In 1992 the ecosystem health of Hervey Bay suffered significantly as a consequence of flooding from the Mary and Burrum Rivers, followed three weeks later by cyclone Fran. The major impacts came as a consequence of high energy waves, swells and currents with the potential to uproot or bury seagrass, and storm water runoff reducing salinity and increasing both turbidity and nutrients. In addition, output from a damaged sewage treatment plant on the Mary River resulted in 1.05 ML of untreated effluent per day being discharged into the river for twelve days. In the following months, Hervey Bay experienced the loss of more than 1,000 km² of seagrass meadows and the displacement, and some mortality, of an estimated 1,650 dugongs. The damage to the seagrass, that also functions as a nursery ground for juvenile fish and prawns, was subsequently reflected in the low commercial fish catches.

Consultation with the mayor of the Hervey Bay City Council, Heads of Chemical Engineering, Zoology and the Centre for Microscopy and Microanalysis at the University of Queensland, and an Environmental Protection Agency representative confirmed that a water quality and biodiversity study of phytoplankton, seagrass and seagrass epiphytes would be useful to enhance the understanding and recovery of the area. Consequently, a PhD research program was developed in 1993 with engagement between the university, local and state government departments, local business, volunteer groups and individuals.

Outcomes included a rigorous monthly, seasonal and annual baseline water quality dataset that provided council engineers with the information required to make important managerial decisions for the future sustainability of the region and a baseline dataset for future studies. Using regression analysis and various multivariate statistical methods, links were established between key physical and chemical water quality parameters and the concentration and assemblage structure of diatoms in the water column as phytoplankton, and as epiphytes on the seagrass leaf surface. Some key determinants of the potential causes of altered community composition and biodiversity were isolated and as a result, waste water inputs into the bay ceased and were redirected. Habitat characteristics for each seagrass site and limits for seagrass compensation depth using light attenuation theory were also established.

The research conducted in Hervey Bay was in response to community concern about sustainability issues including water quality, declines in seagrass meadows and dugong death and mass migration. A similar program was established for Moreton Bay in the mid 90’s and stage one was initiated on the Sunshine Coast in August 2007 following a flood and intermittent coastal algal blooms. Engagement between the University of the Sunshine Coast, local business and community members has enabled the commencement of the baseline water quality monitoring program with a seed grant and in-kind assistance. Support by local and state government departments and other funding bodies will be sought to expand and continue the program in the longer term. This study has provided two undergraduate science students with Workplace Learning Projects at the University of the Sunshine Coast, with another project currently on offer.

Improved understanding of the processes that define phytoplankton biodiversity and the diversity of other marine plant and animal groups in this subtropical area is useful for promoting conservation and sustainability within the general population, government departments and commercial sectors, with the aim of clarifying possible links to catchment activity and climate change. Development of this research program in collaboration with the University of Queensland, aims to provide local councils nationally with the ability to monitor...
their near shore marine environments to provide the information required to assess sustainability strategies at the local level. Engagement between government departments, local industry partners and community groups within each region will be promoted.

INTRODUCTION

The human and ecological value of the near and offshore coastal zones can be related to our knowledge, perception and understanding of the diversity and ecology of the marine life that resides in these areas. The local economy of many coastal zones is based on tourism, recreational activities and fishing industries that rely heavily either directly or indirectly on the health and delicate balance of near and offshore marine environments. When change is detected as a result of catchment practices or natural phenomena, adverse effects may occur that upset the balance of marine ecological systems, which in turn affect the local economy.

Estuarine environments have been ranked among Australia’s most valuable natural resources for the importance of both their ecological processes and economic development (Smith et al., 2001). The most conspicuous effects of increased runoff as a result of human activity and exacerbated by potential climate change includes floods and waste water discharge, increased turbidity, nutrient inputs and eutrophication (Zann, 1995; NRC, 2000), phytoplankton blooms (Bell and Elmetri, 1995) and increased epiphytic algal populations which alter marine community structure and biodiversity (John, 2000).

