NORTH WEST SHELF
JOINT ENVIRONMENTAL
MANAGEMENT STUDY

Management strategy evaluation specification for Australia's North West Shelf

NWSJEMS

TECHNICAL REPORT No. 15

• E. Fulton • K. Sainsbury • D. McDonald • D. Hayes
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June 2006

CSIRO

Government of Western Australia
Department of Environment

National Library of Australia Catologuing-in-Publication data:

Management strategy evaluation specification for
Australia's North West Shelf.

Bibliography.
Includes index.
ISBN 1 921061 77 4 (pbk.).

1. Wildlife management - Western Australia - North West Shelf - Simulation methods. 2. Natural resources - Co-management - Western Australia - North West Shelf. 3. Wildlife resources - Subsistence vs. recreational use - Western Australia - North West Shelf - Planning. 4. Wildlife management - Western Australia - North West Shelf - Simulation methods. 5. North West Shelf (W.A.) - Environmental conditions. I. Fulton E. A. II. CSIRO. Marine and Atmospheric Research. III. Western Australia. Dept. of Environmental Protection. (Series : Technical report (CSIRO. Marine and Atmospheric Research. North West Shelf Joint Environmental Management Study) ; no. 15).

333.9164120916574

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Includes index.
ISBN 1 921061 78 2 (CD-ROM).

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Final report

North West Shelf Joint Environmental Management Study Final Report

List of technical reports

NWSJEMS Technical Report No. 1
Review of research and data relevant to marine environmental management of Australia's North West Shelf.
A. Heyward, A. Revill and C. Sherwood

NWSJEMS Technical Report No. 2
Bibliography of research and data relevant to marine environmental management of Australia's North West Shelf.
P. Jernakoff, L. Scott, A. Heyward, A. Revill and C. Sherwood

NWSJEMS Technical Report No. 3
Summary of international conventions, Commonwealth and State legislation and other instruments affecting marine resource allocation, use, conservation and environmental protection on the North West Shelf of Australia.
D. Gordon

NWSJEMS Technical Report No. 4
Information access and inquiry.
P. Brodie and M. Fuller

NWSJEMS Technical Report No. 5
Data warehouse and metadata holdings relevant to Australia's North West Shelf.
P. Brodie, M. Fuller, T. Rees and L. Wilkes

NWSJEMS Technical Report No. 6
Modelling circulation and connectivity on Australia's North West Shelf.
S. Condie, J. Andrewartha, J. Mansbridge and J. Waring

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Modelling suspended sediment transport on Australia's North West Shelf.
N. Margvelashvili, J. Andrewartha, S. Condie, M. Herzfeld, J. Parslow, P. Sakov and J. Waring

NWSJEMS Technical Report No. 8
Biogeochemical modelling on Australia's North West Shelf.
M. Herzfeld, J. Parslow, P. Sakov and J. Andrewartha

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Trophic webs and modelling of Australia's North West Shelf.
C. Bulman

NWSJEMS Technical Report No. 10
The spatial distribution of commercial fishery production on Australia’s North West Shelf.
F. Althaus, K. Woolley, X. He, P. Stephenson and R. Little

NWSJEMS Technical Report No. 11
Benthic habitat dynamics and models on Australia’s North West Shelf.
E. Fulton, B. Hatfield, F. Althaus and K. Sainsbury

NWSJEMS Technical Report No. 12
Ecosystem characterisation of Australia’s North West Shelf.
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Contaminants on Australia’s North West Shelf: sources, impacts, pathways and effects.
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NWSJEMS Technical Report No. 14
Management strategy evaluation results and discussion for Australia’s North West Shelf.
R. Little, E. Fulton, R. Gray, D. Hayes, V. Lyne, R. Scott, K. Sainsbury and D. McDonald

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E. Fulton, K. Sainsbury, D. McDonald, D. Hayes, V. Lyne, R. Little, M. Fuller, S. Condie, R. Gray, R. Scott, H. Webb, B. Hatfield and M. Martin

NWSJEMS Technical Report No. 16
Ecosystem model specification within an agent based framework.
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NWSJEMS Technical Report No. 17
Management strategy evaluations for multiple use management of Australia’s North West Shelf – Visualisation software and user guide.
B. Hatfield, L. Thomas and R. Scott

NWSJEMS Technical Report No. 18
Background quality for coastal marine waters of the North West Shelf, Western Australia.
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ACRONYMS

ACOM	Australian Community Ocean Model
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AGSO	Australian Geological Survey Organisation now Geoscience Australia
AHC	Australian Heritage Commission
AIMS	Australian Institute of Marine Science
AMSA	Australian Maritime Safety Authority
ANCA	Australian Nature Conservation Agency
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZLIC	Australian and New Zealand Land Information Council
APPEA	Australian Petroleum, Production and Exploration Association
AQIA	Australian Quarantine Inspection Service
ARMCANZ	Agricultural Resources Management council of Australia and New Zealand
ASIC	Australian Seafood Industry Council
ASDD	Australian Spatial Data Directory
CAAB	Codes for Australian Aquatic Biota
CAES	Catch and Effort Statistics
CALM	Department of Conservation and Land Management (WA Government)
CAMBA	China Australia Migratory Birds Agreement
CDF	Common data format
CITIES	Convention on International Trade in Endangered Species
CTD	conductivity-temperature-depth
CMAR	CSIRO Marine and Atmospheric Research
CMR	CSIRO Marine Research
COAG	Council of Australian Governments
ConnIe	Connectivity Interface
CPUE	Catch per unit effort
CSIRO	Commonwealth Science and Industrial Research Organisation
DCA	detrended correspondence analysis
DIC	Dissolved inorganic carbon
DISR	Department of Industry, Science and Resources (Commonwealth)
DEP	Department of Environmental Protection (WA Government)
DOM	Dissolved organic matter
DPIE	Department of Primary Industries and Energy
DRD	Department of Resources Development (WA Government)
EA	Environment Australia
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPP	Environmental Protection Policy
ENSO	El Nino Southern Oscillation
EQC	Environmental Quality Criteria (Western Australia)
EQO	Environmental Quality Objective (Western Australia)
ESD	Ecologically Sustainable Development
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
GA	Geoscience Australia formerly AGSO
GESAMP	Joint Group of Experts on Scientific Aspects of Environmental Protection
GIS	Geographic Information System
ICESD	Intergovernmental Committee on Ecologically Sustainable Development
ICS	International Chamber of Shipping
IOC	International Oceanographic Commission
IGAE	Intergovernmental Agreement on the Environment
ICOMOS	International Council for Monuments and Sites
IMO	International Maritime Organisation

IPCC	Intergovernmental Panel on Climate Change
IUNC	International Union for Conservation of Nature and Natural Resources
IWC	International Whaling Commission
JAMBA	Japan Australian Migratory Birds Agreement
LNG	Liquified natural gas
MarLIN	Marine Laboratories Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MECO	Model of Estuaries and Coastal Oceans
MOU	Memorandum of Understanding
MPAs	Marine Protected Areas
MEMS	Marine Environmental Management Study
MSE	Management Strategy Evaluation
NCEP - NCAR	National Centre for Environmental Prediction – National Centre for Atmospheric Research
NEPC	National Environmental Protection Council
NEPM	National Environment Protection Measures
NGOs	Non government organisations
NRSMPA	National Representative System of Marine Protected Areas
NWQMS	National Water Quality Management Strategy
NWS	North West Shelf
NWSJEMS	North West Shelf Joint Environmental Management Study
NWSMEMS	North West Shelf Marine Environmental Management Study
ICIMF	Oil Company International Marine Forum
OCS	Offshore Constitutional Settlement
PFW	Produced formation water
P(SL)A	Petroleum (Submerged Lands) Act
PSU	Practical salinity units
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SOI	Southern Oscillation Index
SMCWS	Southern Metropolitan Coastal Waters Study (Western Australia)
TBT	Tributyl Tin
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention of the Law of the Sea
UNEP	United Nations Environment Program
UNESCO	United Nations Environment, Social and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WADEP	Western Australian Department of Environmental Protection
WADME	Western Australian Department of Minerals and Energy
WAEPA	Western Australian Environmental Protection Authority
WALIS	Western Australian Land Information System
WAPC	Western Australian Planning Commission
WHC	World Heritage Commission
WOD	World Ocean Database
www	world wide web

TECHNICAL SUMMARY

Management Strategy Evaluation (MSE) is a simulation based framework that can be used to test, compare and evaluate the outcomes of management strategies against defined performance measures derived from the objectives of management or other stakeholders. It explicitly includes uncertainty in the dynamics of the ecosystem and socio-economic system, the effects of human uses or activities, and the implementation of monitoring and management measures. Consequently it can examine the robustness of existing or proposed strategies to deliver management objectives despite recognised uncertainties.

This report is one of a set of reports describing application of the management strategy evaluation methodology to multiple use management on the North West Shelf (NWS) of Australia. Companion reports provide the details of the model formulation (Gray et al. 2006) and the results and interpretation of the MSE analysis (Little et al. 2006). This report provides the overall structure of the MSE application, including specification of the models used to represent the North West Shelf system and key uncertainties, the future human development scenarios that were considered, and the management strategies that were evaluated. These model specifications, development scenarios and management strategies constitute the three dimensions of the MSE analysis.

The three model specifications defined both model structures and the model parameter values within both agent-based sub-models and more traditional equation-based sub-models. Several different structures were examined for representing both biophysical processes and human impacts. Combinations of model structure and parameter values were considered that could reasonably match the available historical data (within the 80% confidence intervals). Within these constraints, one combination of sub-model structures and parameter values was selected based on the most optimistic interpretation of the system’s productivity and resilience to human impacts (e.g. productive fish resources with fast habitat recovery and low uptake of contaminants). A second combination was based on the most pessimistic interpretations of these same characteristics, and a third intermediate combination was based on reasonable expectation.

