Fisheries Research Report No. 218, 2011

Assessing possible environmental causes behind the reduced colonisation of Western Rock Lobster puerulus collectors by a wide suite of species

FRDC Report – Project 2008/085

Simon de Lestang – Department of Fisheries
Jason How – Department of Fisheries
Shelley Foster – University of Western Australia

Government of **Western Australia**
Department of **Fisheries**

Australian Government
Fisheries Research and Development Corporation

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

Fish for the future

Correct citation:

de Lestang, S., How, J. and Foster, S. (2011). Assessing possible environmental causes behind the reduced colonisation of Western Rock Lobster puerulus collectors by a wide suite of species. FRDC project 2008/085. Fisheries Research Report No. 218. Department of Fisheries, Western Australia. 60pp.

Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

A complete list of Fisheries Research Reports is available online at **www.fish.wa.gov.au**

The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

ISSN: 1035 - 4549 ISBN: 978-1-921845-15-4

Contents

2008/085 Assessing possible environmental causes behind the reduced colonisation of Western Rock Lobster puerulus collectors by a wide suite of species

PRINCIPAL INVESTIGATOR: Dr S. de Lestang

ADDRESS: Department of Fisheries
PO Box 20
North Beach, W.A. 6920
Telephone: 08 92030174 Fax: 08 92030199

Objectives

1) Begin monitoring the community composition of marine flora and fauna along the Western Australian coastline during this current poor settlement period.
2) Develop standard methodology for monitoring the spatial and temporal variability in the settlement of marine flora and fauna.
3) Determine what environmental parameters may be linked to the majority of variation in the floral and faunal communities colonizing puerulus collectors, focusing on those relating to puerulus settlement.
4) Identify indicator marine flora and fauna species for monitoring the influences of environmental change on Western Australian marine environment.
5) Detect any known or potential introduced marine pests within the Western Australian environment.

Non Technical Summary

This project was initiated as part of a response to the lower than expected puerulus settlement for the western rock lobster (*Panulirus cygnus*) on the Western Australian coast during 2008. This departure of settlement rates from a long standing relationship with environmental variables (e.g. water temperature, Leeuwin Current), corresponded with anecdotal information that there appeared to be a reduction in the colonization of the collectors by other invertebrate species, namely shrimps and crabs. The puerulus monitoring occurs monthly with 10 locations from Coral Bay to Cape Mentelle. The aim of this project was to establish the methodology for monitoring macro invertebrate communities associated with puerulus collectors and the environmental conditions that may be influencing these communities along the coast. The project could also identify what species could potentially be used as indicators to monitor climate change effects along the West Australian coast and enable the detection of some potential marine pests, using an existing sampling regime.

This project began during the second of two seasons (2008/09 and 2009/10) when settlement was well below that expected based on historical relationships. As a result this project has produced a baseline of community composition data against which to compare future compositions with variations in puerulus levels.

The standard methodology established during this project was consistent with a number of other similar studies, both in terms of the detail of taxonomic classification and the number of samples obtained for any one site and season. Five sites spanning over 1000 km of coastline from Coral Bay to Warnbro were examined for each of two seasons (winter and spring), with two of these sites examined for all four seasons. This allowed for an examination of the spatial and seasonal variation of the macro invertebrate communities.

Overall 157 740 individuals were counted from 55 samples that were processed encompassing 67 taxa. Amphipoda was the dominant Order encompassing almost half of all individuals and three times greater in abundance than the second most abundant taxa (Class – Gastropoda), which in turn were, double that of Isopoda, Tanaidacea and Ostracoda (Class). Choa taxa accumulation curves were produced for each sample, which at the order classification level, indicated that four replicate samples were sufficient to account for the majority of the within sample variation in community composition. This current work indicates that Order may be close to the preferred level of taxonomic resolution as it provides more information on community structure than the Phyla or Class level and as such will be used for subsequent analysis.

The compositions of the communities were found to vary significantly both spatially and seasonally , with the main difference occurring between sites located in the tropics/sub-tropics, from those in temperate locations. This was mainly attributable to the greater abundance of taxa in the temperate locations compared with the tropics. Spatial and monthly variation in environmental parameters measured during this study did not correlate well with variation in the structure of the communities despite their clear spatial and temporal differences. The dominant separation of tropical/subtropical from temperate locations probably indicates the importance of the surrounding habitat with the settlement on the collectors. Benthic habitat variation has yet to be quantified, but will be the focus of further work. The positive relationships between the abundance of some taxa and water temperature and the negative relationships between abundance and water motion may be related to levels of productivity and habitat stability, respectively. In the temperate locations, copepods displayed a significant negative relationship with puerulus abundance, which may reflect their different seasonal variation in abundance.

Climate change in the West Australian coastal zone is predicted to result in increased water temperatures and salinity and less frequent and severe storm events. These environmental factors were found to significantly influence the abundance of a number of taxa found commonly on the collectors. These relationships, along with the discovery of some individuals outside of their normal distributional range, such as the tropical species *Strombus mutabilis* being found at Dongara, indicates that the monitoring of a range of species on the puerulus collectors can provide an indication of the localised environment and the impact of climate change.

While no introduced or marine pest species were identified in this study, a protocol was established, in collaboration with West Australian Museum and marine pest specialists within the Department of Fisheries, to monitor future samples for marine pests that may settle on the collectors.

This project has provided a valuable baseline indication of the macro invertebrate communities associated with puerulus collectors during a period of below average settlement. The methodology developed will provide a cost effective way to monitor these communities, with a number of taxa potentially providing valuable information to monitor environmental change along the West Australian coast. It will also enable the assessment of whether the annual variation in puerulus settlement is reflected in the change to other macro invertebrates.

Outcomes achieved to date

1. A sampling regime was developed (four replicate samples for each location) that was appropriate to adequately describe the macro invertebrate community at the Order level, with this level of taxonomic resolution providing a robust measure of community composition. The monitoring program has been adopted by the Department of Fisheries and integrated into the current puerulus monitoring program. This has resulted in a cost-effective long-term monitoring program assessing faunal communities.
2. This study has provided a baseline to compare future community changes with changes in puerulus settlement.
3. The monitoring of a range of species on the puerulus collectors will enable an assessment of the impact of climate change on the macro invertebrate community.
4. A protocol was established, in collaboration with West Australian Museum to monitor future samples for marine pests that may settle on the collectors.

Keywords

Marco invertebrate communities, puerulus, western rock lobster, *Panulirus cygnus*, environmental effects, habitat, marine pests

Acknowledgments

This project required the collection of considerable samples from puerulus collectors along the coast. This was not possible without the assistance of the puerulus monitoring team, Mark Rossbach, Owen Young, Josh Dornan, Rhys Allen and Adam Eastman. Samples were also provided from collectors serviced by contractors at Cape Mentelle and Point Quobba and Coral Bay, so thanks must go to Dennis Cuthburt, Tim Meecham and the Department of Environment and Conservation staff from the Exmouth office, particularly, Claire O'Calloghan and Huw Dilley.

Taxonomic expertise was provided willingly from Dr. Anne Brearley (University of Western Australia) and Dr. Andrew Hosie (Western Australia Museum), which enabled the identification of potential range extension of gastropoda species and fine scale taxonomic resolution of Decapoda (particularly crabs).

The initial concept for this project was developed by Dr. Matthew Pember, with Dr. David Abdo as the initial Principal Investigator. Their initiation of the project and continued interest in the project was of considerable assistance.

The Fisheries Research Development Corporation, as part of their Tactical Research Fund, provided funding central to the undertaking of this project.

1.0 Background

The western rock lobster fishery is the largest single species fishery in Australia, and the first fishery world wide to attain Marine Stewardship Council certification (Caputi et al 2008). The management of this fishery has been aided by the ability to predict catches three to four years in advance, based on the strong relationship between puerulus settlement and future catch (Caputi et al. 1995 and de Lestang et al. 2009).

Puerulus are the post-larval / settlement phase of the western rock lobster (*Panulirus cygnus*), and is a non-feeding free-swimming stage that moves from an offshore region in the vicinity of the continental shelf break to the near-shore areas before moulting to a juvenile form (Phillips 1972, Phillips and Macmillan 1987). Puerulus have been found to settle mainly in areas with macroalgal or seagrass cover on or near hard substrates (Phillips et al. 2003). This settlement behaviour enabled the development of puerulus collectors designed to mimic these habitat qualities, which therefore provided a platform from which the recruitment rate of puerulus could be monitored (Phillips 1972; Caputi et al. 1995). Some puerulus collectors have been monitored for over 40 years, with sampling conducted on every full moon period at the same sites using the same type of collectors. This has provided a very valuable long-term data set of settlement rates (Caputi et al. 2008).

Levels of puerulus settlement at most sites show very strong relationships with environmental variables that occur during their 9-11 month larval life. The most significant relationships exist between offshore water temperatures during their early larval life and the frequency of frontal storms towards the end of the larval period, i.e. during settlement (Caputi et al 2001). Recently however, there have been two years (2008/09 and 2009/10) of unexpectedly low levels of puerulus settlement, with the relationships with water temperature and storms not explaining their levels (Brown 2009).

These anomalous low puerulus settlements instigated a risk assessment workshop to identify the potential causes behind the low puerulus settlement (Brown 2009). There were several potential causes considered, with the two major ones being a reduction in the breeding stock (in particular areas) and alterations to the oceanographic / climatic conditions (either short or long term) (or a combination of both). An outcome of this workshop was the identification of several projects that would increase understanding of the causes behind the low levels of puerulus settlement (Brown 2009).

There was anecdotal evidence from West Australian Department of Fisheries staff servicing the puerulus collectors who had noticed that, with the drop in puerulus, there had been a concomitant decline in other fauna typically associated with the puerulus collectors, e.g. shrimps and crabs. This project was initiated to determine the links between the abundance of puerulus and other relatively similar species on the collectors to aid in understanding the likely causes behind the recent low puerulus settlements.

Environmental determinants of recruitment can affect larval dispersal, as well as survival of larval and juvenile stages (de Lestang et al. in press). Factors influencing growth and survival include temperature, salinity, water motion, light and nutrient availability, while large scale dispersal is largely driven by oceanic currents (Jenkins et al. 2009). Even in a single location, these environmental factors can be highly variable through time. Temporal patterns can be observed on various levels such as diurnal, seasonal or inter-annual. Of these, seasonality is a characteristic of almost all ecosystems and animals have evolved means by which to cope with variability in their environment imposed by seasonal changes (Gili & Petraitis 2009). Seasons determine the input of energy from solar radiation and in turn, control the annual cycles of oceanographic and atmospheric conditions.

Populations may respond to seasonal changes in the environment, becoming more abundant with increased food availability. Alternatively, organisms may respond behaviourally or physiologically to environmental seasonality (Gili & Petraitis 2009). As a response to reduced food availability, individuals may reallocate their food resources to storage and consequently become less active. The crab, *Carcinus maenas*, moves offshore in winter to avoid wave action and the extremely low nearshore temperatures, while returning inshore in spring and summer to breed (Hunter & Naylor 1993). Alternatively, animals may migrate offshore in summer to breed (e.g. *Panulirus cygnus*, Caputi et al. 2008) or to avoid high water temperature / low oxygen waters (e.g. *Portunus pelagicus*, de Lestang et al., 2003). Since organisms tend to respond to a suite of environmental conditions rather than a single factor, studies incorporating a combination of environmental factors, are more likely gain an accurate understanding of the effects of seasonality on abundances and community structure. Nutrients and food availability are key factors affecting benthic communities, which in turn are affected by water temperature and light availability. In this study the impacts of a suite of environmental parameters on community structure have been examined, with potential indicator taxa identified to examine future influences of environmental changes on the marine environment.

Finally, the examination of taxa settling on puerulus collectors provides the opportunity to detect any marine pests. The translocation of marine organisms from their natural environment to another area is assisted by human activity, in particular by the global movement of vessels (commercial and recreational) where organisms are moved about in ballast water and as biofouling on vessel hulls. This translocation of marine organisms is a world-wide problem and second only to habitat change and loss, in reducing global biodiversity (Millennium Ecosystem Assessment 2005). It is estimated that one, in six - ten, of displaced marine organisms will become Introduced Marine Pests (IMP; Anonymous 2002). Marine environments which are highly disturbed/modified have increased vulnerability to invasion by IMPs.

The Australian and state/territory governments are implementing Australia's National System for the Prevention and Management of Marine Pest Incursions (the National System). It is the National Introduced Marine Pests Coordination Group (NIMPCG) that is coordinating the measures and arrangements under the National System. NIMPCG have identified 55 species (Appendix C) to target when undertaking IMP monitoring around Australia.

This project provides an excellent opportunity to detect any of these identified species as part of a rigorous existing monitoring program.

The novel aspect of this research required first the development a standard methodology for sampling flora and fauna associated with the puerulus collectors, and then the implementation of this during the current low settlement period to establish a dataset that could be compared to future samples collected during times of varying levels of puerulus settlement.

2.0 Need

Western Rock Lobster puerulus settlement has been unexpectedly low over the past two settlement years (2008/09 and 2009/10), with the 2008/09 settlement being the lowest on record. This extremely weak settlement has occurred despite environmental conditions being favourable for an above average settlement (i.e. a strong Leeuwin Current, warm sea temperatures and *la Niña* conditions). The recent poor settlements could be attributed to a number of possible scenarios, including, reduced egg production from depleted brood stock or a shift/change in oceanic conditions possibly due to climate change. Understanding what scenario(s) are responsible will be crucial for the effective conservation and management of the Western Rock Lobster stock, and ultimately the longevity of the fishery. Anecdotal evidence suggests that colonisation of the puerulus collectors by a number of other species commonly found during processing of these collectors have also been extremely low in recent times. . Establishing a baseline for marine flora and fauna communities colonising the puerulus collectors over a range of 1000 km during this time of extremely low settlement (i.e. prior to the end of the settlement season in April 2009) and determining how these communities vary in relation to the varied environmental conditions experienced, will provide valuable information as to what may be influencing puerulus settlement. If settlement of other marine flora and fauna show a related response to that of the Western Rock Lobster pueruli, it could indicate environmental change may be responsible for the decreased settlement. This data will complement other research, such as the oceanographic modeling research (FRDC project 2008/087 and 2009/018), and is crucial to the effective management of the Western Rock Lobster fishery. Furthermore, this spatial analysis conducted on a monthly scale has the potential to further identify possible indicator species of localised environmental conditions that could continue to be monitored as part of the standard Western Rock Lobster puerulus monitoring program.

3.0 Objectives

1. Begin monitoring the community composition of marine flora and fauna along the Western Australian coastline during this current poor settlement period.
2. Develop standard methodology for monitoring the spatial and temporal variability in the settlement of marine flora and fauna.
3. Determine what environmental parameters may be linked to the majority of variation in the floral and faunal communities colonizing puerulus collectors, focusing on those relating to puerulus settlement.
4. Identify indicator marine flora and fauna species for monitoring the influences of environmental change on Western Australian marine environment.
5. Detect any known or potential introduced marine pests within the Western Australian environment.

4.0 Methods

4.1 Objective 1

Begin monitoring the community composition of marine flora and fauna along the Western Australian coastline during this current poor settlement period.

In March 2009, there were nine sites monitored as part of the Department of Fisheries puerulus program. An additional site was established in May 2009 at Coral Bay to examine puerulus settlement in an area north of the commercial fishery (Figure 1).

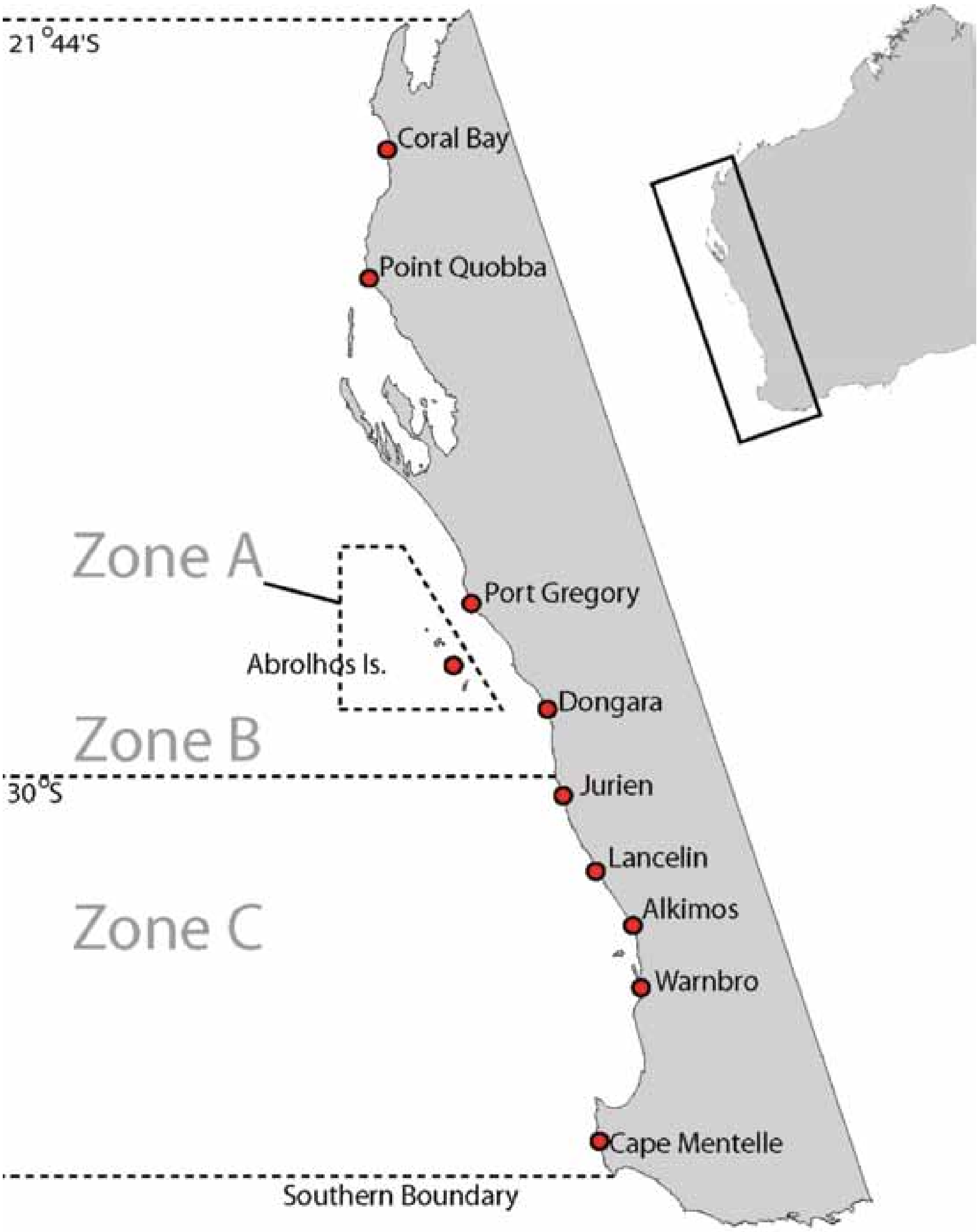

Figure 1. Location of puerulus monitoring sites (red) along the West Australian coast, with the boundary of the fishery and zones for the Western Rock Lobster Managed Fishery (dotted line).

The collection of all flora and fauna associated with the puerulus collectors began in May 2009 at all ten puerulus monitoring sites. Monthly collections continued from the ten sites (when logistically possible) until the writing of this report (August 2010), resulting in over 750 samples from this 15-month period. The collection of samples is planned to continue. The period of sampling to date encompasses a time of unexpectedly low puerulus settlement (Figure 2).