Eutrophication is a major national and international problem because it can lead to harmful algal blooms (HAB’s), shellfish contamination, anoxic and hypoxic events, fish kills and changes in biodiversity. These impacts affect human health directly and indirectly in the food supply. The blooms may significantly decrease light penetration to benthic flora and fauna through enhanced turbidity as well as promoting growth of algal epiphytes on seagrass, coral and other sub-aquatic vegetation and substrates (Tomasko & Lapointe, 1991). During the past two decades the effects on human health and economic impacts of HAB’s have increased in frequency, intensity and geographical distribution (Hallegraf, 1993). Many events have been documented which affect a wide range of marine biota along the food chain including benthic filter feeding molluscs (mussels, surf clams, razor clams, softshell clams, scallops, butter clams, oysters, gastropods), crustaceans (lobsters, crabs), fish (anchovies, herring, salmon, menhaden, sandlance, mackerel), squid, zooplankton and other benthic invertebrates, sea lions, otters, birds (brown pelicans, Brandts cormorants), dolphins, whales and humans (Anderson, 1995). Some biota affected, form the basis of fisheries in some locations or are the focus of tourism activities.

Epiphytes are organisms that grow on plants and include macroalgae and periphyton. Changes in species composition and biomass of seagrass epiphyte assemblages, is a typical response to eutrophication (Burt et. al., 1995). John (2000) found that the relatively high universality of epiphytic diatom distribution makes them ideal bio-monitors at the regional and national level and developed a predictive model of environmental health by linking epiphytic diatom attachment rates and assemblage structure to water quality parameters.

Nutrient enrichment, and hence eutrophication, stimulates the growth of phytoplankton and epiphytic algae and thus reduces the spectral quality and/or quantity of light available to the photosynthetic tissues of attachment substrates and other benthic organisms (Anderson et. al., 2002). When the quality and quantity of light change significantly, the effects can cascade throughout an ecosystem from the highest plants and animals down to the micro-organisms (ANZECC/ARMCANZ, 2000). The consequence is decline in the biodiversity of habitat structure for that ecosystem and death or migration of the animals that depend on these habitats for survival. These interrelationships affect the balance and ultimate health of the marine ecosystem and understanding them is vital to the effective management for healthy marine systems and sustainable human use of these areas.

Adequate light reaching the benthos is critical for the survival and growth of coral reefs, seagrass, juvenile fish and prawns and other benthic organisms (Masini et. al., 1995). Threatened and endangered species such as dugongs, dolphins, humpback whales and various turtles are coastal inhabitants that rely on the healthy waterways of Hervey Bay and
the Sunshine Coast. Recreational and commercial fishing activities, linked to a growing tourism industry, are also affected by estuarine, coastal marine and offshore marine dynamics, as is the recreational diving industry which makes use of similar areas. Baseline water quality data is fundamental to understanding the influence of coastal processes on the health of near-shore marine systems and to detect potential effects of climate change. Local councils and regional government departments that are concerned with catchment management practices and other activities that influence the water quality at diffuse and point sources to waterways, require this information upon which informed decisions can be based.

Education of the potential stakeholders in a region that may be adversely affected by reduced water quality is the first step in encouraging community participation and involvement of local industry in a research program. In Hervey Bay, the mayor of the Hervey Bay City Council and many local business owners and community members had witnessed first hand some effects of reduced water quality prior to the research proposal being presented. Seagrass meadows had noticeably reduced in size, fish catches had decreased and dugongs were seen floundering close to shore with skin lesions apparent. Hervey Bay had developed a multimillion dollar tourism industry based on the migration of humpback whales through this area and relied on the fishery to support both commercial and recreational fishing industries. Local and regional government departments and local businesses also depend on the success of tourism in this region and a concern that reduced water quality may also adversely affect the area V humpback whale population that migrate along the east coast of Australia to visit Hervey Bay, was paramount.

Conferencing at the University of Queensland and in Hervey Bay was followed by commitments to assist with financial and 'in-kind' support and the postgraduate monitoring and research program commenced. The nature of the program included academic aspects as well as the potential for the practical application of the raw data generated from the intensive monitoring program to local areas of concern. Regular reports and meetings between the university, council and regional government departments provided the information required for management groups to identify problem areas and consequently modify existing water management strategies. Since this time, engagement between government and community sectors has been successful in establishing various terrestrial and coast based monitoring programs including Landcare, Water Watch and Seagrass watch (Goyne et. al., 1999; Zeller and Petroeschovsky, 2006).

This paper describes a case study in Hervey Bay where a novel approach was used to generate the funding required to conduct water quality and biodiversity research in this region. Engagement between the University of Queensland, the Hervey Bay City Council, government departments, local business and community members succeeded in producing enough funding (~ $150 K) to support a monitoring program that was critical to local management and to the advancement in the knowledge of marine ecology. Ultimately, regional engagement can produce economically efficient research outcomes to the benefit of all stakeholders in the quest for sustainability.

