

Briefing on the Research Voyage of the RV *Southern Surveyor* SS 03/2005 (February 2005)

Title

Effects of trawling on the benthos and biodiversity of the Northern Prawn Fishery.

*A collaborative research voyage between
Geosciences Australia, the National Ocean Office and CSIRO Marine Research*

Itinerary

Depart: Cairns, 10:00a.m., Wednesday, 23 February 2005 **Arrive:** Weipa, 10:00a.m. Monday, 21 March 2005

Investigators

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Background & Rationale

A comprehensive benthic survey of the south-western Gulf of Carpentaria will be completed in February–March 2005. CSIRO Marine Research (CMR), Geoscience Australia (GA) and the National Oceans Office (NOO) are chartering the National Facility RV *Southern Surveyor* for a total of 50 days of research-at-sea in the Gulf of Carpentaria with a value of ~\$3 millions. Two research voyages will be conducted—one focussed in the fishing grounds of the south-west of the Gulf for a total of 27.5 days, and another for 22.5 days, led by Geoscience Australia (coded SS04/2005), focussed on hard bottom habitats offering an opportunity for complementary sampling on deep water reefs and untrawlable grounds never assessed before.

The research voyage to the south-western Gulf of Carpentaria (SS03/2005) it is expected to deliver a fundamental knowledge base and management tools following on a two-pronged approach (a) by gaining understanding of key benthic features and ecological processes that drive the benthic ecosystem functioning under a range of fishing intensities in four major environmental regions of the Gulf of Carpentaria and (b). by integrating these knowledge into models, tools and management advice that will support the environmental sustainability of the Northern Prawn Fisheries and will contribute to the regional planing and conservation processes in the Northern Planing Area. Specifically, it will provide knowledge of and tools for evaluating benthic habitats and communities and lead to strategies for managing the effects of prawn trawling. It will extend our understanding of the effects of trawling by quantifying the accumulated, broad scale (beyond the trawl track) effects of multiple years of trawling by commercial fishers. Management strategy evaluation (MSE) tools based on the new information will be used to compare alternative spatial management scenarios and enable environmental sustainability objectives to be combined with stock and economic objectives in NPF management systems.

The effects of fishing on the environment (benthic habitats and communities) and non-target species (bycatch and byproduct) must be managed to ensure that fishing is sustainable into the future. Since the early 1990s, there has been significant research in the Northern Prawn Fishery on the bycatch from trawls (e.g. FRDC 1993/179) and how to reduce the bycatch through the introduction of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) (e.g. FRDC 1996/257, 1998/202, 2000/173, 2002/035). However, relatively little is known about the effects of fishing on the benthic habitats, communities and key ecological processes of the NPF.

The first study to address this important area was a desktop evaluation of historical environmental and biological data (Surrogates I, FRDC 2000/160) to try to identify environmental surrogates that could be used to characterise the environmental impact of prawn trawling in the NPF. This study, which relied mostly on benthic community sampling from prawn trawls, was only able to identify weak surrogates to characterise the benthic community because of the lack of simultaneous, integrated and dedicated sampling to characterise the benthic habitats of the fishery. It also highlighted significant gaps in the information for the NPF (e.g. shallow water habitats and regions outside of the Gulf of Carpentaria, i.e. west of Cape Arnhem).

Currently, CSIRO is looking at the effects of trawling on the benthos of the NPF (FRDC 2002/102), but has been restricted to a small-scale, experimental trawl knock-down and recovery experiment over a 3-year period. The major field work component of that project to characterise the benthic communities in the NPF, though seen as a high priority by NORMAC, was deleted from the project because of funding constraints.

The SS03/2005 research voyage builds and expands on this current and historical work in several important ways:

- It will be the first survey to characterise the benthic community and key ecosystem processes in trawled and untrawled areas of the Gulf of Carpentaria using a wide array of sampling equipment simultaneously on the *RV Southern Surveyor*. The survey will provide data with dramatically more power to quantify trawling effects than existing data for two reasons. First, all taxa, rather than specific taxa such as prawns, will be assessed. Second, biological, geological and physical data will be sampled simultaneously at each site, and will therefore not have the spatial and temporal variation that data are combined from different cruises, often over several years.
- It will be the first attempt to quantify the broad scale effects of commercial fishing, which differ from the effects seen in knock-down experiments. The changes observed in a knock-down experiment (a 'pulse event') are those caused by the direct effects of a single trawl event, whereas the changes observed after years of commercial trawling (a 'press' event) are those caused by accumulated effects and indirect effects of trophic interactions etc. We will design a natural experiment to test for the press effects of trawling using historical and current patterns of trawl intensity and frequency.
- By surveying the above in four different geo-chemo-physical environments of the Gulf of Carpentaria stratified according to different fisheries intensities we will be able to contribute with sound information baseline of benthic biodiversity and productivity and functioning process that will support the bioregionalization and conservation processes of the NPA. Undertaken by DEH and NOO. In turn, the resulting survey strategy will provide the foundation for the development of a larger exploration and characterisation of or northern Australia's marine ecosystems

