haliotis ruber
Hapalochlena maculosa
Heliocidaris erythrogramma
Herdmania momus
Hinea brasiliana
Hormosira banksii
Hydatina physis
Hydroides elegans
Idanthyrsus pennatus
Idanthyrsus pennatus
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton variegatus
Janua pseudocorrugata
Laurencia sp
Leathesia difformis
Leptograpsus variegatus
Limatula strangei
Martensia
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Nassarius particeps
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoacmaea petterdi
Onithochiton quercinus
Ophiocoma dentata
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Ostrea angasi
Oulactis muscosa
Padina fraseri
Paguristes squasmosus
Pagurus lacertosus
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia
Peyssonnelia
Phascolosoma noduliferum
Plagusia chabrus
Plaxiphora albida
Pyura stolonifera
Ralfsia sp.
Rhynchocinetes rugulosus
Sabellastarte indica
Sargassum verruculosum
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Symplegma oceania
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Turbo militaris
Turbo torquatus
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Brickyard Point

Acanthochiton granostriatus
Actinia tenebrosa
Actinia australis
Agnewia tritoniformis
Allostichaster polyplax
Alope australis
Anthothoe albocincta
Astrostole insularis
Austraeolis ornata
Austrobalanus imperator
Austromegabalanus nigrescens
Balanus variegatus
Baseodiscus hemprichii
Bembicium nanum
Botrylloides leachi
Bugula avicularia
Bullina lineata
Cabestana spengleri
Callistochiton antiquus
Catomerus polymerus
Caulerpa filiformis
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton jugosus
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Codium lucasii
Colpomenia sinuosa
Conus papilliferus
Corallina officinalis
Coscinasterias calamaria
Cryptoplax mystica
Dardanus setifer
Dictyota dichotoma
Dilophus marginatus
Diodora lineata
Diopatra dentata
Ectocarpus sp
Enteromorpha intestinalis
Eudistoma prolifera
Eulaeospira convexis
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena Impertusa
Gigartina sp
Gracilaria sp
Granata imbricata
Haliclona sp.
Haliotis ruber
Hapalochlena maculosa
Heliocidaris erythrogramma
Herdmania momus
Hildenbrandia prototypus
Hormosira banksii
Hydroides elegans
Ibla quadrivalvis
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton variegatus
Ischnochiton versicolor
Janua pseudocorrugata
Kerguelenella sp
Laurencia sp
Lepidonotus bowerbankii
Lepidonotus melanogrammus
Leptograpsus variegatus
Leptosynapta dolabrifera
Lima nimbifer
Lobophora variegata
Melobesia
Membranipora membranacea
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nereid sp.
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoplana australis
Onithochiton quercinus
Ophionereis schayeri
Oulactis muscosa
Ozius truncatus
Padina fraseri
Paguristes squasmosus
Pagurus lacertosus
Pagurus sinuatus
Patella peroni
Patelloida latistrigata
Patelloida mufria
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia
Phascolosoma noduliferum
Phidolopora avicularia
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Porolithon
Pterocladia capillacea
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Rhynchocinetes rugulosus
Sabellastarte indica
Saccostrea cucullata
Sargassum verruculosum
Sargassum vestitum
Schizoporella errata
Scutus antipodes
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Splanchnidium rugosum
Symplegma oceania
Terebella sp.
Tesseropora rosea
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Tugali parmaphoidea
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Bass Point