METHODS

The methods used for the Hervey Bay study will be presented followed by the proposed stages of progress for the Sunshine Coast research program.

Community engagement

Interaction, meetings and individual discussions with key local business owners, government representatives and concerned individuals were arranged and conducted with the aim of identifying stakeholders and the respective levels of involvement from each area. Research proposals and projected budgets were customized, targeted and submitted to these groups. Expectations of research outcomes were written into each proposal with reciprocal arrangements for delivery and implementation.

Sampling area and strategy in Hervey Bay
Fortnightly surveys of nine sites selected from a pilot study of 30 sites in 1993, were conducted between January 1994 and February 1995 to produce a total of 25 data sets (figure 1).

Figure 1: Survey sites for 1994 (white numbers) in Hervey Bay and the Great Sandy Straits.

**Physico-chemical water quality parameters**

Depth profiles of temperature, pH, dissolved oxygen, salinity and redox potential were obtained using a Scout® Hydrolab at 1-meter intervals over the full depth of the water column. Surface current speed and direction were measured with a survey boat at anchor by timing a buoyant object transit over a 10m length. Wind speed and direction, sea state, visibility and percentage cloud cover were recorded at each site. Water samples for Chl a analyses were collected from a depth of 0.5m below the surface and processed for analysis following the methods of Strickland and Parsons (1972).

Samples for nutrient analysis were collected at 0.5m depth, filtered through Sartorious (0.45 µm) filters and frozen immediately on dry ice in pre-washed polypropylene containers for analysis of soluble reactive phosphate (SRP), nitrate + nitrite (NOx) and ammonia (NH4+) at the Government Chemical Laboratories. Water clarity was assessed by recording optical depth or Secchi depth using a standard Secchi disc and recorded to the nearest 0.1m, measuring turbidity using a Hach turbidimeter (model 2100A) in nephelometric turbidity units (NTU) and calculating total suspended solids (TSS) according to standard methods. Position fixing of survey sites was achieved using a hand held compass with reference to buoys and land marks.

**Phytoplankton and epiphyte diversity**

Unfiltered water samples collected from a depth of 0.5m were preserved with Lugol’s solution and stored at 4°C for analysis. Samples were concentrated and counted using a light microscope to view a 0.05mL sample on an English Finder slide under a large glass cover slip. Identifications to genus level, and in some cases to species level, were possible at between 100x and 400x magnification. A photographic identification catalogue of phytoplankton species in Hervey Bay has been compiled.

Sites for seagrass epiphyte examination were coincident with water quality survey sites to investigate the relationship between the physico-chemical water quality parameters and the changes to epiphytic micro-algal assemblage structure on seagrass leaves throughout an
annual cycle. Light microscopy was performed on fresh samples. Mid-leaf sections were
dissected, air dried on filter paper in a covered petri dish in a fume hood, platinum coated and
imaged with the Jeol 6400 Field Emission Scanning Electron Microscope. Image analysis was
performed on 573 electron micrographs (n = 3 to 12) taken at 500X magnification to assess
seagrass epiphyte assemblage structure on the leaves of 5 seagrass species at 4 sites. An
identification catalogue of microalgal epiphytes on seagrass in Hervey Bay is being compiled
for future reference.

**Statistical analyses**

Rainfall data was summarized and plotted as monthly means for the catchment area. Monthly
and seasonal means and standard deviations were calculated for all physico-chemical water
quality, phytoplankton and epiphyte data from the 1993, 1994 and 1995 surveys. Following
data transformations, principle component analyses (PCA) were performed to construct a two
dimensional profile that best represent the geographical separation of survey sites on the
basis of water quality (environmental and habitat health). Non metric multidimensional scaling
(MDS) was performed on seasonal data for four sites to determine the dominant links
between the physico-chemical characteristics of water quality and biodiversity in the
phytoplankton and epiphyte assemblages. The BIOENV program in PRIMER (Clarke and
Gorley, 2001; Clarke and Warwick, 2001) matched biotic to environmental variables by rank
correlation of (dis)similarity matrices. The ANOSIM test for a two-way crossed analysis with
no replication was used to establish patterns of phytoplankton and epiphyte species
composition between sites and between surveys. The SIMPER routine was used to determine
species which are typical of a group and that may act as good discriminators between groups.
These species may become indicator species for a particular habitat type or indicative for the
status of environmental health at a particular site.

