Northern Territory Government

greening the Territory

A Territory Government initiative

Darwin Harbour Region

Other Projects and Monitoring 2011

www.greeningnt.nt.gov.au

Darwin Harbour Region
Other Projects and Monitoring 2011

This report was edited by Julia Fortune and John Drewry.
Articles were provided by staff at the following: (1) Department of Natural Resources, Environment, The Arts and Sport, (2) the Museum and Art Gallery of the Northern Territory, (3) the Department of Planning and Infrastructure, (4) Charles Darwin University (CDU) and (5) the Australian Institute of Marine Science (AIMS).

Aquatic Health Unit. Department of Natural Resources, Environment, The Arts and Sport. Palmerston NT 0831.

Website: www.nt.gov.au/nreta/water/aquatic/index.html

This report can be cited as: J. Fortune and J. Drewry (Editors). 2011. Darwin Harbour Region Research and Monitoring 2011. Department of Natural Resources, Environment, The Arts and Sport. Report number 18/2011D. Palmerston, NT, Australia.

Specific articles can be cited as: *Paper author* (2011). *Paper Title* in "Darwin Harbour Region - Research and Monitoring" edited by Julia Fortune and John Drewry *pp.* Report 18/2011D. Department of Natural Resources, Environment, The Arts and Sport. Palmerston, NT, Australia.

Disclaimer

The information contained in this report comprises general statements based on scientific research and monitoring. The reader is advised that some information may be unavailable, incomplete or unable to be applied in areas outside the Darwin Harbour region. Information may be superseded by future scientific studies, new technology and/or industry practices.

ISBN 978-1-921519-88-8

Report No 18/2011D

Cover: Dorsal fins of coastal dolphins

Acknowledgements

The project was supported by the Darwin Harbour Advisory Committee.

Data and information in this report were obtained from projects funded by organisations including the Northern Territory Government and the Australian Government.

Contents

Introduction

Darwin Harbour Region Report Cards 2011

This report is a supplement to the Darwin Harbour Region Report Cards 2011.

Report contents

This report provides information on a selection of marine species that live in the waters of Darwin Harbour, such as seagrasses, corals, fish and coastal dolphins. Like many other species, they depend on the Harbour's healthy waters.

A summary of selected research and priority monitoring activities in the Darwin Harbour region is also presented in this report. These include a Seagrass-Watch program, an underwater survey of fish diversity and research on sponges and microbial communities to help us understand and assess the extent of human impacts on the important environments of Darwin Harbour.

Other studies included in the report examine the use of sponges and marine worms in coastal waters to detect human impacts, and the important role of landscape features such as wetlands in the catchment in mitigating the effects of sediment and nutrient loads on the estuary.

Activities to improve water quality in our urban areas are also described, including water sensitive urban designs and the efforts of local volunteers in monitoring and cleaning up our catchment and coastline.

Marine Biodiversity in the Darwin Harbour Region

Introduction

This section presents information on a few of the species the region is home to and that are currently subject to expanded monitoring effort in the region. Like many others, these important species depend on the Harbour's waters and a range of important marine and coastal habitats.

Marine habitats in Darwin Harbour include intertidal and subtidal mudflats, bare rocky outcrops in the high intertidal zone, coral reefs and subtidal rocky reefs. The Harbour is fringed by extensive mangrove forests which provide important habitat, generate food supply for other species and maintain the productivity of the harbour. These habitats are home to a diverse range of species of flora and fauna. Estimates of marine invertebrate species richness exceed 3,000 species. The checklist of marine fish species includes 415 species. The Harbour is also home to four species of marine turtle, three species of coastal dolphin, a diverse fauna of marine snakes, and many species of shorebirds and mangrove-dependent bird species. The ways in which these animals use harbour habitats are frequently poorly understood. Many are small, sedentary and cryptic and spend their entire lives within Harbour waters. Others such as some pelagic fish visit the Harbour during seasonal journeys around the northern coastline. Migratory waders visit the Harbour shorelines as part of their migration passage. All depend on high quality stewardship to ensure that they continue to be part of this highly valued coastal environment.

Coral reefs of Darwin Harbour – monitoring the rainforests of the sea

Tony Griffiths and Neil Smit, Department of Natural Resources, Environment, The Arts and Sport

Often called “rainforests of the sea”, coral reefs form some of the most diverse ecosystems on Earth. They occupy less than one tenth of one percent of the world’s ocean surface, about half the area of France, yet they provide a home for twenty-five percent of all marine species.

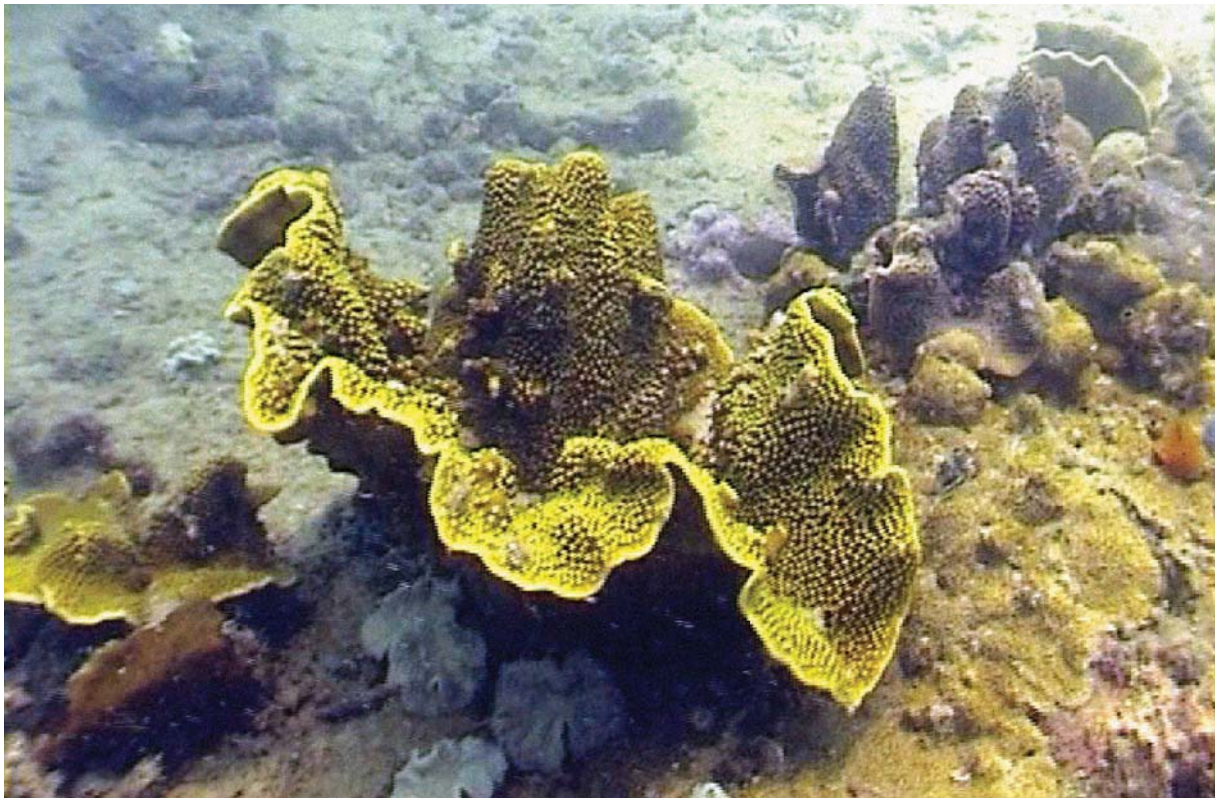
Biodiversity of hard corals in the Northern Territory is high. For example, 222 species have been found along the coast of Arnhem Land. In Darwin Harbour, there are 55 species of hard coral. Well developed coral reefs in the Harbour are confined to only four locations (Channel Island, Wickham Point, Weed Reef and South Shell Island) where relatively high water clarity, high currents and therefore low sedimentation rate create “refuges” where corals reefs can form.

