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ABSTRACT

Australia's marine environment hosts a high level of diverse endemic species along with some of the highest biodiversity in the world. Two-thirds of the population of Australia are living in coastal areas and can be considered a threat to marine life which is very vulnerable to human impacts. Although marine environments conserve high economic values, long-term research on changes in marine life and its conservation are very limited. This paper provides insight into the implementation of marine education in the science curricula and discusses the advantages of involving schools in long-term monitoring of marine environments for management purposes. (Contains 10 references.) (YDS)

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School Projects for Monitoring the State of the Marine Environment

by

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School Projects for Monitoring the State of the Marine Environment

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As inhabitants of an island continent, the sea can be regarded as very important to Australian's. Two-thirds of our population live in coastal towns and cities (Zann, 2000). The area of sea in Australia is much larger than the land area, with almost 70 000 kilometers of coastline. This provides us with many opportunities, such as sustenance and recreation, but it also leaves our marine environment extremely vulnerable to human impacts. Monitoring these impacts will require the collection of long term data using standardized experimental designs. With good planning and coordination, school students could contribute to the collection of useful monitoring data and at the same time be introduced to some of the methods used by marine ecologists.

Marine Biodiversity

Coastal and oceanic systems harbor far more biological diversity than do terrestrial ecosystems. This is not surprising in light of the fact that seas and oceans cover a significantly greater proportion of the earth (71%) than is covered by land. Marine systems are extraordinarily rich at all levels of biodiversity, from genetic to taxonomic and ecosystem diversity (Ray & Grassle 1991; Agardy 1997). For example, 28 phyla are represented in the marine environment, compared with only 11 on land. Thirteen phyla are exclusively marine. Nevertheless, the assessment of marine biodiversity lags along way behind biodiversity assessment in terrestrial ecosystems, with seven times more terrestrial species named.

Australia's marine environments contain some of the highest levels of marine biodiversity and endemism in the world. By far the majority of marine species found in temperate Australian waters do not occur anywhere else in the world. For example, it has been estimated that there are more than 15 000 species of marine molluscs in Australian waters (Ponder 1998) and ninety five percent of marine molluscs are endemic to Australia's southern coastal waters (Allen 1999). Australia's temperate coastline also has the highest diversity of red and brown algae, bryozoans (lace corals), crustaceans and ascidians (sea squirts), in the world (Zann, 1995).

Threats and Human Impacts

Recognition of the threats to marine biodiversity is fairly recent and consequently, most of the research into conservation in Australia has concentrated on our unique bird and mammalian fauna (Jones and Kaly, 2000). More recently however, there has been widespread concern over the decline in our marine habitats, including coral reefs, seagrass beds, temperate kelp forests, saltmarshes and mangroves. The threats to all these ecosystems appear to relate directly or indirectly to habitat destruction from coastal development, environmental pollution or over-exploitation by humans (ESAC, 1996; Jones and Kaly, 2000).

Intertidal habitats are particularly vulnerable to human impacts because they are relatively limited in area and are usually the most accessible of marine habitats. All intertidal reefs in urban areas are under pressure from human foraging activities and recreational trampling. Urban run-off from storm water drains and sewage outfalls also causes significant disturbance to intertidal and subtidal reefs. Significant areas of marine habitat around coastal cities have been reclaimed or altered by seawalls, port development, industry, housing and tourism and recreational facilities. Boatharbours and marinas are typically associated with degraded water quality from fossils fuel usage and antifouling paints. The introduction of foreign pests and diseases is also serious problem for the Australian marine environment, with over 140 species introduced or with potential to be introduced (Furlani, 1997). There are currently no real options available for the eradication or control of marine introduced species once they have established. Water pollution and water-borne pests can not be easily isolated in the marine environment.

Despite it's high conservation and economic values, Australia's marine environment remains inadequately studied. It is not possible to provide a simple assessment of the state of Australia's marine environment because of its vast size and great diversity, the wide range of complex issues affecting it, and the many gaps in our scientific knowledge (Zann, 1995). Nevertheless, the state of Australia's marine environment can generally be described as good in comparison to other developed countries (Zann, 1995). This is because the marine environment in most remote, (undeveloped) areas is almost pristine. However, the state of the marine environment adjacent to highly developed urban, industrial and intensively farmed areas is typically locally poor.

Long-term scientific information is essential for accurately assessing changes in the marine environment. However, this type of research has been very scattered in Australia and is lacking altogether in many areas. For example, the effects of human recreational uses on intertidal reeds are not well understood or monitored. Marine conservation is seriously impeded by our general ignorance of the coastal zone. Research aimed at improving the baseline data through systematic assessment of marine biota is necessary (Zann, 1995; ESAC, 1996). Long-term monitoring is required to assess natural changes in the marine environment, as well as any changes bought about by human activities.