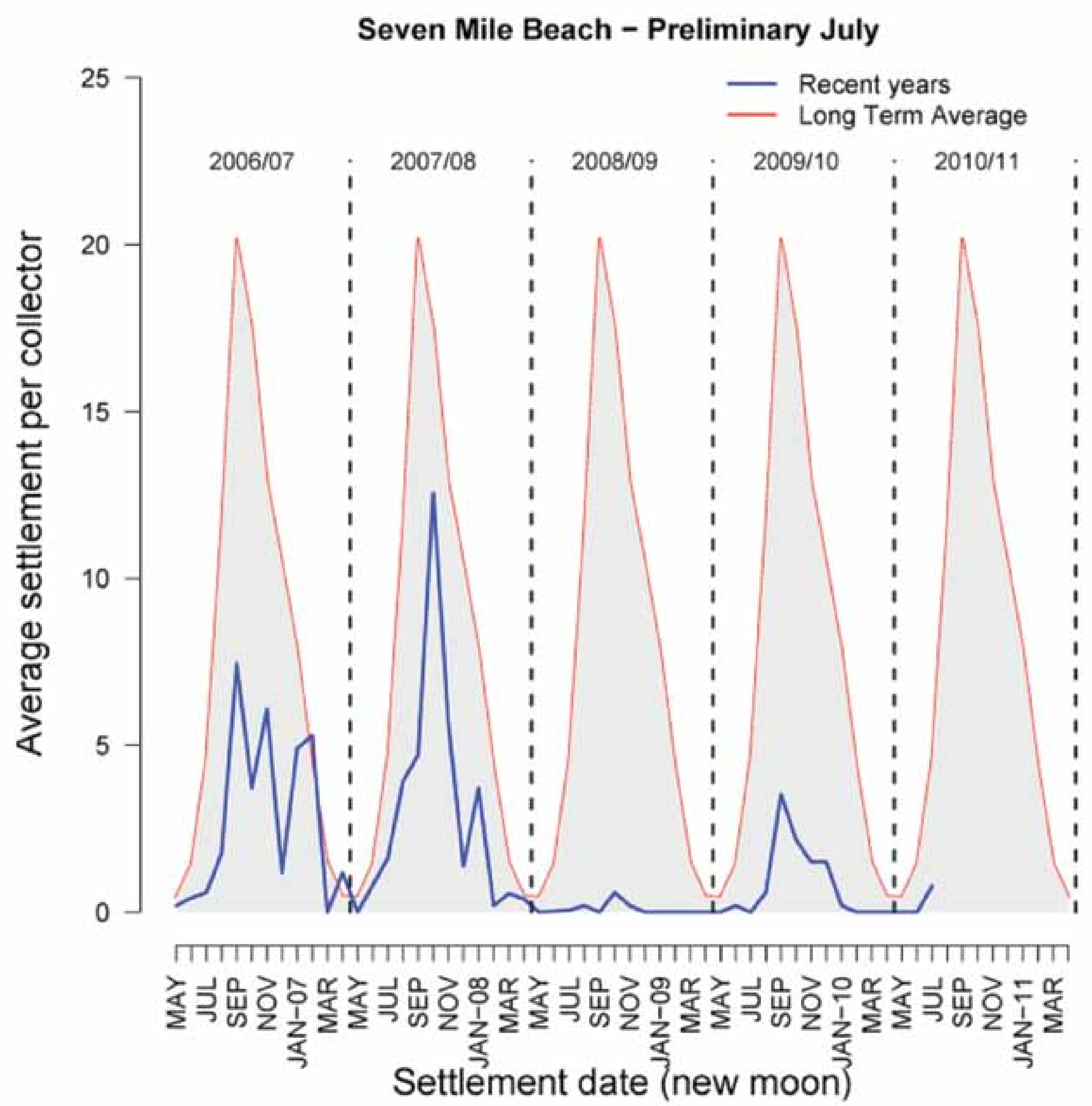

Figure 2. Puerulus settlement rates at Dongara (Seven Mile Beach) for the last four settlement seasons, compared with the long term average (red) from (http://www.fish.wa.gov.au/docs/pub/PuerulusSettlement/). Black box indicates the current collection period of floral and faunal samples from the collectors.

The settlement season during which sampling began was one of two (potentially more) seasons when settlement was well below that expected based on historical environmental relationships between offshore water temperature and settlement rates (Figure 3). Subsequently, collection of flora and fauna associated with puerulus collectors provide a baseline of community structure information against which to compare community composition when (if) puerulus levels increase.

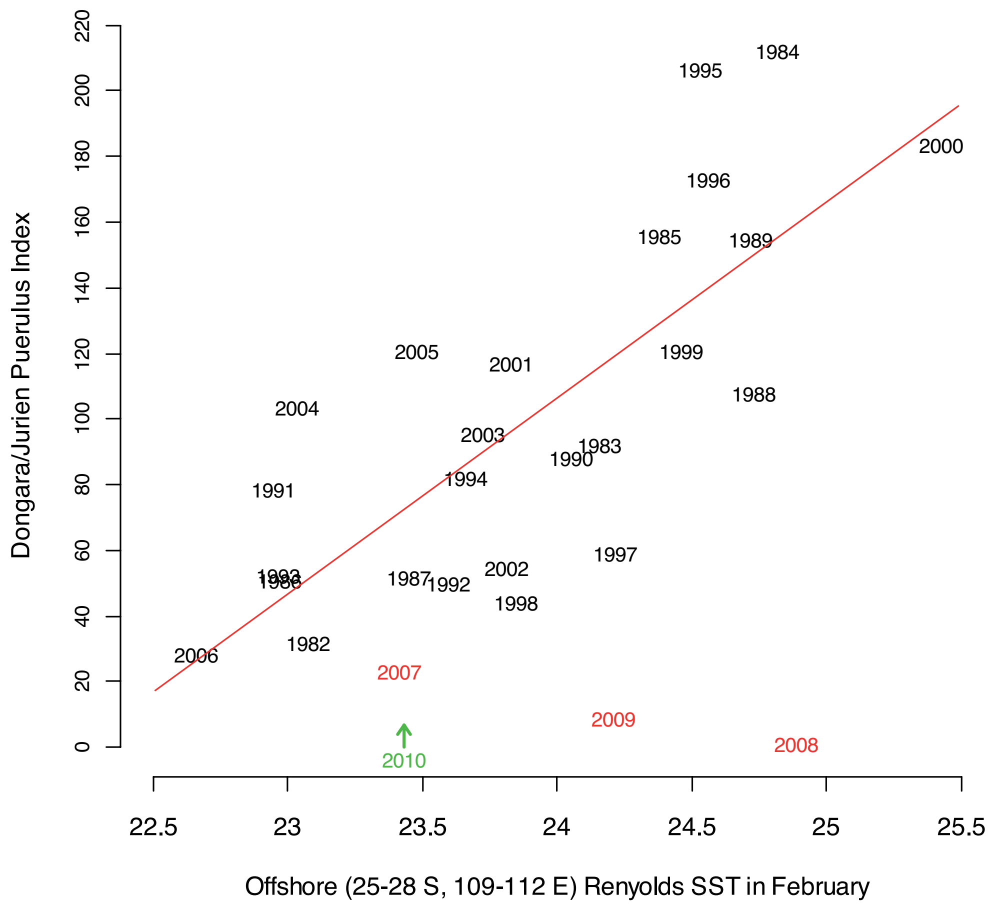

Figure 3. Relationship between offshore water temperatures and the settlement index for Dongara and Jurien. Red numbers indicate years of settlement outlying the linear relationship, with the green arrow and year indicating the location of the expected settlement for the 2010/11 season.

4.2 Objective 2

Develop standard methodology for monitoring the spatial and temporal variability in the settlement of marine flora and fauna.

This study used a pre-existing puerulus monitoring protocol, which provided a through sampling framework that has been rigorously tested statistically (Caputi et al. 2008). Sampling specific to this project required, *in-situ* preservation, laboratory sieving and permanent storage, sorting and identification and finally, data recording of floral and faunal compositions.

4.2.1 Collection

Collectors were sampled every full moon period (five days either side of the full moon), with each sheet removed and placed face down in a rack for shaking over a collection tray. An aluminium shaker frame is slid over the P.V.C. backing board and, holding the shaker by the handles, operators gave 20 "bangs" of the frame onto the upper lip of the collection tray. The tray was then checked for puerulus before the sheet was banged another 10 times over the tray. If any more pueruli appear in the tray after the second set of shaking, then the panel is given another ten shakes, with this process continuing until no further pueruli appear. The sheet is then removed from the frame with the process repeated for the remaining two sheets.

After all three sheets have been shaken, the number of puerulus and post-puerulus are counted and removed. Puerulus data is entered into the database for later analysis along with the rest of the community composition data. This has been the standard methodology since the inception of sampling in the late 1960s.

4.2.2 *In-situ* preservation

The flora and fauna dislodged through the aforementioned collection process are retained in the collection tray. The contents of this tray are then poured into a labelled calico bag before being secured closed with a cable tie. The calico bag acts as a sieve, retaining all particular matter and releasing water. Once the water has drained out of the bag it would then be placed into a drum of ethanol for initial preservation, where it was stored until sorting.

4.2.3 Sieving and Storage

Upon returning to the laboratory, the contents of each calico bag were separately run through a 500 µm sieve to aid in the removal of fine particulate matter (i.e. silt) which when present can make sorting of a sample very difficult and time consuming. Once sieved, the samples were then placed into a labelled plastic container and filled with fresh 70% ethanol for storage until sorting.

4.2.4 Sorting and Identification

Mobile invertebrates were the dominant taxa in the samples and hence they have been the initial focus of sorting and identification. Additional effort was applied to identifying as precisely as possible those species belonging to the same Class (Malacostraca) as *Panulirus cygnus* because it was felt that a member of this group was most likely to have similar behaviours. Fauna were sorted and counted into various taxonomic groups. A range of texts were used to assist sorting and identification (including Jones & Morgan 1994 and Shepherd et al. 1997, parts I, II & III), as well as taxonomic assistance offered by Dr. Anne Brearley (University of Western Australia) and Dr. Andrew Hosie (Western Australia Museum). Macro algae were removed from the sample and stored separately for future identification and recording. The abundance of taxa was recorded for each sample.

4.3 Objectives 3 & 4

Determine what environmental parameters may be linked to the majority of variation in the floral and faunal communities colonizing puerulus collectors, focusing on those relating to puerulus settlement.

Identify indicator marine flora and fauna species for monitoring the influences of environmental change on Western Australian marine environment.

4.3.1 Study sites

Due to the time-consuming nature of processing the faunal samples, this study has focussed on analysing five of the ten puerulus monitoring sites for macro invertebrate community structure (samples from other sites have been stored for future analysis). Locations chosen spanned the entire fishery (Figure 4), representing a spatial separation of over 11^{o} in latitude (over 1000km), and consisted of historically good and average settlement sites (Figures 4, 5).

At each site up to four replicate collectors were analysed for both winter (August 2009), and spring (November 2009). At Dongara and Warnbro, autumn (May 2009) and summer (January 2010) were also analysed.

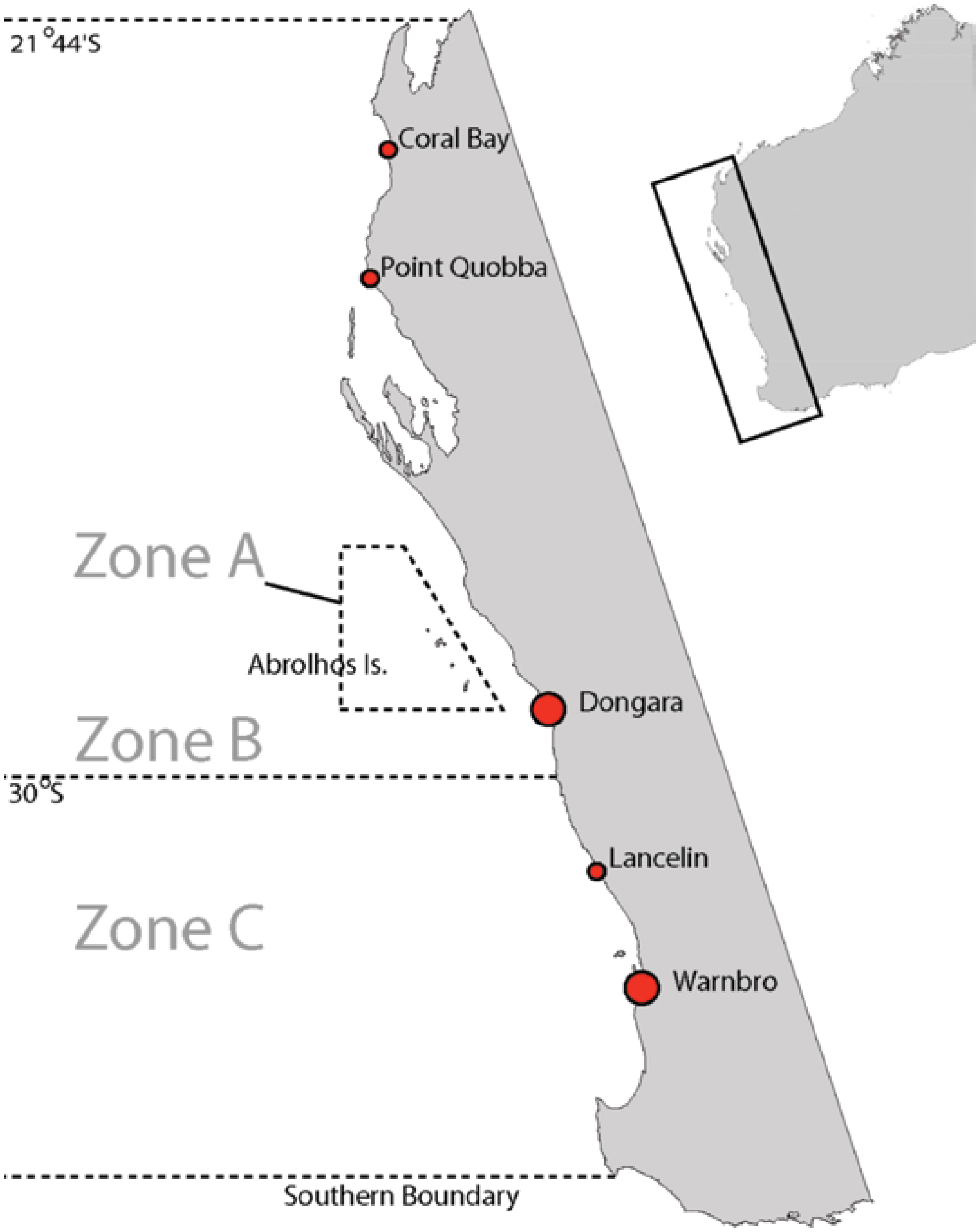

Figure 4. Location of sites where samples were analysed for two seasons (small circles) and those where four season were examined (large circles).

Sampling seasons were structured so as to sample months that included a contrast in puerulus settlement rates where possible (Figure 5).

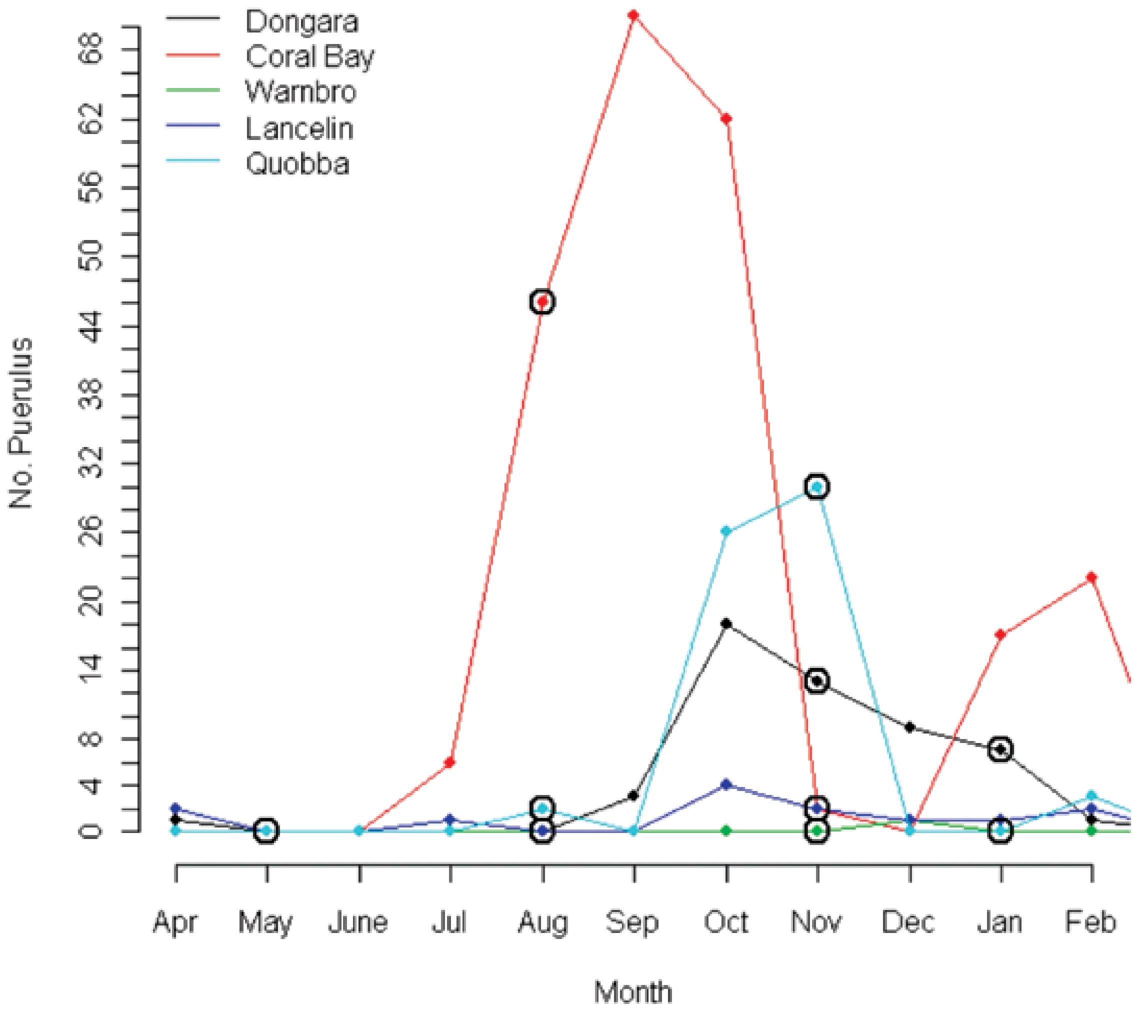

Figure 5. Numbers of puerulus recorded at the five locations during the sampling period. (Circles indicate the month of sampling other species on the collectors).

Puerulus monitoring sites (Figure 1 & 4) as shown here for Dongara, typically have puerulus collectors in the lee of a near shore reef, on or near small patch reefs or seagrass meadows (Figure 6).

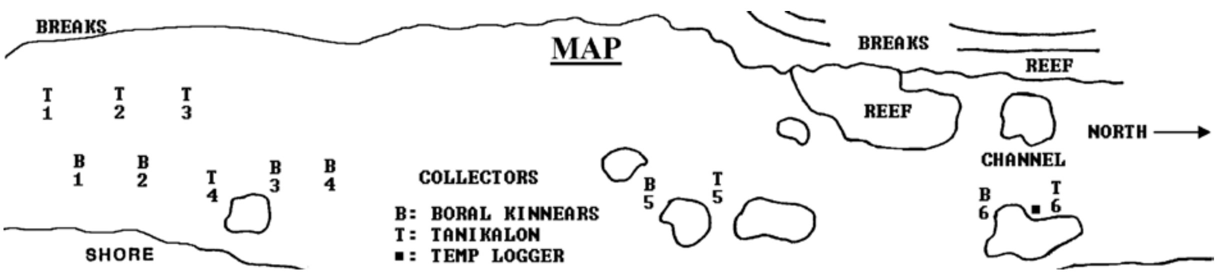

Figure 6. Schematic diagram of the location of puerulus collectors (T1-6 & B1-6) showing breaking waves (breaks) on the near shore reef and patches of inshore reef (open polygons). Location of wave logger (filled circle) and temperature logger (filled square) are also shown.

4.3.2 Environmental Data

With climate change in the Indian Ocean and more specifically the West Australian coastal zone predicted to result in increased water temperatures, increased salinity and less frequent and severe storm events (Maunsell Australia 2009), we examined the effect of the temperature, salinity and wave magnitude, on individual taxa abundances. This was to elucidate any potential indicator taxa for monitoring the influence of environmental change on the West Australian coast.

Each site had a high-resolution temperature logger secured to one of the collector moorings (Stowaway Tidbit temperature logger TBI32), approximately 2 m below surface. This recorded water temperature every hour to the nearest 0.1°C. Temperature measurements from the loggers were compared to a mercury thermometer measurement, carried out during monthly collections and measurements were standardised if significant differences were found (Pearce et al. 1999).

An existing wave logger design was modified as part of this study (Appendix B) and deployed at each location to record static acceleration every 10 minutes on the vertical and horizontal axis, resulting in a relative water motion reading (Evans & Abdo 2010).

During the puerulus collection fieldwork, two water samples were collected to determine salinity.

Equipment loss or failure resulted in not all sites having all available environmental parameters measured. Water movement data was not available at Warnbro and Lancelin for winter (August 2009) as logger design was being modified (see Appendix B). Estimates of Warnbro water movement were estimated based on a linear relationship between monthly water movement either side of August (e.g. from July 2009 to October 2009).

With the loss of the initial loggers design from Lancelin, no estimates of water movement were available prior to October 2009. As such, water movement at this site was estimated based on correlations with water movement recorded at similar nearby sites. The most similar site (based on the magnitude of variation in the ratios of water movements) was Dongara. The loss of two separate loggers at Point Quobba, resulted in no water movement data for this site. As such, Point Quobba water movement was given the maximum-recorded water movement of any site for each season. From the loss of both wave loggers and puerulus collectors at this site due to water movement, coupled with personal observations, this is a conservative estimate of water movement at this site.