Coral reefs are considered to be among the most sensitive ecosystems to long-term climate change, pollution, dredging and other environmental and anthropogenic factors. As a result, coral reef monitoring is also a central tool in a holistic strategy of assessment of the “health” condition of marine biota. For example, coral bleaching is a severe and widespread threat, which has caused substantial loss of shallow coral reefs worldwide. It is also the most damaging process among all known to impact coral reefs. In the Northern Territory coral bleaching usually occurs during the hottest months of the year (November-December), during the build-up period when the weather is still and hot with low cloud cover (leading to increased surface water temperature). However, the key risk to coral reefs is posed by elevated amounts of suspended sediment that can settle on coral reefs, for example as the result of extensive dredging programs proposed for Harbour developments. Turbidity is a major factor governing the coral reef extent and survival.

As part of enhanced monitoring in Darwin Harbour, NRETAS is in the process of establishing a monitoring program based on “live coral percent cover monitoring” (LCPCM), a technique recommended by the Global Coral Reef Monitoring Network (GCRMN). This technique estimates the area of live coral within each reef. Surveys will occur once a year, 1 to 4 months after the ‘build-up’ period.

Initially, this monitoring will be established and run by NRETAS staff in cooperation with Larrakia rangers. Eventually, after obtaining necessary skills, Larrakia rangers will take over running the field component of the coral reef monitoring in Darwin Harbour. Coral bleaching events and substantial changes in coral cover will be reported to the Global Coral Reef Monitoring Network (GCRMN).

Reef locations in Darwin Harbour.



Peacock Coral (Mycedium elephantotus) common over a wide range of habitats. This coral species is relatively tolerant to turbid water and elevated sedimentation. This is a photosynthetic stony coral, however, it will extend feeding tentacles at night catching zooplankton. Photo Victor Gomelyuk

A small coral community consisting of branching anemone Actinodendron plumosum or soft coral Litophyton sp. (white and yellow-white, close to the centre, at 6 o'clock and in left upper corner), centre – orange coloured soft coral Glomerate Tree Coral Dendrophthya sp. surrounded by branching colonies of hard coral Acropora sp. Acropora belongs to the most fast growing corals – growing up to 10 cm per year. Photo Victor Gomelyuk

Marine mammals

Carol Palmer, Department of Natural Resources, Environment, The Arts and Sport

Darwin Harbour is home to several species of marine mammals, including three types of dolphins (the Indo-Pacific bottlenose, Indo-Pacific humpback and the Australian snubfin), dugong, occasionally false-killer whales (which is actually a dolphin) and rarely seen larger whales (pilot, sperm, blue and humpback whales).

While none of the coastal dolphins and dugongs are listed as endangered in the Northern Territory, they are among the world's most threatened mammals, primarily because they live in areas that overlap directly with human activities. They occur in discrete and localised populations, and are not known to undertake migrations or large scale movements (like larger whales).

The Indo-Pacific humpback dolphin is the most commonly sighted dolphin in the harbour and is present all year round. At Vesteys and Casuarina beaches dugongs can be seen often, due to the large areas of seagrass for them to feed on.

Research on coastal dolphins in Darwin Harbour started in 2008 and was designed to reveal spatial and temporal patterns in habitat use within the Harbour and adjacent areas. The research uses photo-identification of the dolphin's dorsal fins to identify individual animals. Regular surveys are conducted to record the number of animals and take photos. This program has recently been expanded to include Bynoe Harbour and will increase the ability to detect changes in the populations and relate this to changes in the environment. To clarify the importance of Darwin and Bynoe Harbours to dugongs, an aerial survey will be undertaken to assess dugong populations in both harbours and to the Western Australian border.

Furthermore, dolphins are susceptible to pollutants in coastal waters that are influenced by agriculture and urban development. Pollutants can include persistent organic pollutants (POPs). These are compounds like pesticides and industrial chemicals which can accumulate in predators at the top of the food chain. Exposure to POPs in marine mammals can affect reproduction and immune suppression. In Australian waters, there is currently little information on the effects of pollutants on coastal dolphin species. Tissue samples are being collected as part of a research program in the Darwin Harbour region.

Dorsal fin of coastal dolphin in Darwin Harbour used for identification.

Mapping our marine habitats for sound planning, development and conservation

Tony Griffiths, Department of Natural Resources, Environment, The Arts and Sport

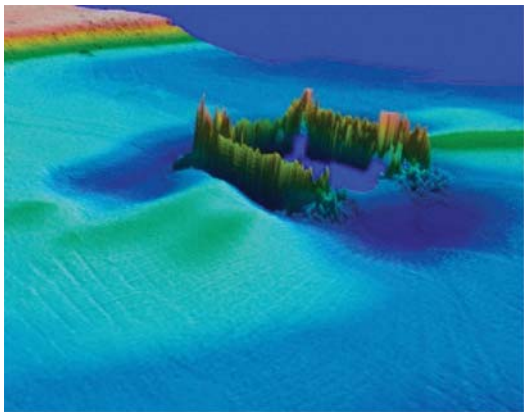
Darwin Harbour supports a diverse range of estuarine and marine habitats, including coral reefs, seagrass meadows and mudflats. However, many of these habitats are poorly described and mapped. This limits our ability to make good decisions on future development in the harbour. As part of enhanced monitoring of Darwin Harbour, the NT Government has provided additional funds to commence habitat mapping in Darwin Harbour.

The mapping of seafloor habitats has come along way thanks to advances in technology. There are three stages to mapping marine habitats: 1) bathymetry survey, 2) field sampling and 3) spatial modelling.

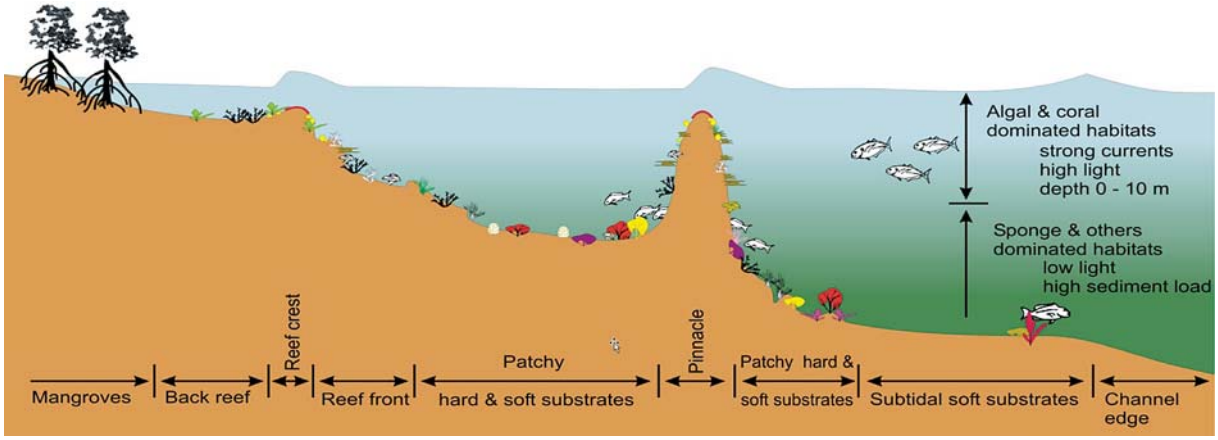
Bathymetric maps typically show seafloor relief or terrain as contour lines (called depth contours or isobaths). The data for bathymetric mapping is collected using multi-beam echo sounder mounted on a vessel which systematically surveys the sea floor. In collaboration with the Australian Institute of Marine Science, Geoscience Australia and the Darwin Port Corporation, a bathymetric survey has just been completed in Darwin Harbour. This represents the first complete survey of the harbour.