The three development scenarios were specified to account for uncertainty in the future level of industrial activity on the North West Shelf region. The first development scenario represented recent (i.e. 2002) levels of infrastructure, residential and industrial development and environmental protection. The second development scenario represented the planned development over the next five years with no subsequent development. The third development scenario represents a repeated cycle of development of the type planned for the next five years after a further five years. Each scenario included developments in each of the four industry sectors: oil and gas, coastal development, fishing, and conservation.

The three management strategies chosen for evaluation focused on the same four sectors and were closely aligned to existing sector-by-sector legislative requirements. The first management strategy broadly represented the combination of sectoral management strategies in place in 2002. The second management strategy included potential modifications to existing sectoral strategies that might allow some management objectives to be met more effectively to bring the individual sectors up to “state-of-the-

art" management for that sector (separate to the management of the other sectors). The third strategy was a set of co-ordinated sectoral strategies, with shared monitoring and the potential for multi-sectoral management responses. This is a potential form of "true" ecosystem-based-management where cross sector considerations are explicitly considered.

1. INTRODUCTION

This report is one of a set of reports describing application of the management strategy evaluation (MSE) approach to multiple use management on the North West Shelf (NWS) of Australia. This report provides the overall structure of the MSE application, including specification (parameterisation) of:

- the models used to represent the North West Shelf system and key uncertainties;
- the future human development scenarios that were considered; and
- the management strategies that were evaluated.

These elements constitute the three dimensions of the MSE analysis and are described in detail in sections 2, 3 and 4 of this report respectively. Section 5 describes the indicators of environmental and economic outcomes that were used in the MSE analysis to compare management strategeies. The sources of information used in the analysis are provided in a series of appendicies, including information on the human uses focused on in the MSE analysis and how this information was used to determine the parameters of the models. Parameter values are also fully documented in appendices. Companion reports provide the details of the model formulation (i.e. Gray et al. 2006) and the results and interpretation of the MSE analysis (i.e. Little et al. 2006).

1.1 The biophysical environment of the North West Shelf

The North West Shelf study area extends along 1 500 km of the Pilbara coast from North West Cape to Port Hedland and offshore from the coastal fringe to the 200 metre depth contour (figure 1.1.1). It encompasses an ocean area of 110 000 square kilometres, of which 32 000 square kilometres correspond to waters shallower than 25 m. About 25 000 square kilometres are under Western Australian State jurisdiction and the remaining area is under the jurisdiction of the Commonwealth of Australia.

The continental shelf in this region is broad and characterised by a tropical hydrographic regime (Wyrtki, 1961; Buchan & Stroud, 1993; Condie et al. 2003; Condie et al. 2006). There is a sharp distinction between naturally turbid inshore waters driven by energetic tides and clearer offshore waters influenced by the tropical waters of the Indo-Pacific throughflow. The biological productivity of the region is relatively high by Australian standards (Tranter, 1962; Kabanova, 1968; Motoda et al. 1978; Condie & Dunn, 2006). The Indo-West Pacific fish (Allen & Swainston, 1988; Sainsbury et al. 1997) and crustacea (Ward & Rainer, 1988; Bulman, 2006) are also characterised by high levels of diversity.

The seabed is mostly calcareous sands and fine muds (Jones 1973; McLoughlin & Young, 1985) and supports variable coverages of macrobenthic fauna, such as sponges and soft corals (Sainsbury, 1991; Bowman Bishaw Gorham, 1995; Fulton et al. 2006). These biogenic habitats are diverse and extensive in some areas and have been shown to play a significant role in structuring the distribution of fish species in the area (Sainsbury et al. 1997). Hard coral reefs are limited to shallow areas around islands and outer peninsulars, where water turbidity is sufficiently relatively low.

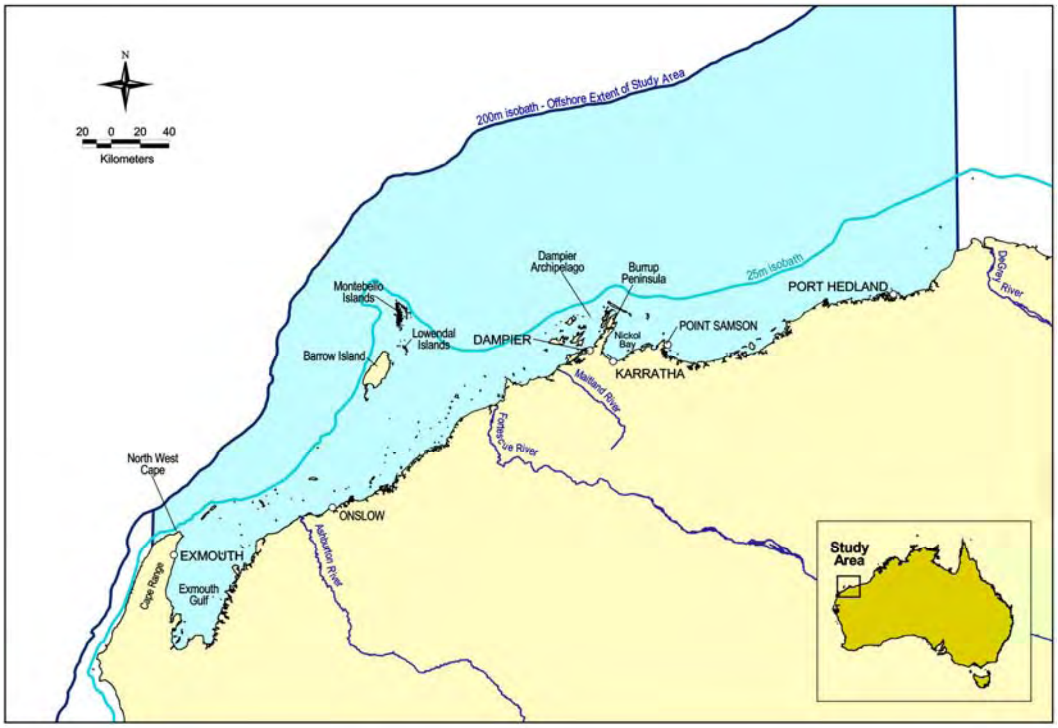

Figure 1.1.1: Map of the study area.

1.2 Human activities on the North West Shelf

The North West Shelf supports extensive industrial activity including commercial fisheries, oil and gas exploration and production, and coastal activities such as port operations, salt production, and other forms of coastal development and infrastructure building. The scale of these activities is reflected in figures taken from environmental impact statements for the region (Appendix D).

Fisheries

The four significant commercial fisheries in the Pilbara are the Nickol Bay Prawn Fishery, the Onslow Prawn Fishery, the Pilbara Fin Fish Trawl Fishery and the Pilbara Trap Fishery. Diving for pearl oyster is also carried out, although these operations are mainly focused along the Kimberly coast. Established fishing operations are located at Onslow, Dampier, Point Samson and Port Hedland.

The major fisheries operating within the last four decades have been:

- a Japanese trawl fishery targeting *Lethrinus* in depths of 30 to 120 m from 116°E to 117°30’E (1959 to 1963);

- a Taiwanese pair trawl fishery taking many species including *Nemipterus*, *Saurida*, *Lutjanus* and *Lethrinus* in depths of 30 to 120 m (1972 to early 1990s);
- the current domestic Australian trap fishery that targets *Lethrinus*, *Lutjanus* and *Epinephelus* in areas out to 80 m that had previously seen little trawling (1984 to present); and
- the domestic Australian trawl fishery targeting mainly *Nemipterus*, *Saurida*, *Lutjanus, Epinephelus* and *Lethrinus* in depths of 30 to 120 m, east of 116°45'E (1989 to present).

The total catch for the region in the 1999/2000 season was 3356 tonnes and was estimated to have a value of A$18.6 million.

The prawn fisheries operate in Commonwealth and State waters in Exmouth Gulf and around Onslow and Nickol Bay, where they are managed by the Department of Fisheries Western Australia (DFWA). An assessment of those fisheries under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) documents the main characteristics of the fisheries and their potential interactions with conservation values (DEH 2004 and table 1.2.1).

Table 1.2.1: Excerpt from DEH (2004) giving the characteristics of the Onslow Prawn Managed Fishery (OPMF) and the Nickol Bay Prawn Managed Fishery (NBPMF).

Area	Specified Indian Ocean waters adjacent to the State of Western Aurstralia (Commonwealth and State waters).
Fishery status	OPMF is fully exploited. NBPMF is fully exploited
Taget species	Western king prawns (*Panaeus latisulcatus*), brown tiger prawns (*Penaeus endeavouri*), endeavour prawns (*Metapenaeus endeavouri*) and banana prawns (*Penaeus merguiensis*).
Byproduct species	Not limited, includes black tiger and coral prawns, bugs, blue swimmer crabs, finfish and scallops.
Gear	Otter trawl, configuration varies between areas.
Season	OPMF: Varies between areas, generally from March to Novemeber. NBPMF: Year round, designated nursery areas open in May and close between August and November.
Commercial harvest	Variable – 12 year catch history is 60 – 130 t for OPMF and 22 – 500 t for NBPMF.
Value of commercial harvest (5 year annyal average)	OPMF: $1.3 million. NBPMF: $2.9 million.
Commercial licences issued	31 in OPMF and 14 in NBPMF.
Managemtn arrangements	Input controlled through: • limited entry; • seasonal and area closeures; and • gear and boat restictions
Export	Up to 80% of product exported to Asia.
Bycatch	Various, includes invertebrate and fish species.
Interaction with threatened species	Capture of seasnakes, syngnathids and turtles. Also potential interactions with dugong.

All the prawn fisheries are assessed as fully exploited. Management controls comprise:

- limitation of the number of vessels licenced to fish;
- seasonal and area closures;
- restrictions on number and size of nets that can be used; and
- requirement for all vessels to carry satellite based Vessel Monitoring to record their location.

Interactions occur between the fishery and some threatened species (sea snakes and, to a lesser extent, sea turtles) and a large number of fish and invertebrate by-catch species. Full implementation of Bycatch Reduction Devices, aimed at reducing all bycatch, began in 2003 along with protection of designated nursery areas for both fisheries.

