Trophodynamics in coastal marine systems PROJECT DETAILS

Ecological Interactions in coastal marine ecosystems: Trophodynamics

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BACKGROUND

A three-year collaborative research program investigating ecological interactions in midwest coastal reef communities has been built around the Jurien Bay Marine Park (INSERT WEB LINK), using multiple-use management zones within the park as large scale manipulations of predator abundance. The trophodynamics project is part of the large WA Midwest Coast Collaborative Study (funded by SRFME, the Strategic Research Fund for the Marine Environment), and benefits from concurrent studies on habitat characterization, benthic community biodiversity, and major predator groups (finfish and rock lobster), as indicated in Figure 1.

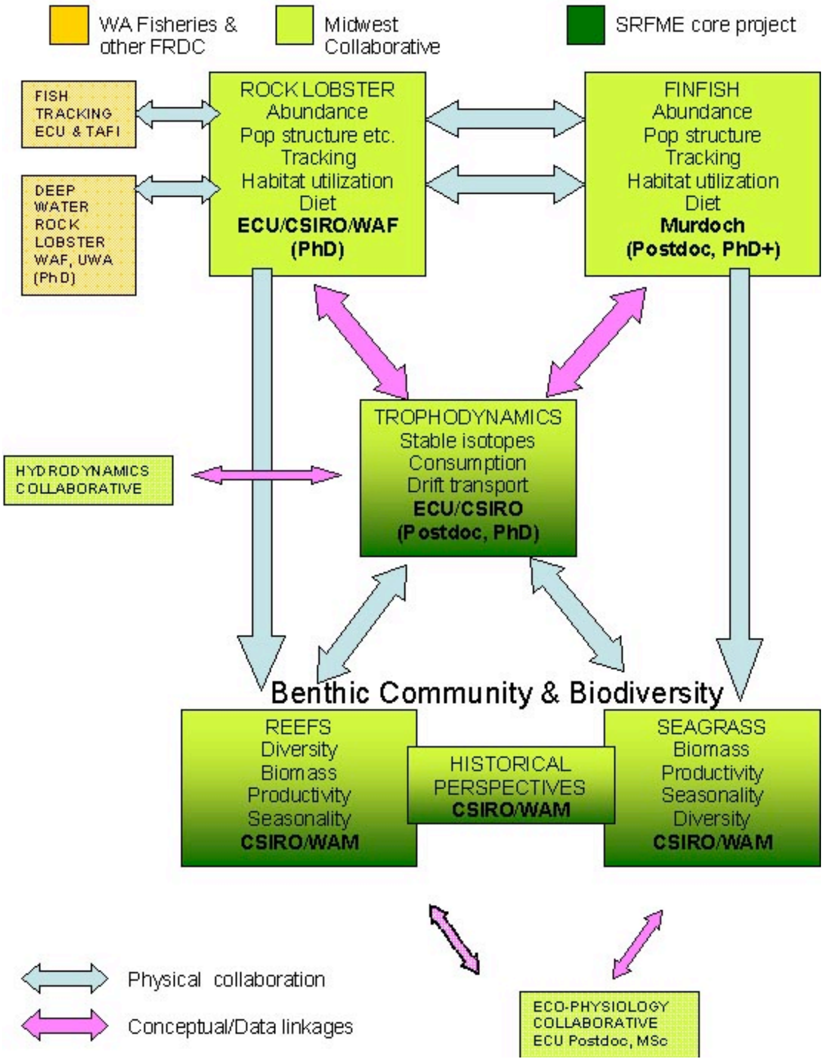

Figure 1. WA Midwest Coast Collaborative Study ecological interactions. The diagram indicates the main thematic components of the study, key institutional involvements, and their potential inter-relationships.