As only one salinity measure was available for Point Quobba, it was removed from analysis when tropical sites were examined independently.

The establishment of the new site at Coral Bay during this project resulted in a few additional logistical issues resulting in no temperature or salinity measures being taken at this site at the time of sampling. Salinity was removed from analysis when tropical sites were examined independently.

4.3.4 Data Analysis

The data were examined using Primer 6 (Clarke & Warwick 2001) to examine taxa accumulation curves to assess the level of sampling required to account for the majority of species present, community composition differences (non-metric multi dimensional scaling – nMDS; analysis of similarity –ANOSIM), identify taxa responsible for possible differences (SIMPER), as well as impacts of environmental parameters on community composition (BIOENV).

Univariate analysis was also conducted on specific groups of taxa to further investigate trends identified from multivariate analysis. This was done using R (R Development Core Team 2009) with appropriate transformations (ln (x+constant) predominantly) to satisfy the assumptions of normality and equal variance (Clark and Warwick, 2001).

4.4 Objective 5

Detect any known or potential introduced marine pests within the Western Australian environment.

As part of the process of sorting the samples all specimens were compared to a list of 55 marine pests as identified by National Introduced Marine Pests Coordination Group (Appendix C), and introduced marine species (Wells et al. 2009).

5.0 Results / Discussion

5.1 Objective 1 & 2

Develop standard methodology for monitoring the spatial and temporal variability in the settlement of marine flora and fauna.

Overall 157 740 individual were counted from the 55 samples that were processed encompassing 67 taxa (Table 1).

Choa taxa accumulation curves were produced for each sample (season and site - Figure 7). At the order classification level, four replicate samples appeared sufficient to account for the majority of the within sample variation in community composition (Figure 7).

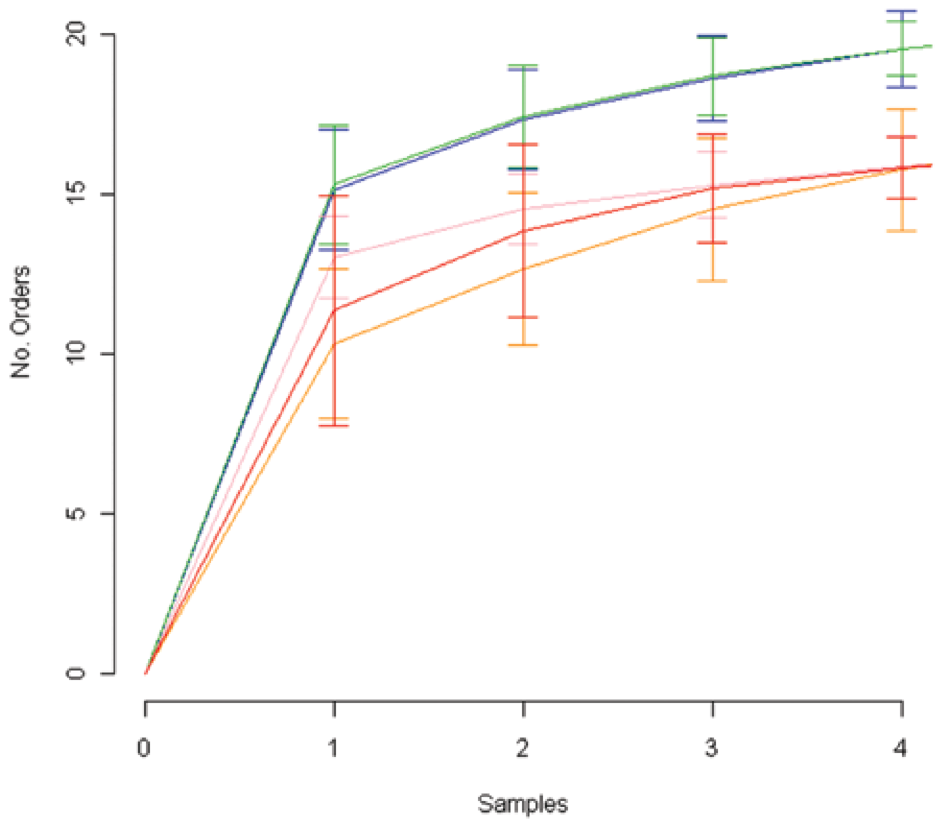

Figure 7. Choa taxa accumulation curves, indicating the average number of orders (±sd) for each location (averaged over the seasons), using data from a varying number of samples per month (1- 4) for Warnbro (blue), Lancelin (green), Dongara (pink), Point Quobba (orange) and Coral Bay (red).

Table 1. Taxonomic groups (bold) and their taxonomic level used for the initial sorting of macro invertebrates.

Phylum	Sub-phylum	Class	Sub-class	Order	Suborder	Infraorder	Family	Sub Family	Genus	Species / Taxon
Platyhelminthes										
Nemerteans										
Annelida		**Polychaeta**								
Mollusca		**Gastropoda**								
Mollusca		Gastropoda	Opisthobranchia	**Nudibranchia**						
Mollusca		Gastropoda	Opisthobranchia	**Cephalaspidea**						
Mollusca		**Polyplacophoran**								
Mollusca		**Bivalvia**								
Athropoda	Chelicerata	Arachnida		Acariformes	Prostigmata		**Halacaridae**			
Arthropoda	Chelicerata	**Pycnogonida**								
Arthropoda	Crustacea	Ostracoda								**Mottled hairy**
Arthropoda	Crustacea	Ostracoda								**Dimpled**
Arthropoda	Crustacea	Ostracoda								**Big yellow soft**
Arthropoda	Crustacea	**Copepoda**								
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	**Caridae**				
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Palinura	Palinuridae		**Panulirus**	
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Thalamitinae	Thalamita	**Thalamita sima**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Thalamitinae	Thalamita	**Thalamita admete**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Thalamitinae	Thalamita	**Thalamita woodmasoni**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Thalamitinae	Thalamita	**Thalamita danae**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Thalamitinae	Thalamita	**Thalamita parvidens**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Portuninae	Portunus	**Portunus pubescens**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Portunoidae	Portuninae	Portunus	**Portunus sp. 1**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Inachinae	Dumea	**Dumea latipes**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Inachinae	Dumea	**Majid Dumea smooth**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Epialtinae	Acanthonyx	**Acanthonyx euryseroche**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Epialtinae	Acanthonyx	**Acanthonyx sp. 2**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Epialtinae	Simocarcinus	**Simocarcinus obtusirostrus**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Majinae	Schizophrys	**Schizophrys rufescens**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	**Majinae**		
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae	Epialtinae	**Menaethius**	
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae			**Majid triangle crab**

Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Majidae			**Unknown Majid**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Xanthidae	Zalasiinae		**Actaea peronii**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Xanthidae			**Xanthid clown crab**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Xanthidae			**Xanthid blushing crab**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		Halicarcinus	**Halicarcinus ovatus**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		Halicarcinus	**Halicarcinus sp. 2**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		Halicarcinus	**Halicarcinus sp. 3**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		Halicarcinus	**Halicarcinus sp. 4**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		Halicarcinus	**Halicarcinus sp. 5**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Hymenosomatidae		**Halicarcinus**	
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	Pilumnidae	Pilumninae	Pilumnus	**Pilumnus sp. 1**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Heterotremata	**Pilumnidae**			
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Thoracotremata	Graspidoidea	Plagusiinae	Plagusia	**Plagusia sp. 1**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Thoracotremata	Graspidoidea	Plagusiinae	Plagusia	**Plagusia sp. 2**
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Anomura	**Galatheidae**			
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Anomura	Porcellanidae		**Pisidia**	
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Drominacea	**Dromiidae**			
Arthropoda	Crustacea	Malacostraca		Decapoda	**Pleocyemata**					Megalope
Arthropoda	Crustacea	Malacostraca		Decapoda	Pleocyemata	Thoracotremata	Graspidoidea	Plagusiinae	**Plagusia**	Megalope
Arthropoda	Crustacea	Malacostraca		Decapoda	**Pleocyemata**					Megalope
Arthropoda	Crustacea	Malacostraca		Decapoda	**Pleocyemata**					Megalope
Arthropoda	Crustacea	Malacostraca		**Mysidacea**						
Arthropoda	Crustacea	Malacostraca		**Cumacea**						
Arthropoda	Crustacea	Malacostraca		**Tanaidacea**						
Arthropoda	Crustacea	Malacostraca		Isopoda	**Anthuridae**					
Arthropoda	Crustacea	Malacostraca		Isopoda	**Flabellifera**					
Arthropoda	Crustacea	Malacostraca		Isopoda	**Valvifera**					
Arthropoda	Crustacea	Malacostraca		Isopoda	Asellota		**Januridae**			
Arthropoda	Crustacea	Malacostraca		**Amphipoda**						
Arthropoda	Crustacea	Malacostraca		Amphipoda	**Caprellidae**					
Sipuncula										
Echinodermata		Stelleroidea	**Asteroidea**							
Echinodermata		Stelleroidea	**Ophiuroidae**							
Echinodermata		**Echinoidea**								
Echinodermata		**Crinoidea**								

Taxa were identified to their lowest possible taxonomic level (Table 1), which resulted in some taxa being identified to species and some only to class. This enabled an examination on how the measure of community composition changed according to the level of taxonomic resolution. Taxa were aggregated from their lowest taxonomic resolution up to order, class or phyla with the resulting community structure examined. Where individuals were only examined to a higher taxonomic level e.g. Nermetea, this identification, despite being a phyla level, was used as its lowest taxonomic resolution so as to incorporate all individuals in the analysis. A second stage MDS (Primer 6; Warwick and Clarke 2001) was used to examine the relatedness of community structure produced from the phyla, class, order and taxa (down to species level) analysis (Table 2).

Table 2. Correlation (permuted) of community structure from macro invertebrate assemblages analysed at different taxonomic levels from Phyla to lowest taxa level (L.Taxa). All correlations were highly significant ($p<0.001$).

	Phyla	Class	Order
Class	0.772		
Order	0.678	0.946	
L.Taxa	0.605	0.890	0.957

There was a very high, and significant ($p<0.001$) similarity of community structure between macro-invertebrate assemblages at the phyla to lowest possible taxa level. The highest similarity was between the lowest possible taxa and order assemblages (shaded grey), but classification to the phyla level also produced a similar community structure to that of the lowest possible taxa. However the only taxa that were identified to a finer scale than Order were the Malacostraca. Therefore examining the data set at the lowest possible taxonomic level resulted in all taxa except the Malacostraca still being examined at the Order level. Further work is required to identify many of the non-Malacostraca down to lower taxonomic levels.

This analysis suggests that the Order level provides more information on community structure than either the Phyla or Class levels. Since this level was the lowest level identified for many taxa, the analysis appears to be indicating that finer scale identification is preferable. However, the identification of individuals to species level, as was undertaken for many taxa of the Malacostraca, is a labour intensive process that requires advanced taxonomic skills. A good description of community structure at higher levels of taxonomic resolution is the preferred option as it reduces much of the necessary taxonomic expertise and time taken to process samples. This enables greater efficiency in processing samples, and would reduce the overall cost of this monitoring program in the future. This current work indicates that Order may be close to the preferred level of taxonomic resolution and as such will be used for subsequent analysis, however future work will further examine this finding.

The current puerulus-monitoring program run by the Department of Fisheries (Caputi et al 2008) provided a cost-effective opportunity to monitor the spatial and temporal variation in community composition. The spatial array of sites spanned 1000 km and provided one of the largest spatial scales known to examine macro invertebrate community composition on artificial collectors. This combined with monthly samples provided an opportunity to examine long-term inter-annual temporal patterns as well as seasonal or monthly variation. Artificial collectors, such as these puerulus collectors, have been shown to provide a representative community composition to adjacent natural systems, providing a valuable management tool to examine changes in community composition of the habitats (Edgar and Klumpp 2003).

Studies utilising similar methods have been conducted elsewhere in Australia and have been aimed at examining spatial, seasonal or inter annual patterns in community structure. Methodologies from these studies were broadly similar, with preservation of samples either using Formalin (10%) (Edgar 1991), ethanol (Cameron 2009) or a combination of the two (Gatt 2009). While there is some debate as to the appropriate sieve size, the use of the 500 µm sieve here is comparable with Edgar (1991) and intermediate of Cameron (1 mm; 2009) and Gatt (350 µm; 2009).

The level of replication determined as appropriate by this study and the level of taxonomic resolution also appear to be consistent with previous work. Three replicate collectors were used in a New South Wales study (Gatt 2009) while a study in South Australia used 5 – 12 collectors, with a finer taxonomic resolution, though no species accumulation curve was used to assess the appropriate number of replicates (Cameron 2009). The use of four replicate collectors was appropriate for this study to adequately describe the macro invertebrate community at the Order level (Figure 4), with this level of taxonomic resolution providing a robust measure of community composition.

5.2 Objective 3

Determine what environmental parameters may be linked to the majority of variation in the floral and faunal communities colonizing puerulus collectors, focusing on those relating to puerulus settlement

5.2.1 Community Structure

Given the similarity in community structure using a range of taxonomic levels (Objective 2 – Table 2), the following analyses were undertaken at the Order level.

Of the 157 740 individuals identified, Amphipoda was the dominant Order encompassing almost half of all individuals (Figure 8). Amphipods were over three times greater in abundance than the second most abundant taxa (Class – Gastropoda), which in turn were, double that of Isopoda, Tanaidacea and Ostracoda (Class). To reduce the impact of these dominant taxa on the overall community structure analysis, transformations were applied (either forth-root or natural logarithm depending on the form of analysis) to all abundance data (see later).

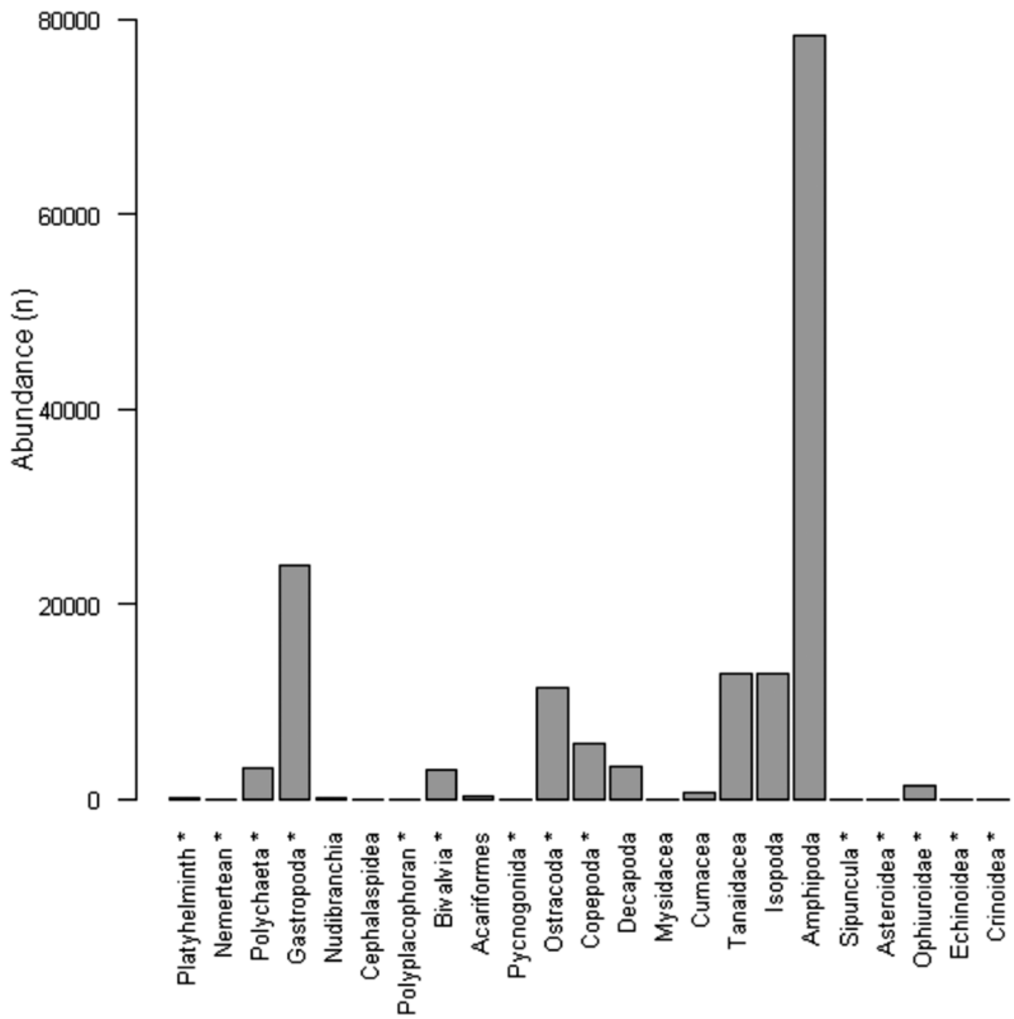

Figure 8. Abundance of individuals from all samples according to their taxonomic order. * indicates taxa classified to a higher taxonomic resolution than Order.

Prior to non-metric multivariate analysis all abundance data was forth-root transformed to remove 'skewness' from the data and to down-weigh the influence of very abundant taxa (Clark and Warwick, 2001). nMDS of the community composition of macro-invertebrates at an Order level showed a marked separation between different sites and seasons (Figure 9). ANOSIM confirmed both the spatial and temporal separations in community composition were significant ($R=0.875$; $p<0.001$ and $R=0.465$; $p<0.001$, respectively). Pairwise examination of groups (location and season) showed that significant differences in community composition existed between all sites and most seasons with the exception of spring and autumn (Table 3).

Table 3. Pairwise comparisons of spatial and seasonal factors. C – Coral Bay; Q – Point Quobba; D – Dongara; L – Lancelin; W – Warnbro | S – Summer; A – Autumn; W – Winter; Sp – Spring;

Group 1	Group 2	R statistic	Sig. Level (%)
Spatial Differences			
C	D	1	0.1
C	L	1	0.3
C	Q	0.915	0.1
C	W	1	0.1
D	L	0.63	0.1
D	Q	1	0.2
D	W	0.833	0.1
L	Q	1	0.1
L	W	0.656	0.1
Q	W	1	0.3
Temporal Differences			
W	Sp	0.469	0.1
W	S	0.688	0.2
W	A	0.406	1.7
Sp	S	0.448	0.2
Sp	A	0.214	9.2
S	A	0.417	0.1

The main separation of sites existed between the two northern sites (to the left of the MDS plot) and the three southern sites (to the right of the MDS plot – Figure 9.) Within each site the winter samples separated out and were located above corresponding spring and summer samples for that location. The southern locations (on the right of the MDS plot) also showed a progressive distribution from the top of the plot to the bottom, with the most southern location (Warnbro) being positioned at the bottom and the most northern location of these three (Dongara) being at the top.

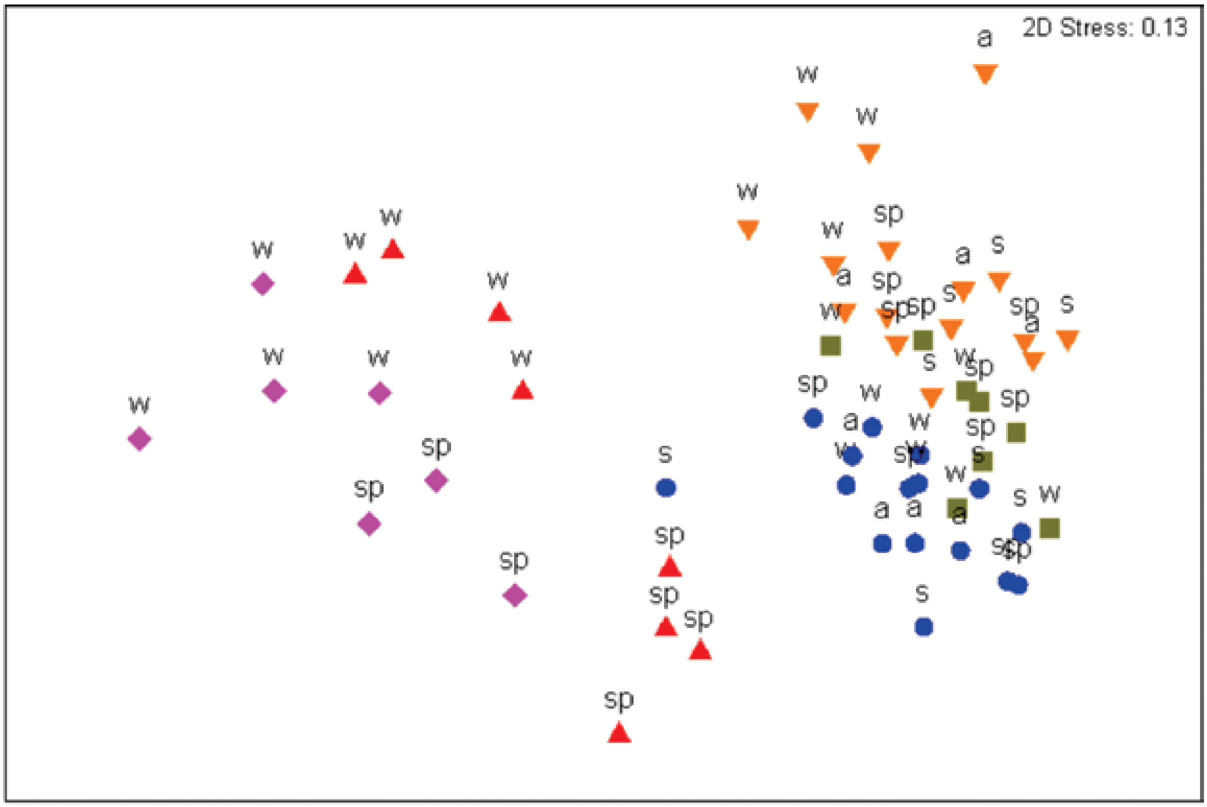

Figure 9. **nMDS of collectors from Coral Bay (red), Point Quobba (pink), Dongara (orange), Lancelin (green), and Warnbro (blue), for winter (w), spring (sp), summer (s) and autumn (a).**

Geographical separation of locations was the most dominant factor in the variation of community composition as illustrated by the high ANOSIM significance value. This separation in community composition between locations at a large spatial scale has also been recorded in other studies, though the spatial separation of sites was not as great as seen in this study. Cameron (2009) revealed very different community composition between sites within different fishing zones for lobsters (*Jasus edwardsii*) in South Australia, with sites separated by at least 300 km.