Catches in the prawn fisheries are highly variable year-to-year (figure 1.2.1) and significant shifts are apparent in their spatial and temporal pattern. This variability may reflect species dependent sensitivity to environmental forcing (e.g. rainfall) or other ecological factors (e.g. competition between species).

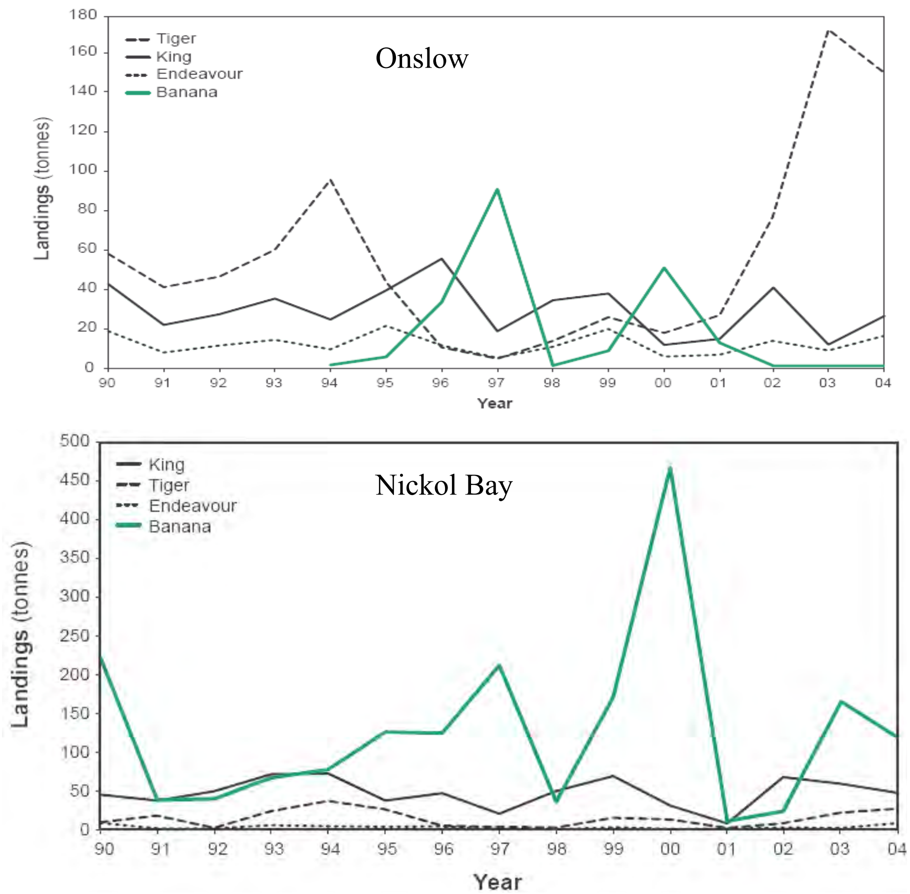

Figure 1.2.1: Annual variations in the landings of prawn catch from Onslow (top) and Nickol Bay (bottom) from 1990 to 2004 for king (solid black line), tiger (dashed line), endeavor (dotted line) and banana (blue colored line and shaded) prawns. (From the Department of Fisheries of Western Australia *State of the Fisheries Report 2004 - 2005.*)

Management of these highly variable target species within acceptable limits is a major challenge for any management strategy, particularly when combined with EBPC requirements to address ecological impacts of the fishery. Key recommendations made after the last EPBC assessment (DEH 2004) included requirements for monitoring and minimising protected species interactions, bycatch and other marine environmental impacts related to spawning areas, nursery grounds, feeding areas, and benthic habitats.

Oil and gas extraction

Oil was first discovered in Western Australia at Rough Range in 1953 with exploration of crude oil and condensate beginning in 1962 and 1972 respectively. The industry has grown rapidly and by 2001 there were 44 fields producing in four sedimentary basins with the majority of these fields (32) contained within the Northern Carnarvon basin (figure 1.2.2). During 2001 these fields collectively produced 26 Gm^3 of gas and 20 Gl of oil and condensate valued at 9.4 trillion dollars.

Woodside Energy and BHP Billiton Petroleum operations in the Pilbara region produced A$4.2 billion of crude oil, A$2.9 billion of LNG, A$1.7 billion of condensate, A$600 million of natural gas and over A$400 million of LPG products. The major oil and gas project in the Pilbara is the A$12 billion North West Shelf Joint Venture. The project is located on the Burrup Peninsula and currently has a production capacity of over 7.5 megatonnes per annum of LNG that is primarily exported to Japan. The North West Shelf Joint Venture project is equally owned by Woodside Energy; BP Developments Australia; Chevron Texaco Australia; BHP Billiton Petroleum; Shell Development (Australia); and Japan Australia LNG (MIMI).

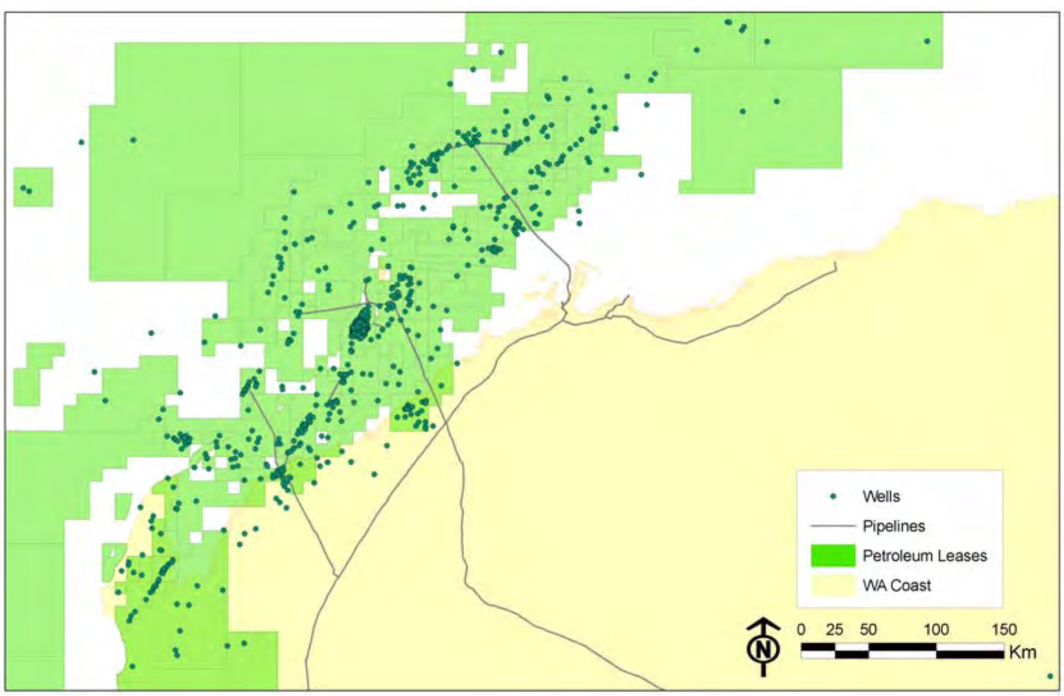

Figure 1.2.2: Petroleum leases, all wells drilled including exploration and production, and major pipelines.

Coastal industries and development

The major coastal industries in the study region are associated with oil and gas processing and distribution, salt production, and iron ore processing:

Oil and gas

Woodside's on-shore gas plant is located near Karratha and is Australia's largest gas processing plant. The plant produces natural gas, liquid petroleum gas and condensate. A number of pipelines transport gas from the Pilbara to WA domestic markets (figure 1.2.2).

Mermaid Marine Australia Limited at Dampier is a major service facility for the oil and gas industry. The organisation operates a fleet of fifteen tugs, workboats and barges undertaking all forms of offshore activity including exploration support, supply, survey and berthing assistance.

Salt production

The two salt producers on the North West Shelf are Dampier Salt Ltd and Onslow Salt Pty Ltd. Dampier Salt Ltd has two major operations located at Port Hedland and Dampier. In 2002, the Pilbara produced over six million tonnes of salt that represented 70 percent of the total salt produced in Western Australia for that year. The value of the Pilbara region's salt production over this period was estimated to be A$180 million.

Iron ore

Iron ore was discovered in the Pilbara region in the 1800s and the industry has now grown to include 22 iron ore mining and processing operations employing 9000 people. More than 95 percent of Australia's iron ore exports are exported through the ports on the North West Shelf. In 2001, 157 million tonnes of iron ore worth A$5.1 billion was produced. The two major operators in the region are BHP Billiton Iron Ore and Rio Tinto (owner of Hamersley Iron and a majority holding in Robe River Iron Associates).

BHP Billiton Iron Ore has six mining operations in the Pilbara producing around 80 million wet tonnes of iron ore. The ore is railed to processing and shipping facilities at Port Hedland (where the Western Power electricity production facility generates a significant proportion of Western Australia's electricity needs). Two port facilities located on opposite sides of Port Hedland harbour are connected by a 1.4 km under-harbour tunnel conveyor. Over 500 ships are loaded each year, the largest are up to 230 metres long and carry up to 260 000 tonnes of ore.

Hammersley Iron is located at Karratha and is one of the world's leading iron ore producers, supplying 77 million tonnes of iron ore per year. Hamersley Iron uses gas to fire its 120-megawatt Dampier power station, which provides power to its mining facilities, port and processing operations at Dampier, the towns of Dampier, Tom Price and Paraburdoo, and the Dampier Salt facilities, with any surplus sold to Western Power's western Pilbara grid. Robe River operates two open pit mines in the Pilbara region, railing to a dedicated port at Cape Lambert from where over 40 million tonnes of iron ore are exported per year.

1.3 Management strategy evaluation

Management strategy evaluation (MSE) is a simulation based framework that can be used to test, compare and evaluate the outcomes of management strategies against defined performance measures that are derived from the objectives of management (e.g. Sainsbury et al. 2000; Sainsbury & Sumalia, 2003). A management strategy in this context is a combination of:

- a monitoring program;
- status assessments of indicators based on analyses of the monitoring data;
- defined management responses that depend on the status assessments; and
- implementation of the management measures.