**Light measurements**

The first objective was to correlate Secchi disc depths measured at a particular site to the
light extinction coefficient and the second, was to include light attenuation with water column
characteristics measured throughout the study to describe the seagrass habitat
characteristics at each site. Sites for examination were selected to represent a range of light
conditions from turbid to very clear water. Light was measured using a spherical light sensor
(Li-Cor 4π).

**RESULTS**

Results of the Hervey Bay case study include community engagement, water quality and
rainfall data, phytoplankton and seagrass epiphyte assessment, dry and post flood
comparisons, species abundance and biodiversity and links between key water quality
parameters and changes in the species diversity of microalgae in the water column as
phytoplankton and as epiphytes on seagrass. Habitat characteristics including light
attenuation for a deep water seagrass site will also be presented.

**Community engagement**

Table 1 shows the groups engaged for particular activities to achieve specific research
outcomes in Hervey Bay.

Table 1: List of groups involved in financing research program in Hervey Bay during 1993 and
1995 (Hervey Bay City Council – HBCC).

<table>
<thead>
<tr>
<th>Task/Activity</th>
<th>Provider</th>
<th>Financed</th>
<th>In-kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport to Hervey Bay</td>
<td>Chemical Engineering Vehicle, University of Qld</td>
<td>HBCC (fuel)</td>
<td>UQ</td>
</tr>
<tr>
<td>Accommodation</td>
<td>Windmill Caravan Park</td>
<td>HBCC</td>
<td></td>
</tr>
<tr>
<td>Vessel transport to survey sites</td>
<td>Hervey Bay Marina, Hervey Bay State Emergency Service, DASM Research Services, Fund raising by PhD</td>
<td>Hervey Bay Marina, SES,</td>
<td></td>
</tr>
</tbody>
</table>
Physico-chemical water quality factors and rainfall

The annual means and standard deviations, maximum and minimum for physico-chemical water quality parameters were calculated for nine sites that were monitored in 1994. The bubble overlay of Chl a on the seasonal water quality PCA in figure 2 shows that Chl a concentrations are a strong influence on the arrangement of sites. This indicates a clear geographical basis to the water quality gradient that exists from sites close to point sources to more distant sites.

Figure 2: Principle component analysis (PCA) plot for seasonal water quality parameters with bubble overlay of Chl a (µg/L) values.

Phytoplankton Assemblages

A total of 150 phytoplankton species were identified and detailed analyses of assemblage structure and links to water quality were assessed at 4 sites: two point sources at the Mary River (site 35) and Pulgul Creek (site 10) and two sites following the water quality gradient into the bay; the Artificial Reef (site 2) and the S2 Buoy (site 16). Non-metric multi-
dimensional scaling (MDS) of seasonal phytoplankton assemblage structure for each site is illustrated in figure 3 and shows that site differences are apparent (stress 0.17).

Figure 3: Ordination (MDS) of seasonal phytoplankton assemblages for sites 2, 10, 16 and 35 (s=summer, a=autumn, w=winter and sp=spring; stress 0.17).

The BIOENV program calculated that Chl a, secchi depth, SRP and pH were most strongly linked (ρ = 0.63) to seasonal changes of phytoplankton assemblage structure and therefore, are strong determinants of phytoplankton assemblage structure. The phytoplankton species that primarily account for the observed assemblage differences between sites and similarities within sites were investigated using SIMPER (similarity of percentages) in PRIMER.

**Flood effects on water quality and phytoplankton assemblage structure**

Physico-chemical water quality parameters, phytoplankton cell density and phytoplankton species diversity were recorded in February 1995 when the catchment received 2,783 mm of rainfall and compared to the same sites in February 1994 when the catchment received 874 mm of rain. The results are presented for comparison in table 2.

Table 2. Post flood water quality parameters in February 1995 compared to February 1994.

