Strategic Research Fund for the Marine Environment (SRFME)

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volume **one**

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CHAPTER 5

5. SRFME CORE PROJECTS

Following are concise summaries of the scientific outcomes of the three Core SRFME projects: Biophysical Oceanography off Western Australia, Coastal Ecosystems and Biodiversity, and Integrated Modelling. The comprehensive details of the Core projects can be found in Volume Two of this SRFME Final Report.

5.1 Concise Summaries of SRFME CORE Projects

5.1.1 Biophysical Oceanography off Western Australia

Biophysical Oceanography off Western Australia: Biological Communities, Pattern, Process, and Ecosystem Dynamics across the Continental Shelf and Slope

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Executive summary

A significant aim of SRFME was to characterize the continental shelf/slope pelagic ecosystem off southwestern WA: to describe the plankton communities and their dominant patterns of spatial and temporal variability, to assess the physical, chemical and biological processes driving this variability, and to collaborate with the other SRFME projects to develop a quantitative, integrated understanding of the biogeochemical and ecosystem dynamics. To achieve this, we undertook monthly sampling from 2002 – 2004 along an onshore-offshore transect off Two Rocks from nearshore to the outer continental shelf (100 m water depth), which we extended quarterly to offshore waters (1000 m depth). Cruise sampling was combined with satellite observations of sea-surface temperature (SST), ocean colour and altimetry, and subsurface measurements of currents and temperature from moorings. The program involved six core research components:

1) The physical structure and nutrient dynamics within the water column

2) Phytoplankton community composition, biomass and productivity

3) Microzooplankton communities and their grazing dynamics

4) Mesozooplankton communities and their grazing dynamics

5) Ichthyoplankton community composition and ecology

6) Spatial structure of zooplankton and micronekton communities

Standard sampling protocols included: meteorological (wind, air temperature) observations from coastal stations; vertical CTD (conductivity-temperature-depth) casts with concurrent measurement of in situ fluorescence, dissolved oxygen and subsurface irradiance; discrete water column samples for analysis of salinity, dissolved nutrients (nitrate+nitrite, ammonium, phosphate and silicate), chlorophyll a, HPLC pigments, particulate organic carbon, phytoplankton and microzooplankton species composition and abundance, primary production, and microzooplankton grazing; bongo net samples for mesozooplankton biomass, species composition, grazing rates and secondary production; low-frequency acoustic transects, and high-frequency acoustic vertical profiles in combination with targeted water column zooplankton sampling.

Summer conditions on the shelf and offshore were oligotrophic, characterized by a shallow upper mixed layer, with a strong thermocline and well stratified water column. Surface waters were nitrate-depleted and generally contained low phytoplankton biomass levels (< 0.2 mg m-3), overlying a deep chlorophyll maximum (DCM) layer located between the 0.1% and 1.0% light levels. The DCM was frequently associated with a deep nitracline (100 m water depth). In contrast, in late autumn and winter, the upper mixed layer deepened and stratification weakened, leading to shoaling of the nitracline and DCM. Except for the lagoon environment, where no clear seasonal cycle was observed, phytoplankton biomass integrated through the water column was generally twice as high from April – September as in the spring and summer (October – February). Satellite observations indicate that the late autumn/early winter bloom over the shelf and slope is a coherent feature from approximately the Abrolhos Islands to Cape Leeuwin and coincides with the seasonal intensification of the Leeuwin Current. This leads us to hypothesize that the enhanced meander and eddy activity along the shelf break may spin-up nutrients, which are then exchanged across the shelf. Alternatively the intensified Leeuwin may entrain nutrients in the north, where the nutricline is shallower, and advect them southward. The seasonal breakdown in stratification may also facilitate vertical convective mixing of nutrients into the euphotic zone. These nutrients could have regenerated within the water column below the nutricline in deeper water or within the sediments on the continental shelf and exchanged with the overlying water column. These hypotheses remain to be tested.

Phytoplankton biomass and production integrated over the water column were generally several-fold higher offshore, although maximum volumetric chlorophyll concentrations were observed inshore. Integrated chlorophyll concentrations on the shelf and offshore generally ranged from 20 – 40 mg chl a m-2, compared to 5 – 15 mg chl a m-2 inshore. This difference was considerably reduced in spring and summer, because the seasonal cycle was less clear in the lagoon environment. Annual phytoplankton production over the study period was 46 g C.m-2.yr-1 inshore and about 115 g C.m-2.yr-1 on the shelf and offshore—relatively oligotrophic for a coastal environment. Not unexpectedly, given the nutrient depleted conditions generally observed in the euphotic zone, biomass and production were far greater in the small phytoplankton size fraction (< 5 um): the median percentage of biomass and primary productivity in the small size fraction was 5 and 12%, respectively. Based on analysis of HPLC pigments, distinct phytoplankton assemblages were observed on the inner shelf and further offshore, and between summer and winter. The outer shelf and offshore stations were characterised by high prochlorophyte and unicellular cyanobacteria populations. Small flagellates were most prevalent on the shelf, and periodic blooms of larger diatoms dominated inshore waters. Small haptophytes were ubiquitous.

Zooplankton biomass was also generally greatest in late autumn and winter. The assemblages differed significantly in nearshore and shelf/offshore waters and between winter and other seasons, following patterns among species groups observed elsewhere in coastal waters. Diversity was generally higher on the shelf and offshore than inshore.