MSE can be used to compare, in terms of the performance measures, strategies that differ in any of these aspects.

Because the MSE methodology compares management strategies using performance measures derived from management objectives, the comparisons are of overall management performance, rather than of performance of intermediate parts such as scientific accuracy of the monitoring program or the kind of management response. MSE treats the ecosystem, the human uses and the management system as a single coupled system, and evaluates the contribution of any part in terms of the overall outcomes rather than by performance of that part in isolation. This is because the outcome from the whole system is a function of the interacting parts. For example, an accurate monitoring program is unlikely to result in good overall outcomes if it delivers to an unresponsive management system, whereas good outcomes could be obtained from inaccurate monitoring that delivers into a suitably designed and responsive management system.

MSE explicitly includes uncertainty at all levels including:

- the dynamics of the ecosystem or socio-economic system;
- the effects of human use or activity;
- the monitoring program; and
- implementation of management measures.

Consequently it can examine the robustness of existing or proposed strategies to deliver management objectives despite recognised uncertainties. However, the conclusions about the robustness of a management strategy ultimately depend on adequate representation of uncertainty in the models that are used. While recognised uncertainties can be included in the MSE methodology, like other methodologies, it is vulnerable to uncertainties that are not yet recognised or recognisable.

Because it explicitly includes uncertainty, the MSE methodology can be used to estimate the gain in management performance from investments that resolve key uncertainties. In this context it is ideally suited to the development and testing of adaptive management strategies that make use of a ‘detection-correction’ feedback loop to robustly achieve desired outcomes despite uncertainty. This is typically in the form of monitoring and status assessments of indicators to detect departure from intent, with any necessary correction through planned management responses. Hence, MSE can be used to determine the monitoring, assessment and management response that will robustly lead to the desired management outcomes under the recognised uncertainties.

Management strategy evaluation for multiple uses

One of the key objectives of NWSJEMS was to develop and demonstrate science-based methods and tools to support integrated regional planning and multiple-use management for ecologically sustainable development of the North West Shelf ecosystem, including management of the individual and cumulative effects of the various human uses and activities. While MSE has been applied previously to the management of individual industry sectors or activities, such as fisheries (Sainsbury et al. 2000), forestry (Sit & Taylor, 1998), water allocation (Walter et al. 2000), and insect pest control (Andow & Ives, 2002), it has not previously been applied to multiple human uses at the ecosystem level.

There are significant challenges in applying MSE to the multiple use management of the North West Shelf ecosystem. These stem from the high level of uncertainty about ecosystem processes and the complexity of representing the impacts, the benefits, the future development, and the interaction of management strategies of several industry sectors acting simultaneously. However, the fundamental approach is the same as for simpler applications and involves:

- defining the management objectives, indicators and performance measures for the industry sectors, the management agencies, and for the bioeconomics of the region as a whole;
- developing models to represent the range of ways the biophysical world may work;
- developing models to represent the activities, impacts and benefits from the industry sectors and other human uses, including expected future industrial developments; and
- developing models to represent possible monitoring and management strategies.

Together these models are designed to simulate environmental, social and economic conditions associated with the state of an ecosystem, as it evolves in response to natural forcing and human use (figure 1.3.1). Once they have been calibrated against available historical information and the *model specifications* have been defined, they can be used to compare the range of outcomes expected under potential *future scenarios* with alternative *management strategies*.

Model specifications

A *model specification* is a description of the computer representation of the real system, including both the natural ecosystem and relevant components of human society. Uncertainty or inadequacy in process understanding usually leads to several alternative model specifications, all consistent with available system information, but varying in their structure and/or parametre values. These various specifications represent alternative hypotheses about how the system behaves in response to natural events and human actions and can include uncertainties about natural events (e.g. frequency and nature of catastrophic events) and human actions (e.g. motivations and behavioural rules).

Development scenarios

A *development scenario* is a statement of how various factors that impact on the system may change into the future. It is not included explicitly in the model specifications, but rather is used as input to the models. In the present context, development scenarios typically include demographic changes, industrial development, and climate change and variability.

Management strategies

A *management strategy* is an existing or planned course of action employed, in the current context, by a government regulator or planner that constrains human use to achieve environmental, social or economic objectives. Along with these objectives, the management strategy must include a monitoring strategy that measures the state of the managed system through time and space and allows environmental, social and economic *indicators* to be calculated. Management responses are initiated and implemented based on the interpretation of these indicators relative to some target or *performance measure*.

MSE can also include industry-sector or business strategies aimed at achieving industry-wide or business outcomes. These have a similar structure to the management strategy of a regulator in that they contain objectives, monitoring and decisions in response to the monitoring information. Strategies at government, industry-sector or business level are all conducted within the context of relevant policy or governance arrangements. In the case of government regulators all or part of this may be provided through legislation.

MSE outputs

For each combination of *model specification, scenario* and *strategy,* MSE provides output data in the form of data files, maps (e.g. GIS layers), and other graphical representations of the properties and indicator variables of interest. The display of these data may then be used to compare and contrast different combinations of *model specification, scenario* or *strategy.* Overlays of maps and images can be used to describe the spatial characteristics of the ecosystem at particular times. Such overlays can be updated through time to produce animated maps and images that show the dynamical evolution of the modelled system under the various combinations.

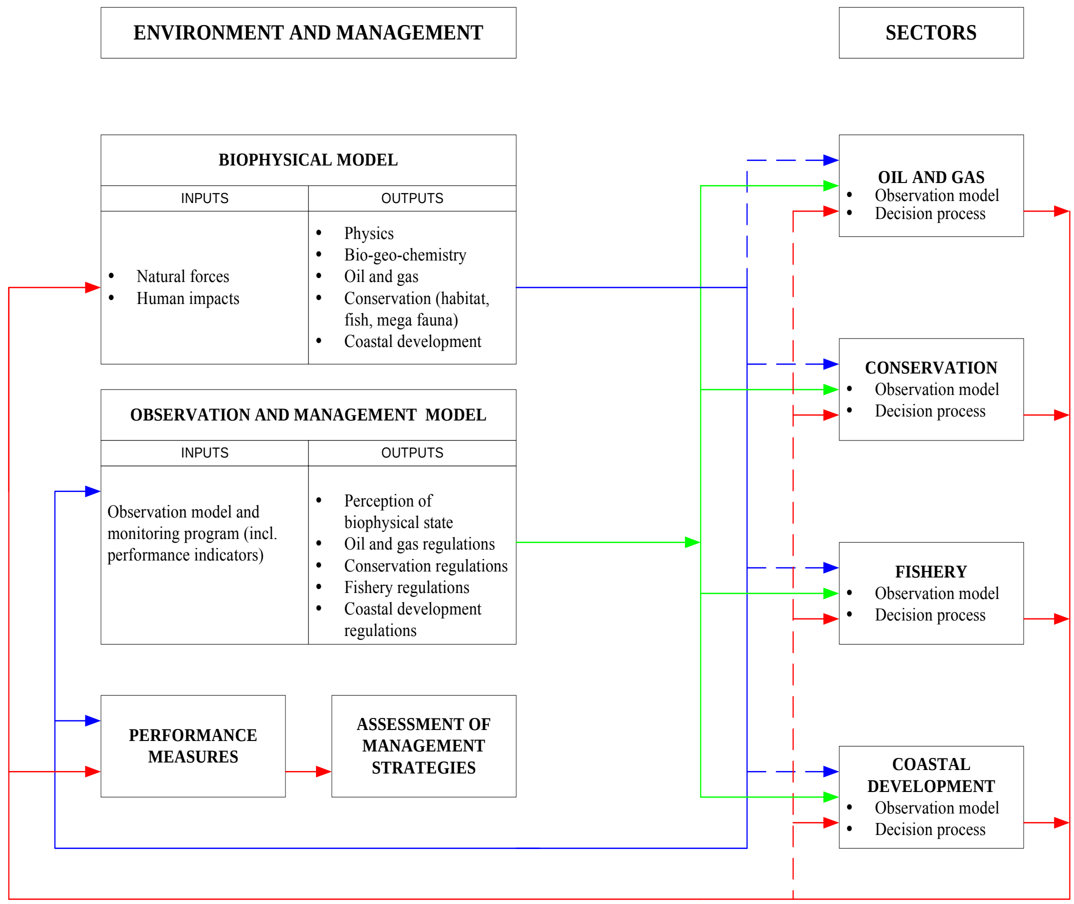

Figure 1.3.1: The multiple-use MSE model framework. The components represented on the left side of the figure include both the biophysical ecosystem and the socioeconomic model of the region, as well as the management objectives and derived performance measures with which to judge the overall outcomes of the management strategy being evaluated. The socioeconomic model of the region generates performance measures that integrate across all activities and industries, as well as providing population and other inputs to the industry sector models. The right side of the figure contains the various human use sectors, including both their development and regulation. The human use sectors considered in NWSJEMS are oil and gas, fisheries, coastal development and conservation. For each industry sector, the sector models represent the activity of that industry, which provides both impacts in the biophysical model and costs/benefits to that industry sector. The assessment and monitoring models provide the information available through the monitoring and assessment program to inform industry or government for decision makers. For the oil and gas, coastal development and fisheries sectors there are separate industry and government observation programs. The management/policy/governance models make use of the information available through monitoring and assessment to reach decisions about change in industry activities or in government management measures. Industry and government decision making is made separately in the context of the relevant policy and governance arrangements. The tactical sector management model provides implementation of the decisions reached by the industry and by government regulators and included tactical responses by industry to changed regulation. The solid lines indicate the direct or primary effects of one component on another, while broken lines indicate indirect or secondary effects.

1.4 Specification of multiple use management strategy evaluation for the North West Shelf region

MSE requires a computer representation of the natural ecosystem which influences, and is influenced by, human activity. This computer representation is made up of three components:

- an 'operating model' of the biophysical and human systems involved, including models of human impacts and the representation of uncertainty;
- a range of scenarios for future social and industrial development in the region; and
- prospective management strategies (i.e. monitoring, assessment of monitoring information, management response to the assessed information, and implementation of the management response).