The second stage involves carrying out surveys of the actual seafloor to describe the type of sediment (e.g. rock, mud or sand) and the animals and plants that occur there. This is done using a range of techniques including grab samples, trawls and remote video cameras. Experts at the Museum and Art Gallery of the NT then identify samples.

The final stage is the analysis of the data to model the different habitats. This is typically done using Geographic Information Systems. Each of the different layers of information (water depth, substrate type, plants and animals) is modelled to identify the unique habitats. These can then be mapped and used by a whole range of people for different uses including environmental impact assessment and monitoring.



Multi-beam sonar image



Conceptualisation of geographic information layers and habitats.

A clearer picture of fish diversity in Darwin Harbour

Victor Gomelyuk, Department of Natural Resources, Environment, The Arts and Sport

Darwin Harbour includes 3,227 square kilometres of land and water and is one of the largest harbours in Australia. The diverse habitats of Darwin Harbour support very high fish diversity with 415 fish species now known from the Harbour. These range in size from large tiger sharks *Galeocerdo cuvieri* which commonly grow to a length of 3 to 4 m to tiny goby fish *Pandaka lidwilli* (maximum size 16 mm).

Darwin Harbour is undoubtedly the most important location for recreational fishing in the Northern Territory and more than 30% of all recreational fishing in the Territory takes place in Darwin Harbour, Shoal Bay and nearby areas. It is important therefore to protect biodiversity and maintain fish resources of the Harbour on a sustainable level so people can continue to enjoy good fishing and that recreational and cultural values are maintained.

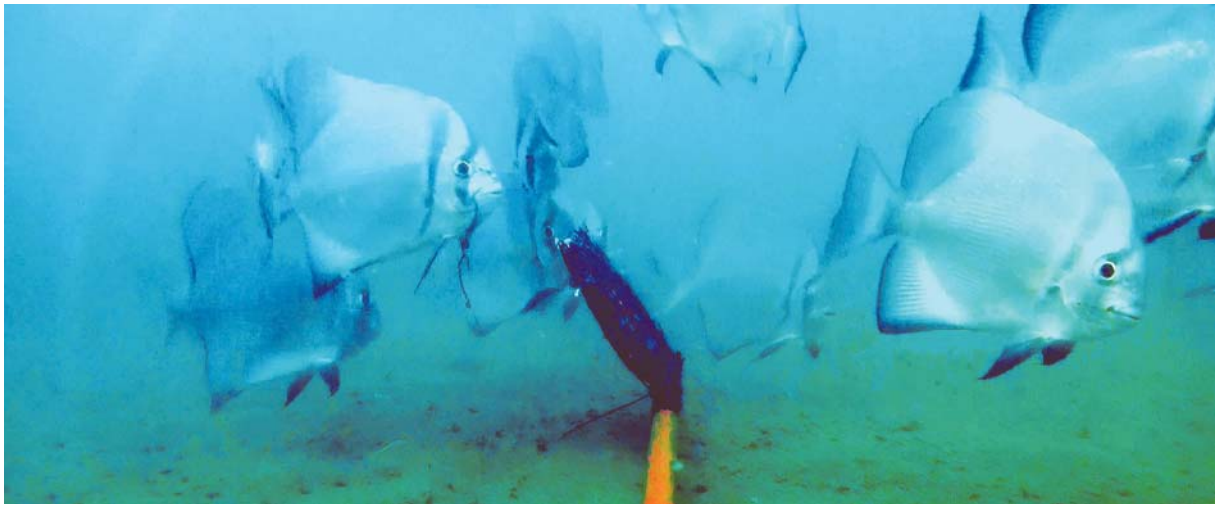
As part of an enhanced monitoring program in Darwin Harbour, a new fish survey and monitoring based on non-extractive, environmentally friendly remote underwater video survey method has been established. Researchers at Australian Institute of Marine Science (AIMS) have adapted video cameras in underwater housings made of PVC pipe. Combined with the canister of crushed pilchards to attract fish, this device called a Baited Remote Underwater Video Station (BRUVS) can capture the benefits of both underwater visual counts and trapping in surveys of bottom-dwelling fish. The BRUVS is robust and cheap enough to meet the high risk of loss due to snagging, shark attack and strong currents.

In order to get a clear picture of fish distribution and abundance in the Harbour, 14 sites representing wrecks, rocky and coral reefs in shallow (5-8 m) and deeper water (up to 20 m) were randomly allocated in different parts of the Harbour for “video fishing”.

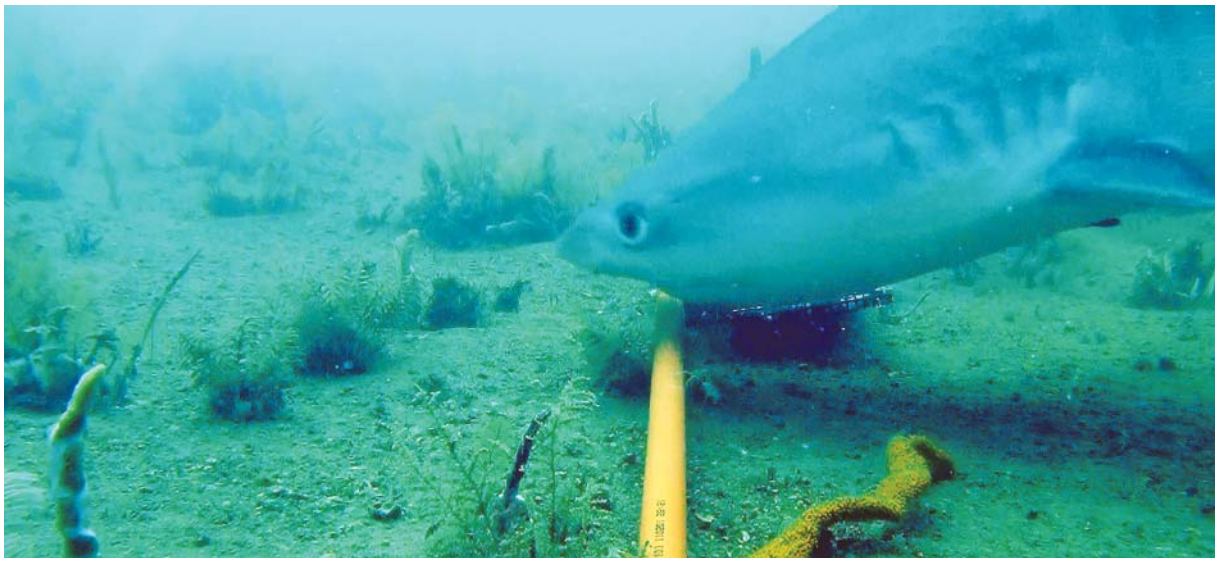
To complement the video camera surveys, Fisheries Research Unit (Department of Resources) will conduct surveys in mangrove creeks and other fish habitats where visibility is much lower.

BRUVS configuration for underwater video. Photo: Victor Gomelyuk.