Marine education

Effective management of Australia's marine environment depends on public understanding of the marine environment. The people of Australia must recognise the threats to our marine ecosystems and want to protect them. Formal education at schools provides much of the knowledge and skills that help people make informed decisions. Furthermore, secondary education provides training for future marine scientists and managers. In recent years, there has been a general increase in environmental topics taught by schools. However, these topics are often biased towards the terrestrial environment. Consequently, most Australians leave school with little more than a basic understanding of the marine environment and the issues facing it (Zann, 1995).

Marine education should be incorporated into the curricula for all schools, irrespective of how remote they are from the sea. At some stage in their lifetime, nearly all Australians will visit and therefore potentially impact upon the ocean. Many basic ideas in biology can be taught using marine ecosystems, such as species adaptation and community structure. Furthermore, the interconnected and ever-changing nature of the environment could be explained and used to illustrate some of the difficulties in marine management. The need for conservation strategies specifically relevant to marine organisms should also be explained, including fishing closures and fisheries bag and size limits.

Clearly, hands-on marine education will be limited in many Australian schools due to logistical problems. However, it is particularly relevant to the quarter of our population that lives within 3 kilometres of the coast (see Zann, 1995). In addition to providing a general marine education, schools in this region should consider developing projects that involve the collection of "real" data from their local marine environment. The main advantage of this would be to teach students some of the methods that are used by ecologists in the marine environment. The data collected by the students could be used to reinforce basic statistical techniques, such the calculation of means, medians, mode and range. Graphing the data in histograms would reinforce the visual aspects of data presentation. The collection and presentation of "real" data might provide some students with a unique connection to their local marine environment and may lead to a broader appreciation for the role of ecological science in environmental management. An added advantage of a well designed monitoring project is that the students could simultaneously learn and further our general knowledge of temporal changes in marine ecosystems. If schools could maintain all the data collected by students in different years it might become useful for monitoring the state of their local marine environment.

The advantages of school involvement in long-term monitoring

Long-term monitoring programs are typically difficult to establish in the marine environment due to the high cost of marine studies and the difficulties in obtaining long-term funding for research and monitoring. Marine communities are typically highly variable in space and time (e.g. Underwood, 1998). This means that a lot of replication is required in the sampling regime in order to accurately quantify the distribution and abundance of marine organisms. The collection of baseline data over large areas of marine habitat presents problems to scientists and resource managers because they are limited in both time and personnel.

School groups have one major advantage for the collection of base-line data and that is numbers. For example, a class of 20 students working in pairs could collect data from at least 100 quadrats at one location during a single field trip. This high degree of replication would effectively minimize the effects of small scale variation, thus providing a good set of baseline data for detecting future change. Variation between the researchers (i.e. the pairs of students) could present a potential problem for the collection of accurate environmental data. However, it should be possible to minimize these effects by using highly reproducible methods and selecting appropriate marine organisms for the study (discussed below).

In order to detect long-term changes in the local marine environment science teachers would have to commit to a specific project. This would require collecting the same data for many years and maintaining the data in a database. For comparison purposes, it would be necessary to sample the same site, at the same times of year, using exactly the same methodology. The same class, as opposed to the same students, should also be used each year (e.g. Year 10 science or Year 11 Biology). This is important because students who have been involved in the project previously could improve through experience or possibly loose interest and become careless. However, less variation would be expected between new groups of students (of similar age and education), who are introduced to the project for the first time. Repetition of a standardised project for several years may not be possible in some schools for a variety of reasons. Nevertheless, given the great paucity of baseline information in our marine environment, it is still possible that any information collected by students could turn out to be useful in the long-term.

Planning and coordination

In order to obtain a broader perspective on the state of the marine environment at a particular study site, it is necessary to place the site in a regional context by examining several other locations for comparison. However, comparisons between locations using the data collected by school groups would require cooperation between several schools within a region. Standardized methods would have to be used for the data collection at every location and the project should preferably be undertaken by similar classes at each school. It would also be necessary to maintain a centralized database The benefits of this type of cooperation, however, would be great. The students could see how their local marine environment compares to other areas but more importantly, the data could potentially be used to detect human impacts over that which could otherwise be attributed to natural variation. Due to the large temporal variation in the marine environment, human impacts resulting from new developments can only be detected by comparing the impact site to control sites using repeated standardised sampling regimes.