The MSE application to the North West Shelf region uses three different specifications of each of these three components, giving a 3 by 3 by 3 matrix of combinations through which to explore and compare sensitivities and outcomes. This matrix is made up of three operating model specifications, three development scenarios and three management strategies, giving 27 combinations for evaluation and comparison. This allows initial screening of behaviour that could be examined using a more complete or targeted MSE exploration of the options and outcomes (figure 1.4.1). In particular, it allows examination of the robustness of the different management strategies in delivering desired management outcomes for a range of possible future socio-economic development, despite uncertainty about how the ecosystem works. Although clearly a great simplification of the full range of interactions among these three dimensions, the 27 combinations chosen are sufficient to demonstrate the utility of MSE as a science-based aid to regional and sectoral planning and decision making.

Three *model specifications* were chosen that reflect:

- an optimistic interpretation of the ecosystem's productivity and resilience;
- a central or base-case interpretation; and
- a pessimistic interpretation.

These different model specifications reflect uncertainty about the dynamics of the ecosystem, both with respect to the structuring of the model and the values of the parameters in the model. Each model consists of sub-models of various processes or entities in the ecosystem that were individually modified to give the three models used in the MSE comparisons. So, for example, the optimistic operating model was optimistic in all of its submodel specifications.

Three *development scenarios* were chosen that represent:

1. the 2003 levels of infrastructure, residential and industrial development and environmental protection, with no further development;
2. planned industrial development over the following five years (i.e. development for the next five years that is presently under construction or at an advanced stage of planning or approval) with no further development from 2008; and
3. as in (2) to 2008, followed by similar development over the following 5 years, with no further development from 2013.

Each development scenario contains an individual development plan for each of the four industry sectors considered (i.e. oil and gas, coastal development, fishing, and conservation) according to the development planned for that sector in the five years from December 2002.

The three development scenarios can be regarded as examining the consequences of no further development, one 5-year pulse of additional development, and two 5-year pulses of further development. The first development scenario allows examination of the long-term outcomes of the present level of development, recognising that many relevant environmental and economic outcomes are relatively slow to fully manifest and that all outcomes of the present level of development may not yet be observable in the real world. Similarly, the second development scenario examines the short and long-term consequences of the development planned in the next five years. The third scenario considers the consequences of sustaining this development over 10 years.

Three *management strategies* were chosen to reflect different possible approaches to government management and regulation:

- status quo management arrangements taken to be the sectorally based management strategies in place at the start of 2003;
- enhanced status quo management arrangements, which maintained the form of the current sectorally based management strategies but increased the monitoring, assessment and implementation with the intention of reflecting the best outcomes likely to be achieved by this structure of management; and
- enhanced regional management arrangements, which set regional indicators and benchmarks, coordinated monitoring, shared the results of monitoring and assessment among sectors, and provided a multi-sectoral management response if undesirable trends were detected in monitored indicators.

The MSE calculations and comparisons were conducted to represent the 12 year period January 2003 to December 2014. Within each cell of the 3 by 3 by 3 matrix (figure 1.4.1) several hundred indicators were calculated and provided at several time and space scales (section 4.6). For relevant indicators statistical measures of variability are also provided that reflect stochasticity in ecological, human use, monitoring and management processes (i.e.stochasticity in processes other than the uncertainty in model structure and parameter values represented by the different model specifications). Two computer visualisation packages are provided to allow examination of these indicators; one tailored for scientific exploration, diagnosis and statistical analysis, and the other for more general visualisation and inspection (Hatfield et al. 2006).

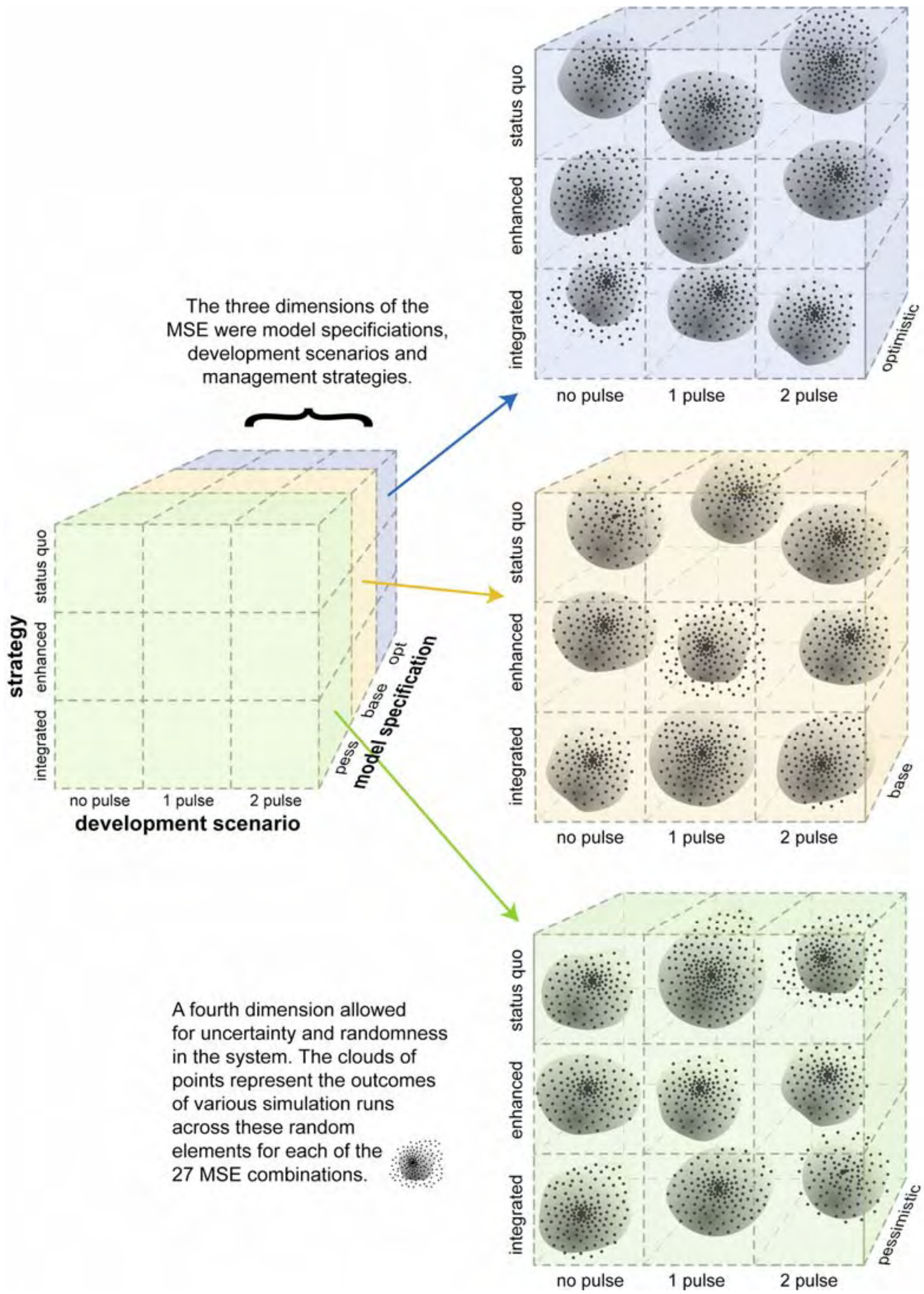

Figure 1.4.1: Schematic of the 3 by 3 by 3 matrix representing the three dimensions of the MSE analysis: model specification, development scenario, and strategy. Comparisons can be made among any of the cells of the cube, and the slices of the cube (right) allow comparison of the management strategy and development scenarios for each of the three model specifications. Within each cell the MSE results provide the indicators and performance measures, at various time and space scales, along with measures of variability in them associated with stochasticity in ecological, human use, monitoring and management processes (i.e. stochasticity in processes other than the uncertainty in model structure and parameter values represented by the different model specifications).

2. MODEL SPECIFICATIONS

The models used for the MSE calculations are described in detail in Gray et al. 2006 and are comprised of a combination of agent-based sub-models and the more usual equation based sub-models. The agent-based models are comprised of agents, objects or entities that behave autonomously. These agents are aware of, or interact with, one another and their local environment through simple internal rules for decision making, movement, action or reaction. Aggregate behaviour is the result of a large number of these interactions, and can be complex even if the interaction rules are simple. Agent-based modelling has been successfully applied to predict movement of gas or fluid particles, population and ecological properties from individual animal interactions, business selections in financial markets, and human responses on battlefields. Agent-based models are particularly appropriate where complex behaviour is thought to arise from discrete interactions or decisions by heterogeneous entities, such as movement of animals or economic decision making of humans. Agent-based models are easily modified, can represent complex system behaviour and situations that are not well summarised by average or 'mean field' descriptions. However, because they are more computationally intensive than equation-based models, the MSE model uses equation-based sub-models where the unit of interest represents a large number of individuals and so the particular benefits of agent-based sub-models are not evident (e.g. entire populations or habitat patches that are many kilometres in scale).

The two main aspects of specification for MSE models are the model structure and the model parameters for a given model structure. Several different structures were examined for the sub-models of the main biophysical processes and human impacts, including alternative equation-based and agent-based variations for many sub-models. Combinations of model structure and parameter values were examined that could reasonably match any available historical data. Goodness of fit to historical data was measured by the sum of squared differences between the observations and model predictions. Model parameters corresponding approximately to the least squares estimates and the 80% confidence intervals were used to identify a reasonable span of possible parameter values and sub-model behaviours.

From the range of sub-model structure and parameter combinations that satisfied the above criteria, an 'optimistic' set was chosen corresponding to relatively high levels of system productivity and resilience to human impacts (i.e. relatively productive fish resources, fast recovery of habitat after disturbance, and low uptake or fast elimination of contaminants by organisms). A 'pessimistic' set was similarly chosen corresponding to relatively low levels of system productivity and resilience to human impacts (i.e. relatively unproductive fish resources, slow habitat recovery after disturbance, and high uptake or slow elimination of contaminants by organisms). The sub-models for the 'base-case' interpretation used the least squares parameter estimates, where these could be reasonably calculated, or otherwise the most reasonable estimates available from studies reported in the scientific literature.