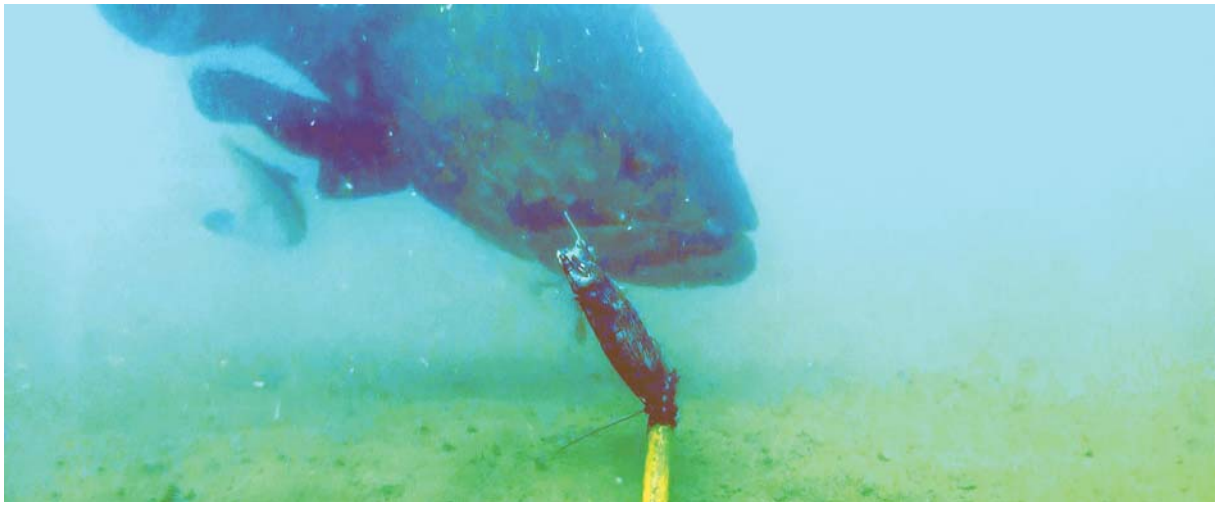
These ongoing surveys will provide data on fish biodiversity and community composition in different habitats. It will also provide an important factor for selecting sites and key aspects of fish communities for further Darwin Harbour biodiversity monitoring.



Batfish congregating around the baited canister



A young Tiger shark (Galeocerdo cuvieri) attracted to the baited canister



Giant Groper

Marine worms – indicators of environmental change

Chris Glasby, Museum and Art Gallery of the NT

Polychaetes, or bristle worms as they are sometimes called, are the most common annelids or marine worms in the sea. They are related to or (as recent phylogenetic studies suggest) probably include the earthworms and leeches. They range in size from microscopic forms that live between intertidal sand-grains to subtidal giants over a metre long. Almost every part of Darwin Harbour below the highest tide level is suitable polychaete habitat: about 70 species are known to live in the harsh mangrove mudflats, and perhaps 500 species live below the intertidal on soft muddy bottoms, rocky and coral reefs, seagrass beds, wrecks and wharf pylons; most species will spend a small portion of their early larval life in the water column. The exact numbers of species is uncertain, because many species are new to science and yet to be formally described. The polychaete fauna of Darwin Harbour appears to be similar to other macro-tidal coasts of northern Australia, particularly the Kimberley coast.

Polychaetes feed in many different ways – filter feeders, deposit (or sediment) feeders, carnivores etc – and many have short lifecycles and can quickly alter their abundance in response to changing environmental conditions. These features make polychaetes good indicators of environmental disturbance in marine benthic habitats. For example, in the pristine organic-rich mangrove muds of Darwin Harbour, researchers have found that herbivores (including detritus feeders) are the most species-rich and abundant, followed by carnivores and sub-surface deposit feeders; however, in disturbed mangrove areas subjected to increased erosion, a fourth group of feeders known as surface deposit feeders, become the most numerous. These faunal composition changes can happen quite quickly – before more noticeable, potentially catastrophic, habitat changes. The effects of disturbances on polychaete communities in deeper waters of Darwin Harbour are just beginning to be investigated.

Polychaetes are also an important part of the food chain. They are a favourite food for many fishes and wading birds including important migratory species. They are the major prey of the commercially important tiger prawns. Some polychaetes consume food items that we can be thankful for, for example species of nereidids, or ragworms, are known to consume larvae, such as biting midges (sandflies), and actively burrowing deposit-feeding polychaetes simultaneously aerate and cleanse the sediment by consuming organic matter and reducing nitrate and phosphate build up.

Not all polychaetes are beneficial. One group called Serpulidae, or fan worms as they are sometimes called, build calcareous tubes which they attach to hard substrates. Some species may become a nuisance when their larvae settle on the hulls of vessels and the insides of intake/outflow pipes where they can severely affect water flow. These fouling serpulid species provide habitat for other smaller invertebrates, which compound the problem. Examples from

Hydroides sanctaecrucis tubes. Photo: Chris Glasby

Darwin Harbour are *Hydroides sanctaecrucis*, a species now established in the Harbour that was introduced to ports and harbours of northern Australia from the Caribbean, and *Hydroides elegans*, a widespread circumtropical species. Fortunately, as a result of Darwin Harbour's strong seasonal influx of freshwater, populations of both species undergo periods of boom and bust, so neither species appears to reach plague proportions.

Documentation of the taxonomy and systematics of Darwin Harbour polychaetes is ongoing with the ultimate goal of providing a list of all species, their habitats and distributions. In addition, collaborative studies on the biology of ecologically important species are providing us with a better knowledge of our native marine invertebrate fauna, the ability to recognise introduced species, and the possibility of utilising particular species for our own benefit.

Hydroides santaecrucis found at Cullen Bay. Photo: Chris Glasby

Seagrass monitoring, Seagrass-Watch in Darwin Harbour

Neil Smit, Department of Natural Resources, Environment, The Arts and Sport

Seagrasses live in the coastal waters of most of the worlds' continents. They are the main diet of dugongs and green turtles and provide a habitat for many, smaller marine animals, some of which, like prawns and fish, are commercially important. They also absorb nutrients from coastal run-off and stabilise sediment, helping to keep the water clear. Up to as many as 10 species (or 14%) of the world's seagrass species are endangered due to coastal developments and habitat loss.

Seagrasses are unique amongst flowering plants, in that almost all of the 72 species can live entirely immersed in seawater. Seagrass meadows in Darwin Harbour are located off Casuarina and Vesteys Beaches and are dominated by two common species: *Halodule uninervis* and *Halodule pinifolia*. These are favourite food for dugongs and are why we often see these wonderful animals in the harbour.

Seagrass meadow distribution for Fannie Bay and Mindil beach areas.

As part of an enhanced monitoring program in Darwin Harbour, a new program is being established for seagrass. The program will join Seagrass-Watch, a global scientific, non-destructive, seagrass assessment and monitoring program. It was established in 1998 in Australia, and is now conducted at approximately 260 sites across 17 countries.

Seagrass-Watch aims to raise awareness on the condition and trend of near-shore seagrass ecosystems and involves collaboration and partnerships between community, qualified scientists and the data users.

Dugong (Dugong dugong). A frequent visitor to Darwin Harbour. Better knowledge of habitat use by dugongs and other species in the harbour is a priority area for future research to help protect them from habitat loss, boat strikes and pollution.

Other Projects and Monitoring

The Howard River Toadlet in the Darwin region

Peter Dostine, Department of Natural Resources, Environment, The Arts and Sport

The Darwin region of the Top End is home to more than twenty species of native frogs. Most of these species occur widely across northern Australia. While some of these species have colonised suburban landscapes, where ornamental fishponds and drain pipes provide adequate substitutes for habitat elements used for breeding and dry season refuge, most species are dependent on retention of native vegetation for survival.