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Chl a</th>
<th>Cells &gt;20µm</th>
<th>Secchi</th>
<th>SRP</th>
<th>Temp</th>
<th>pH</th>
<th>Salinity</th>
<th>%O2</th>
<th>Redox</th>
<th>Turbidity</th>
<th>Cells/mL</th>
<th>Species</th>
<th>Shannon</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>1994</td>
<td>1.25</td>
<td>0.54</td>
<td>1.3</td>
<td>4.5</td>
<td>26.6</td>
<td>8.07</td>
<td>33.1</td>
<td>100.7</td>
<td>0.123</td>
<td>2.70</td>
<td>38</td>
<td>23</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>11.2</td>
<td>8.5</td>
<td>0.6</td>
<td>9.0</td>
<td>30.2</td>
<td>8.38</td>
<td>24.8</td>
<td>154.6</td>
<td>0.070</td>
<td>7.20</td>
<td>336</td>
<td>23</td>
<td>1.6</td>
</tr>
<tr>
<td>116</td>
<td>1994</td>
<td>0.28</td>
<td>0.19</td>
<td>7.9</td>
<td>4.3</td>
<td>26.9</td>
<td>8.16</td>
<td>37.2</td>
<td>111.9</td>
<td>0.260</td>
<td>0.59</td>
<td>19</td>
<td>19</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>1.30</td>
<td>0.73</td>
<td>3.1</td>
<td>3.0</td>
<td>26.0</td>
<td>8.24</td>
<td>34.4</td>
<td>121.1</td>
<td>0.060</td>
<td>1.36</td>
<td>253</td>
<td>27</td>
<td>2.9</td>
</tr>
<tr>
<td>335</td>
<td>1994</td>
<td>1.00</td>
<td>0.39</td>
<td>2.4</td>
<td>4.0</td>
<td>26.8</td>
<td>8.16</td>
<td>36.8</td>
<td>101.0</td>
<td>0.138</td>
<td>1.80</td>
<td>38</td>
<td>10</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>17.4</td>
<td>3.7</td>
<td>1.8</td>
<td>12.0</td>
<td>23.4</td>
<td>8.19</td>
<td>28.3</td>
<td>125.7</td>
<td>0.120</td>
<td>6.26</td>
<td>679</td>
<td>38</td>
<td>3.1</td>
</tr>
</tbody>
</table>

The effect of the flood in February 1995 produced an increase in Chl a and SRP concentrations, pH, oxygen saturations and turbidity while Secchi depth, salinity and redox potential decreased. Site 35 at the Mary River mouth in the Great Sandy Straits, experienced the greatest impact from the flood event with an increase in diatom diversity from 10 to 38 species and a cell density from 38 to 679 cells/mL.

**Seagrass epiphyte assemblage structure**

Remnant seagrass patches recovering from the 1992 demise were located in 1993 and monitored for seasonal growth patterns, species succession and epiphyte biodiversity during
1994. An estimate of seagrass shoot density, expressed as a percentage cover, is shown monthly for each site (figure 4).

Image analysis of 573 scanning electron micrographs identified 35 species and showed microalgal epiphyte assemblages on the leaves of Zostera marina, Halodule uninervis, Halophila ovalis, Halophila decipiens and Halophila spinulosa. Halophila ovalis was the most widespread seagrass species and had greatest density of epiphyte attachment. Analysis of the epiphyte assemblages on seagrass leaves at inter-tidal, shallow and deep water sites showed that epiphyte loads decreased with distance offshore. H. ovalis recorded the highest average annual epiphyte loads with the diatoms Diatoma vulgare and Cocconeis scutellum representing 19.6% and 17.2% of the total epiphyte cover. Highest cell density was recorded in autumn, followed by summer and winter. Spring recorded the lowest epiphyte cover. The microalgal epiphytic assemblage structure on H. ovalis varied with changes in the water quality and depth from the point source near shore sites, to the offshore survey sites. The BIOENV program revealed that the combination of NOx and temperature were most strongly linked (ρ = 0.32) to, or best “explain”, the variations in seasonal epiphyte assemblage structure on H. ovalis.

The MDS of epiphyte assemblage structure presented in figure 5 clearly shows a similar pattern to the site differences observed for water quality (Fig. 2) and phytoplankton assemblage structure (Fig. 3). The pattern evident in the MDS in figure 5 shows clearly the placement of sites 10 and 30 towards the left hand side of the plot and sites 16 and 17 toward
Figure 5: MDS of seasonal epiphyte assemblages on H. ovalis (stress 0.12); S=summer, A=autumn, W=winter, Sp=spring.

Habitat characteristics

A representative illustration of a habitat characteristics model for an offshore seagrass site in Hervey Bay is presented in figure 6. The diagram characterizes the site by setting values for the physical, chemical and biological parameters of the environmental variables in this particular habitat. Coral reefs, rocky reefs and sandy zones can all be parameterized to derive baseline datasets for each habitat type.