The spatial separation of sites shown in this study occur both between climate zones (tropical/sub-tropical and temperate), as well as latitudinally within the temperate climate zone.

Seasonal variation was also not unexpected, with this being recorded previously for macrofaunal composition associated with puerulus collectors in N.S.W (Gatt 2009). However, samples from the same season across multiple years at the same sites, were not similar, indicating inter-annual variation in community composition (Gatt 2009). As the samples collected during this study do not encompass multiple years changes in community composition have not been examined.

5.2.2 Environmental Influence on Community Structure

A number of studies on western rock lobster, that have highlighted environmental influences on puerulus settlement rates and locations (Caputi & Brown 1993; Caputi et al 2001; Caputi 2008). They demonstrate that puerulus settlement is influenced primarily by the Leeuwin Current, which controls both the magnitude and peak locations of settlement, and the occurrence of westerly winds in winter/spring. In this study we examined relationships between the community composition and localised temperature, salinity and water movement. BIOENV, which relates environmental measures with changes in community composition, failed to detect any significant relationships between the community composition of all sites and seasons and either water temperature, salinity or water movement (Rho=0.177, p>0.4).

However, the distinct separation of tropical/sub-tropical locations (Coral Bay and Point Quobba) from the temperate locations (Dongara, Lancelin and Warnbro) and the apparent latitudinal separation of the temperate sites, and seasons within these temperate sites, (summer and winter separated from each other with autumn and spring intermetiate), would seem to indicate a potential thermal driver on community composition. There is obviously another factor causing these seperations, especially the very marked spatial separation between the northern and southern locations. The most obvious difference between the tropical/sub-tropical and temeperate locations, apart from oceanic condictions, seems to be the localised habitat around the collectors (Plate 1). Habitat surrounding the collectors located in temperate areas are dominated by either macroalgae or seagrass beds associated with limestone reef (Plate 1a). The tropical/sub-tropical sites are surrounded by coral communities with little to no seagrass being present (Plate 1b).

Plate 1. Comparison of surrounding bethos from a) temperate (Lancelin – seagrass/limestone complex with wave logger in the background) and b) tropical (Coral Bay – coral reef).

Previous studies have demonstrated the influence surrounding habitats have on the macro invertebrate community composition (Virnstein and Howard 1987, Wildsmith et al. 2005, Stella et al. 2010). Exact habitat composition at each site are yet to be quantified, but continued research is planned to explore the effects of these differences as a potential driver of the community structures reported here.

Flora associated with collectors was separated from the faunal component, but has not been identified to date. Epiphytes have been shown to influence the invertebrate community structure (Martin-Smith 1993), and with some of the samples processed in this project containing large amounts of epiphytic algae, this may play an important role in community structure.

When BIOENV analysis was used to examine environmental effects on community composition in just either the tropics/sub-tropics (Rho=0.429, p>0.35) or temperate (Rho=0.211, p>0.3) locations, it still failed to determine any significant correlations between environmental factors and community structure.

5.3 Objective 4

Identify indicator marine flora and fauna species for monitoring the influences of environmental change on Western Australian marine environment.

5.3.2 Orders influencing community composition changes

There were a total of 24 orders (or higher taxonomic levels) that were identified from the five sites. As a result, most sites had representatives of that order within their species composition (Figure 10).

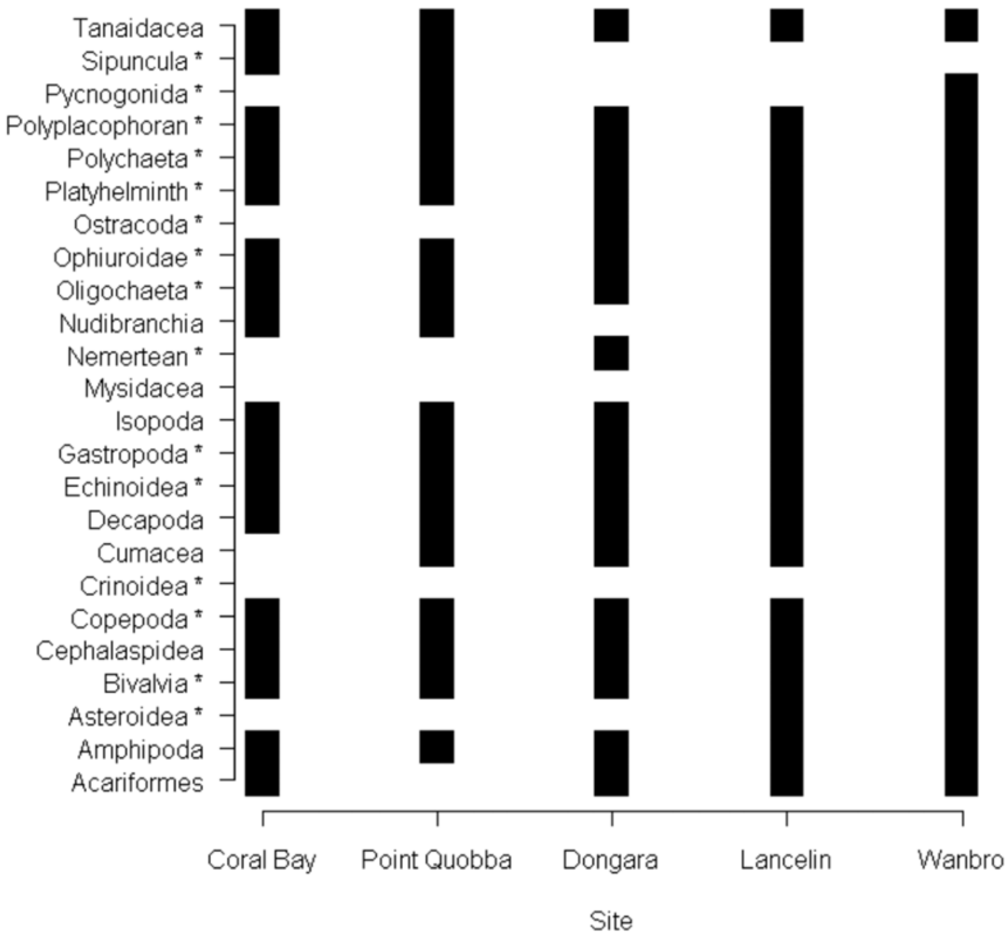

Figure 10. Presence (filled square) or absence of an order (or higher – denoted with *) within the macro-invertebrate community from the five sampled sites.

Most noticeably was the presence of almost all orders at the Warnbro (southern most) site, with reduced numbers of orders progressively present in more northern sites. Ostracoda were not recorded at the northern locations of Coral Bay or Point Quobba, while Sipuncula were only recorded at these northern locations.

As there was limited difference in the occurrence of orders between locations, changes in community compositions were largely driven by changes in the relative abundances of these orders as opposed to their presence or absence at certain locations. There was a clear and significant ($p<0.001$) difference in the mean abundances of individuals from the five locations (Figure 11).

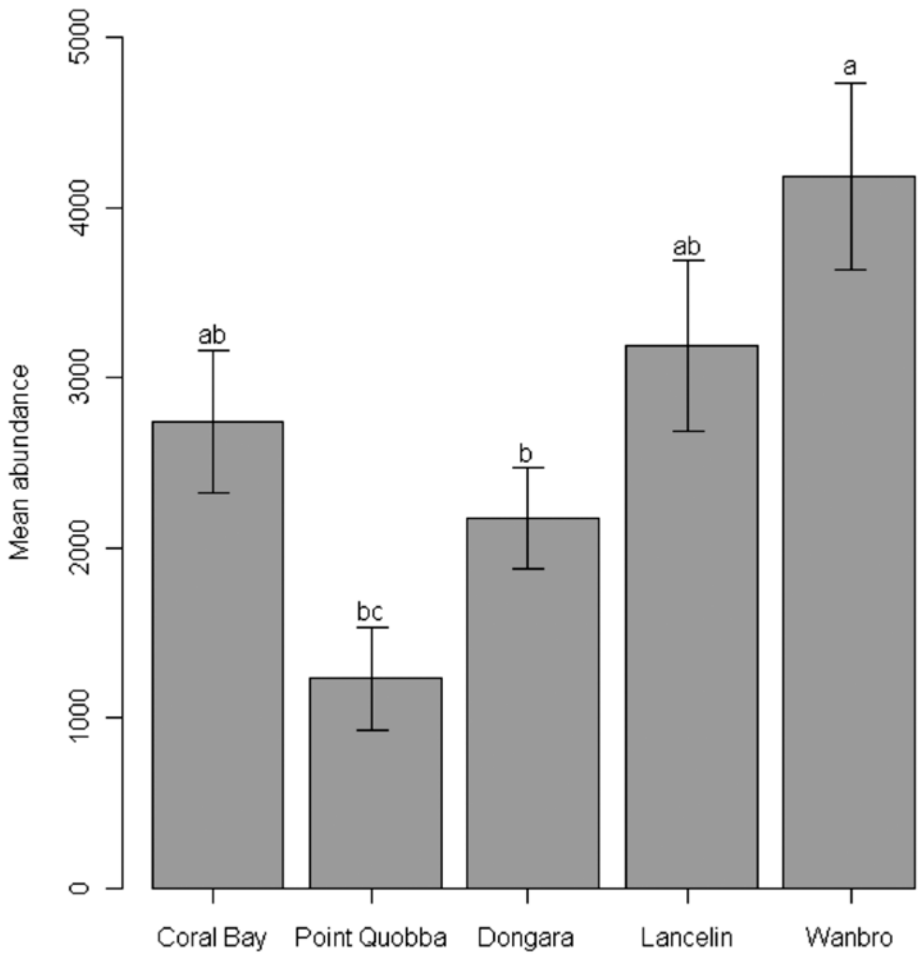

Figure 11. Mean abundance (±SE) of all individuals collected at the five sites. Letters indicate where significant pair-wise differences occur.

Point Quobba had the lowest mean abundance of all sites and was significantly lower than all other sites except for Dongara. Contrasting this was Warnbro, which had the highest relative abundance, and significantly more than Dongara and Point Quobba. With the exception of Coral Bay, there appears to be an increasing trend in mean abundance from sites in a more southerly (temperate) direction. This is mainly driven by the abundances of amphipods since they contributed at least 70% to the total abundances at each site.

Orders that contributed most to community composition differences between locations (as determined by SIMPER) were examined individually (Figure 12).

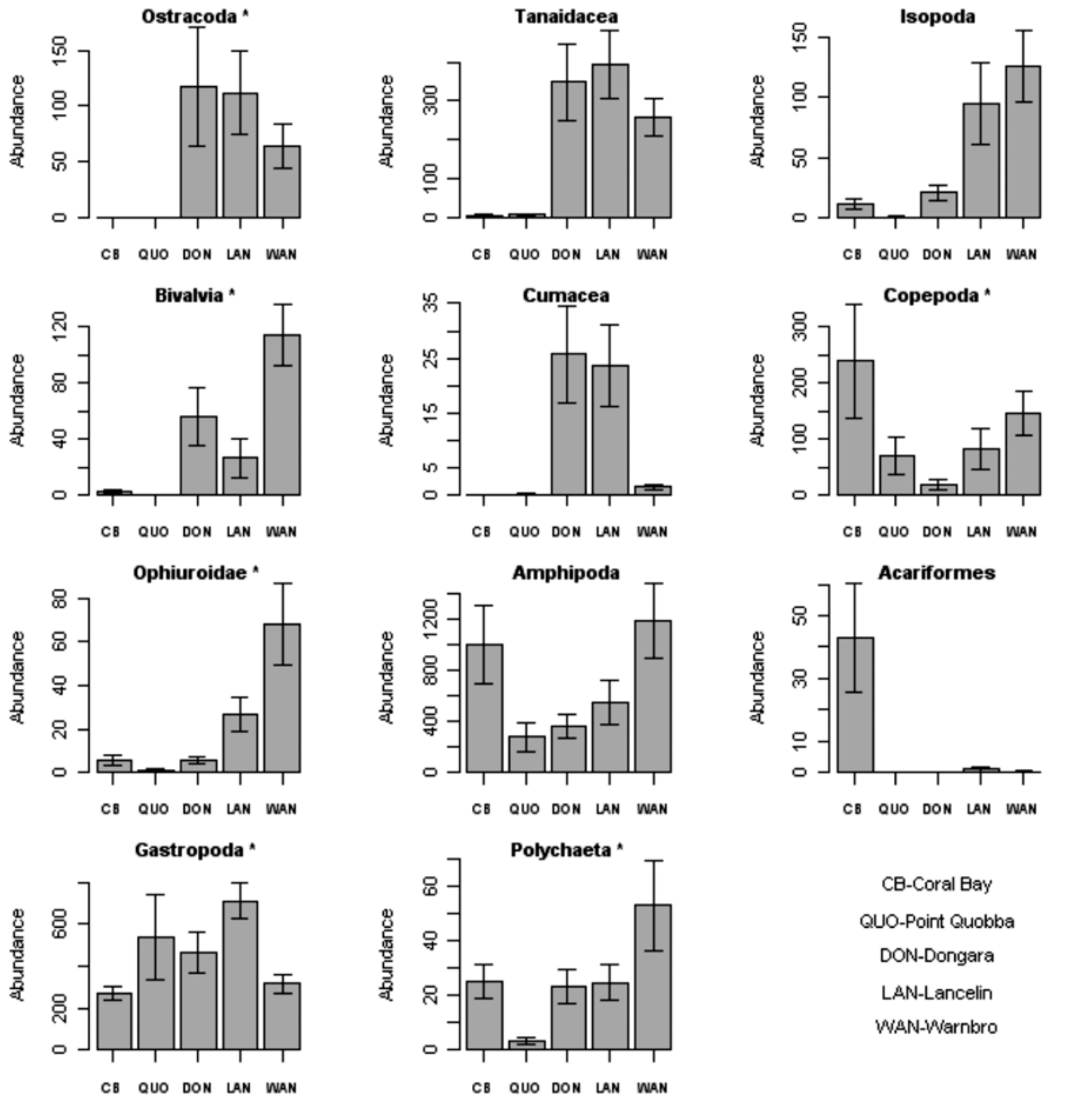

Figure 12. Mean untransformed abundance (±SE) of key orders for differentiating community structure, by site. * Indicates taxa only classified to a higher taxonomic resolution than Order.

Variation of Orders abundances accounts for the majority of the dissimilarity between sites (Figure 12) and between seasons at a site, as opposed to the presence or absence of particular Orders. The lack of Ostracoda was a major driving factor in the difference in communities between the northern topical/sub-tropical locations and those situated to the south. However, the reduced abundance of Tanaidacea, Bivalvia, Isopoda and Cumacaea at these sites, also significantly contributed to the difference in community structure.

5.3.3 Environmental impacts on taxa abundance

The habitat surrounding the collectors appears to be a main factor influencing community compositions at each location. Therefore the data set has been split into tropical/sub-tropical and temperate locations to further examine relationships between environmental factors and the abundance of individual Orders.

5.3.3.1 *Tropical / Sub-tropical locations*

Of the 18 Orders present in tropical/sub-tropical locations, ten showed a significant relationship with either temperature or water movement (Table 4).

Table 4. Coefficients and their significance from multiple linear regression of Order abundance (log(x+1)) at Tropical / Sub-tropical sites and temperature (Temp) and relative water movement (Wave). Bold indicates significant coefficients.

Order	Intercept	Temp	Wave	Adjusted R squares
Amphipoda	7.0584	-0.0958	-1.1754	-0.0616
Tanaidacea	**-22.0321***	1.003**	0.5055	0.5862
Isopoda	12.4761	-0.4329	-1.6268*	0.0655
Decapoda	1.1913	-0.0271	-0.2237	0.0041
Cumacea	-3.8579	0.1548	0.3019	0.1555
Pycnogonida *	-6.1146	0.2453	0.4785	0.1555
Copepoda *	19.4109	-0.5101	-2.7524*	0.2635
Bivalvia *	12.3612	-0.4027	-2.01*	0.3576
Gastropoda *	-10.2063	0.6409*	1.075	0.2919
Polyplacophoran *	4.1935	-0.0805	-1.501**	0.6066
Nudibranchia	-19.8024*	0.8911*	0.6251	0.4023
Cephalaspidea	-1.6961	0.0797	0.0372	-0.1231
Ophiuroidae *	2.8845	0.029	-2.1669*	0.5841
Echinoidea *	2.2016	-0.0616	-0.3675	-0.1149
Polychaeta *	18.068	-0.5257	-3.35***	0.3826
Platyhelminth *	-2.5462	0.153	-0.5055	0.6406
Acariformes	**28.8152***	-0.8726	-6.1833***	0.7521
Sipuncula *	-4.9871	0.2112	0.2366	0.0767

The abundances of Tanaidacea, Gastropoda and Nudibranchia, were all positively related to water temperature with the Tanaidacea showing the strongest relationship (Figure 13).

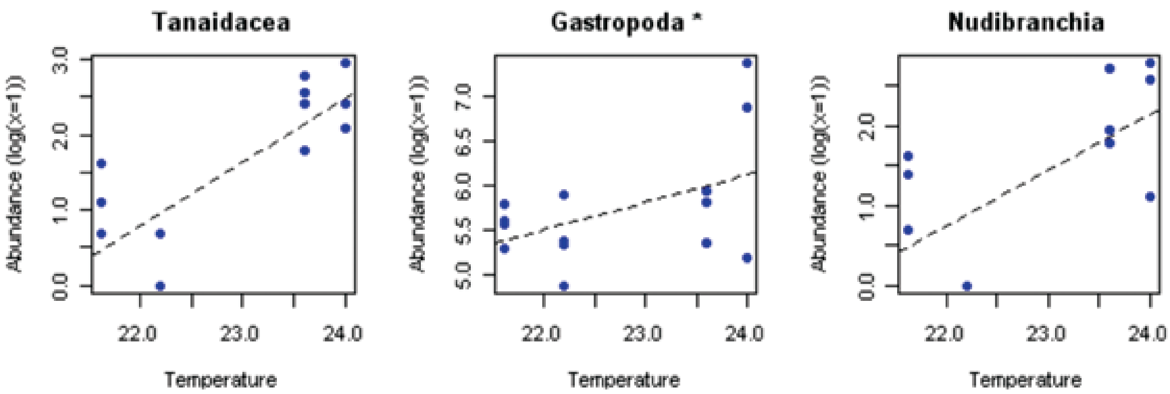

Figure 13. Relationship between the abundance (log(x+1) transformed) of taxa and water temperature for tropical and sub-tropical sites (Coral Bay and Point Quobba).

The abundance of seven Orders all showed significant negative relationships with water movement, with reducing abundances occurring at increasing levels of water movement. Acariformes were only found in the lowest water movement period (i.e. November at Coral Bay) (Figure 14).