The Howard River Toadlet is a small frog species belonging to the genus *Uperoleia*. It is relatively new to science, having been formally described as *Uperoleia daviesae* as recently as 2005. In contrast to most other frog species of the Darwin region, it has a restricted distribution and is confined to specific habitats within the hinterland of Darwin. It is classified as Vulnerable under NT legislation on the basis of its restricted distribution, the small number of individual sites where it is known to be present, and threats to its habitat. The Howard River Toadlet occurs within the catchments of the Howard and Elizabeth Rivers, including the catchment of Bennett Creek in the Weddell development area. Most known populations occur on seasonally-inundated sandy heaths on the Howard Sand Plains. These heaths also support populations of rare and endangered plant species.

The Howard River Toadlet is threatened by land clearing for mineral extraction, and suburban and agricultural expansion, as well as by recreational misuse of essential habitat. There are currently no explicit conservation measures in place for this species, although further surveys are being undertaken to better delineate the distribution of the species. Additional research on the ecology of the species will inform management guidelines for effective conservation.

The Howard River toadlet. Restricted to areas of sandy heath habitat in the Howard Sand Plains region and the Elizabeth River catchment. Photo: Ian Morris

Darwin beaches bacteriological assessment – sources and tracking

Karen Gibb, Charles Darwin University (CDU)

The closure of some Darwin beaches in 2010 and 2011 due to elevated *E. coli* and enterococci has caused community concern because of the perceived threat to human health. People want to know where the contamination is coming from and key concerns are that a) it might be human faecal contamination, and b) it might be coming from the waste treatment plants.

Until recently, *E. coli* and enterococci were the two indicators used to measure water quality in the NT. National Health and Medical Research Council recreational guidelines have recently been adopted and do not recommend the use of *E. coli* in marine systems and are no longer part of routine testing in the NT. A fundamental problem with conventional water quality tests is that the bacteria come from a variety of sources. As a consequence, even if the test is “positive”, we do not know either the source or whether the contamination is faecal and human.

There are several reasons why the conventional indicators are not always reliable indicators of faecal or human faecal contamination:

1. Many warm- and cold-blooded animals contain indicator bacteria in their faeces.
2. Diet affects the diversity of indicators so reliable patterns attributable to a particular host species are extremely difficult to obtain.
3. The popular indicators can grow naturally in the environment in habitats such as ponds, beach sand, soil and plant cavities. There is evidence that these strains have evolved as unique environmental strains.
4. Indicator bacteria are not well correlated with either pathogens or pathogen survival profiles.

Key Questions:

A collaborative project between Charles Darwin University, The Department of Natural Resources, Environment, The Arts and Sport, Department of Health, Darwin City Council and Power Water Corporation started in May 2011 to address key questions:

- Does the contamination on Darwin beaches include human faeces?
- What is the most likely source of the contamination?

Contamination may come from two different types of sources:

- A point source, such as a waste treatment plant; or
- A diffuse, intermittent and indirect route, or non-point source of contamination. This may include (1) faeces from humans and other animals (for instance, creeks contaminated by faeces from wildlife), (2) sites where detritus builds up and is flushed out in rain events or higher than usual tides, or (3) beach sediment that supports indicator bacteria that have adapted to life outside the host.

In June we sampled water and sediment at various sites along the in-shore catchment and beaches. We then extracted DNA from the water and sediment, and also from *E. coli* and enterococci cultures grown from these samples.

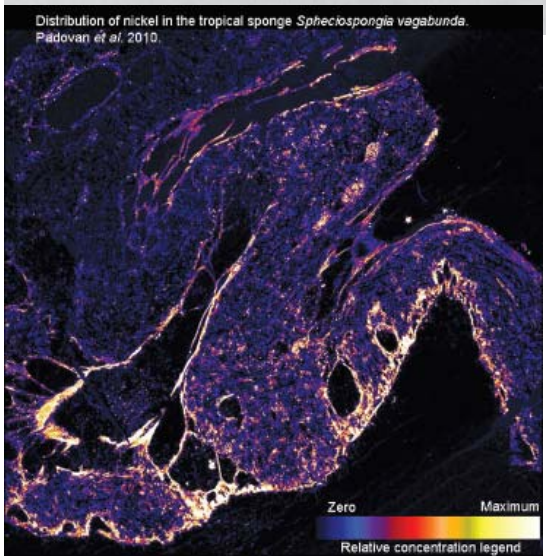
The next phase is to use genetic biomarkers to obtain a genetic fingerprint that will allow us to match similar sites. From this we will build a picture of sources of contamination. We will also use human faecal DNA markers to test for contamination in the same water and sediment samples. The findings of this project will help inform a Taskforce established to investigate sources of bacteria on beaches and development of actions to address these sources.

Researchers Anna Padovan and Julia Fortune sampling at the estuarine reaches of Rapid Creek.
Photo: Dion Lambrinidis

Elevated metals in the tropical sponge, *Spheciospongia vagabunda*, in Darwin Harbour

Anna Padovan (CDU/AIMS), Niels Munksgaard (CDU), Belinda Alvarez (MAGNT), David Parry (AIMS), Karen Gibb (CDU)

Sponges have been successfully used as biomonitors for pollution in marine environments. A study was initiated to analyse pollutant trace metals and other element concentrations in the sponge *Spheciospongia vagabunda* in relation to sewage effluent discharge in Darwin Harbour. To assess the impact of sewage effluent, sponges, sediment and seawater from several reference locations in Darwin Harbour (East Point, Stevens Rock, Channel Island, Larrakeyah shore), and directly at the Larrakeyah sewage outfall, were analysed for pollutant trace metals and other elements. Seawater from all reference locations showed little variation in the concentration of the elements measured: phosphorus (P), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd) and lead (Pb). The Larrakeyah point of sewage effluent discharge (diffuser) site had significantly higher concentrations than reference sites for all the elements listed above except cadmium. This effect was highly localised however at 400 metres from the diffuser, levels were characteristic of Darwin Harbour background seawater. Sediment at the diffuser site had elevated concentrations of P, Fe, Co, Ni, Cu, Zn, As and Pb.



Spheciospongia vagabunda specimens had element concentrations that were site specific and unrelated to the outfall. Of particular note were the high concentrations of iron (956-6620 ppm) and nickel (575-1670 ppm) found in the sponge tissue. Zinc (210-883 ppm), cadmium (13-111 ppm) and cobalt (65-156 ppm) were also present at high concentrations in the sampled individuals. Micron-scale x-ray imaging of *S. vagabunda* performed at the Australian Synchrotron (Melbourne) revealed similar distribution patterns of iron, nickel and zinc in the tissue, particularly around sponge water canals and the sponge surface. Researchers are currently investigating the role of zooxanthellae, symbiotic algae occurring in *S. vagabunda*, in the process of metal bioaccumulation.

Top: The symbiotic algae occurring in the sponge S. vagabunda. The role of this species in the bioaccumulation of metals in sponges is being investigated. Photo: Anna Padovan
Above: Micron-scale x-ray imaging of S. vagabunda showing metal distribution.

The Darwin Harbour Water Quality Protection Plan

John Drewry, Department of Natural Resources, Environment, The Arts and Sport

How we look after and manage the Harbour and catchment now and in the future will determine the water quality and ecosystem health. A project called the Darwin Harbour Water Quality Protection Plan (WQPP) is being undertaken that will provide recommendations to help maintain and protect water quality in Darwin Harbour.