Scientific objectives

The survey will provide data for the development of knowledge and tools for managing the effects of prawn trawling on the benthic ecosystems and communities of the Northern Prawn Fishery and to contribute to regional planning and conservation management. It will characterise the benthic communities and key ecosystem processes in four major environmental regions ranging from trawled to untrawled areas of the Gulf of Carpentaria using a wide array of sampling equipment simultaneously on the *RV Southern Surveyor*. It will quantify the broadscale, accumulated effects of commercial fishing, which differ from the direct effects, observed in previous knock-down experiments, which measured the direct effects of single trawling events.

Voyage objectives

The research voyage SS03/2005 has 4 major objectives:

1. Determine the spatial and temporal patterns of trawling across the NPF,
2. Describe the relationship between trawling intensity and frequency and benthic community composition,
3. Assess key benthic ecosystem processes (e.g. productivity, food web) of importance to prawn production and biodiversity along a trawl intensity gradient, and
4. Contribute to the development of an environmental management system for the NPF.
5. Contribute to the processes of bioregionalisation and marine conservation in the NPA.

The survey design is a 'natural experiment' (an existing human-induced ecological phenomenon –i.e. an historical and spatial-explicit benthos subjected to trawl disturbance gradient), to test the effects of trawling on benthic biota and key ecosystem processes. There will be ~ 120-150 sampling stations. Equal numbers of stations will be sampled during day and night. The stations will be distributed among trawling intensity strata within two or three soft-bottom benthic key habitat types. At each sampling station we will (a) sample benthic biota with a prawn net and epibenthic sled, (b) collect surface sediment box core and grab samples, (c) collect water samples, (d) deploy an underwater video camera system, (e) measure water properties with a CTD/turbidity meter, and (f) measure water and sediment flux with a current meter instrument frame.

Planned Outcomes

1. Provides advice on likely environmental targets through an integrated ecosystem-based management strategy system needed for spatially explicit environmental management in the Northern Prawn Fishery. A key ingredient to this system is linking spatial data and process information on benthic ecosystems to the NPF non-spatial management methods developed for target and economic management strategies.
2. Enhances risk assessments for benthic habitats, invertebrates and fish in the NPF through the provision of quantitative data on these variables along a gradient of trawling intensity. This will highlight key habitats and species that are at risk through trawling.
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4. Provides the basis for developing reference points and performance indicators to model and monitor the likely consequences of management actions on the benthic environment.
5. Provides estimates of spatial variation in benthic communities, its biodiversity and key ecological processes to enable more cost-effective sampling of these systems in the future.
6. Provides an integrated information system (across target, byproduct, bycatch and benthos) for the south-western Gulf of Carpentaria, including data on acoustics, geomorphology, sediments, benthic biota and physical and ecological processes.
7. Provide baseline information to support the bioregionalisation of the NPA by mapping and assessing benthic biodiversity on several of the large IMCRA regions of the Gulf of Carpentaria.
8. Support the conservation processes intended for the NPA, in particular the National Representative System of Marine Protected Areas

Major areas of surveying.

The research voyage of *RV Southern Surveyor* (SS 03/2005) will focus the survey in the south-western regions of the Gulf of Carpentaria. We will repeat the natural experiment in four sampling regions that correspond to four separate geo-chemo-physical environments. This number was chosen to balance the generality and the power of the analysis: a larger number of regions would give us more information about how trawling impacts vary among habitats. We believe that it will however decrease the power of predictive tools for assessing the impact of trawling in the benthos, whereas a smaller number of regions surveyed at higher sampling density would increase the power of our analysis and therefore our confidence in being able to detect and predict the trawling impacts in each region.

The sampling regions were chosen with a combination of statistical analysis and knowledge of field biologists familiar with the NPF trawling grounds. For the experimental design, the sampling regions needed to (a) have relatively uniform environmental conditions and (b) contain areas of nil to low and high trawling intensities. Proximity to or overlap with Geoscience Australia sampling sites was also desirable to enable collection of comparable soft and hard bottom data. Areas with relatively uniform environmental conditions were identified by classification and ordination of benthic environmental variables (depth, bottom current stress indices, sediment attributes, temperature, salinity, nutrients, chlorophyll and turbidity). Mixture model classification was used to classify the trawling grounds into several environmental regions, and principal components analysis and box plots were used to check the classified regions for environmental uniformity and to characterise the environment of each region (e.g. muddy, warm, low bottom stress, etc.).