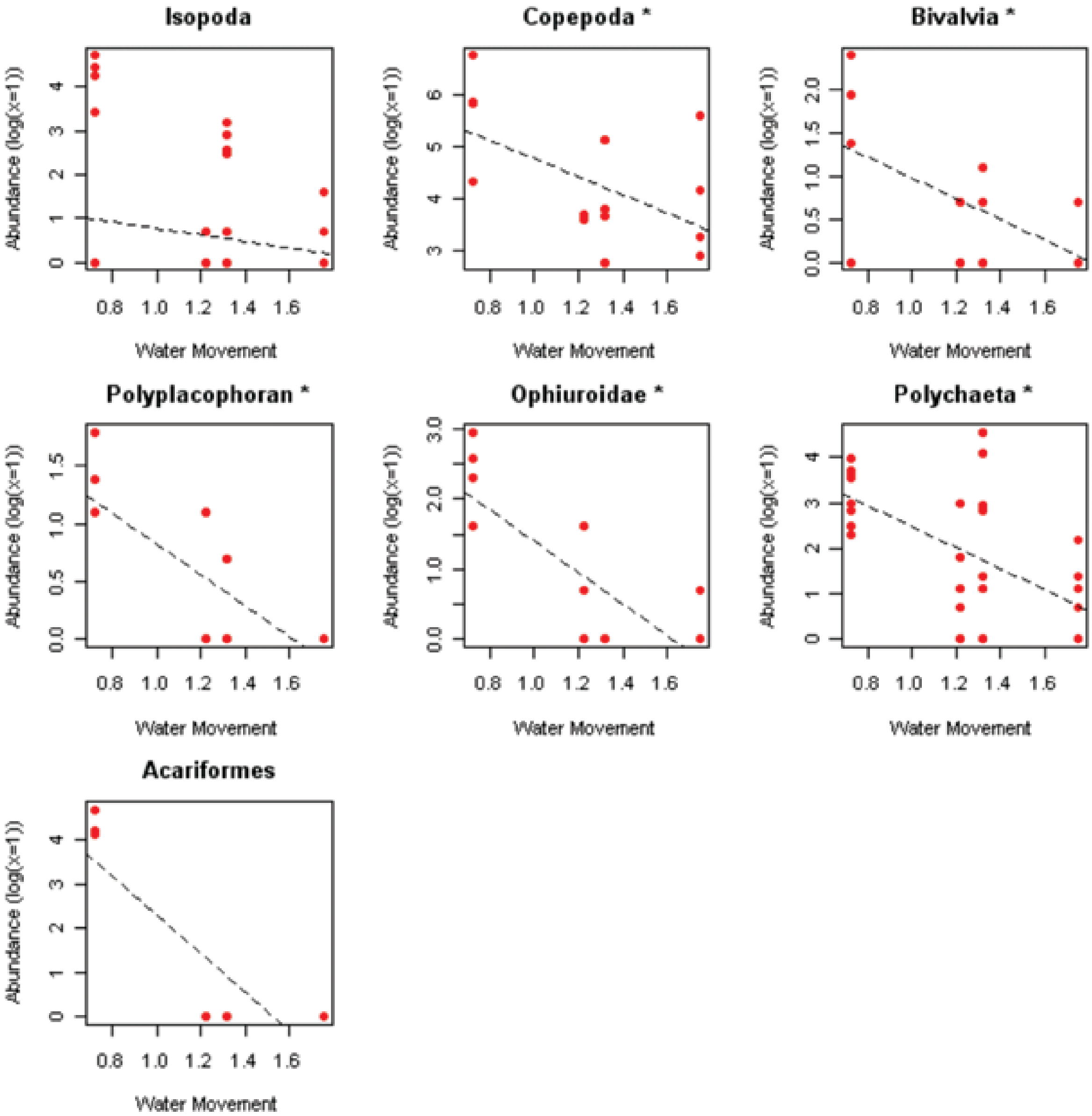

Figure 14. Relationship between the abundance (log(x+1) transformed) of taxa and relative water movement for tropical and sub-tropical sites (Coral Bay and Point Quobba).

5.3.3.2 Temperate

Of the 22 Orders that occurred at the temperate sites (Dongara, Lancelin and Warnbro), nine demonstrated significant effects with water temperature, water movement or salinity. Of these, five varied significantly with two of these factors (Table 5).

Table 5. Coefficients and their significance from multiple linear regression of Order abundance (log(x+1)) at Temperate sites and temperature (Temp), relative water movement (Wave) and salinity (Sal). Bold indicates significant coefficients.

Order	Intercept	Temp	Wave	Sal	R squared
Amphipoda	73.0335	0.0799	-0.3257	-1.9642	-0.0069
Tanaidacea	-40.9455	-0.1673	-0.0912	1.3893*	0.0845
Isopoda	31.764	-0.0842	-0.1371	-0.7741	0.0108
Decapoda	1.3067	0.0107	0.0888	-0.0395	-0.0012
Cumacea	-94.0193***	0.1182	1.7341*	2.5535***	0.4941
Ostracoda *	9.5422	0.0582	-0.3592	-0.2188	-0.017
Mysidacea	20.4514	0.0467	-0.5567	-0.5724	0.1551
Pycnogonida *	6.8809	-0.013	0.08	-0.1849	0.0383
Copepoda *	120.1812**	0.1497	0.1238	-3.356**	0.1832
Bivalvia *	34.2846	-0.077	-1.8193	-0.7533	0.0833
Gastropoda *	-16.677	-0.0049	-0.2486	0.6384	-0.0258
Polyplacophoran *	18.9911	0.0596	0.076	-0.5522	-0.0324
Nudibranchia	28.2188**	0.1127*	0.4324	-0.8591**	0.1303
Cephalaspidea	-4.8877	0.1939*	1.2496*	-0.0051	0.1851
Asteroidea *	4.8515	-0.0038	-0.122	-0.1259	-0.0416
Ophiuroidae *	52.4984	-0.0331	-0.7701	-1.3514	0.0292
Echinoidea *	14.4466	-0.015	0.3444	-0.3968	0.0342
Crinoidea *	8.9207**	0.0331*	-0.064	-0.2645**	0.2883
Polychaeta *	54.1622**	0.085	-0.3034	**-1.4673****	0.1117
Platyhelminth *	49.2606**	-0.0961	-0.9963	**-1.2627***	0.3001
Nemertean *	5.9346	0.172*	1.4848**	-0.3027	0.1244
Acariformes	-0.0493	-0.0168	0.4835	-6.00e-04	0.0614

Seven orders showed a significant relationship with salinity, with all except Tanaidacea and Cumacean showing a negative relationship (Table 5, Figure 15). Copepoda, Polychaeta and Platyhelminth had representatives in each sample collected at low salinity. However at 35.7 for Copepoda and Platyhelminth and 36 ppt for Polychaeta, some samples did not contain these individuals as mean abundance began to fall.

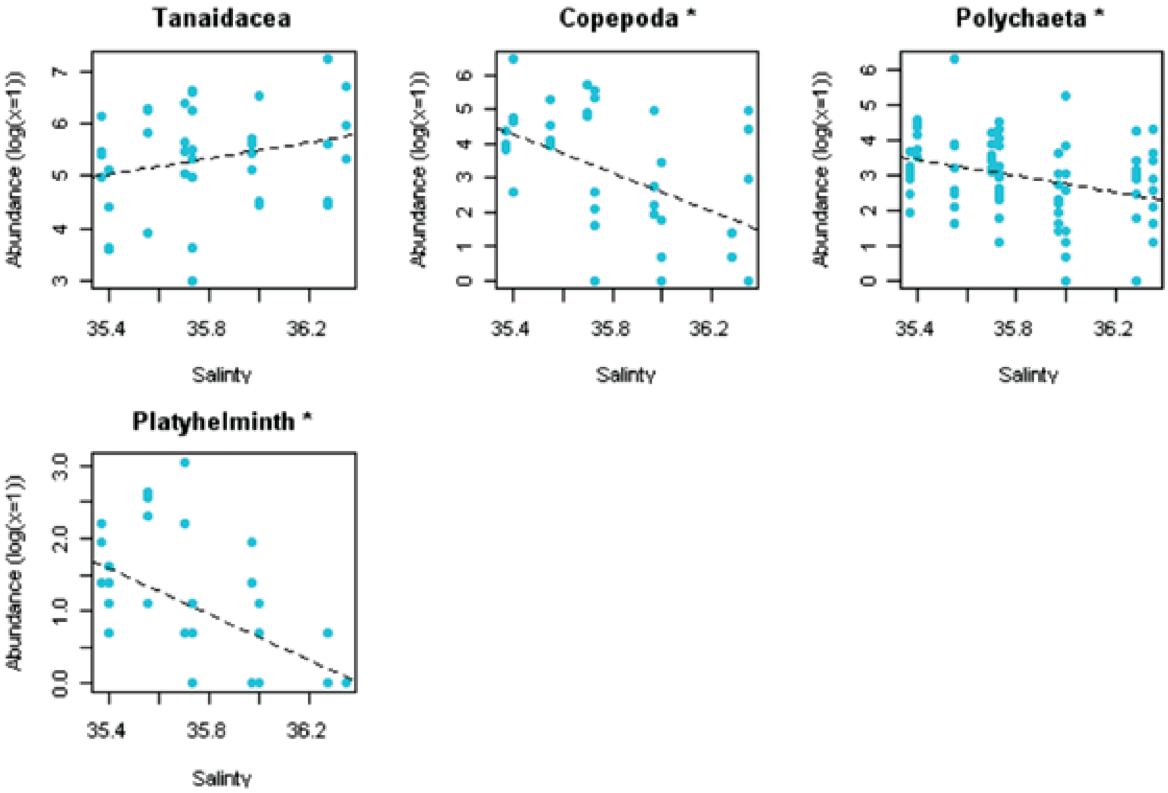

Figure 15. Relationship between the abundance (log(x+1) transformed) of taxa and salinities for temperate locations.

Five Orders showed significant relationships for more than one environmental parameter (Table 4). Cumacea showed a positive relationship for both salinity (blue dots) and water movement as represented by lines at low (5th quantile), mid (mean) and high (95th quantile) (Figure 16). The Nudibrachia demonstrated a significant negative relationship with salinity, however a positive relationship with temperature (as represented by lines for low, mid and high). Finally, there was a significant positive relationship for temperature and wave in Cephalaspidea and Nemertean abundance.

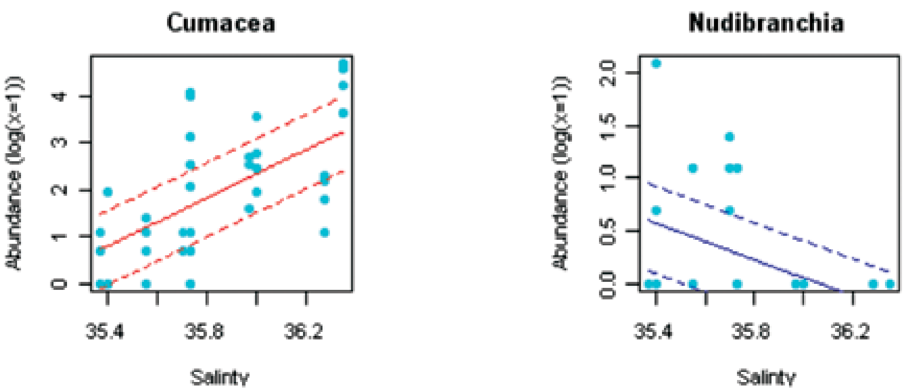

Figure 16. Relationship between the abundance (log(x+1) transformed) of taxa and multiple environmental parameters for the temperate locations. Salinities are shown in light blue dots), water movement in red lines and temperature in dark blue lines. The multiple lines represent three levels of the second most influential parameter in the multiple regression (low (5th quantile), mid (mean) and high (95th quantile).

The positive relationships between the abundance of some taxa and water temperature and the negative relationships between abundance and water motion may be related to levels of productivity and habitat stability, respectively.

All of the fauna examined during this study are polikotherms, whose metabolic rate and activity levels are proportional to the ambient temperature. Periods of increased activity, i.e. feeding and reproduction, would increase the likelihood of many of these fauna encountering and settling on the collectors, thus increasing their abundance in our samples. The negative relationship with water movement (Figure 14) is probably an indication of how difficult in may be for many of these fauna to remain associated with the collectors during periods of high wave action, rather than reflecting a reduced abundance in the area. This is not surprising since periods of high wave action often lead to one or a number of puerulus collectors snapping their chain moorings and washing up on the beach.

There were several orders that demonstrated potential changes in their abundance associated with changing environmental conditions in both the tropical/sub-tropical and temperate locations. With increased sampling and validation of these results, many of these taxa may be used as future indicators of environmental change along the West Australian coast.

The relationships between taxa abundance and environmental variables examined above reflect environmental effects within a year and latitudinally. The correlations within a year may reflect general seasonal variations between abundance and environmental variable rather than a cause and effect. Variations in abundance and taxa between years are necessary to examine these relationships further.

Identification of some taxa to a species level has provided interesting information, and suggests that finer scale identification may be advantageous for reasons other than for describing the community composition. While not yet completed, the finer scale classification of Gastropoda has already identified the juvenile *Strombus mutabilis* at Dongara during winter, a species that has typically been thought to be restricted to tropical waters (Anne Brearley pers. comm.). This may be an example of a shift in this species range, with range shifts previously demonstrated in species as a response to increasing water temperatures (Perry et al. 2005). With water temperatures increasing off the Western Australian coast (Peace and Feng 2007) and predicted to continue, incursions of more tropical species in temperate collectors may become more prevalent. The warm, south-flowing Leeuwin Current also plays a significant role in the distribution of tropical species further south, particularly during La Nina periods when the Leeuwin Current is flowing strongly (Pearce and Hutchins 2009).

5.3.4 Correlations of taxa abundance and puerulus settlement

5.3.4.1 Community-level

The community composition differed significantly (Rho=0.246, $p<0.001$) between samples containing puerulus and those where they were absent (Figure 17a). This was also the case when the number of puerulus was categorised as none (0), low (1-4), moderate (5-9) or high (10+), (Rho=0.273, $p<0.001$) (Figure 17b).

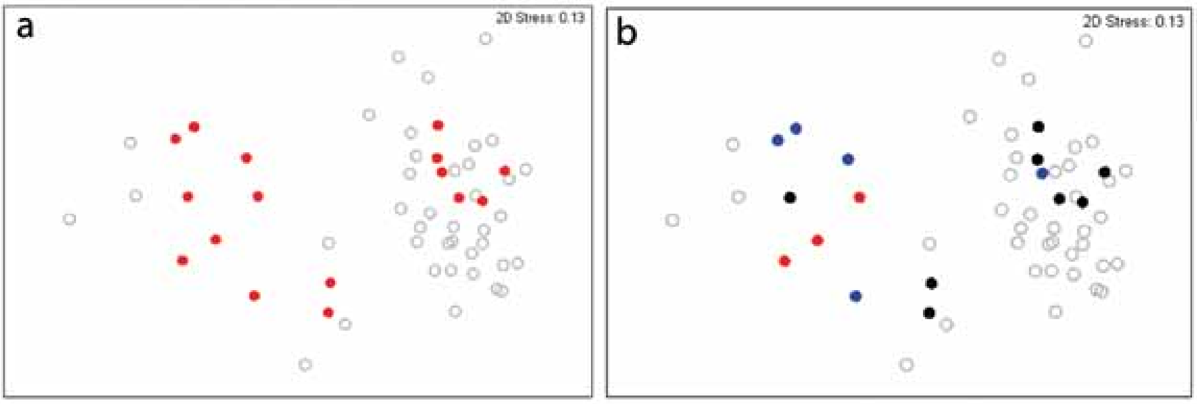

Figure 17. nMDS of community composition showing samples which had a) puerulus (red) or no puerulus (open circle) and b) none (open circle), 1-4 (black), 5-9 (blue) or 10+ (red) puerulus.

Communities containing lobsters were predominantly found in the tropical/subtropical locations to the right of the MDS, with a small cluster on the left of the nMDS at more northern temperate sites (Figure 17a). The categorical approach to puerulus numbers showed no significant difference between the high and moderate puerulus settlement samples, and similarly between the none and low puerulus settlement samples. Again the high and moderate sites appeared to be associated with the tropical/sub-tropical sites compared to the lower settlement samples in the temperate region. SIMPER analysis yielded, unsurprisingly, similar Order abundance difference for puerulus presence absence or categorical settlement as those found between sites, particularly tropical/subtropical and temperate locations.

Due to this obvious separation of tropical/sub-tropical and temperate locations again with puerulus abundances, coupled with significant variation in the timing of puerulus settlement (Figure 5), potential relationships between puerulus and other taxa abundance were explored separately for the tropical/sub-tropical (Coral Bay and Point Quobba) and temperate (Dongara, Lancelin and Warnbro) locations.

5.3.4.2 Tropical / Sub-tropical

The abundances of none of the taxa were found to vary significantly with puerulus abundance.

5.3.4.3 Temperate

In the temperate locations, the Class Copepoda showed a significant negative relationship between its abundance (log (x+1) transformed) and that of puerulus abundance (log (x+1) transformed) (Figure 18).

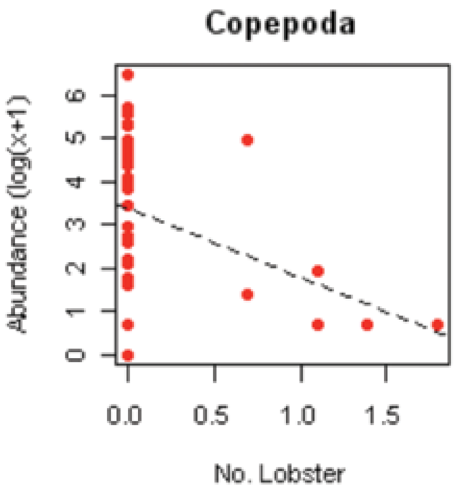

Figure 18. Relationship between the abundance of puerulus (log (x+1)) and that of Copepods. Dashed line indicates the significant regression line.

The occurrence this significant negative relationships between lobsters and Copepoda in the temperate sites, may be reflective of juvenile lobster predation. Though his study focused on larger lobsters than was captured from the puerulus collectors, MacArthur (2009) found that Crustacea was a major taxa ingested by lobsters.

While there is a significant relationship between abundances of different Copepoda and that of puerulus, due to the current low puerulus settlements, it is difficult to assess with any certainty the validity of this relationship or the lack of identification of other potentially important taxa, which may show a relationship with puerulus abundance. It is also possible that the above relationship reflects seasonal variation in abundance of both taxa. Continued monitoring on an annual basis may see these initial patterns continue, though may also elucidate further significant patterns.

5.4 Objective 5

Detect any known or potential introduced marine pests within the Western Australian environment.

Currently, none of the samples processed have produced individuals from the list of marine pests (Appendix C). Classification of specimens to a finer taxonomic level will provide more certainty to this finding.

6.0 Benefits and adoption

This project provided the ability to initiate the monitoring of flora and fauna associated with puerulus collectors during a period of low puerulus settlement. This project enabled a standard methodology to be developed to adequately capture the variation in community structure, such that possible effects of changes in environmental conditions can be monitored.

The monitoring program developed by this project has been adopted by the Department of Fisheries and integrated into the current puerulus monitoring program. This has therefore resulted in the start of a cost-effective long-term monitoring program assessing faunal communities.

In addition, this project modified and deployed a series of water movement loggers at sites throughout the coast. This is providing a valuable data-stream of localised water movement patterns, against which a number of other biological and ecological programs can compare results.

7.0 Further development

Due to the time-consuming nature of the sorting and identification process, future development will focus on increased taxonomic resolution where possible. Additional sites will also be added to the analysis, but most work will focus on examining the habitat or epiphytic influences on community structure. To fully examine possible links between puerulus numbers and co-existing fauna and flora, annual variations in puerulus abundance are required for assessment.

8.0 Planned outcomes and conclusions

All objectives of this project have been met, providing an important baseline against which to compare future environmental changes on some of the floral and faunal communities on the West Australian coast.

Monitoring began during a period of low puerulus settlement to provide a baseline of current macro-invertebrate community composition. While only 5 sites and selected months were examined as part of this report, the collection of samples from the remaining sites and all months will allow more-detailed retrospective analysis of these samples.

A standard methodology has been developed and implemented to capture the biological and environmental data from sites along the West Australian coast. The methodology is broadly consistent with that of previous studies, and its utilisation of a pre-existing monitoring program makes it very cost effective. Analysis on number of collectors necessary to describe the community structure and the level of taxonomic resolution required conducted as part of this study, has further reduced and streamlined the collection of this valuable information.

The majority of variation between samples was spatial, though a significant temporal pattern also existed. Despite this, temperature, salinity and water movement didn't directly influence community composition. Further research into epiphytic and habitat influence may elucidate potential mechanisms in structuring macro invertebrate communities.

While environmental parameters didn't influence the community structure as a whole, there were significant correlations with taxa abundance and environmental conditions. Similarly there were taxa that showed a significant correlation in their abundance and that of puerulus settlement, however these need to be confirmed by examining annual variation. Due to the preliminary nature of this project, it was not possible to definitively identify correlates with either environment or puerulus settlement. However, the continuation of the project through a period of improved puerulus settlements may provide greater contrast against which to identify potential indicator taxa. The collection of tropical species in temperate locations (e.g. *Strombus mutabilis*) does highlight the benefit of such a monitoring program to identify shifts in species' range.