The overall aim of the WQPP is to ensure that water quality objectives (local water quality guidelines) are maintained and that community's values for waterways are protected. Environmental goals that the WQPP can help to achieve include:

- Maintaining or improving water quality;
- Protecting or restoring marine and freshwater habitats;
- Protecting marine and freshwater biodiversity;
- Minimising algal blooms; and
- Minimising nutrients, sediment and other pollutants to waterways.

Protection of Darwin Harbour water quality has been identified as a high priority in the Darwin Harbour Strategy by the Darwin Harbour Advisory Committee. Key stakeholders are helping to develop the WQPP. Several key stakeholders, including government departments and non-government organisations will contribute directly to the plan as it develops. The draft WQPP and its recommendations will be available for public comment in early 2013.

What is the WQPP?

The WQPP is an action plan funded by the Australian Government, in collaboration with the NT Government, using agreed processes under the National Water Quality Management Strategy. Phase 1 of the WQPP included development and declaration of water quality objectives, Beneficial Uses, and development of monitoring activities. Phase 2 is the current project up to 2013. A key component will be recommending future management actions to be implemented with endorsement from key stakeholders to protect or improve water quality.

Some of the components include:

- Updating selected water quality objectives using new monitoring data;
- Development of an integrated decision support system for Darwin Harbour and catchment. This is described in more detail below;
- Recommending management actions (e.g. water sensitive urban design, WSUD) to be implemented and gain endorsement from key stakeholders;
- Identifying strategies for monitoring, modelling and reporting on the effectiveness of control actions;
- Identifying further research that needs to be undertaken as part of the monitoring and modelling strategy;
- Water quality monitoring by Larrakia sea rangers; and
- Identifying gaps in the legislation that should be addressed.

Integrated decision support system

An integrated decision support system (DSS) is being developed as part of the WQPP. It will help improve understanding of the effect of urban and catchment processes and large developments on water quality in both the catchment and Darwin Harbour. It will assist with achieving the objectives of the WQPP by evaluating water quality impacts, targets and management options to improve water quality in the region.

The DSS will combine both catchment and urban modelling and harbour water quality hydrodynamic modelling in a user-friendly interface format. The diagram shows how these different models are being combined into an integrated format and a user-friendly interface. To achieve this integration of results from separate complex models without the DSS would be very difficult and time consuming.

The DSS and many scenarios are being developed with the input of stakeholders. The DSS will help provide information to help answer questions such as:

- What quantity of pollutants come from the catchment?
- What effect would large developments such as Weddell have on water quality in parts of the Harbour?
- What could the effects of future scenarios be on water quality and what are the trade-offs? Scenarios include a base case, climate change scenarios, a ‘2030’ development scenario, effect of Weddell, water sensitive urban design options, and other potential impacts.
- What management action priorities would protect water quality, and to what extent? For example, actions include water sensitive urban design and riparian zone protection.
- Where should management actions be made, and how effective, and cost effective, will these management actions be?
- What water quality targets should be aimed for?
- Most importantly, what are the effects of the above management actions and scenarios on the Harbour water quality?

The DSS will be available to stakeholders to assist in answering the above questions. The DSS can facilitate education to allow stakeholders to use alternative scenarios and learn about the economic and environmental consequences of different actions. With a DSS a non-technical user can easily set up a new scenario and analyse its impacts. Training workshops and materials will be available in late 2012.

The DSS is being built by several leading science providers. Organisations include BMT WBM Pty Ltd, Equatica Pty Ltd, isNRM Pty Ltd, The Australian National University (ANU) and the Australian Institute of Marine Science (AIMS). The DSS development commenced in early 2011 and will be completed by late 2012.

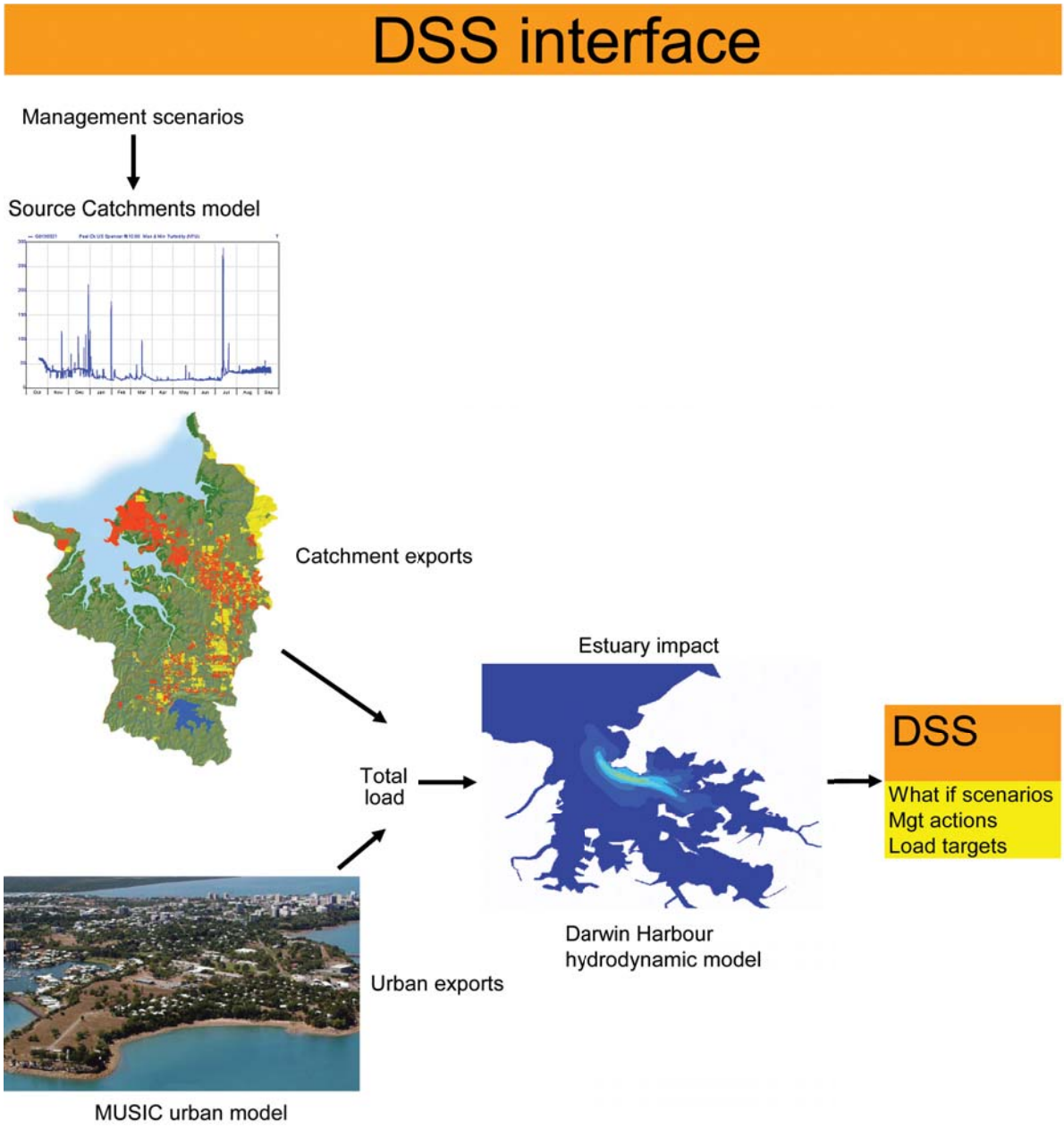


Diagram showing the main components of the WQPP decision support system: catchment, urban and harbour water quality modelling within an integrated framework and user-interface.