In the remainder of this chapter details on each of the main sub-models of the operating model will be provided, including more detailed definition of the optimistic, base-case and pessimistic interpretations. The main sub-models included:

- Water circulation and particle transport

- Primary production and nutrient cycling
- Benthic habitat
- Iconic species dynamics
- Fish species and impacts of fishing
- Dispersal and uptake of contaminants
- Human behaviour and impact

Parameter values corresponding to the optimistic, base-case and pessimistic interpretations are listed in Appendix E.

2.1 Water circulation and particle transport

The model used to compute the currents on the North West Shelf was based on MECO (Model for Estuaries and Coastal Oceans) modelling system, which is documented in Herzfeld et al. (2002). MECO is a general-purpose finite difference hydrodynamic model applicable to scales ranging from estuaries to ocean basins. It has been applied previously to systems such as the Derwent and Huon estuaries in Tasmania, Gippsland Lakes, Port Phillip Bay (Walker, 1999), Bass Strait, the Great Australian Bight and South-eastern Australia (Bruce et al. 2001), and the Gulf of Carpentaria (Condie et al. 1999). A full description of the circulation model as applied to North West Shelf and descriptions of the spatial and temporal characteristics of the circulation and connectivity can be found in Condie et al. (2006).

The model produced data on three nested grids, designed to capture the dynamics over a range of spatial scales. Each of these was a rotated latitude-longitude grid and could be described as follows:

- A large regional model with horizontal resolution of approximately 10 km, extending from Cape Cuvier (south of Coral Bay) to the Bonaparte Archipelago and well beyond the shelf break. This was referred to as the *Northwest model*.
- A smaller regional model with horizontal resolution of approximately 5 km, extending from Ningaloo to Port Hedland and beyond the shelf break. This was referred to as the *Pilbara model*.
- A localised coastal model with horizontal resolution of approximately 1 km, covering the waters around the Dampier Archipelago to depths of almost 50 m. This was referred to as the *Dampier model*.

The circulation and particle transport data produced by these three nested models is very comprehensive and was assumed to be the best description of water circulation and particle transport available for the NWS. However, the run times of these models were much too long to be imbedded directly into MSE model and still allow the multiple runs needed to adequately represent stochasticity. It was not even practical to store the fully detailed circulation model outputs and use them to construct the necessary input to the MSE models. Instead a much simpler statistical model was calibrated against the circulation model outputs and then used to predict the short-term circulation and particle transport within the MSE model. This statistical model was mainly used in the MSE to predict contaminant dispersion and is described in this context in section 2.6.

2.2 Primary production, nutrient cycling and trophic interactions

Detailed models of the primary production, nutrient cycling and trophic interactions have been developed for the North West Shelf (Herzfeld et al. 2006; Bulman, 2006). While agent-based models where also developed incorporating such interactions, they were found to be too slow for deployment at regional scales. Furthermore, the results of Herzfeld et al. (2006) and Bulman (2006) suggest that there is limited interaction of these processes with the human uses examined by the MSE. Instead, the major effects of the human uses were through the more direct consequences of harvesting, habitat modification and water quality. With respect to fisheries this is consistent with the findings of Sainsbury (1988). It was therefore decided not to explicitly represent processes such as primary production (beyond the growth of habitat forming primary producers such as macroalage, mangroves and seagrass, which were included for their habitat role), nutrient cycling and trophic interactions in the current application of the MSE model.

2.3 Benthic habitats

The benthic habitats represented in the MSE included coastal habitats, such as seagrass meadows and mangrove forests, and continental shelf habitats, differentiated by sediment type and coverage of epibenthic fauna such as sponges and soft corals.

A number of statistical and analytical models of the benthic habitats were developed (Fulton et al. 2006) and used to guide both the structure and parameter values used in the operating model. These were most fully developed for the continental shelf seabed habitats because of the availability of relevant historical data. Given these data and the nature of the underlying processes, a metapopulation model was developed to calculate percentage cover, height and biomass of benthic fauna through time. This approach was adapted from previous habitat and metapopulation modelling work (e.g. Levins, 1969; Sainsbury 1991; Tilman & Kareiva, 1997). The benthic habitat models used sediment properties as a contributing factor to the benthic habitat distribution (Jones, 1973; McLoughlin & Young, 1985; Colman & West, 2000; figure 2.3.1).

Parameter values were derived from local habitat data and information from the broader scientific literature. There was relatively little documentation available on historical habitat distributions, which was mostly obtained through structured interviews and workshops with residents, divers and scientists with long-term experience on the NWS. Parameter options were calibrated to be consistent with the available data on each habitat type, as well as the range of views about the historical distributions.

Each of the habitat types was modelled using the ‘benthic agent’ model structure (Gray et al. 2006), which allowed for horizontal and vertical growth of habitat patches, ageing, mortality, fragmentation due to external events (e.g. cyclones, dredging), and either constant or density dependent colonisation of new habitat patches.

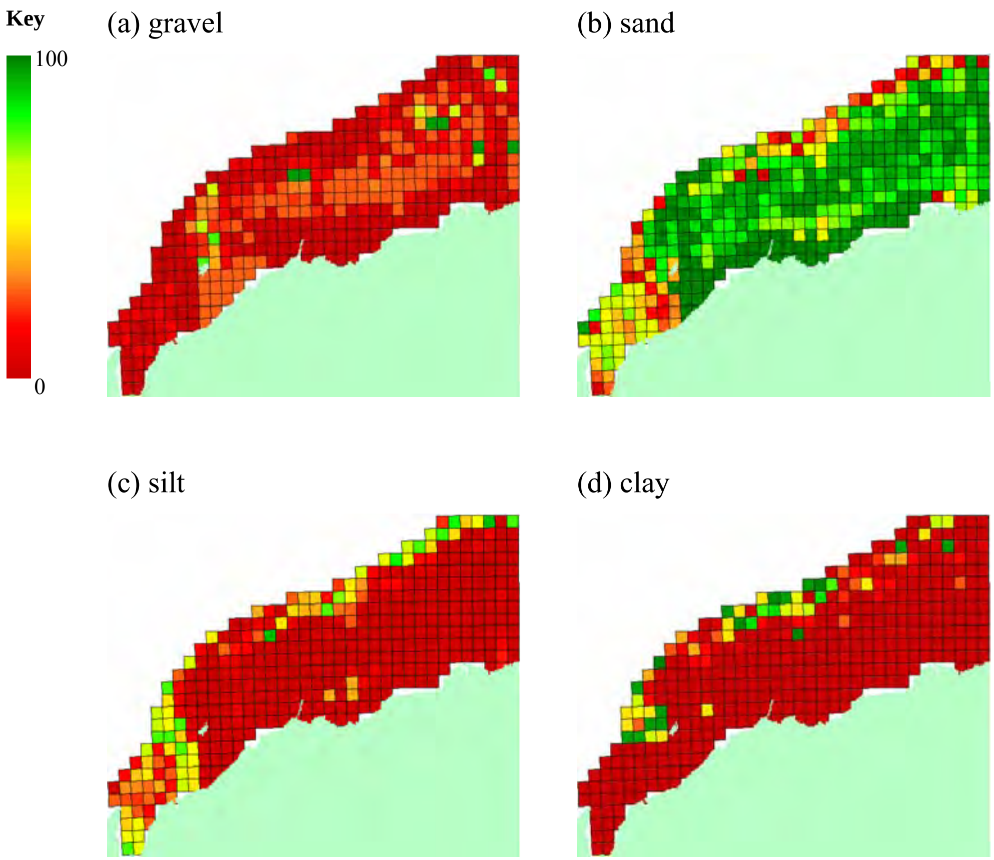

Figure 2.3.1: Sediment composition map. The index (colour key) is a percentage composition of the sediment for the grain type (gravel, sand and silt); similarly for the percentage composition of lay except the scale is 0 to 10 not 0 to 100.

Each agent was represented by a series of habitat polygons covering specified areas with resolutions considered appropriate for the habitat type. For the continental shelf reef habitats, the polygons consisted of a regular grid (six minutes of latitude by six minutes of longitude). The seagrass and macroalgae grids were on a larger grid (12 minute by 12 minute) but restricted to depths of less than 50 m. The mangrove grids were on a finer grid (three minute by three minute) and restricted to the coastline. While these grid sizes were fixed, sub-grid scale fragmentation and and patchiness were modelled in combination with the percentage cover of the various habitat types.

Two formulations of the benthic agent model were used:

1. Coastal mangroves and shelf reef habitats (mainly sponges and soft corals) were represented by an age-structured model, with percentage cover of small and large organisms tracked separately. Small and large were defined as < 100 cm and > 100 cm for mangroves and as < 25 cm and > 25 cm for sponges and soft corals. For any habitat type, patches of these two different size classes may overlap, so while the percent cover of either small or large habitat categories separately is ≤ 100%, the sum of the percent cover of small and large categories is ≤ 200%.
2. Seagrass and macroalgae were represented by a model with light limitation, but no age-structuring.

For each habitat agent the percentage cover, average height and biomass is tracked for each polygon. These statistics were used individually as indicators of the extent and character of each habitat, and in combination as proxies for biodiversity. Empirical observations suggest that there is a direct relationship between biodiversity and the average height of organisms in biogenic habitats such as sponge beds (Keith Sainsbury, Franzis Althaus and Piers Dunstan pers. comm. CSIRO Marine and Atmospheric Research).

Parameter estimation

For continental shelf reef habitat the base-case parameters for the habitat equations were determined by least squares optimisation. The Simplex method of minimising the sum of squares was used to fit the model to the benthos observations, with some parameters further constrained to a biologically meaningful range (Fulton et al. 2006). For the seagrass, macroalgae and mangrove habitats there was very limited documented information available from which to estimate model parameters. For these habitats the base-case parameters were determined from expert information and heuristic fitting to available data on historical cover and distributions (Lyne et al. 2006). The base-case parameter sets for each of the habitat types are given in Appendix B.