Figure 5-11: Habitat characteristics at the offshore site 16 during seagrass recovery; annual average of seasonal means (adapted from Dennison's conceptual model, 1993).
DISCUSSION

Hervey Bay is one of the largest bays along the Queensland coast and provides seagrass habitats of international significance for dugongs (Marsh et al., 1990) and six of the seven species of sea turtle worldwide (Hyland, 1993). Hervey Bay supports important commercial and recreational fisheries and is a popular tourist destination whose numbers are seasonally boosted by hosting the annual procession of humpback whales (Megaptera novaeangliae). Hervey Bay is protected from the open ocean by the largest sand island in the world, Fraser Island, and provides a haven for a large proportion of the area V humpback whales during their return southward migration to the Antarctic, along the east coast of Australia. Water quality and marine biotoxins have been implicated as the cause of death of marine mammals in the past (Anderson and White, 1992) so examination of the potentially toxic source is important in areas that marine mammals frequent.

In 1993, engagement between local and state government departments, the University of Queensland, local business and community groups and individuals established a research program with the aim of establishing a baseline water quality data set for the Hervey Bay region and investigating possible bio-indicators of environmental health specific to Hervey Bay. Areas of particular concern were isolated and the intensive (fortnightly surveys) and extensive (from the Great Sandy Straits to 33 km north of the Mary River mouth) program began.

Water quality gradients were established from major point sources of the Mary River and the Pulgul and Eli Creeks, both of which were discharge points for treated sewerage effluent, into Hervey Bay. Examination of 19 physico-chemical water quality parameters, identification and quantification of two biological forms and assessment of both datasets using multivariate statistical analyses, revealed that two nutrients were involved in determining the density and diversity of phytoplankton and microalgal seagrass epiphytes (Burt et al., 1995 and John, 2000). The nutrient, soluble reactive phosphate (SRP), together with Chl a, Secchi depth and pH was found to be linked to the phytoplankton assemblage structure in the water column and oxides of nitrogen (NOx) and water temperature was linked to the density and distribution of microalgal epiphytes on the leaves of the seagrass Halophila ovalis.

The recovery and succession of each seagrass species at intertidal, shallow and deep water sites was documented and the habitat characteristics for each site were quantified during this period of recovery. The Hervey Bay City Council now recycles sewerage effluent and the seagrass areas that extend from the mouth of the Pulgul and Eli Creeks have recovered (Campbell and McKenzie, 2004). The sustainability of the ecological systems vitally important to Hervey Bay has improved as a result of this research. The ability of the local council to detect change as it occurs in response to catchment practices, sustainability strategies or climate change has been enabled with access to a reliable data set to use as a baseline and biological indicators or response variables to two important nutrients in this dynamic, vitally important, marine ecosystem.

Application of engagement model to the Sunshine Coast

Stage one of the water quality study on the Sunshine Coast includes phytoplankton identification and enumeration, measuring water clarity as indicated by Secchi depth and recording light attenuation in the water column as photosynthetically active radiation (PAR). These parameters will be correlated and related to rainfall data accessed from the Bureau of Meteorology. The first two study objectives form part of two Workplace Learning Projects (WPL) at the University of the Sunshine Coast under the supervision of the author. A desktop statistical study aims to compile existing data collected by Underwater World, Sunreef Diving Services and Gary Cobb, a renowned local nudibranch specialist (Cobb and Willan, 2006). Initial statistical analyses will generate monthly, seasonal and annual means for some physical water quality parameters from 2003 to the present time. Phytoplankton samples have been processed and initial identifications have been performed as part of a WPL project to establish baseline data for phytoplankton density and diversity on the Sunshine Coast. Stage one marks the first post-flood study to document changes in phytoplankton density, diversity and the time it takes for these parameters to return to their baseline levels. It is also the first
study to determine light attenuation coefficients: a measure of water clarity that derives attenuation values from Secchi depth data.

Stage two of the program involves nutrient analyses, chlorophyll a determination and vertical profiling of physical parameters at each survey site to record seasonal means and produce a set of values that characterize each habitat type. The parameters selected for stage two have been linked to changes in biodiversity and assemblage structure of phytoplankton and of seagrass epiphytes (Milham-Scott, 2007) which together, contribute to reduced light reaching the seagrass leaf surface. The same theory applies to other benthic organisms such as coral, sponges and many other invertebrate species.