Actinia tenebrosa
Amphiroa anceps
Anthothoe albocincta
Anthothoe albocincta
Australium tentoriforme
Austrococchlea concamerata
Austromegabalanus nigrescens
Bembicium nanum
Cabestana spengleri
Catomerus polymerus
Cellana tramoserica
Chaetomorpha darwinii
Chamaesipho tasmanica
Champia compressa
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Dardanus setifer
Dictyota dichotoma
Ecklonia radiata
Ectocarpus sp
Enteromorpha intestinalis
Galeolaria caespitosa
Haliclona sp.
Haliotis ruber
Heliocidaris erythrogramma
Holopneustes pycnotilus
Hormosira banksii
Laurencia sp
Leptograpsus variegatus
Montfortula rugosa
Morula marginalba
Nassarius particeps
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Onithochiton quercinus
Oulactis muscosa
Padina fraseri
Patella peroni
Patelloida latistrigata
Patelloida mufria
Patiriella calcar
Patiriella exigua
Petalonia fascia
Peyssonnelia
Phaisantrochus eximius
Phlyctenanthus australis
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pterocladia capillacea
Pyura stolonifera
Ralfsia sp.
Saccostrea glomerata
Sargassum verruculosum
Siphonaria denticulata
Siphonaria virgulata
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Turbo torquatus
Turbo undulatus
Ulva lactuca
Zonaria sp

Bombo Head

Acanthochiton granostriatus
Actinia tenebrosa
Actinia australis
Agnewia tritoniformis
Allostichaster polyplax
Alope australis
Alpheus euphrosyne
Amphiroa anceps
Anthothoe albocincta
Aplysia dactylomela
Astrostole insularis
Australium tentoriforme
Austrobalanus imperator
Austrocochlea concamerata
Austromegabalanus nigrescens
Balanus variegatus
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Canthradella picturata
Catomerus polymerus
Cellana tramoserica
Centrostephanus rodgersii
Chamaesipho tasmanica
Champia compressa
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Colpomenia sinuosa
Corallina officinalis
Coscinasterias calamaria
Coscinasterias muricata
Cryptoplax mystica
Culicia quinaria
Cyclograpsus audouinii
Dardanus setifer
Dentimitrella
Dictyota dichotoma
Diodora lineata
Diopatra dentata
Ecklonia radiata
Ectocarpus sp
Enteromorpha intestinalis
Eulaeospira convexis
Eurythoe complanata
Filograna implexa
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena impertusa
Granata imbricata
Haliclona sp.
Haliotis ruber
Hapalochlena maculosa
Heliocidaris erythrogramma
Herdmania momus
Hormosira banksii
Hydroides elegans
Idanthyrsus pennatus
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton variegatus
Janua pseudocorrugata
Laurencia sp
Lepidonotus melanogrammus
Leptograpsus variegatus
Martensia
Membranipora membranacea
Montfortula rugosa
Morula marginalba
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Nudibranch 2
Onithochiton quercinus
Ophionereis schayeri
Ophiothrix spongicola
Ostrea angasi
Oulactis muscosa
Ozius truncatus
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia fascia
Peyssonnelia
Phascolosoma noduliferum
Phlyctenanthus australis
Phyllacanthus parvispinus
Phyllospora comosa
Plagusia chabrus
Plaxiphora albida
Porphyra sp
Pterocladia capillacea
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Sargassum verruculosum
Schizoporella errata
Scutus antipodes
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Tricellaria porteri
Trichomya hirsuta
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Preservation Point