Water Sensitive Urban Design in the Northern Territory

Phill Piper, Department of Lands and Planning

Darwin Harbour is the receiving environment for all stormwater and wastewater discharges from Darwin and Palmerston. Recent research has identified that although the Harbour is considered to be in a good condition, the impacts of urban stormwater runoff and wastewater discharges are evident. As new development occurs in the region, there is potential for increasing environmental impacts on the Harbour[1].

Given these large development pressures facing the Darwin Region, and the potential impact this will have on the receiving environment within Darwin Harbour, the Northern Territory Government identified that a strategy was required for managing the impacts of urban development on the Harbour. Water Sensitive Urban Design (WSUD) is a new approach to development that takes a holistic approach to the planning and design of urban development that aims to minimise impacts on the natural water cycle and protect the health of aquatic ecosystems.

WSUD is a key requirement of the Australian Government's National Water Initiative and has been supported by funding in all states and territories, as well as through the Australian Government's Coastal Catchment Initiative (CCI) program. The former CCI, and now the Caring for our Country program, targets key priority coastal waterways, determined by conservation significance or the iconic value of a coastal jurisdiction, that are threatened by land based activities.

WSUD has been embedded into legislation as a requirement for new subdivisions in Queensland, NSW and Victoria, where is it widely supported by state and local governments, as well as developers.

Darwin Harbour has been identified as a priority coastal waterway, and in 2006, the Australian Government provided the NT Government (NRETAS) with $1million to prepare a Water Quality Protection Plan for Darwin Harbour. The first phase was completed in 2009. The second phase with separate funding commenced in 2011, and is reported on in another article in this publication.

To complement this, the Department of Planning and Infrastructure was awarded funding of $250,000 through the CCI program to develop a WSUD Strategy for Darwin Harbour. The Strategy included the following:

- A definition of WSUD, including a set of guiding principles
- Clear quantifiable objectives and enforceable targets
- WSUD policy
- Guidelines and tools for WSUD concept development, technical design, operation and maintenance
- Training programs
- WSUD showcase development

The Bellamack development was selected as the showcase development. It included both stormwater treatment systems to minimise pollution to Mitchell Creek and Darwin Harbour,

1. Current predictions for 2050 are that the Darwin Harbour region will experience strong population growth with an expected need for an additional 50,000 to 100,000 new dwellings by 2050.

as well as a recycled pipe network, also known as a “third-pipe” constructed throughout the subdivisional road network, which reduces the amount of potable water consumed. The third pipe is being initially supplied with bore-water to irrigate open space areas within the subdivision. However it has the potential to be plumbed to individual houses at some time in the future.

NRETAS is currently investigating the possibility of water quality monitoring of treatment systems constructed at Bellamack. Water quality monitoring will allow the Northern Territory Government to determine the effectiveness of the treatment systems at removing pollutants from local waterways and Darwin Harbour. The monitoring will also provide insights into the design of treatment systems in the Darwin region and contribute to improvements in design in the future.

The inclusion of WSUD into the NT Planning Scheme has not been completed at this stage. The main reason for this is because the scheme covers the whole of the NT and the CCI project could only be applied to the Greater Darwin region. A similar exercise for the arid centre (Alice Springs) to establish a different set of manuals, guidelines and fact sheets for this very different climatic condition is required before WSUD could be fully incorporated into the Scheme. The Kilgariff residential development in Alice Springs may offer an opportunity to complete some of this work.

WSUD has been proved to be cost-effective in new developments in southern states, and can address future water supply shortages as a result of population increases. Third pipe systems are now standard practice in sub-divisions throughout Australia. In Darwin reuse water could be used for irrigation, toilet and laundry in place of mains water from the Darwin River Dam.

WSUD is being applied to the Johnston (Palmerston) and Kilgariff (Alice Springs) subdivisions and a strategy for applications is being advanced for the new city of Weddell. The NT Government is also currently retrofitting the existing sediment and erosion control basins which drain the western suburbs of Palmerston. The basins have prevented large amounts of sediment from entering Mitchell Creek. The sediment collected in the basins is being removed before the basins are converted into bioretention basins to further improve quality of water discharging to Mitchell Creek and Darwin Harbour.

Johnston subdivision and WSUD treatments at the development stage. Photo: Phill Piper.

Co-ordinating monitoring and research programs in Darwin Harbour

Samantha Fox, Department of Natural Resources, Environment, The Arts and Sport

A number of organisations are monitoring the waterways of Darwin Harbour. For example, the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) is collecting information about water quality and marine biodiversity in Darwin Harbour. ConocoPhillips is monitoring mangroves around Wickham Point to make sure they are healthy and Power and Water Corporation is monitoring water quality near its sewage treatment plant outfalls. OZ Minerals and the Darwin Port Corporation are monitoring water and sediment near East Arm Wharf. The Department of Health, NRETAS and Darwin City Council are working together to check bacteria levels on Darwin Harbour beaches and at Lake Alexander to see whether they are safe for swimming. There is a lot of monitoring activity going on, though we do not always hear about it.

Research organisations, like Charles Darwin University and the Australian Institute of Marine Science, are also conducting research programs in the Harbour. This is to better understand how different plants and animals in Darwin Harbour interact with each other and their environment, and how this marine life is affected by pollution.

At the moment, these and many other monitoring and research programs are conducted separately in Darwin Harbour, with different organisations going out at different times to collect their data, using different methods, writing separate reports and publishing information on separate websites.

Undertaking mangrove surveillance and chemical monitoring at Wickham Point for ConocoPhillips Australia. Photo: Norman Scott (ConocoPhillips Australia).

In June 2010, the Darwin Harbour Advisory Committee and the Northern Territory Government agreed that an Integrated Monitoring and Research Program is needed to coordinate monitoring and research undertaken in the Harbour. A Darwin Harbour Integrated Monitoring and Research Program will help all organisations currently undertaking monitoring and research in Darwin Harbour to better understand the health of the Harbour by enabling these organisations to share their data and information. It will also provide the public and natural resource managers with an overview of Harbour health.

Several organisations have lent their support to the Program, including NRETAS, Power and Water Corporation, Darwin Port Corporation, the Department of Health, Department of Defence, ConocoPhillips, OZ Minerals, INPEX, Darwin City Council, the Australian Institute of Marine Science and Charles Darwin University.

These organisations have formed an Interim Management Committee to manage the Program and NRETAS has provided some people for a Program Design Team to design and develop the Program. It is expected that the Program will be designed and up and running by December 2012.

Darwin Harbour Clean-Up 2011

Lyn Lambeth, SeaNet Officer, OceanWatch Australia

Around 90 volunteers and workers from government, non-government and private agencies collected just over a tonne of general rubbish from Darwin Harbour's coastlines and waters in the second year of the Darwin Harbour Clean-Up on 5 July 2011.

The concept for the clean-up day came from commercial fishers who collect rubbish, including lost or discarded foreign fishing nets, as a part of their daily activities. Working and living on the sea, they are confronted regularly with the negative consequences of rubbish in the sea – including threats to marine life and bird life, the hazards to boating posed by foreign fishing gear and plastics, and seeing formerly pristine, remote beaches now looking more like rubbish dumps.

The clean-up day is a way of bringing together a diverse range of stakeholders to remove rubbish from the Harbour, and its mangroves and coastline. It also helps identify "hotspots" to help with some targeted education and prevention.

The weight of rubbish collected this year was down on last year, which was to be expected given that last year was the first Darwin Harbour Clean-up. The two and a half tonnes collected in 2010 would have included years of accumulated rubbish in some areas, including some very heavy items around Fishermen's Wharf.

As well as the tonne of general rubbish collected by boats and land crews, the Darwin Port Corporation removed an extra 1.6 tonnes of old metal from the water around Fishermen's Wharf.