The broad aim of this study is to examine the trophic linkages of different habitats within a coastal marine environment. This will be achieved through investigating the following specific objectives:

1. To determine the source of primary production that drives the food web for major consumers in a coastal marine environment using biomarker techniques;
2. To determine the spatial and temporal variability in the source of production for major consumers in a coastal marine environment; and
3. To determine the movement patterns of detached reef algae and seagrass into adjacent coastal marine habitats.

Trophodynamic studies undertaken as part of the program will mesh with other proposed and ongoing studies to provide a much better understanding of the flow of energy and nutrients at a range of spatial scales, from the small scale between habitats to larger cross-shelf scales. Studies on the dietary composition through gut content analyses of fish have traditionally been used to examine food webs and trophic linkages in aquatic ecosystems. However, such an approach rarely considers the ultimate source of energy, and provides limited information on the interactions between the various primary producers and consumers in an ecosystem. Analyses of gut contents often provides only a snapshot of the diet of fish at a particular time, when the food consumed by fish often varies considerably over time (hours, days, seasons), during the life cycle of the fish (juveniles to adults) and among habitats (*e.g.* Werner and Gilliam 1984, Hyndes *et al.* 1997). Furthermore, different food types are digested at different rates, whereby hard-shelled prey can often be over-represented in gut-content analyses due to their recognisable fragments remaining in the guts for longer periods. In addition, the pharyngeal grinding of food by certain fish species renders the different food types consumed by these species indistinguishable.

Recently, researchers have recognised stable isotope techniques as a useful tool to identify and trace food/energy sources in coastal ecosystems (*e.g.* Kitting *et al.* 1984, Peterson and Fry 1987, Newell *et al.* 1995, Loneragan *et al.* 1997, Jennings *et al.* 1997, Pinnegar and Polunin 2000). This approach allows the linkages between fish and the various food sources in the coastal environment to be determined through measuring the natural isotopic ratios, typically $^{13}C/^{12}C$ and $^{15}N/^{14}N$, in the different primary producers and consumers. Since ^{13}C exhibits only slight enrichment in tissue from primary producers to the various consumer levels, $^{13}C/^{12}C$ typically is considered useful for tracing the source material in the food web (Peterson and Fry 1987). In comparison, ^{15}N displays a stepwise enrichment of approximately 3‰ between primary producer and each of the different consumer levels. The measurement of $^{15}N/^{14}N$ ratios has therefore been used to provide an estimate of the number of trophic levels in the food web (*e.g.* Fry and Quinones 1994). The combination of these isotopes provides a useful tool to examine the linkages among the various food sources and consumers in coastal environments and thereby provide an indication of the importance of different environments to major consumers.

Many important floral and faunal components of habitats are highly mobile, traveling large distances from one habitat to another. This transport includes the supply of drift algae or seagrass, as well as movements of reef-associated predators into other habitats to feed, or as part of seasonal foraging, ontogenetic or reproductive movements. By quantifying the abundance and origin of drift material, and by modeling the transport of algal and detrital particles we will begin to quantify the ecological linkages between habitats. Movement studies of key predatory species will provide information on the relative importance of different habitats for feeding and foraging. Biomarkers, particularly stable isotope ratios ($\delta^{13}C$, $\delta^{15}N$), will be used to validate and calibrate the relative magnitude of energy flows within the system, as well as the potential for habitat-related and ontogenetic differences in trophic relationships of key species such as lobster.

PRELIMINARY RESULTS

Two major seasonal field studies (Autumn and Spring 2005) have now been completed for the Trophodynamics project, and work is well underway towards interpreting the food web dynamics of the Jurien Bay Marine Park region. During each field trip, sediment, seagrass, algae and invertebrate samples were collected at eight sampling sites within the Jurien Bay and Green Head regions (Fig. 2). These sites are subjected to different exposure regimes (i.e. inshore versus mid-shelf) and levels of marine park protection (i.e. fished versus sanctuary zones), as detailed in Table 1. Over 500 samples have been analysed for carbon and nitrogen isotopic signatures, with an initial focus on elucidating the grazing pathway (which includes seagrass, seagrass leaf epiphytes, brown algae, red algae, gastropods and sea urchins) for Autumn 2005.