Acanthochiton granostriatus
Actinia tenebrosa
Allostichaster polyplax
Alope australis
Alpheus stenuus
Amphiroa anceps
Anthothoe albocincta
Astrostole insularis
Austrobalanus imperator
Austrocochlea concamerata
Austrocochlea constricta
Austromegabalanus nigrescens
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Callioplana marginata
Catomerus polymerus
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Charonia rubicunda
Chiton jugosus
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Coscinasterias calamaria
Cryptoplax mystica
Dardanus setifer
Dictyota dichotoma
Dilophus marginatus
Diodora lineata
Diopatra dentata
Ectocarpus sp
Eulaeospira convexis
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena Impertusa
Gigartina sp
Gracilaria sp
Granata imbricata
Haliclona sp.
Haliotis ruber
Heliocidaris erythrogramma
Herdmania momus
Hildenbrandia prototypus
Hinea brasiliana
Hormosira banksii
Hydroides elegans
Ibla quadrivalvis
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton variegatus
Janua pseudocorrugata
Kerguelenella sp
Laurencia sp
Lepidonotus melanogrammus
Leptograpsus variegatus
Lobophora variegata
Membranipora membranacea
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nereid sp.
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina Pyramidalis
Nodilittorina unifaciata
Onithochiton quercinus
Ophiomyxa australis
Ophionereis schayeri
Oulactis muscosa
Ozius truncatus
Padina fraseri
Paguristes squasmosus
Patella peroni
Patelloida latistrigata
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phascolosoma noduliferum
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pterocladia capillacea
Pyura gibbosa gibbosa
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Sabellastarte indica
Saccostrea cucullata
Sargassum verruculosum
Sargassum vestitum
Schizoporella errata
Scutus antipodes
Siphonaria denticulata
Siphonaria virgulata
Stichopus mollis
Symplegma oceania
Terebella sp.
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Tricellaria porteri
Trichomya hirsuta
Tugali parmaphoidea
Turbo torquatus
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Inyadda Point

Acanthochiton granostriatus
Actinia tenebrosa
Actinia australis
Alope australis
Alpheus euphrosyne
Amphiroa anceps
Anthothoe albocincta
Astrostole insularis
Australonereis ehlersi
Austrobalanus imperator
Austrococchlea constricta
Austromegabalanus nigrescens
Balanus variegatus
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Callioplana marginata
Catomerus polymerus
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton jugosus
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Codium lucasii
Colpomenia sinuosa
Cominella lineolata
Corallina officinalis
Coscinasterias calamaria
Cryptoplax mystica
Dardanus setifer
Dictyota dichotoma
Dilophus marginatus
Diodora lineata
Diopatra dentata
Ecklonia radiata
Ectocarpus sp
Enteromorpha intestinalis
Eulaeospira convexis
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena impertusa
Gigartina sp
Gracilaria sp
Granata imbricata
Haliclona sp.
Haliotis ruber
Hapalochlena maculosa
Heliocidaris erythrogramma
Herdmania momus
Hinea brasiliana
Hormosira banksii
Hydroides elegans
Ibla quadrivalvis
Idanthyrsus pennatus
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton smaragdinus
Ischnochiton versicolor
Janua pseudocorrugata
Kerguelenella sp
Laurencia sp
Lepidonotus melanogrammus
Leptograpsus variegatus
Lobophora variegata
Membranipora membranacea
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Octopus cyaneus
Onchidella patelloides
Onithochiton quercinus
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Oulactis muscosa
Ozius truncatus
Padina fraseri
Paguristes squasmosus
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phascolosoma noduliferum
Phidolopora avicularia
Phlyctenanthus australis
Phyllospora comosa
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Porphyra sp
Pterocladia capillacea
Pyura gibbosa gibbosa
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Rhynchocinetes rugulosus
Sabellastarte indica
Saccostrea cucullata
Sargassum fallax
Sargassum verruculosum
Sargassum vestitum
Scutus antipodes
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Splanchnidium rugosum
Stichopus mollis
Symplegma oceania
Terebella sp.
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Tugali parmaphoidea
Turbo undulatus
Ulva lactuca
Watersipora arcuata
Zonaria sp