Finally, no introduced marine pests identified. With increasing taxonomic resolution, greater certainty as to the occurrence of marine pests can be attained.

9.0 References

Anonymous. (2002). Nationally Listed Threatened Species and Ecological Communities under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. http://www.environment.gov.au/biodiversity/threatened/publications/recovery/guidelines/pubs/recovery-2002.pdf.

Brown, R. (2009). Western Rock Lobster Low Puerulus Settlement Risk Assessment Workshop Held 1 and 2 April 2009. Western Australian Department of Fisheries, 3rd Floor The Atrium, 168 St Georges Terrace, Perth, Western Australia, 6000.

Cameron, S. (2009) Spatial and temporal variation in the colonisation of *Jasus edwardsii* puerulus collectors within South Australian waters. Honours Thesis. Flinders University.

Caputi N. and Brown R.S. (1993) The effect of environment on puerulus settlement of the western rock lobster (*Panulirus cygnus*) in Western Australia. Fisheries *Oceanography* **2**: 1-10.

Caputi, N. (2008) Impact of the Leeuwin Current on the spatial distribution of the puerulus settlement of the western rock lobster (*Panulirus cygnus*) and implications for the fishery of Western Australia Fisheries *Oceanography* **17(2)**: 147-152.

Caputi N., Melville-Smith R., de Lestang S., How J., Thomson A., Stephenson P., Wright I. and Donohue K. (2008) Stock Assessment for the West Coast Rock Lobster Fishery - Draft, Department of Fisheries Western Australia, Perth.

Caputi, N., Brown, R.S. and Chubb, C.F. (1995). Regional prediction of the western Rock Lobster, *Panulirus cygnus*, commercial catch in Western Australia. *Crustaceana,* **68**: 213-226.

Caputi N., Chubb C.F. and Pearce A. (2001) Environmental effects on recruitment of the western rock lobster, *Panulirus cygnus*. *Marine and Freshwater Research* **52**: 1167-1174.

Carlton, J.T. (1985). Transoceanic and interoceanic dispersal of coastal marine organisms. The biology of ballast water. *Oceanography and Marine Biology Annual Review* **23**: 13-374.

Clarke K.R. and Warwick R.M. (2001) Change in marine communities: an approach to statistical analysis and interpretation, Vol. PRIMER-E Ltd., Plymouth.

de Lestang, S., Hall, N.G. and Potter, I.C. (2003). Influence of a deep artificial entrance channel on the biological characteristics of the blue swimmer crab *Portunus pelagicus* in a large microtidal estuary. *Journal of Experimental Marine Biology and Ecology*. **295**: 41-61.

de Lestang, S., Caputi, N. and Melville-Smith, R. (2009). Using fine-scale catch predictions to examine spatial variation in growth and catchability of *Panulirus cygnus* along the west coast of Australia. *New Zealand Journal of marine and Freshwater Research*. **43**: 443-455.

de Lestang, S., Bellchambers, L.M., Caputi, N., Thomson, A.F., Pember, M.B., Johnston, D.J. and Harris, D.C. in press. Stock-recruitment-environment relationship in a *Portunus pelagicus* fishery in Western Australia. Wakefield Publication.

Edgar, G.J. (1991) Distribution patterns of mobile epifauna associated with rope fibre habitats within the Bathurst Harbour Estuary. *Estuarine, Coastal and Shelf Science* **33**: 589-604.

Edgar, G.J. and Klumpp, D.W. (2003) Consistencies over regional scales in assemblages of mobile epifauna associated with natural and artificial plants of different shape. *Aquatic Biology* **75**: 275-291.

Evans, S.N. and Abdo, D.A. 2010. A cost effective technique for measuring relative water movement for studies of benthic organisms. Marine Freshwater Research 61: 1327-1335

Gatt, A.H. (2009) Diversity and dynamics of the epifaunla assemblage of the larval lobster collection devices. Honours Thesis, University of New South Wales.

Gili J. and Petraitis P. (2009) Seasonal Dynamics. In: Wahl M (ed) Marine Hard Bottom Communities: Patterns, Dynamics, Diversity and Change. Springer, Berlin, Heidelberg, p 191-200.

Hunter E. and Naylor E. (1993) Intertidal migration by the crab *Carcinus maenas*. *Marine Ecology Progress Series* **101**: 131-138.

Jenkins S.R., Marshall D. and Fraschetti S. (2009) Settlement and Recruitment. In: Wahl M. (ed) Marine Hard Bottom Communities: Patterns, Dynamics, Diversity and Change. Springer-Verlag, Berlin, p 177-190.

Jones D.S. and Morgan G.J. (1994) A Field Guide to Crustaceans of Australian Waters, Vol. Reed Books, Chatswood, N.S.W.

MacArthur, L.D. (2009) Landscape structure influences the abundance, size structure, movements and trophic linkages of the western rock lobster, *Panulirus cygnus*, in shallow coastal waters. PhD Thesis. Edith Cowan University.

Martin-Smith, K.M. (1993)Abundance of mobile epifauna: the role of habitat complexity and predation by fishes. *Journal of Experimental Marine Biology and Ecology* **174**:243-260.

Maunsell Australia. (2009). Climate Change Risk Assessment for the Australian Indian Ocean Territories. P.93. (http://www.ag.gov.au/www/agd/rwpattach.nsf/VAP/(3273BD3F76A7A5DEDAE36942A54D7D90)~Final+Report+CKI+and+CC.pdf/$file/Final+Report+CKI+and+CC.pdf).

Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being: Biodiversity synthesis. World Resources Institute, Washington DC.

Padilla, D.K., Chotokowski, M.A. and Buchan, L.A.J. (1996). Predicting the spread of Zebra mussels (*Dreissena polymorpha)* to inland waters using boater movement patterns. *Global Ecological and Biogeographical Letters* **5**: 353-359.

Pearce A., Rossbach M., Tait M. and Brown R. (1999) Sea temperature variability off Western Australia 1990 to 1994, Fisheries Research Division, Perth.

Peace, A. and Feng, M. (2007) Observations of warming on the Western Australian continental shelf. *Marine and Freshwater Research*, 2007, **58**, 914–920.

Perry A.L., Low P.J., Ellis J.R. and Reynolds J.D. (2005) Climate change and distribution shifts in marine fishes. Science **308**:1912-1915.

Phillips B. (1972) A semi-quantitative collector of the puerulus larvae of the western rock lobster *Panulirus longipes cygnus* George (Decapoda, Palinuridea). *Crustaceana* **22**:147-154.

Phillips, B.F. and Macmillan, D.L. (1987) Antennal receptors in puerulus and postpuerulus stages of the rock lobster *Panulirus cygnus* (Decapoda: Palinuridae) and their potential role in puerulus navigation. *Journal of Crustacean Biology* **7(1)**: 122-135.

Phillips, B.F., Melville-Smith, R., Rossbach, M., Cheng, Y.W., Caputi, N., Thomson, A., Mills, D. and Crear, B. (2003). Towards establishing techniques for large scale harvesting of pueruli and obtaining a better understanding of mortality rates. FRDC Project 1998/302. p. 138.

R Development Core Team (2009) R: A Language and Environment for Statistical Computing, R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org.

Shepherd S.A., Davies M. and Thomas M.I. (1997) Marine invertebrates of Southern Australia (Parts I, II and III), Vol. South Australian Research and Development Institute & The Flora and Fauna of South Australia Handbooks Committee, Adelaide.

Stella, J.S., Jones, G.P. and Pratchett, M.S. (2010) Variation in the structure of pepifaunal invertebrate assemblages among coral hosts. *Coral Reefs*. DOI:10.1007/s00338-010-0648-8.

Virnstein,R.W. and Howard, R.K. (1987) Motile epifauna of marine macrophytes in the Indian River Lagoon, Florida. II. Comparisons between drift algae and three species of seagrass. *Bulletin of Marine Science* **41(1)**: 13-26.

Wells, F.E., McDonald, J.I. and Huisman, J.M. (2009) Introduced marine species in Western Australia, Department of Fisheries, Perth, Western Australia. 97pp.

Wildsmith M.D., Potter I.C., Valensi F.J. and Platell M.E. (2005) Do the assemblages of benthic macroinvertebrates in nearshore waters of Western Australia vary among habitat types, zones and seasons? *Journal of the Marine Biological Association of the United Kingdom* **85**:217-232.

10.0 Appendices

10.1 Appendix A – Staff

The following staff was involved in this project at some stage, either directly employed or provided in-kind support:

Dr. Simon de Lestang

Mr. Jason How

Miss Shelly Foster

Dr David Abdo

Dr Matthew Pember

Mr Mark Rossbach

Mr Owen Young

Mr Josh Dornan

Mr Rhys Allen

Mr Adam Eastman

Mr Scott Evans

Mr Nick Konzewitsch

Mr Alan Pearce

Ms. Claire O'Calloghan

Mr Huw Dilley

Mr Adrian Thomson

Dr Nick Caputi

10.2 Appendix B – Obtaining water movement data

10.2.1 Background

Water movement, through either wind, swell or current driven movement is a major environmental impact on community structure. Previous means of means of collecting such information often required the use of expensive equipment. However, recent work has developed a more cost-effective way to measure relative water movement between locations (Evans and Abdo 2010).

10.2.2 Methods

Water motion loggers were deployed at sites from Warnbro through to Coral Bay (Figure 1). Subsequent retrieval of the loggers revealed issues with the design for shallow water deployment. Significant wear on the wire underneath the float may have caused the loss of one logger (Lancelin), potentially due to the orbital water motion of waves in the shallow water. A second logger (Alkimos) appeared to be lost due to the failure of the copper swage to bind the two wires together. A member of the public returned the Alkimos logger. This required the modification of the logger to withstand the exposed shallow water sites.

To improve the logger design for shallow water deployment, five designs were placed at Alkimos to compare their durability and measurement comparability over a 24-day period (Figure B1). Logger A was the original version as was deployed at nine sites along the coast. Logger B was the same height as A, however, had a solid stainless steel rod linking the float and wire, to reduce wear on the wire directly under the float. Loggers C and D were shorter to reduce the force acting on the logger and hence potentially increasing its durability. Logger C was attached to the mooring with wire and Logger D with the stainless steel rod, which was shackled directly to the mooring block. Logger E used 6 mm stainless steel chain to link the buoy to the mooring. All new swages were aluminium.

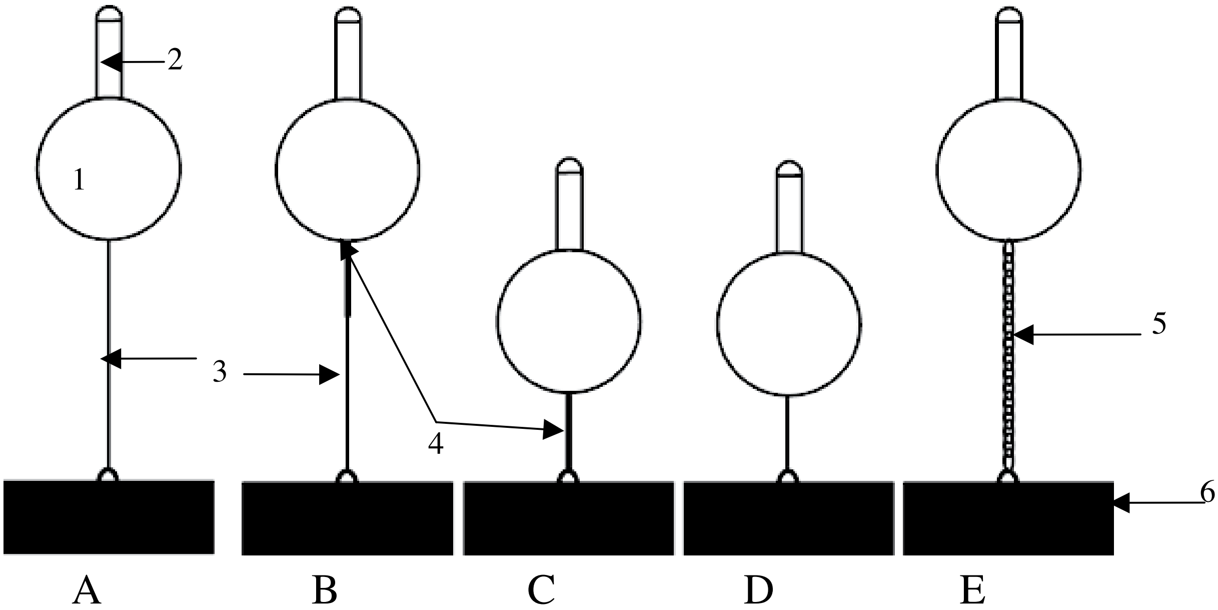

Figure B1. Diagrammatic representation of the five logger designs deployed Alkimos. 1 – Float; 2 – Logger in PVC housing; 3 – Wire; 4 – Stainless steel rod; 5 – Chain; 6 – Mooring block.

10.2.3 Results / Discussion

Only four of the five loggers were retrieved, with all loggers showing significant erosion of the aluminium swages, which likely accounted for the loss of the logger (logger B). The remaining three loggers (C-E) were then compared to version 2 logger used in Evans and Abdo (2010), which was initially deployed along the coast for this project (logger A; Figure B2).

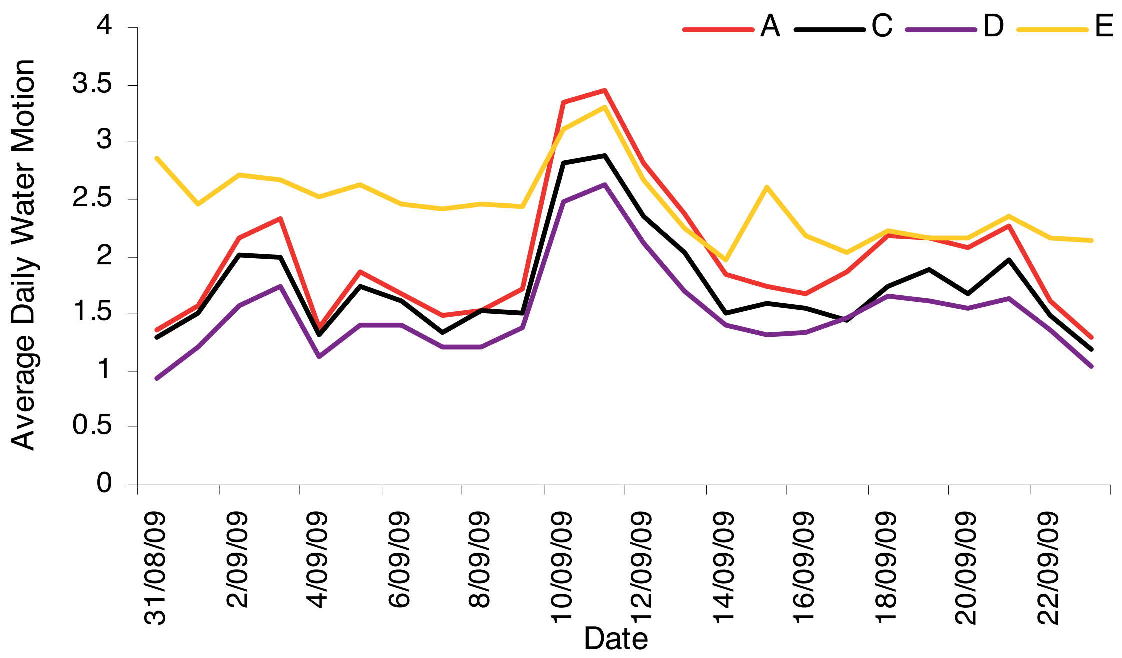

Figure B2. Average daily water motion for the four logger designs (see Fig. B1) retrieved.

Logger E didn't correlate well with logger A ($r^2 = 0.56$) compared to loggers C and D that had an r^2 of 0.98 and 0.99 respectively.

Given logger D's good correlation with logger A, the stainless steel rod from the float eliminating a potential weak point and the direct attachment to the mooring block through a shackle (no need for swages), this was seen as the most appropriate design for determining relative water movement in shallows water (<3m). This design was then deployed at all 10 sites along the coast.

Water movement data has been collected from 9 sites, with the recent design providing data since October 2009 (Figure B3). Data was unavailable for Quobba due to the logger being lost due to storms and, with the site now no longer being monitored, a replacement logger was not installed.

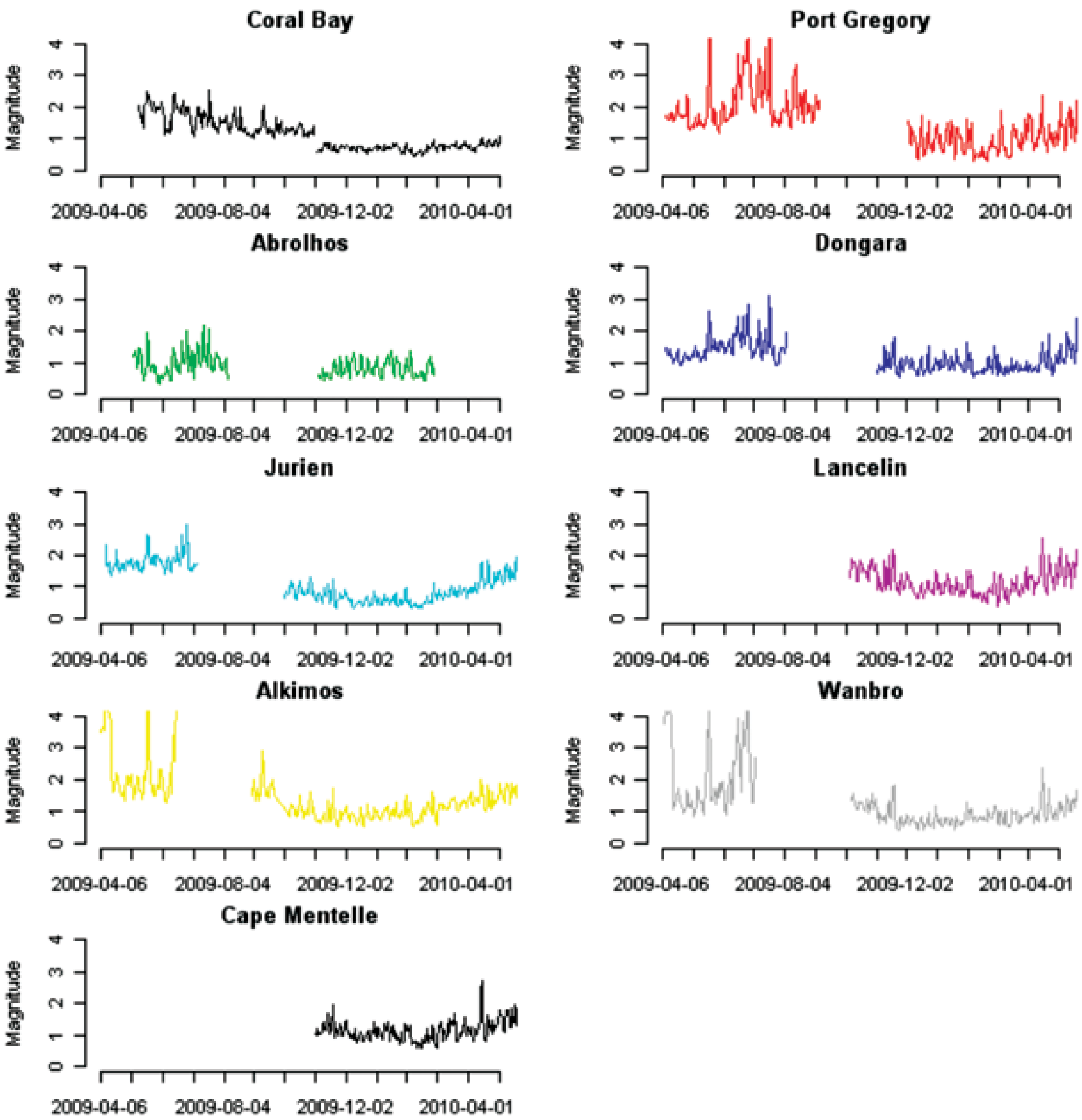

Figure B3. Magnitude of relative water movement from nine sites along the Western Australian coast.