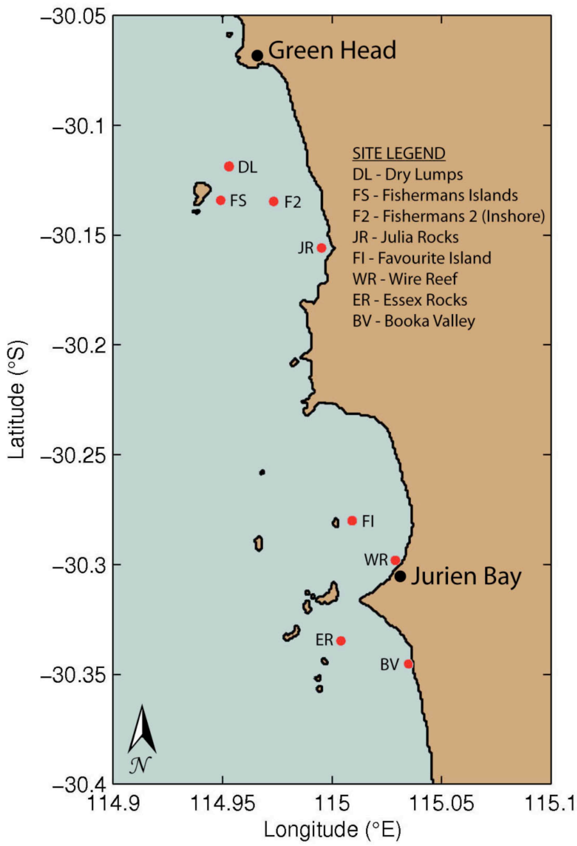

Figure 2. Location of the eight sampling sites for the Trophodynamics project within the Green Head and Jurien Bay regions.

Table 1. Details of the eight sampling sites within the Green Head and Jurien Bay regions.

Region	Location	Zoning Type	Site	Label	Latitude (S)	Longitude (E)
Green Head	Mid-shelf	Fished	Dry Lumps	DL	30°07.130’	114°57.179’
Green Head	Mid-shelf	Sanctuary	Fishermans Island	FS	30°08.050’	114°56.952’
Green Head	Inshore	Sanctuary	Fishermans 2	F2	30°08.080’	114°58.406’
Green Head	Inshore	Fished	Julia Rocks	JR	30°09.352’	114°59.712’
Jurien	Mid-shelf	Fished	Favourite Island	FI	30°16.805’	115°00.552’
Jurien	Inshore	Fished	Wire Reef	WR	30°17.887’	115°01.731’
Jurien	Mid-shelf	Sanctuary	Essex Rocks	ER	30°20.085’	115°00.246’
Jurien	Inshore	Sanctuary	Booka Valley	BV	30°20.723’	115°02.250’

As illustrated in Figure 3, we found a distinct isotopic separation of the seagrass/epiphyte group from the red and brown algae, although some overlap in $\delta^{13}C$

signatures between the brown and red algae makes isotopic differentiation of these primary producers difficult. The grazing and detrital-feeding gastropods form a coherent group, which may be feeding primarily on brown algae with some inclusion of red algae; an additional scenario is that both red algae and seagrass (leaves and/or epiphytes) may form the diet of these gastropods. These preliminary results serve to highlight the need for further analyses using alternative biomarkers, and we will shortly move forward with fatty acid analysis of targeted samples using these C and N isotopic results as a guide.

An unexpected result was obtained for the sea urchin, *Phyllacanthus irregularis*, which was found to be heavily enriched in $\delta^{15}N$ above all organisms currently analysed (including rock lobster). Recent literature (Vanderklift *et al*., in press) indicates that this omnivorous urchin may consume a significant amount of sponges and ascidians in its diet, which we will test further when our samples for these filter-feeding organisms are analysed.