Warden Head

Actinia tenebrosa
Actinia australis
Agnewia tritoniformis
Allostichaster polyplax
Alpheus euphrosyne
Alpheus stenuus
Amblychilepas nigrita
Amphiroa anceps
Anthothoe albocincta
Astrostole insularis
Austraeolis ornata
Austrobalanus imperator
Austrocochlea concamerata
Austrocochlea constricta
Austromegabalanus nigrescens
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Catomerus polymerus
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton pelliserpentis
Chlamys lividus
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium lucasii
Colpomenia sinuosa
Corallina officinalis
Corynactis australis
Coscinasterias calamaria
Cypraea caputserpentis
Cystophora sp.
Dictyota dichotoma
Dilophus marginatus
Diodora lineata
Diopatra dentata
Ectocarpus sp
Eulaeospira convexis
Galeolaria caespitosa
Gelidium pusillum
Gena Impertusa
Gigartina sp
Gracilaria sp
Granata imbricata
Haliclona sp.
Heliocidaris erythrogramma
Herdmania momus
Hinea brasiliana
Hormosira banksii
Ischnochiton australis
Janua pseudocorrugata
Kerguelenella sp
Laurencia sp
Leptograpsus variegatus
Lobophora variegata
Mitra carbonaria
Moneta annulus
Montfortula rugosa
Morula marginalba
Nassarius particeps
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Octopus cyaneus
Octopus cyaneus
Onithochiton quercinus
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Oulactis muscosa
Ozius truncatus
Padina fraseri
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phascolosoma noduliferum
Phlyctenanthus australis
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pterocladia capillacea
Pyrazus sp.
Pyura gibbosa gibbosa
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Sabellastarte indica
Saccostrea cucullata
Saccostrea cucullata
Sargassum fallax
Sargassum verruculosum
Sargassum vestitum
Scutus antipodes
Siphonaria denticulata
Siphonaria virgulata
Splanchnidium rugosum
Stichopus mollis
Symplegma oceania
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Tugali parmaphoidea
Turbo undulatus
Ulva lactuca
Umbraculum sinicum
Watersipora arcuata
Zonaria sp

Wasp Head

Actinia tenebrosa
Agnewia tritoniformis
Anthothoe albocincta
Austrococchlea concamerata
Austromegabalanus nigrescens
Bembicium nanum
Cabestana spengleri
Canthradella picturata
Catomerus polymerus
Cellana tramoserica
Chamaesipho tasmanica
Champia compressa
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Colpomenia sinuosa
Corallina officinalis
Dentimitrella
Diopatra dentata
Ectocarpus sp
Enteromorpha intestinalis
Galeolaria caespitosa
Gelidium pusillum
Granata imbricata
Haliclona sp.
Heliocidaris erythrogramma
Hormosira banksii
Idanthyrsus pennatus
Laurencia sp
Leathesia difformis
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina unifaciata
Notoacmaea petterdi
Oulactis muscosa
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phaisantrochus eximius
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pyura stolonifera
Ralfsia sp.
Sabellidae
Sargassum verruculosum
Siphonaria denticulata
Siphonaria virgulata
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Turbo undulatus
Ulva lactuca
Zonaria sp