Within each sampling environmental region, sampling sites were evenly distributed among according to two fishing intensity strata—zero and high. Only two fishing strata will be sampled to maximise the power of the survey to detect trawling impacts in this highly variable environment. Sampling sites were selected on a 1-nm grid. Fishing intensity and frequency was estimated from AFMA's Vessel Monitoring System (VMS) data for 1999–2003. Zero fishing grid cells were defined as those that were trawled for an average of less than 1 hour per year (h y^{-1}). High fishing intensity cells were trawled an average of at least 24 h y^{-1} and for at least 6 h in 4 of the 5 years, including the last year (2003). The zero fishing stratum used a 1 h y^{-1} cut-off rather than a 0-h cut-off because it is more important for the zero fishing sites to be environmentally similar to the high fishing sites than to have really never been fished. The swept area of 1 h y^{-1} of trawling is about 5% of a grid cell. The selection of sampling sites within the fishing strata was random, but modified to consider steaming time, fishers' untrawled ground maps and records of previous successful research trawls.

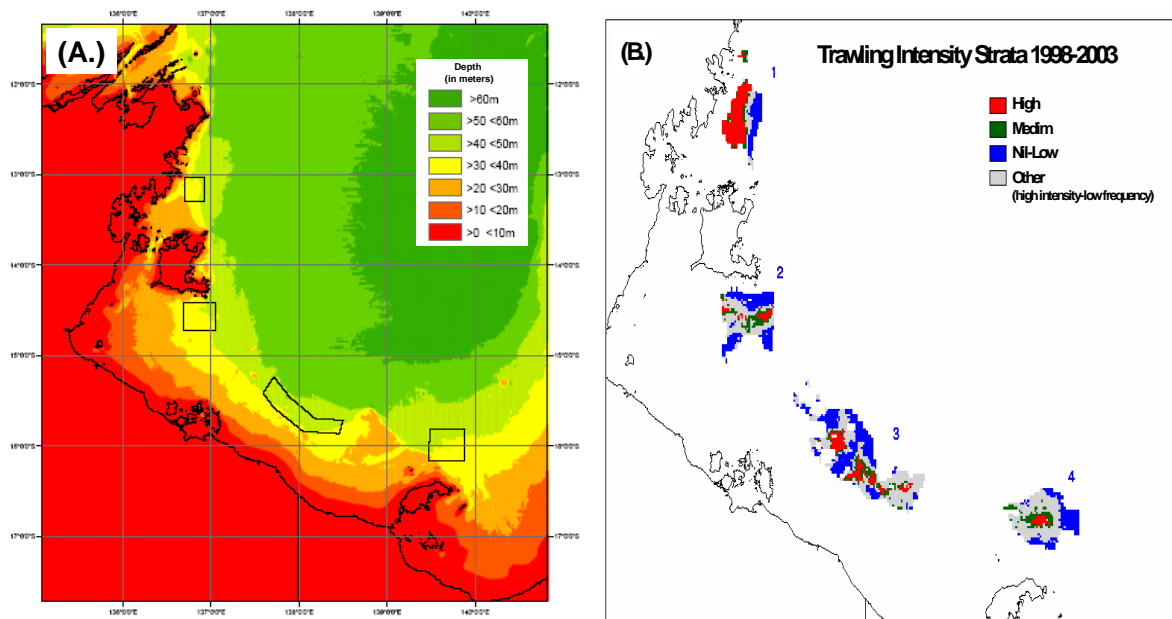


Figure 1. (A.) Four areas of different geo-chemo-physical environments and bathymetry. (B.) Overall trawl intensities to be surveyed for all 4 environmental regions of the Gulf of Carpentaria.

Southern Surveyor equipment

- Echo sounder
- Conductivity, temperature, depth (CTD)
- Transmissometer
- Acoustic Doppler Current Profiler (ADCP)
- Smith-McIntyre sediment grab

User equipment

- Benthic sled (1.5 m)
- Prawn sampling net (12-fathom banana prawn net)
- Box core
- Smith-Mac sediment grab
- Rock dredge (from Geoscience Australia)
- Towed video
- Mini ROV
- On-board digital photo system

Personnel list

Name	Organisation	Role
Peter Rothlisberg	CMR	Chief Scientist
Rodrigo Bustamante	CMR	Principal Investigator
Michelle Burford	Griffith University	Algal physiologist, process ecologist
Vicki Passlow	Geoscience Australia	Paleo-Sedimentologist
Alix Post	Geoscience Australia	Paleo-Sedimentologist
John Salini	CMR	Fish Biologist
Ted Wassenburg	CMR	Invertebrate Biologist
Tom Okey	CMR	Benthic Ecologist
Wayne Rochester	CMR	Numerical Ecologist
Gary Fry	CMR	Fish Biologist
Mark Tonks	CMR	Fish Biologist
Pamela Brodie	CMR – National Facility	Voyage manager/Computing
Lindsay MacDonald	CMR – National Facility	Electronics Support
Neal Johnston	CMR – National Facility	Hydrochemistry Support