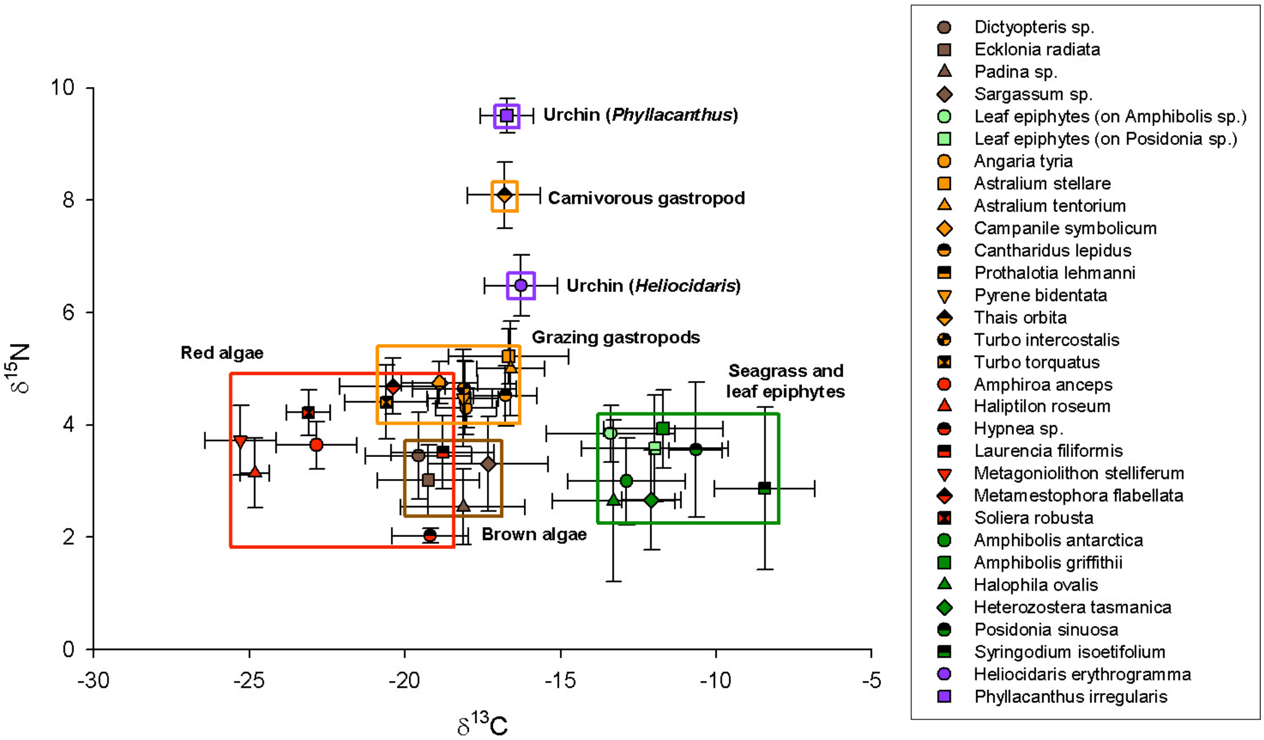

Figure 3. Isotopic analyses of seagrass, algae, gastropod and sea urchin samples collected in Autumn (April/May 2005) from all sites within the study area; values are mean ± s.d.

In addition to the field-based trophic work, preliminary studies on isotope enrichment have been undertaken using two species of cultured finfish. Interestingly, both species show a significant $\delta^{13}C$ enrichment of ~ 2.5 and 3 $^{o}/_{oo}$ as compared to their food source, challenging the standard assumption of minimal C enrichment between an organism and its food source, and indicating that we should be cautious with our interpretations of trophic relationships based on the presently accepted model. We are currently designing a series of aquaria experiments to more fully explore this issue and quantify the isotopic relationships between food sources and other key consumers in the marine environment.