The grazing of mesozooplankton was examined using a modified experimental and analytical design, which enabled the impact on both the microzooplankton and phytoplankton to be examined using a single set of experiments. Their direct grazing impact on the phytoplankton was generally low, but their impact on the microzooplankton increased with distance offshore. Increased densities of mesozooplankton grazed down an increasing proportion of the microzooplankton secondary production, which led to a decrease in the proportion of primary production grazed — a trophic cascade observed in our experimental chambers, as least.

Experiments were carried out to assess zooplankton secondary production based on copepod egg production, and the results were compared with a new enzyme assay and simple models based primarily on body size and temperature, which assume that production is not food-limited. The results of the copepod egg production method were generally lower, a possible indication of food limitation in our region. Levels of copepod egg production (0.4 – 10 mg C m-2 d-1) were comparable to levels observed in the North West Cape region but were considerably lower than the levels reported from more productive shelf regions in the world ocean. No significant relationships were found between secondary production based on the enzyme or copepod egg production methods and either total or large phytoplankton primary production.

Acoustics was used to examine the distribution of mesozooplankton (copepod-sized organisms) vertically through the water column using TAPS, an instrument with 6 frequencies from 256 kHz – 3 mHz, whereas larger macrozooplankton (e.g. krill) and micronekton (e.g. small fish) were acoustically sampled along the onshore-offshore transect during quarterly cruises with a three-frequency (70, 120 and 200 kHz) acoustic system. A pump sampler was deployed in conjunction with TAPS. Initial results indicate a good relationship between copepod abundance and acoustic backscatter at the higher frequencies (> 420 kHz). The regression relationships show that the instrument is limited by its signal-to-noise ratio, due to the relatively low abundance of zooplankton in WA waters.

Principal component analysis was used to examine spatial and seasonal patterns in the cross-shelf distribution of acoustic backscattering at lower frequencies (70 - 200 kHz) integrated through the water column. Two patterns explained 50% of the variance in the data from 8 cruises. The first component (31% of variance explained) was based on a pattern of very high inshore biomass in the autumn with the opposite being found in winter. The second component identified a summer pattern in which the highest acoustic backscattering was found in the inner shelf in summer.

Mixing frequencies appears promising as a means to separate major groups, and to assess relationships between topography and water mass features and the broad-scale distribution of large zooplankton and nekton. Non-gas bladdered organisms (e.g. euphausiids) have particularly high reflectivity at 200 kHz, so it is possible to distinguish a layer of krill from a layer of, say, small fish. However further ground-truthing is still required to assess these relationships.

The project also integrates two postgraduate projects that characterized the microzooplankton and ichthyoplankton assemblages in the region, as well as the role of microzooplankton grazing. Particularly clear onshore-offshore and seasonal assemblages were seen in the ichthyoplankton, which were related to water mass structure and the seasonal characteristics of spawning in the region. The inshore region was characterized by reef fishes, e.g. gobies, clinids, blennies and tripterygiids, whereas pelagic fishes, such as clupeids and carangids dominated over the shelf. Oceanic fishes, such as myctophids, phosichthyids and gonostomatids dominated the ichthyoplankton at the shelf break and over the slope. However the changing seasonal dynamics of the Leeuwin and Capes Currents were clearly seen in the ichthyofauna assemblages.

Microzooplankton biomass peaked in winter, consistent with the winter peak in chlorophyll. Species richness was significantly higher on the shelf and offshore than nearshore, which was ascribed to the generally less stable inshore environment. Dilution experiments indicated that the microzooplankton consumed on average 60% of primary production. Growth of the picoplankton was particularly closely coupled with microzooplankton grazing.

Key areas for future research include:

1. The mechanisms underlying the late autumn bloom. Several hypotheses have been identified, which will be further examined during a cruise of the Southern Surveyor in May 2007.
2. Remote sensing of the WA marine environment. Remotely sensed data will be used to further examine patterns of productivity in the region and their inter-annual variability. Using SRFME and other data sets, the ability to predict primary productivity (and possibly nutrient content) from ocean colour nd SST data will be tested.
3. Coupling between pelagic and benthic components of the lagoon and shelf ecosystems. Benthic regeneration of nutrients to the water column will be further examined along a depth gradient, as will the relative role of benthic and pelagic grazers in consuming pelagic production.

5.1.2 Coastal Ecosystems and Biodiversity

Investigators / Institutions

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Executive Summary

Western Australia is unusual in possessing high-biomass, high-productivity benthic ecosystems despite the relatively low-nutrient waters of this coastal region that result from the low-rainfall climate and the influence of the Leeuwin current. The drivers of productivity and spatial distribution of WA's coastal ecosystems are poorly understood, and there is increasing need for improved information on fundamental aspects of benthic community structure and variability in the wake of increasing pressures resulting from population growth and development. Improved understanding of benthic ecosystems can support efforts to manage growing human impacts, will better enable us to determine their likely response to human influences, and will help ensure their future health and sustainability.

The SRFME study focused on improving understanding of one major habitat type –coastal rocky reefs – that had previously received relatively little attention. Rocky reefs are an important habitat type in nearshore coastal waters, supporting a diverse assemblage of benthic macroalgae and associated fish and invertebrates. Aside from the biodiversity associated with