10.3 Appendix C – National Introduced Marine Pests

Coordination Group 55 pest monitoring species

Group and Species	Group and Species
BALLAST WATER	
Dinoflagellates	Diatoms
Alexandrium catenella	*Chaetoceros convolutus*
Alexandrium minutum	*Chaetoceros concavicornis*
Alexandrium monilatum	*Psuedo-nitzschia seriata*
Alexandrium tamarense	Ctenophorans
Dinophysis norvegica	*Beroe ovata*
Gymnodium catenatum	*Mnemiopsis leidyi*
Pfisterisia piscicida	*Acartica tonsa*
HULL FOULING	
Algae	Cnidarians
Bonnemaisonia hamifera	*Blackfordia virginica*
Caulerpa racemosa	Polychaetes
Caulerpa taxifolia	*Sabella spallanzanii*
Codium fragile fragile	*Hydroides dianthus*
Grateloupis turuturu	*Marenzellaria spp.*
Sargassum muticum	Barnacles
Unidaria pinnatifida	*Balanus eburneus*
Womersleyella setacea	*Balanus improvisus*
Bivalves	Crabs
Corbula amurensis	*Callinectes sapidus*
Ensis directus	*Carcinus maenus*
Limnoperna fortunei	*Charybdis japonica*
Mya arenaria	*Eriocheir spp.*
Varicorbula gibba	*Hemigrapsis sanguineus*
Musculista senhousia	*Hemigrapsis takanoi*
Mytilopsis sallei	*Rhithropanopeus harrisii*
Perna perna	Ascidians
Perna viridis	*Didemnum spp.*
Crassostrea gigas	Seastar
Gastropods	*Asterias amurensis*
Crepidula fornicata	Fish
Rapana venosa	*Neogobius melanostomus*
Copepods	*Siganus luridus*
Psuedodiaptomus marinius	*Siganus rivulatus*
Tortanus dextrilobatus	*Tridentiger barbatus*
	Tridentiger bifasciatus

10.4 Appendix D – Raw Data

Taxa	ID	N
Amphipod	WM2	2328
Caprellid	WM2	14
Tanaid	WM2	238
Flabellifera	WM2	23
cf Januridae	WM2	562
Shrimp	WM2	132
Cumacean	WM2	2
Mottled hairy	WM2	58
Dimpled	WM2	1
Big yellow soft	WM2	10
Copepod	WM2	299
Bivalve	WM2	68
Gastropoda	WM2	122
Opistho nudibranch	WM2	1
Ophiuroid	WM2	30
Echinoid	WM2	4
Polychaete	WM2	24
Polychaete	WM2	65
Platyhelminth	WM2	1
Arachnid mite	WM2	3
Majid Dumea latipes	WM2	9
Majid Schzophrys rufescens	WM2	1
Halicarcinus ovatus	WM2	3
Halicarcinus sp. 2	WM2	1
Pilumnid Pilumnus sp. 1	WM2	2
Porcellanidae Pisidia sp.	WM2	1
Amphipod	WM3	1436
Caprellid	WM3	86
Tanaid	WM3	605
Flabellifera	WM3	22
cf Januridae	WM3	354
Shrimp	WM3	28
Cumacean	WM3	2
Mottled hairy	WM3	191
Dimpled	WM3	8
Big yellow soft	WM3	5
Pycnogonid	WM3	2
Copepod	WM3	299
Bivalve	WM3	30
Gastropoda	WM3	167

Taxa	ID	N
Polyplacophoran	WM3	2
Opistho nudibranch	WM3	3
Asteroid	WM3	1
Ophiuroid	WM3	8
Echinoid	WM3	2
Polychaete	WM3	23
Polychaete	WM3	35
Platyhelminth	WM3	20
Halicarcinus ovatus	WM3	1
Halicarcinus sp. 3	WM3	1
Amphipod	WM4	1695
Caprellid	WM4	109
Tanaid	WM4	283
Flabellifera	WM4	43
cf Januridae	WM4	464
Shrimp	WM4	138
Cumacean	WM4	2
Mottled hairy	WM4	211
Dimpled	WM4	147
Big yellow soft	WM4	30
Pycnogonid	WM4	1
Copepod	WM4	135
Bivalve	WM4	274
Gastropoda	WM4	453
Polyplacophoran	WM4	1
Opistho nudibranch	WM4	2
Opistho bubble shell	WM4	1
Ophiuroid	WM4	145
Echinoid	WM4	10
Polychaete	WM4	47
Polychaete	WM4	35
Platyhelminth	WM4	8
Majid Dumea latipes	WM4	12
Halicarcinus ovatus	WM4	1
Halicarcinus sp. 2	WM4	1
Unknown Halicarcinus	WM4	3
Pilumnid Pilumnus sp. 1	WM4	3
Porcellanidae Pisidia sp.	WM4	3
Unidentified	WM4	2
Amphipod	WM6	1039
Caprellid	WM6	2

Taxa	ID	N
Tanaid	WM6	154
Flabellifera	WM6	46
cf Januridae	WM6	205
Anthuridae	WM6	1
Shrimp	WM6	368
Cumacean	WM6	1
Mottled hairy	WM6	33
Dimpled	WM6	4
Big yellow soft	WM6	15
Copepod	WM6	121
Bivalve	WM6	73
Gastropoda	WM6	141
Opistho nudibranch	WM6	1
Ophiuroid	WM6	25
Polychaete	WM6	21
Polychaete	WM6	29
Platyhelminth	WM6	1
Majid Dumea latipes	WM6	29
Halicarcinus ovatus	WM6	1
Halicarcinus sp. 3	WM6	1
Unknown Halicarcinus	WM6	1
Pilumnid Pilumnus sp. 1	WM6	1
Porcellanidae Pisidia sp.	WM6	3
Unidentified	WM6	1
Amphipod	WA2	1027
Tanaid	WA2	146
Flabellifera	WA2	82
cf Januridae	WA2	322
Valvifera	WA2	13
Shrimp	WA2	27
Mottled hairy	WA2	34
Dimpled	WA2	10
Pycnogonid	WA2	1
Copepod	WA2	54
Bivalve	WA2	65
Gastropoda	WA2	63
Ophiuroid	WA2	12
Echinoid	WA2	1
Polychaete	WA2	17
Polychaete	WA2	25
Platyhelminth	WA2	3
Arachnid mite	WA2	2
Majid Dumea latipes	WA2	2

Taxa	ID	N
Halicarcinus ovatus	WA2	5
Halicarcinus sp. 2	WA2	1
Halicarcinus sp. 3	WA2	1
Pilumnid Pilumnus sp. 1	WA2	1
Porcellanidae Pisidia sp.	WA2	1
Amphipod	WA3	1148
Caprellid	WA3	9
Tanaid	WA3	237
Flabellifera	WA3	20
cf Januridae	WA3	727
Valvifera	WA3	7
Cumacean	WA3	1
Mottled hairy	WA3	29
Dimpled	WA3	4
Pycnogonid	WA3	1
Copepod	WA3	77
Bivalve	WA3	64
Gastropoda	WA3	217
Ophiuroid	WA3	3
Polychaete	WA3	24
Polychaete	WA3	6
Platyhelminth	WA3	6
Majid Dumea latipes	WA3	1
Halicarcinus ovatus	WA3	1
Halicarcinus sp. 2	WA3	1
Unknown Halicarcinus	WA3	1
Unidentified	WA3	1
Amphipod	WA4	1020
Caprellid	WA4	15
Tanaid	WA4	220
Flabellifera	WA4	65
cf Januridae	WA4	402
Shrimp	WA4	31
Cumacean	WA4	2
Mottled hairy	WA4	65
Dimpled	WA4	80
Big yellow soft	WA4	5
Copepod	WA4	46
Bivalve	WA4	124
Gastropoda	WA4	314
Polyplacophoran	WA4	1
Ophiuroid	WA4	101
Echinoid	WA4	2

Taxa	ID	N
Polychaete	WA4	20
Polychaete	WA4	24
Platyhelminth	WA4	8
Majid Dumea latipes	WA4	2
Unknown Majid	WA4	1
Halicarcinus ovatus	WA4	2
Unknown Halicarcinus	WA4	1
Unidentified	WA4	1
Amphipod	WA6	1053
Caprellid	WA6	3
Tanaid	WA6	467
Flabellifera	WA6	48
cf Januridae	WA6	468
Valvifera	WA6	12
Shrimp	WA6	162
Cumacean	WA6	1
Mottled hairy	WA6	18
Dimpled	WA6	12
Big yellow soft	WA6	1
Copepod	WA6	48
Bivalve	WA6	251
Gastropoda	WA6	368
Polyplacophoran	WA6	1
Ophiuroid	WA6	103
Echinoid	WA6	2
Polychaete	WA6	38
Polychaete	WA6	11
Platyhelminth	WA6	8
Majid Dumea latipes	WA6	7
Halicarcinus ovatus	WA6	4
Halicarcinus sp. 2	WA6	7
Pilumnid Pilumnus sp. 1	WA6	1
Amphipod	WN2	6265
Caprellid	WN2	1
Tanaid	WN2	544
Flabellifera	WN2	54
cf Januridae	WN2	1146
Anthuridae	WN2	1
Shrimp	WN2	34
Cumacean	WN2	1
Mottled hairy	WN2	78
Dimpled	WN2	15
Big yellow soft	WN2	1

Taxa	ID	N
Mysid	WN2	2
Copepod	WN2	200
Bivalve	WN2	81
Gastropoda	WN2	371
Asteroid	WN2	1
Ophiuroid	WN2	43
Echinoid	WN2	1
Polychaete	WN2	545
Polychaete	WN2	11
Platyhelminth	WN2	9
Majid Dumea latipes	WN2	4
Unknown Majid	WN2	1
Halicarcinus sp. 2	WN2	1
Unidentified	WN2	1
Amphipod	WN3	1407
Tanaid	WN3	339
Flabellifera	WN3	16
cf Januridae	WN3	562
Shrimp	WN3	29
Mottled hairy	WN3	22
Big yellow soft	WN3	1
Copepod	WN3	58
Bivalve	WN3	63
Gastropoda	WN3	299
Polychaete	WN3	23
Polychaete	WN3	7
Platyhelminth	WN3	2
Halicarcinus sp. 2	WN3	1
Halicarcinus sp. 3	WN3	1
Unidentified	WN3	1
Megalopae 2 small clear	WN3	1
Amphipod	WN4	5214
Caprellid	WN4	12
Tanaid	WN4	516
Flabellifera	WN4	23
cf Januridae	WN4	945
Anthuridae	WN4	1
Shrimp	WN4	20
Cumacean	WN4	2
Mottled hairy	WN4	169
Dimpled	WN4	122
Big yellow soft	WN4	2
Mysid	WN4	1

Taxa	ID	N
Pycnogonid	WN4	1
Copepod	WN4	91
Bivalve	WN4	303
Gastropoda	WN4	579
Polyplacophoran	WN4	4
Opistho nudibranch	WN4	2
Ophiuroid	WN4	176
Echinoid	WN4	1
Polychaete	WN4	49
Polychaete	WN4	12
Platyhelminth	WN4	13
Majid Dumea latipes	WN4	2
Halicarcinus ovatus	WN4	3
Halicarcinus sp. 2	WN4	6
Halicarcinus sp. 3	WN4	1
Halicarcinus sp. 4	WN4	2
Unknown Halicarcinus	WN4	1
Unidentified	WN4	1
Amphipod	WN6	2660
Tanaid	WN6	49
Flabellifera	WN6	74
cf Januridae	WN6	311
Shrimp	WN6	48
Cumacean	WN6	3
Mottled hairy	WN6	84
Dimpled	WN6	16
Big yellow soft	WN6	1
Copepod	WN6	51
Bivalve	WN6	128
Gastropoda	WN6	249
Asteroid	WN6	1
Ophiuroid	WN6	114
Polychaete	WN6	45
Polychaete	WN6	4
Platyhelminth	WN6	12
Nemertean	WN6	1
Majid Dumea latipes	WN6	3
Unknown Majid	WN6	1
Halicarcinus ovatus	WN6	2
Halicarcinus sp. 2	WN6	2
Porcellanidae Pisidia sp.	WN6	1
Megalopae 2 small clear	WN6	1
Amphipod	WJ2	2047

Taxa	ID	N
Caprellid	WJ2	24
Tanaid	WJ2	81
Flabellifera	WJ2	37
cf Januridae	WJ2	252
Shrimp	WJ2	6
Mottled hairy	WJ2	453
Dimpled	WJ2	12
Big yellow soft	WJ2	8
Mysid	WJ2	2
Copepod	WJ2	12
Bivalve	WJ2	108
Gastropoda	WJ2	501
Polyplacophoran	WJ2	4
Ophiuroid	WJ2	57
Polychaete	WJ2	62
Polychaete	WJ2	89
Platyhelminth	WJ2	2
Majid Dumea latipes	WJ2	3
Pilumnid Pilumnus sp. 1	WJ2	7
Megalopae 2 small clear	WJ2	1
Amphipod	WJ3	4990
Caprellid	WJ3	8
Tanaid	WJ3	37
Flabellifera	WJ3	48
cf Januridae	WJ3	95
Valvifera	WJ3	3
Shrimp	WJ3	9
Mottled hairy	WJ3	203
Dimpled	WJ3	2
Big yellow soft	WJ3	5
Mysid	WJ3	14
Copepod	WJ3	113
Bivalve	WJ3	74
Gastropoda	WJ3	634
Polyplacophoran	WJ3	6
Opistho nudibranch	WJ3	1
Asteroid	WJ3	1
Ophiuroid	WJ3	17
Crinoid	WJ3	1
Polychaete	WJ3	32
Polychaete	WJ3	79
Platyhelminth	WJ3	4
Halicarcinus sp. 5	WJ3	1

Taxa	ID	N
Pilumnid Pilumnus sp. 1	WJ3	1
Unidentified	WJ3	1
Amphipod	WJ5	2412
Caprellid	WJ5	45
Tanaid	WJ5	166
Flabellifera	WJ5	73
cf Januridae	WJ5	506
Shrimp	WJ5	45
Cumacean	WJ5	6
Mottled hairy	WJ5	832
Dimpled	WJ5	53
Big yellow soft	WJ5	14
Copepod	WJ5	646
Bivalve	WJ5	122
Gastropoda	WJ5	515
Polyplacophoran	WJ5	2
Ophiuroid	WJ5	259
Crinoid	WJ5	1
Polychaete	WJ5	77
Polychaete	WJ5	95
Platyhelminth	WJ5	3
Majid Dumea latipes	WJ5	4
Majid Schzophrys rufescens	WJ5	1
Unknown Majid	WJ5	1
Halicarcinus sp. 2	WJ5	1
Halicarcinus sp. 3	WJ5	1
Unknown Halicarcinus	WJ5	1
Pilumnid Pilumnus sp. 1	WJ5	3
Unidentified	WJ5	1
Megalopae 2 small clear	WJ5	1
Amphipod	WJ6	1962
Tanaid	WJ6	35
Flabellifera	WJ6	10
cf Januridae	WJ6	40
Valvifera	WJ6	2
Anthuridae	WJ6	1
Shrimp	WJ6	54
Mottled hairy	WJ6	3
Big yellow soft	WJ6	1
Copepod	WJ6	104
Bivalve	WJ6	7
Gastropoda	WJ6	60

Taxa	ID	N
Opistho nudibranch	WJ6	7
Echinoid	WJ6	1
Polychaete	WJ6	41
Polychaete	WJ6	84
Platyhelminth	WJ6	1
Majid Dumea latipes	WJ6	8
Unknown Majid	WJ6	1
Halicarcinus ovatus	WJ6	4
Amphipod	LA1	1065
Tanaid	LA1	745
Flabellifera	LA1	35
cf Januridae	LA1	147
Shrimp	LA1	10
Cumacean	LA1	22
Mottled hairy	LA1	316
Dimpled	LA1	30
Copepod	LA1	7
Bivalve	LA1	69
Gastropoda	LA1	594
Polyplacophoran	LA1	2
Ophiuroid	LA1	11
Echinoid	LA1	1
Polychaete	LA1	11
Polychaete	LA1	57
Majid Dumea latipes	LA1	4
Simocarcinus obtusirostrus	LA1	1
Halicarcinus ovatus	LA1	4
Halicarcinus sp. 3	LA1	2
Pilumnid Pilumnus sp. 1	LA1	6
Grapsid Plagusia sp. 2	LA1	2
Amphipod	LA3	1023
Tanaid	LA3	146
Flabellifera	LA3	62
cf Januridae	LA3	218
Valvifera	LA3	3
Shrimp	LA3	22
Cumacean	LA3	12
Mottled hairy	LA3	16
Copepod	LA3	4
Bivalve	LA3	2
Gastropoda	LA3	252
Polyplacophoran	LA3	3

Taxa	ID	N
Ophiuroid	LA3	2
Polychaete	LA3	9
Polychaete	LA3	20
Majid Dumea latipes	LA3	2
Unknown Majid	LA3	1
Halicarcinus ovatus	LA3	1
Pilumnid Pilumnus sp. 1	LA3	5
Amphipod	LA4	2448
Tanaid	LA4	768
Flabellifera	LA4	48
cf Januridae	LA4	985
Valvifera	LA4	2
Shrimp	LA4	131
Cumacean	LA4	54
Mottled hairy	LA4	456
Dimpled	LA4	4
Copepod	LA4	258
Bivalve	LA4	4
Gastropoda	LA4	1000
Polyplacophoran	LA4	6
Opistho bubble shell	LA4	1
Asteroid	LA4	1
Ophiuroid	LA4	39
Polychaete	LA4	72
Polychaete	LA4	25
Platyhelminth	LA4	1
Nemertean	LA4	1
Arachnid mite	LA4	2
Majid Dumea latipes	LA4	7
Majid Acanthonyx sp. 2	LA4	4
Majid Majinae	LA4	1
Halicarcinus ovatus	LA4	1
Unknown Halicarcinus	LA4	1
Pilumnid Pilumnus sp. 1	LA4	3
Amphipod	LA5	1080
Caprellid	LA5	3
Tanaid	LA5	520
Flabellifera	LA5	45
cf Januridae	LA5	415
Valvifera	LA5	7
Anthuridae	LA5	1
Shrimp	LA5	64
Cumacean	LA5	59

Taxa	ID	N
Mottled hairy	LA5	292
Dimpled	LA5	2
Big yellow soft	LA5	1
Copepod	LA5	206
Bivalve	LA5	4
Gastropoda	LA5	945
Opistho nudibranch	LA5	2
Ophiuroid	LA5	9
Polychaete	LA5	91
Polychaete	LA5	10
Platyhelminth	LA5	2
Nemertean	LA5	8
Arachnid mite	LA5	6
Portunid Thalamita parvidens	LA5	1
Majid Dumea latipes	LA5	2
Pilumnid Pilumnus sp. 1	LA5	1
Unidentified	LA5	1
Amphipod	LN1	984
Tanaid	LN1	278
Flabellifera	LN1	168
cf Januridae	LN1	108
Valvifera	LN1	1
Anthuridae	LN1	6
Shrimp	LN1	36
Lobster	LN1	2
Cumacean	LN1	4
Mottled hairy	LN1	484
Dimpled	LN1	7
Big yellow soft	LN1	1
Mysid	LN1	2
Copepod	LN1	6
Bivalve	LN1	107
Gastropoda	LN1	735
Ophiuroid	LN1	31
Echinoid	LN1	5
Polychaete	LN1	14
Polychaete	LN1	9
Majid Dumea latipes	LN1	6
Majid Acanthonyx sp. 2	LN1	2
Unknown Majid	LN1	2
Halicarcinus ovatus	LN1	1
Halicarcinus sp. 3	LN1	1

Taxa	ID	N
Pilumnid Pilumnus sp. 1	LN1	3
Unidentified	LN1	1
Amphipod	LN3	592
Tanaid	LN3	234
Flabellifera	LN3	71
cf Januridae	LN3	198
Anthuridae	LN3	3
Shrimp	LN3	9
Cumacean	LN3	12
Mottled hairy	LN3	170
Copepod	LN3	8
Bivalve	LN3	13
Gastropoda	LN3	529
Asteroid	LN3	1
Ophiuroid	LN3	12
Polychaete	LN3	20
Polychaete	LN3	3
Majid Dumea latipes	LN3	3
Pilumnid Pilumnus sp. 1	LN3	5
Amphipod	LN4	857
Tanaid	LN4	166
Flabellifera	LN4	28
cf Januridae	LN4	266
Anthuridae	LN4	2
Shrimp	LN4	42
Cumacean	LN4	14
Mottled hairy	LN4	389
Big yellow soft	LN4	2
Mysid	LN4	3
Copepod	LN4	15
Bivalve	LN4	7
Gastropoda	LN4	863
Polyplacophoran	LN4	7
Asteroid	LN4	1
Ophiuroid	LN4	69
Polychaete	LN4	8
Polychaete	LN4	4
Platyhelminth	LN4	3
Nemertean	LN4	1
Majid Dumea latipes	LN4	1
Majid Acanthonyx sp. 2	LN4	3
Unknown Majid	LN4	2
Pilumnid Pilumnus sp. 1	LN4	4