The pessimistic and optimistic parameterisations were determined by considering the extremes of the relevant parameters in the literature and by exploring the dynamics of the system in the parameter space around the base case results. The pessimistic parameters were selected so that the impact of disturbances on the habitat groups was stronger than in the base case and the rates of recovery were slower. Conversely, in the optimistic specification, the parameters were selected so that impacts were smaller and the rates of recovery faster. However, the parameter selection was constrained such that the resulting habitat cover predictions were plausible given the available data sets and expert opinions on historical habitat cover. Where statistical methods could be applied, the 80% confidence interval was used to identify the optimistic and pessimistic bounds. The optimistic and pessimistic bounds were much wider for the seagrass, macroaglae and mangrove habitats than for the continental shelf habitats, because of the different quantity and quality of the information available.

The model of the continental shelf habitats provides a relatively good description of the available observations for both small reef habitat (figure 2.3.2) and large reef habitat (figure 2.3.3). The temporally-pooled residuals between prediction and observation are generally low, although there are some exceptions in the case of small reef habitat (figure 2.3.3). There is also a suggestion of a decreasing trend in residuals for small benthos through time, but no such trend is apparent for large benthos.

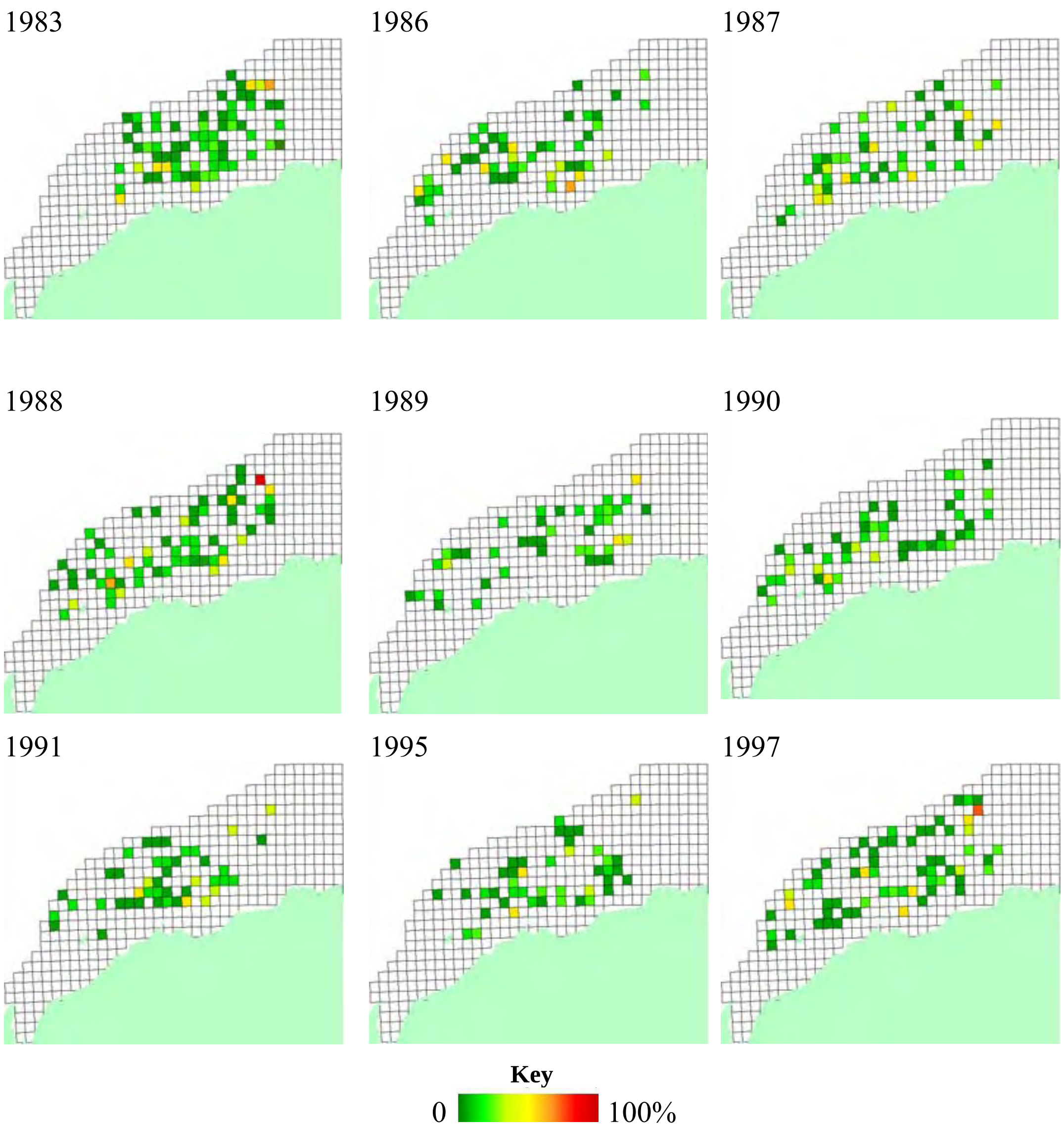

Figure 2.3.1: Relative fit of model to observations through time for small benthos (< 25cm in height). Colours indicate the absolute difference between the percent cover observed and that predicted by the model. For example, if the model predicted 60% coverage but only 10% was observed, then the map would show 50% in that cell.

When considering the percentage cover per grid cell predicted by the model, 84% of the predictions for large reef habitat and 70% for small reef habitat fall within the credibility bands of observed values. While the tails of these distributions fall away quickly (figure 2.3.4) there was at least one prediction that differed from the observation by as much as 90%. There is a tendency for the model to underestimate the cover of large reef habitat (i.e. the curve in figure 2.3.4 is shifted to the left) which is not evident for small habitat. These mismatches are mostly due to sub-grid scale patches of reef habitat that are not well resolved by the model. Nevertheless the model generally provides a good representation of overall distributions and general levels of cover.

There were insufficient data to repeat the quantitative fitting process and model testing for the seagrasses, macroalgae and mangroves. In the MSE context this necessitated large differences in the optimistic and pessimistic specifications so as to encompass the underlying uncertainties. While a small amount of data was available on the species present and their overall geographic range (Walker & Prince, 1987; Semeniuk, 1994; Semeniuk & Semeniuk, 1995; Carr & Livesey, 1996; Semeniuk & Semeniuk, 1997; Bridgewater & Cresswell, 1999; Australian State of the Environment Committee 2001; Prince, 2001), the required fine-scale information on the spatial distributions, presence-absence and depletion-recovery rates was mainly obtained through expert information (McCook et al. 1995; Paling, 1996; McGuinness, 1997; Moran & Stephenson, 2000; Kathiresan & Bingham, 2001; Lyne et al. 2006). As a result the parameters for these habitat forming groups were calibrated via a sensitivity analysis to give the best match to available data.

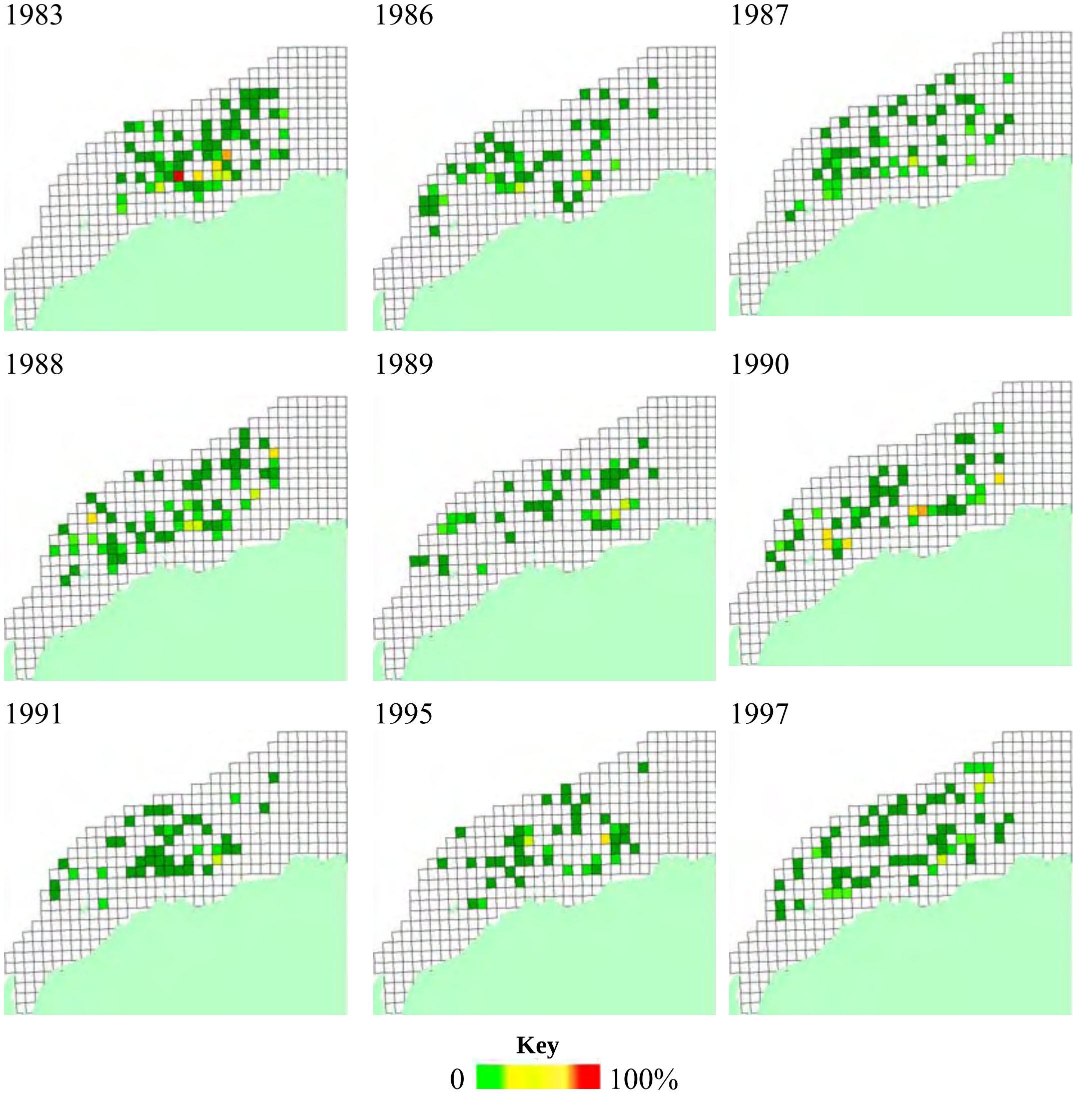

Figure 2.3.2: Relative fit of model to observations through time for large benthos (> 25cm in height). Colours indicate the absolute difference between the percent cover observed and that predicted by the model.