Stage three will further characterise each site by documenting biological diversity as well as sediment type. Research on the colonization of the artificial reef HMAS Brisbane will be referred to for the biological component of this survey site (Walker et. al., 2007) and the establishment of Reef Check on the Sunshine Coast will provide additional biological data from other near and offshore reefs. Habitat characteristics for natural and artificial reefs, rocky reefs and sandy zones within near and offshore marine environments of the Sunshine Coast will be established. A baseline data set is required in order to detect changes that may occur in particular habitats and ecosystems. This is the essence of sustainability – to detect change.

A flow diagram that describes the overall program is presented in figure 2.

The model presented for the case study in Hervey Bay is being applied to water quality and biodiversity research that has commenced and is to be extended on the Sunshine Coast.

Figure 7. Overview of the proposed research program for the marine ecosystems of the Sunshine Coast.

Benefits of local engagement with global importance

Engagement between the University of the Sunshine Coast, Sunreef Diving, Underwater World, Australia Zoo, Complete Framing Australia and local community members has recently been established to progress the marine water quality research on the Sunshine Coast in a manner similar to the research conducted in Hervey Bay. Similarities include seagrass habitats of significance for dugongs, important commercial and recreational fisheries, popular tourist destination, a seasonal host to the annual migration of humpback whales (Megaptera novaeangliae) and natural and artificial reefs. Statistical analysis of historical data will set the scene for recent collections to provide a baseline data set for future studies.

The benefits include: 1. Access to a reliable monthly and seasonal water quality data base will enable detection of spatial and temporal changes that may occur in specific parameters (e.g. temperature, salinity, nutrients or microalgae). This data base will be made available by the University of the Sunshine Coast to the wider community in Australia and overseas to
facilitate the development of a long term database similar to that developed for the Irish Sea (1950-2008; Marine Environmental Change Network).

2. Knowledge of the effects of increased runoff on the offshore underwater marine environment has implications for sustainability studies, encouraging conservation and promoting modified land use practices.

3. Linkage of the research with established monitoring programs like Environmental Health Monitoring Program in rivers within the catchment, Reef Check and existing biological monitoring of the ex-HMAS Brisbane (Walker et. al., 2007) will develop regional engagement with a range of government bodies, community groups and other scientists to improve local understanding and knowledge upon which informed managerial decisions can be based.

4. The knowledge of seasonal and annual means for water quality and biodiversity data is paramount as migration patterns, feeding regimes and breeding behaviours of significant marine biota change throughout an annual cycle and detection of these changes is important to our understanding and consideration of these activities to ensure the survival of threatened and endangered species. The improved understanding may encourage the collection of similar data from other regions to provide a holistic and global view of changes occurring to the sub-aquatic marine environment of our planet.

The Sunshine Coast lies on a latitude that borders subtropical and temperate zones – a location that promotes great diversity among plant and animal groups; yet it is a zone that has been the focus of little research, given the inherent interest of the hard coral areas of the tropics (Bellwood et. al., 2006) and the macro algae dominated communities of temperate areas (Cummins et. al., 2004). Nevertheless, this intermediate zone supports a growing recreational diving industry supported by Underwater World and several scuba diving services that explore fringing and offshore reefs, as well as the recently established artificial reef of the ex-HMAS Brisbane, which is surrounded by a 35.5 ha conservation park.

The Sunshine Coast experienced a major flood (1 in 100 year) in August 2007 and has a recent history of many oceanic blooms of Trichodesmium. Fish kills in Tooway Creek at Moffat Beach in 2003 and 2004 (Moore et. al., 2006), unspecified algal blooms (Gaston et. al., 2006) and blooms of Hinksia sordid at Noosa main beach during the summer of 2003 – 2004, 2004 – 2005 and 2005 – 2006 (Moore et. al., 2006) have also been documented. The results of a fish tissue sampling study that covered three estuaries within a 100 km strip of the Sunshine Coast, revealed sewerage contamination among 17 fish species (Schlacher et. al., 2005).

Post flood fortnightly surveys of phytoplankton and water clarity began in August 2007 at four river mouth sites and three offshore sites. The study commenced with the engagement and assistance of local business, with in-kind support to date of approximately $25,000 and a seed grant for $5,000 from the University of the Sunshine Coast. The program plans to progress in 3 stages and is modelled on the research program established for Hervey Bay in the 1990’s.

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