Taxa	ID	N
Unidentified	LN4	2
Amphipod	LN5	732
Caprellid	LN5	3
Tanaid	LN5	302
Flabellifera	LN5	27
cf Januridae	LN5	183
Anthuridae	LN5	4
Shrimp	LN5	23
Cumacean	LN5	12
Mottled hairy	LN5	502
Dimpled	LN5	4
Big yellow soft	LN5	2
Mysid	LN5	1
Copepod	LN5	147
Bivalve	LN5	4
Gastropoda	LN5	763
Polyplacophoran	LN5	2
Ophiuroid	LN5	39
Polychaete	LN5	37
Polychaete	LN5	6
Platyhelminth	LN5	6
Nemertean	LN5	1
Arachnid mite	LN5	1
Majid Dumea latipes	LN5	1
Majid Acanthonyx sp. 2	LN5	5
Unknown Majid	LN5	5
Halicarcinus ovatus	LN5	2
Halicarcinus sp. 2	LN5	1
Halicarcinus sp. 5	LN5	1
Pilumnid Pilumnus sp. 1	LN5	4
Unidentified	LN5	1
Amphipod	DM1	555
Tanaid	DM1	90
Flabellifera	DM1	20
cf Januridae	DM1	105
Anthuridae	DM1	5
Shrimp	DM1	86
Cumacean	DM1	34
Mottled hairy	DM1	251
Big yellow soft	DM1	8
Copepod	DM1	30
Bivalve	DM1	23
Gastropoda	DM1	387

Taxa	ID	N
Opistho bubble shell	DM1	44
Ophiuroid	DM1	2
Polychaete	DM1	187
Polychaete	DM1	1
Platyhelminth	DM1	2
Nemertean	DM1	12
Portunid Thalamita sima	DM1	2
Majid Dumea latipes	DM1	15
Majid Menaethius sp.	DM1	2
Unknown Majid	DM1	1
Xanthid Actaea peronii	DM1	1
Amphipod	DM3	129
Tanaid	DM3	85
Flabellifera	DM3	2
cf Januridae	DM3	19
Shrimp	DM3	11
Cumacean	DM3	11
Mottled hairy	DM3	142
Big yellow soft	DM3	4
Bivalve	DM3	14
Gastropoda	DM3	22
Opistho bubble shell	DM3	1
Ophiuroid	DM3	2
Polychaete	DM3	12
Platyhelminth	DM3	1
Majid Dumea latipes	DM3	15
Xanthid Actaea peronii	DM3	4
Unidentified	DM3	1
Amphipod	DM5	1614
Tanaid	DM5	87
Flabellifera	DM5	20
cf Januridae	DM5	83
Valvifera	DM5	1
Anthuridae	DM5	2
Shrimp	DM5	28
Cumacean	DM5	6
Mottled hairy	DM5	70
Copepod	DM5	1
Bivalve	DM5	20
Gastropoda	DM5	259
Ophiuroid	DM5	1
Polychaete	DM5	20
Polychaete	DM5	2

Taxa	ID	N
Nemertean	DM5	2
Majid Dumea latipes	DM5	20
Halicarcinus ovatus	DM5	1
Halicarcinus sp. 2	DM5	1
Halicarcinus sp. 5	DM5	2
Unidentified	DM5	2
Amphipod	DM6	523
Tanaid	DM6	700
Flabellifera	DM6	1
cf Januridae	DM6	109
Shrimp	DM6	7
Cumacean	DM6	15
Mottled hairy	DM6	275
Big yellow soft	DM6	1
Copepod	DM6	5
Bivalve	DM6	109
Gastropoda	DM6	1129
Opistho bubble shell	DM6	4
Ophiuroid	DM6	26
Polychaete	DM6	45
Polychaete	DM6	3
Platyhelminth	DM6	1
Nemertean	DM6	16
Majid Dumea latipes	DM6	14
Majid Menaethius sp.	DM6	1
Xanthid Actaea peronii	DM6	2
Halicarcinus sp. 3	DM6	1
Halicarcinus sp. 5	DM6	1
Amphipod	DA1	331
Tanaid	DA1	203
Flabellifera	DA1	7
cf Januridae	DA1	39
Valvifera	DA1	1
Shrimp	DA1	29
Cumacean	DA1	7
Mottled hairy	DA1	30
Big yellow soft	DA1	4
Copepod	DA1	12
Bivalve	DA1	4
Gastropoda	DA1	110
Opistho bubble shell	DA1	2
Ophiuroid	DA1	3
Polychaete	DA1	13

Taxa	ID	N
Polychaete	DA1	18
Majid Dumea latipes	DA1	3
Halicarcinus ovatus	DA1	1
Unknown Halicarcinus	DA1	1
Amphipod	DA3	418
Tanaid	DA3	19
Flabellifera	DA3	2
cf Januridae	DA3	67
Shrimp	DA3	4
Cumacean	DA3	2
Mottled hairy	DA3	26
Dimpled	DA3	2
Copepod	DA3	4
Bivalve	DA3	12
Gastropoda	DA3	280
Polychaete	DA3	5
Polychaete	DA3	11
Majid Dumea latipes	DA3	1
Majid Menaethius sp.	DA3	1
Halicarcinus sp. 5	DA3	1
Unidentified	DA3	1
Amphipod	DA5	396
Tanaid	DA5	245
cf Januridae	DA5	122
Shrimp	DA5	4
Mottled hairy	DA5	8
Dimpled	DA5	1
Bivalve	DA5	6
Gastropoda	DA5	58
Ophiuroid	DA5	1
Polychaete	DA5	9
Polychaete	DA5	2
Halicarcinus ovatus	DA5	2
Amphipod	DA6	233
Tanaid	DA6	37
Flabellifera	DA6	1
cf Januridae	DA6	25
Shrimp	DA6	6
Cumacean	DA6	1
Mottled hairy	DA6	24
Big yellow soft	DA6	1
Bivalve	DA6	51
Gastropoda	DA6	466

Taxa	ID	N
Ophiuroid	DA6	2
Echinoid	DA6	1
Polychaete	DA6	10
Polychaete	DA6	46
Nemertean	DA6	1
Xanthid Actaea peronii	DA6	1
Halicarcinus ovatus	DA6	1
Amphipod	DN1	685
Tanaid	DN1	277
Flabellifera	DN1	19
cf Januridae	DN1	19
Valvifera	DN1	4
Shrimp	DN1	55
Lobster	DN1	1
Cumacean	DN1	8
Mottled hairy	DN1	74
Big yellow soft	DN1	22
Copepod	DN1	3
Bivalve	DN1	14
Gastropoda	DN1	69
Ophiuroid	DN1	6
Polychaete	DN1	11
Polychaete	DN1	20
Platyhelminth	DN1	1
Halicarcinus ovatus	DN1	2
Halicarcinus sp. 2	DN1	1
Amphipod	DN3	1832
Tanaid	DN3	84
Flabellifera	DN3	6
cf Januridae	DN3	13
Shrimp	DN3	25
Lobster	DN3	3
Cumacean	DN3	9
Mottled hairy	DN3	376
Big yellow soft	DN3	1
Copepod	DN3	1
Bivalve	DN3	31
Gastropoda	DN3	244
Opistho bubble shell	DN3	1
Ophiuroid	DN3	1
Polychaete	DN3	5
Platyhelminth	DN3	1
Halicarcinus ovatus	DN3	3

Taxa	ID	N
Halicarcinus sp. 2	DN3	1
Halicarcinus sp. 5	DN3	1
Unidentified	DN3	1
Amphipod	DN5	1352
Tanaid	DN5	1405
Flabellifera	DN5	7
cf Januridae	DN5	385
Valvifera	DN5	4
Shrimp	DN5	19
Lobster	DN5	5
Cumacean	DN5	2
Mottled hairy	DN5	57
Dimpled	DN5	2
Copepod	DN5	1
Bivalve	DN5	25
Gastropoda	DN5	264
Ophiuroid	DN5	2
Polychaete	DN5	17
Polychaete	DN5	22
Majid Dumea latipes	DN5	2
Majid Acanthonyx sp. 2	DN5	1
Halicarcinus ovatus	DN5	2
Unknown Halicarcinus	DN5	1
Pilumnid Pilumnus sp. 1	DN5	1
Amphipod	DN6	1180
Tanaid	DN6	90
cf Januridae	DN6	15
Shrimp	DN6	9
Lobster	DN6	2
Cumacean	DN6	5
Mottled hairy	DN6	2304
Dimpled	DN6	2
Big yellow soft	DN6	20
Copepod	DN6	1
Bivalve	DN6	259
Gastropoda	DN6	436
Ophiuroid	DN6	8
Echinoid	DN6	1
Polychaete	DN6	69
Polychaete	DN6	29
Platyhelminth	DN6	1
Amphipod	DJ1	759
Tanaid	DJ1	204

Taxa	ID	N
Flabellifera	DJ1	51
cf Januridae	DJ1	26
Valvifera	DJ1	1
Anthuridae	DJ1	1
Shrimp	DJ1	78
Cumacean	DJ1	68
Mottled hairy	DJ1	278
Big yellow soft	DJ1	7
Bivalve	DJ1	6
Gastropoda	DJ1	968
Polyplacophoran	DJ1	2
Opistho bubble shell	DJ1	2
Ophiuroid	DJ1	8
Polychaete	DJ1	73
Polychaete	DJ1	2
Halicarcinus ovatus	DJ1	1
Halicarcinus sp. 5	DJ1	2
Pilumnid Pilumnus sp. 1	DJ1	2
cf Dromiidae sp. 1	DJ1	1
Amphipod	DJ3	604
Tanaid	DJ3	840
Flabellifera	DJ3	9
cf Januridae	DJ3	33
Shrimp	DJ3	56
Cumacean	DJ3	98
Mottled hairy	DJ3	256
Dimpled	DJ3	1
Big yellow soft	DJ3	13
Copepod	DJ3	82
Bivalve	DJ3	22
Gastropoda	DJ3	953
Opistho bubble shell	DJ3	1
Ophiuroid	DJ3	14
Polychaete	DJ3	12
Polychaete	DJ3	4
Portunid Thalamita sima	DJ3	1
Majid Dumea latipes	DJ3	1
Unknown Majid	DJ3	1
Xanthid Actaea peronii	DJ3	1
Unknown Halicarcinus	DJ3	1
Unidentified	DJ3	3
Amphipod	DJ5	881
Tanaid	DJ5	397

Taxa	ID	N
Flabellifera	DJ5	9
cf Januridae	DJ5	50
Anthuridae	DJ5	3
Shrimp	DJ5	59
Lobster	DJ5	1
Cumacean	DJ5	109
Mottled hairy	DJ5	238
Dimpled	DJ5	1
Big yellow soft	DJ5	1
Copepod	DJ5	141
Bivalve	DJ5	32
Gastropoda	DJ5	1185
Polyplacophoran	DJ5	1
Opistho bubble shell	DJ5	1
Ophiuroid	DJ5	3
Polychaete	DJ5	30
Polychaete	DJ5	17
Arachnid mite	DJ5	1
Portunid Thalamita sima	DJ5	1
Majid Dumea latipes	DJ5	1
Halicarcinus ovatus	DJ5	1
Halicarcinus sp. 2	DJ5	2
Pilumnid Pilumnus sp. 1	DJ5	2
Amphipod	DJ6	130
Tanaid	DJ6	820
Flabellifera	DJ6	1
cf Januridae	DJ6	24
Shrimp	DJ6	37
Cumacean	DJ6	37
Mottled hairy	DJ6	1145
Dimpled	DJ6	5
Copepod	DJ6	18
Bivalve	DJ6	268
Gastropoda	DJ6	562
Polyplacophoran	DJ6	2
Ophiuroid	DJ6	12
Polychaete	DJ6	37
Polychaete	DJ6	7
Portunid Thalamita sima	DJ6	3
Halicarcinus sp. 2	DJ6	1
Amphipod	QAA	337
Tanaid	QAA	1
cf Januridae	QAA	4

Taxa	ID	N
Shrimp	QAA	9
Copepod	QAA	17
Gastropoda	QAA	261
Opistho nudibranch	QAA	1
Opistho bubble shell	QAA	1
Polychaete	QAA	2
Majid Acanthonyx euryseroche	QAA	7
Megalopae 2 small clear	QAA	1
Amphipod	QAB	318
Tanaid	QAB	2
cf Januridae	QAB	1
Shrimp	QAB	22
Lobster	QAB	2
Copepod	QAB	63
Bivalve	QAB	1
Gastropoda	QAB	199
Opistho nudibranch	QAB	4
Echinoid	QAB	1
Polychaete	QAB	8
Polychaete	QAB	1
Portunid Thalamita admete	QAB	2
Portunid Thalamita woodmasoni	QAB	2
Majid Acanthonyx euryseroche	QAB	2
Megalopae 1 large red	QAB	1
Amphipod	QAC	87
Tanaid	QAC	4
Shrimp	QAC	6
Copepod	QAC	273
Gastropoda	QAC	274
Opistho nudibranch	QAC	1
Polychaete	QAC	3
Portunid Thalamita woodmasoni	QAC	4
Majid Dumea latipes	QAC	1
Grapsid Plagusia sp. 1	QAC	3
Unidentified	QAC	1
Amphipod	QAD	298
Tanaid	QAD	1
Flabellifera	QAD	1
cf Januridae	QAD	1

Taxa	ID	N
Shrimp	QAD	11
Copepod	QAD	25
Gastropoda	QAD	328
Opistho nudibranch	QAD	3
Ophiuroid	QAD	1
Echinoid	QAD	1
Polychaete	QAD	1
Portunid Thalamita woodmasoni	QAD	2
Majid Dumea smooth	QAD	1
Amphipod	QN1	860
Tanaid	QN1	18
Flabellifera	QN1	1
Shrimp	QN1	136
Lobster	QN1	5
Cumacean	QN1	1
Pycnogonid	QN1	2
Copepod	QN1	40
Bivalve	QN1	1
Gastropoda	QN1	1572
Polyplacophoran	QN1	2
Opistho nudibranch	QN1	12
Opistho bubble shell	QN1	1
Ophiuroid	QN1	4
Echinoid	QN1	1
Polychaete	QN1	19
Majid Dumea smooth	QN1	1
Majid Acanthonyx euryseroche	QN1	2
Majid triangle crab	QN1	1
Pilumnid smooth	QN1	2
Grapsid Plagusia sp. 1	QN1	3
c.f. Galatheidae	QN1	1
Unidentified	QN1	1
Megalopae 1 large red	QN1	1
Megalopae 2 small clear	QN1	1
Amphipod	QN2	649
Tanaid	QN2	10
Shrimp	QN2	34
Lobster	QN2	12
Copepod	QN2	36
Gastropoda	QN2	953
Opistho nudibranch	QN2	15

Taxa	ID	N
Polychaete	QN2	5
Polychaete	QN2	2
Platyhelminth	QN2	1
Majid Acanthonyx euryseroche	QN2	2
Unknown Majid	QN2	1
Pilumnid Pilumnus sp. 1	QN2	1
Megalopae 3 large clear 1 spine	QN2	1
Amphipod	QN3	1316
Tanaid	QN3	7
cf Januridae	QN3	1
Shrimp	QN3	47
Lobster	QN3	13
Copepod	QN3	37
Gastropoda	QN3	179
Opistho nudibranch	QN3	2
Ophiuroid	QN3	1
Polychaete	QN3	5
Polychaete	QN3	1
Platyhelminth	QN3	1
Sipunculid	QN3	2
Portunid Thalamita danae	QN3	1
Portunid Portunus pubescens	QN3	1
Grapsid Plagusia sp. 1	QN3	1
Unidentified	QN3	1
Megalopae 1 large red	QN3	2
Amphipod	CA1	3039
cf Januridae	CA1	11
Shrimp	CA1	12
Lobster	CA1	9
Copepod	CA1	43
Gastropoda	CA1	207
Polychaete	CA1	18
Portunid Portunus sp. 1	CA1	8
Majid Acanthonyx euryseroche	CA1	18
Megalopae 1 large red	CA1	1
Megalopae 2 small clear	CA1	1
Amphipod	CA2	725
cf Januridae	CA2	12
Shrimp	CA2	11

Taxa	ID	N
Lobster	CA2	7
Copepod	CA2	172
Bivalve	CA2	1
Gastropoda	CA2	132
Polychaete	CA2	16
Portunid Portunus pubescens	CA2	1
Portunid Portunus sp. 1	CA2	11
Majid Acanthonyx euryseroche	CA2	9
Unknown Majid	CA2	1
Grapsid Plagusia sp. 1	CA2	9
Megalopae 1 large red	CA2	1
Amphipod	CA3	1245
Flabellifera	CA3	1
cf Januridae	CA3	17
Shrimp	CA3	70
Lobster	CA3	6
Copepod	CA3	15
Bivalve	CA3	2
Gastropoda	CA3	363
Polyplacophoran	CA3	1
Polychaete	CA3	93
Polychaete	CA3	2
Portunid Thalamita admete	CA3	1
Portunid Portunus sp. 1	CA3	5
Majid Dumea smooth	CA3	1
Majid Acanthonyx euryseroche	CA3	32
Grapsid Plagusia sp. 1	CA3	7
Megalopae 1 large red	CA3	3
Megalopae 2 small clear	CA3	4
Amphipod	CA4	2524
Tanaid	CA4	1
Flabellifera	CA4	1
cf Januridae	CA4	23
Shrimp	CA4	87
Lobster	CA4	17
Copepod	CA4	38
Bivalve	CA4	2
Gastropoda	CA4	217
Echinoid	CA4	1
Polychaete	CA4	58

Taxa	ID	N
Polychaete	CA4	3
Portunid Thalamita admete	CA4	2
Portunid Portunus pubescens	CA4	5
Portunid Portunus sp. 1	CA4	5
Majid Acanthonyx euryseroche	CA4	16
Unidentified	CA4	1
Megalopae 2 small clear	CA4	2
Megalopae 3 large clear 1 spine	CA4	1
Amphipod	CN1	1814
Tanaid	CN1	10
cf Januridae	CN1	69
Shrimp	CN1	17
Lobster	CN1	1
Copepod	CN1	360
Bivalve	CN1	3
Gastropoda	CN1	210
Polyplacophoran	CN1	3
Opistho nudibranch	CN1	5
Ophiuroid	CN1	12
Polychaete	CN1	52
Polychaete	CN1	9
Platyhelminth	CN1	1
Arachnid mite	CN1	108
Portunid Portunus pubescens	CN1	4
Portunid Portunus sp. 1	CN1	3
Unknown Majid	CN1	1
Grapsid Plagusia sp. 1	CN1	1
Amphipod	CN2	3592
Tanaid	CN2	5
cf Januridae	CN2	30
Shrimp	CN2	23
Copepod	CN2	870
Gastropoda	CN2	332
Polyplacophoran	CN2	2
Opistho nudibranch	CN2	6
Opistho bubble shell	CN2	2
Ophiuroid	CN2	9
Echinoid	CN2	1
Polychaete	CN2	34

Taxa	ID	N
Polychaete	CN2	16
Platyhelminth	CN2	2
Arachnid mite	CN2	108
Portunid Thalamita admete	CN2	2
Portunid Portunus pubescens	CN2	3
Portunid Portunus sp. 1	CN2	2
Majid Acanthonyx euryseroche	CN2	2
Unknown Majid	CN2	5
Unidentified	CN2	1
Megalopae 1 large red	CN2	2
Megalopae 2 small clear	CN2	1
Amphipod	CN3	1780
Tanaid	CN3	15
cf Januridae	CN3	110
Shrimp	CN3	80
Copepod	CN3	339
Bivalve	CN3	6
Gastropoda	CN3	375
Polyplacophoran	CN3	5
Opistho nudibranch	CN3	14
Ophiuroid	CN3	18
Polychaete	CN3	39
Polychaete	CN3	19
Platyhelminth	CN3	1
Arachnid mite	CN3	66
Sipunculid	CN3	1
Portunid Thalamita admete	CN3	8
Portunid Portunus pubescens	CN3	10
Portunid Portunus sp. 1	CN3	9
Majid Acanthonyx euryseroche	CN3	10
Unknown Majid	CN3	2
Xanthid clown crab	CN3	1
Grapsid Plagusia sp. 1	CN3	1
c.f. Galatheidae	CN3	2
Megalopae 3 large clear 1 spine	CN3	3
Amphipod	CN4	1216
Tanaid	CN4	12

Taxa	ID	N
cf Januridae	CN4	85
Shrimp	CN4	68
Lobster	CN4	1
Copepod	CN4	75
Bivalve	CN4	10
Gastropoda	CN4	334
Polyplacophoran	CN4	2
Opistho nudibranch	CN4	6
Ophiuroid	CN4	4
Echinoid	CN4	4
Polychaete	CN4	35
Polychaete	CN4	11
Platyhelminth	CN4	1
Arachnid mite	CN4	61
Portunid Thalamita admete	CN4	1
Portunid Portunus pubescens	CN4	12
Portunid Portunus sp. 1	CN4	4
Majid Acanthonyx euryseroche	CN4	5
Xanthid blushing crab	CN4	1
c.f. Galatheidae	CN4	1
Unidentified	CN4	1
Megalopae 3 large clear 1 spine	CN4	2