Wagonga Head

Acanthochiton granostriatus
Actinia tenebrosa
Agnewia tritoniformis
Allostichaster polyplax
Alope australis
Alpheus euphrosyne
Amphiroa anceps
Anthothoe albocincta
Aplysia dactylomela
Astrostole insularis
Australium tentoriforme
Austrocochlea concamerata
Austrocochlea constricta
Balanoglossus australiensis
Balanus variegatus
Baseodiscus hemprichii
Bembicium nanum
Botrylloides leachi
Cabestana spengleri
Canthradella picturata
Catomerus polymerus
Caulerpa filiformis
Cellana tramoserica
Centrostephanus rodgersii
Chaetomorpha darwinii
Chamaesipho tasmanica
Champia compressa
Charonia rubicunda
Chiridota gigas
Chiton jugosus
Chiton pelliserpentis
Chthamalus antennatus
Cladophora sp.
Cnidopus verater
Codium fragile
Colpomenia sinuosa
Cominella lineolata
Conus anemone
Corallina officinalis
Coscinasterias calamaria
Coscinasterias muricata
Cryptoplax mystica
Culicia quinaria
Cyclograpsus audouinii
Dardanus setifer
Dentimitrella
Dictyota dichotoma
Diodora lineata
Diopatra dentata
Dolabella
Dolabrifera dolabrifera
Ecklonia radiata
Enteromorpha intestinalis
Eulaeospira convexis
Galeolaria caespitosa
Galeolaria hystrix
Gelidium pusillum
Gena impertusa
Gracilaria sp
Granata imbricata
Haliclona sp.
Haliotis ruber
Hapalochlena maculosa
Heliocidaris erythrogramma
Herdmania momus
Hinea brasiliana
Holopneustes pycnotilus
Hormosira banksii
Hydroides elegans
Idanthyrsus pennatus
Ischnochiton australis
Ischnochiton elongatus
Ischnochiton variegatus
Janua pseudocorrugata
Laurencia sp
Lepidonotus melanogrammus
Leptograpsus variegatus
Leptosynapta dolabrifera
Martensia
Membranipora membranacea
Mitra carbonaria
Montfortula rugosa
Morula marginalba
Naxia tumida
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Notoplana australis
Onithochiton quercinus
Ophiomyxa australis
Ophionereis schayeri
Ophiothrix spongicola
Oulactis muscosa
Padina fraseri
Palaemon serenus
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Patiriella gunnii
Patiriella calcar
Patiriella exigua
Petalonia fascia
Peyssonnelia
Phascolosoma noduliferum
Phyllospora comosa
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Porphyra sp
Pyura stolonifera
Ralfsia sp.
Rhynchocinetes rugulosus
Saccostrea glomerata
Sargassum verruculosum
Schizoporella errata
Scutus antipodes
Serpula vermicularis
Siphonaria denticulata
Siphonaria virgulata
Symplegma oceania
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Thysanozoon sp.
Trichomya hirsuta
Turbo torquatus
Turbo undulatus
Umbraculum sinicum
Watersipora arcuata
Zonaria sp

Short Point

Actinia tenebrosa
Actinia australis
Agnewia tritoniformis
Alope australis
Amphiroa anceps
Austrobalanus imperator
Austrocochlea concamerata
Austromegabalanus nigrescens
Bembicium nanum
Cabestana spengleri
Catomerus polymerus
Cellana tramoserica
Centrostephanus rodgersii
Chamaesipho tasmanica
Chiton pelliserpentis
Chthamalus antennatus
Cnidopus verater
Colpomenia sinuosa
Corallina officinalis
Culicia quinaria
Cystophora sp.
Dentimitrella
Dictyota dichotoma
Dilophus marginatus
Ectocarpus sp
Enteromorpha intestinalis
Galeolaria caespitosa
Gelidium pusillum
Gigartina sp
Haliclona sp.
Heliocidaris erythrogramma
Hildenbrandia prototypus
Hormosira banksii
Idanthyrsus pennatus
Kerguelenella sp
Laurencia sp
Leathesia difformis
Leptograpsus variegatus
Membranipora membranacea
Montfortula rugosa
Morula marginalba
Neogoniolithon sp
Nerita atramentosa
Nodilittorina acutispira
Nodilittorina pyramidalis
Nodilittorina unifaciata
Oulactis muscosa
Ozius truncatus
Patella peroni
Patelloida alticocastata
Patelloida latistrigata
Patelloida mufria
Patiriella calcar
Patiriella exigua
Petalonia fascia
Phlyctenanthus australis
Plagusia chabrus
Plaxiphora albida
Polysiphonia sp.
Pterocladia capillacea
Pyura stolonifera
Ralfsia sp.
Rhodymenia australis
Sabellastarte indica
Saccostrea glomerata
Sargassum verruculosum
Scutus antipodes
Siphonaria denticulata
Siphonaria virgulata
Splanchnidium rugosum
Symplegma oceania
Tesseropora rosea
Tethya corticata
Tetraclitella purpurascens
Thias orbita
Trichomya hirsuta
Turbo undulatus
Ulva lactuca
Zonaria sp