Eight boats with crews from 5 to 10 people, including several Parks and Wildlife Junior Rangers, cleaned up the mangroves and water between Stokes Hill Wharf and Hudson Creek, while 6 land-based crews cleaned up hotspots around Darwin and over on Cox Peninsula.

For the first time, divers organised by the Museum and Art Gallery of the Northern Territory searched Lake Alexander at East Point Reserve for rubbish and debris. Whilst the dive crew reported back that the bottom of Lake Alexander was free of rubbish, land-based volunteers collected bags of common rubbish around the lake.

Items found in Darwin Harbour waters and around the coast included:

- 8 tyres;
- several chairs;
- 150 metres of fishing line;
- 4500 plastic bags;
- 5200 aluminium cans;
- 1700 plastic drink bottles;
- 1900 pieces of cardboard (mainly fireworks); and
- 63 thongs.

The number of aluminium cans was down on last year's tally of 7600, while the number of plastic bottles remained more or less the same. There were no intact shopping trolleys recovered this year, compared to the 17 collected in 2010.

While there was a drop in the overall weight of rubbish collected this year, the data showed that numbers of items such as aluminium cans and plastic bottles were more or less the same in most hotspots. The main hotspots are from Mandorah Beach Hotel to West Point on Cox Peninsula (aluminium cans), Sadgroves Creek to Hudson Creek, including Fishermen's Wharf (plastic bottles, plastic bags, glass bottles, aluminium cans), and Coconut Grove to Ludmilla Creek (plastic bottles, plastic bags, glass bottles, aluminium cans).

Fireworks, counted as paper/cardboard, were found in high numbers at West Point (Cox Peninsula), Rapid Creek, Coconut Grove and Lake Alexander. The concern with fireworks casings entering our waters is that most of them contain an inner cylinder of hard plastic, or have a hard plastic base or rocket tail.

The 2011 Darwin Harbour Clean-up is organised by the Northern Territory Seafood Council and OceanWatch Australia's SeaNet Program through funding from the Australian Government's Caring for our Country initiative and Territory Natural Resource Management's Coastcare Program.

Volunteers collected over a tonne of rubbish at the 2011 Darwin Harbour clean up day

Monitoring the water quality of Darwin region lagoons

Julia Schult, Department of Natural Resources, Environment, The Arts and Sport

Small freshwater wetlands are a feature of the Darwin region with more than 130 of these lagoons found in the wider Darwin area. Lagoons range in size from under 1 ha to over 100 ha. Many of these wetlands dry out in the later part of the dry season but some remain as permanent water bodies throughout the year. An impermeable layer of mud and clay at the bottom of the wetland prevents the loss of water to the ground below, so that the lagoons become “perched” above the groundwater water table.

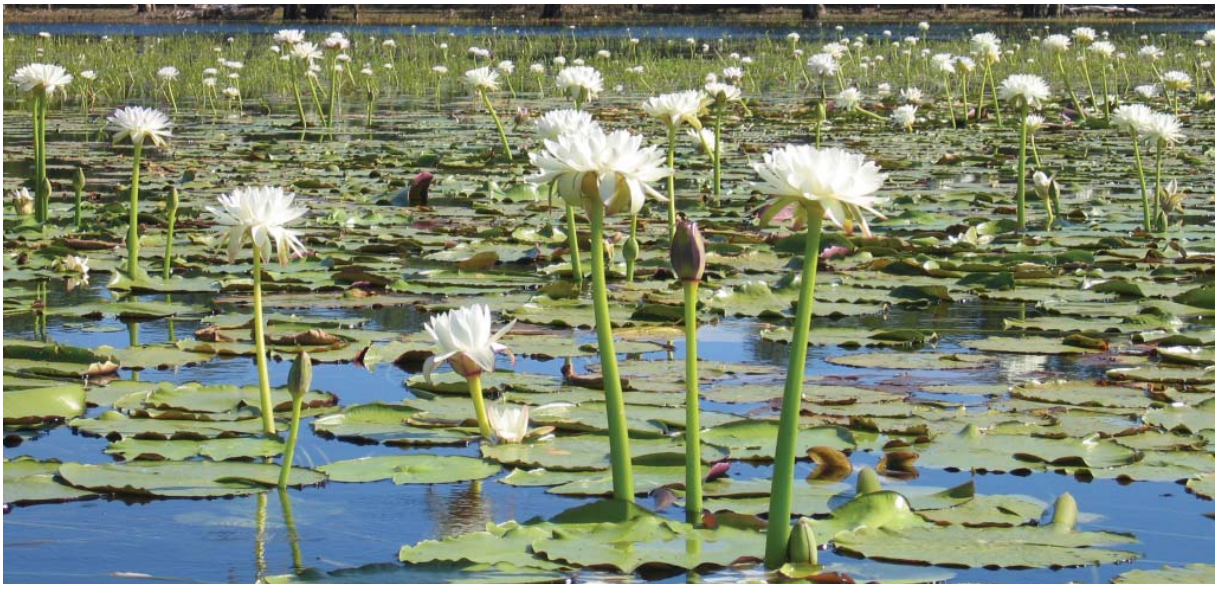
The lagoons are home to frogs, fish, turtles and other aquatic animals, as well as many plants. They attract large numbers of water birds in the dry season when the more permanent lagoons become refuges in a dry landscape. Indigenous people use the lagoons to hunt for food and undertake traditional activities. These landscape features can reduce the amount of sediment and nutrients entering Darwin Harbour by capturing and storing pollutants.

Lagoons in urban and rural Darwin are also valued as recreational areas. Some are protected in public reserves, e.g. Knuckey’s and McMinn’s Lagoon, and managed by local councils and Landcare groups, others are on crown land or within private properties.

Several projects have monitored the water quality of about 10 lagoons in the Darwin region in the last five years. This information can be used to see whether the lagoons’ water quality is changing with increased development, and gain an understanding of the effects of seasonal changes on the lagoons.

In 2010/11 a joint project was initiated between the Aquatic Health Unit of NRETAS and Conservation Volunteers Australia (CVA) to carry out monthly water quality monitoring of seven lagoons. The project has given local and international volunteers the opportunity to get a better appreciation of the beauty and importance of these wetlands, while contributing to their protection in the future.

McMinn’s Lagoon in the heart of Humpty Doo is one of the lagoons monitored by Conservation Volunteers Australia in 2010–11. Rural residents value the lagoon for its beauty and tranquillity. Photo: Barry Ledwidge



Water lilies (Nymphaea violacea). Water lilies are a feature of many freshwater lagoons in the wet season. Photo: Gisela Lamche

Sampling equipment and training was provided by the Aquatic Health Unit with CVA volunteers collecting samples for chemical analysis and measuring water quality and water levels on site. The indicators measured included nutrient and sediment concentrations, pH, turbidity and oxygen levels.

Increasing development in the rural area puts pressure on many of these wetlands, as they are surrounded by new subdivisions and increased density of residential properties. Increased nutrient and sediment inputs are the most likely impact from rural development, though to date the water quality of the few lagoons that have been monitored have not changed appreciably over recent years. It is important to know the natural water quality of the lagoons to allow us to detect any impacts in the future.

The information collected during this project will be used to develop water quality guidelines for freshwater lagoons. To protect these beautiful wetland refuges in Darwin's rural region, we also need to know about the animal and plants in the lagoons. One of the biggest threats to the lagoons are introduced plants and fish, which people can spread without realising their detrimental ecological effects.

Volunteers are being instructed by their team leader on how to accurately measure water levels. Photo: Barry Ledwidge

www.**greening**nt.nt.gov.au