Well thought out planning is also required to identify suitable aspects of the marine environment for the students to study. Ideally the projects should involve potential human impacts. One fairly straightforward example that would be applicable for the entire Australia coastline is the amount and type of rubbish that is washed up on our beaches. The students could walk a standard transect, say 30m, along a tide-line and collect all of the rubbish they find (wearing rubber gloves of coarse). The rubbish could then be weighed and categorized (e.g. cigarette butts, plastic, glass ect.) and the teachers could discuss the potential sources of the rubbish (e.g. storm water drains, creeks, wind, people on the beach). This could raise some awareness about where rubbish can end up when it is chucked out the car window and, in the long term, it could be useful for monitoring the relative effectiveness of environmental awareness programs in different coastal regions.

Some marine organisms could also be targeted for school projects. However, different species will vary in their suitability for monitoring. For example, the most abundant species in a community are not generally considered appropriate biological indicators because they are likely to have a high rate of reproduction and good dispersal. Furthermore, the students could quickly loose enthusiasm for a project that involves counting thousands of individuals! The species should also be easy to identify and preferably show some known response to human impacts. Below I have provided some examples of species that have been selected for monitoring on intertidal reefs in the Illawarra region NSW. These species could be used throughout southeast Australia, but for teachers working in other regions and/or other marine habitats it would be advisable to consult a local marine ecologist. In general, it would be advantageous to work with a qualified ecologist. They could provide advise on appropriate methods for the data collection and may be willing to maintain the data over the long term and eventually perform some statistical analyses when appropriate.

Teachers should also prepare a standardised data sheet for the students to fill in. Space should be provided to record details such as the location, the date (including year), the time and weather conditions, including swell and tide for intertidal studies. A table should be drawn up to record the data collected from each quadrat. At the bottom of the sheet some teachers may also like to provide room to record some other potentially interesting information, such as the number of fishermen or sightings of introduced species or rare species (such as Sooty Oystercatchers in NSW).

The Illawarra intertidal monitoring project

A small intertidal monitoring project is currently being trialled with a couple of secondary schools in the Illawarra region around Wollongong, NSW. The projects have been summarized below to provide an indication of the type of data that can be collected and the methods used.

Limpets

The limpet *Cellana tramoserica* has been selected because it is often collected by humans for food an bait. They also provide an important source of food for whelks (predatory snails) and the Sooty Oystercatcher, which is a rare and endangered bird listed on Schedule 2 of the NSW Threatened Species Conservation Act, 1995. Previous studies have shown that the removal of limpets from rock platforms can completely alter the community structure. Information on the abundance of limpets is being collected by randomly tossing 0.5m x 0.5m ($0.25m^2$) quadrats onto the rock platform in the mid-intertidal zone (a harmless marker like a sock can be tossed instead to mark the center of the quadrat). The quadrats can be prepared very cheaply from PVC pipe. The number of limpets found in each quadrat is then recorded. The size of the limpets can also be recorded using a pair of plastic calipers. Any changes in the size distribution of limpets would be of interest because one could assume that the largest specimens would be targeted by humans. The main limitation of this project is that there are several cryptic species that could be falsely identified and recorded (e.g. the false limpets, *Siphonaria* spp). Teachers could familiarize themselves with the different species and explain these to their students. However, one would expect that the rate of misidentification would not vary greatly between years.

Neptunes Necklace

Neptunes Necklace is the common name for the alga *Hormosira banksii*. It provides habitat and food for a range of intertidal organisms. However, it has been shown to be susceptible to human trampling. Constant trampling can prevent the regeneration of Neptunes Necklace, leading to a reduction in the total area of rock platform covered by this alga. The percent cover of neptunes necklace can be estimated in quadrats by placing a grid over the quadrat and counting the number of squares that are occupied by neptunes necklace. The same random quadrats can be used as those used to collect the limpet data.

Filter feeders

Cunjevoi is the common name for the sea squirt *Pyura stolonifera*. It is a filter feeding invertebrate and thus is potentially vulnerable to water borne pollutants. Cunjevoi is an important source of food for several species of large whelks and the Sooty Oystercatcher. It is also harvested by recreational fisherman for bait and sometimes food. The rate of human harvesting can be monitored along 5m transects in the "cunjevoi zone" (low intertidal) by counting the number of intact cunjevoi and the number of harvested ones, within 0.5m on either side of the transect. Harvested cunjevoi can be identified by the presence of the cut bases, which usually have some pink flesh exposed if recently harvested. The transect can simply be a piece of rope with lead weights attached to prevent it from washing away.

The main limitation of this project is that cunjevoi only occurs in the swash zone and on many rockplatforms this area will be too dangerous for school students to access. Nevertheless, it may be possible on reefs that are relatively sheltered from swell on very low tides (<0.3m). Oysters are an alternative filter feeding organism on heavily wave exposed rock platforms and these can be found in the high intertidal zone. However, oysters could be too abundant to count at the more estuarine sites.

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