The model fitting and sensitivity analyses indicate that the model is most sensitive to the mortality rate and vulnerability parameters. The values of these parameters are often quite small so minor differences in value represent substantial changes in relative rates. These small variations in mortality rates and vulnerability were used to discriminate between the optimistic, base, and pessimistic model specifications. In particular, the growth rate and trawl damage rate of reef habitat were varied between model specifications. The exact values used were selected on the basis of the net effect on model output, but all were drawn from the range of credible values given by the parameter fitting and all were well within the range found in the scientific literature.

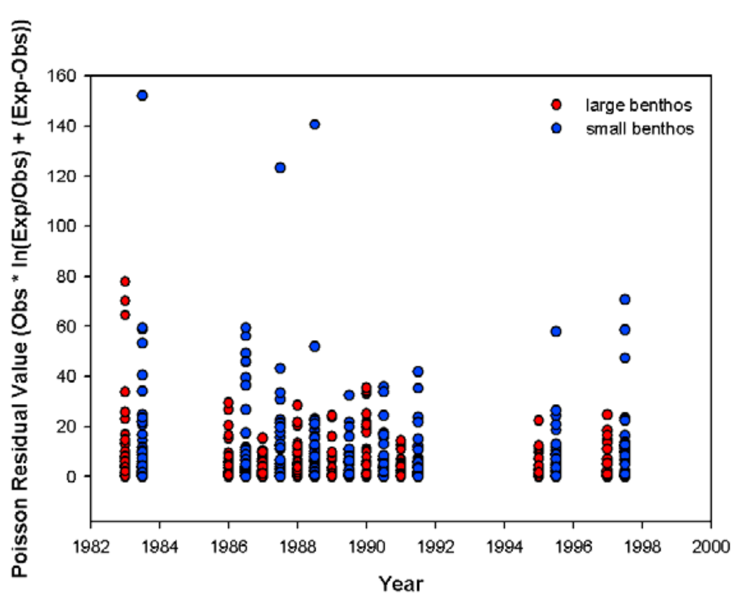

Figure 2.3.3: The Poisson residual plot (from the least squares optimisation fitting the benthic habitat dynamics model to the observed coverage of benthos).

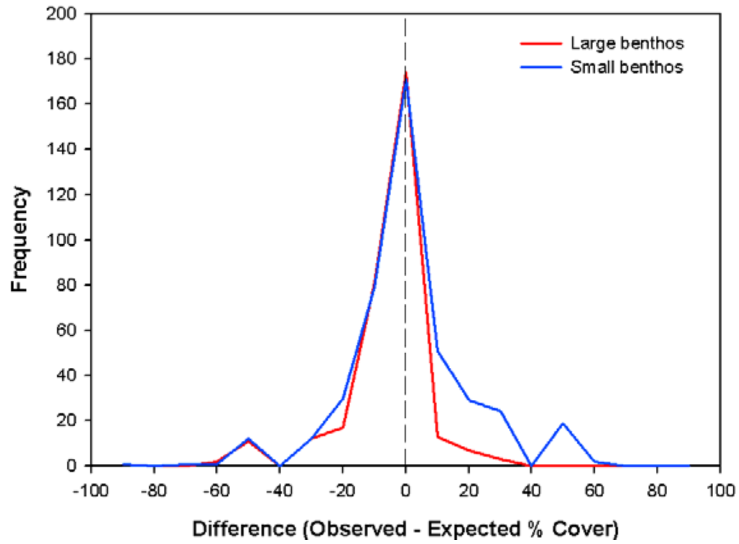

Figure 2.3.4: The distribution of the differences between observed reef habitat cover and the percentage cover predicted by the benthic dynamics model.

2.4 Iconic species

The iconic species examined in the MSE are turtles and sharks. For both groups the populations were represented by the ‘animal agent’ model for post-larval stages and the ‘blastula agent’ for reproduction and spatial dynamics of very early life history stages (Gray et al. 2006). This representation supported density-dependent processes that can apply to natural mortality at egg, larval and post-larval stages. It also allowed for spatially explicit treatment of all pre-adult stages, which were confined to suitable habitats. Model sensitivity to this representation was evaluated by also implementing a more classical population model representation. Biological parameters for these species were taken from the literature (Limpus et al. 1984; Limpus & Reed, 1985; Kailola et al. 1993; Limpus et al. 1994; Last & Stevens, 1994; Chaloupka & Musick, 1997; Environment Australia 2000; Chaloupka, 2002; Chaloupka, 2003; Stephenson & Chidlow, 2003; Fishbase 2005) and modified slightly during model calibration to give plausible biomass levels under observed levels of fishing pressure and catch.

There was a domestic fishery directed at turtles on the North West Shelf from around 1958 to 1973, in which about 60 000 turtles were taken including 5 000 to 6 000 per annum in the later years of the fishery (pers. comm. 2005 from Bob Prince, CALM, and Kellie Pendoley and Liz McLellan, Asia Pacific Marine Turtle Programme WWF International). More recent fishery catches of turtles have been as incidental bycatch. Between 1999 and 2002 a reporting program involving five of the 45 prawn fishing vessels in Onslow and Nickol Bay recorded a total of 22 turtles (all adults) implying an annual bycatch of approximately 66 adult turtles. Bycatch exclusion devices began being used in the fishery in 2003, and there have been no reported turtle captures since.

As for the other ecological model components, parameterisation for the pessimistic and optimistic model specifications were selected by considering the extremes of the literature values and by exploring the dynamics of the model system in the parameter space around the base case. Parameter sets were then chosen to give relatively low vulnerability and/or fast recovery for the optimistic case and vice versa for the pessimistic case, while still giving plausible historical trajectories of total biomass and catch. This process was particularly problematic for turtles, which suffer from undocumented mortality such as catch beyond the Australian jurisdiction, injuries as they pass through nets (Limpus et al. 1984), vessel strikes, egg collecting and other disruptions to nests or nesting. While inclusion of three models helps to span such contingencies, the recovery dynamics are sensitive to the model structure even after tuning to the same data and literature parameters (Little et al. 2006) and there remains a significant risk that turtle recovery rates were overestimated even in the pessimistic model.

Initial biomasses

The initial turtle biomass estimates where primarily based on information relating to *Chelonia mydas* (Green), but also included available data on *Lepidochelys olivacea* (Olive Ridley), *Caretta caretta* (Loggerhead), *Eretmochelys imbricata* (Hawskbill), *Natator depressus* (Flatback) and *Dermochelys coriacea* (Leatherback). The primary data sources were:

- Australia-wide stock estimates given in the 1995 Status of the Marine Environment Report (Zann 1995) and the Australian State of the Environment Report 2001 (Australian State of the Environment Committee, 2001);
- values estimated from the 1997 survey of the Gulf of Carpentaria (Marsh et al. 2004);
- the 1985 survey of the northern Great Barrier Reef Marine Park (Marsh & Saalfield 1989);
- values given for other northern Australian sites (Limpus et al. 1984; Limpus & Reed 1985; Limpus et al. 1994; Chaloupka 2002; Chaloupka 2003); and
- expert information (pers. comm. Bob Prince, Leader of the Western Australian Marine Turtle Project CALM; Kellie Pendoley, Western Australian turtle researcher; and Liz McLellan, Asia Pacific Marine Turtle Programme, WWF International).

The expert information provided important information on a poorly documented commercial turtle fishery that was active in the Pilbara area in the early 1970s and likely to have had substantial impacts on populations. Together these data sources lead to a final estimate for the turtle abundance of between 18000 and 45000 individuals (assuming an average adult weight of 50 kg).

The initial biomass of sharks on the North West Shelf was calculated using the value given for coastal sharks in the Ecopath model developed for the North West Shelf (Bulman 2006). Using the Ecopath model value of 0.03 tonnes per km^2, a total abundance of between 10000 and 28000 individuals was derived. This equates to an average total biomass of roughly 1260 t (assuming an average adult shark is between 45 and 125 kg in weight).

2.5 Fish species and impacts of fishing

Fish population dynamics are represented by age-structured models that account for reproduction, natural mortality and fishing mortality. These models are calibrated for the major species groups as detailed in the companion model specification report (Gray et al. 2006). The initial conditions in the first year of the model are controlled by the parameters α and β of the Beverton-Holt function, which specify the initial number of larvae and hence the remaining age structure of each fish population:

$$B_{larva,t} = N_{i,0,t} = \frac{S_{i,t} \cdot \alpha}{\beta + S_{i,t}}$$

$$N_{i,a,0} = N_{i,a-1,0} \exp(-M)$$

Where $N_{i,0,t}$ is the number of age a (years) in agent i at time t, $S_{i,t}$ is the female spawning biomass (equivalent to 0.5 of the total adult biomass) for species i at time t and M is annual mortality rate. Selection of these parameters for each species was done by running the historical period of the model over a range of values and comparing the initial biomass of the simulation to the range of species biomasses thought to occur in nature. Parameters were selected at three levels within this range of biomass to give the optimistic, base-case and pessimistic specifications (figure 2.5.1).

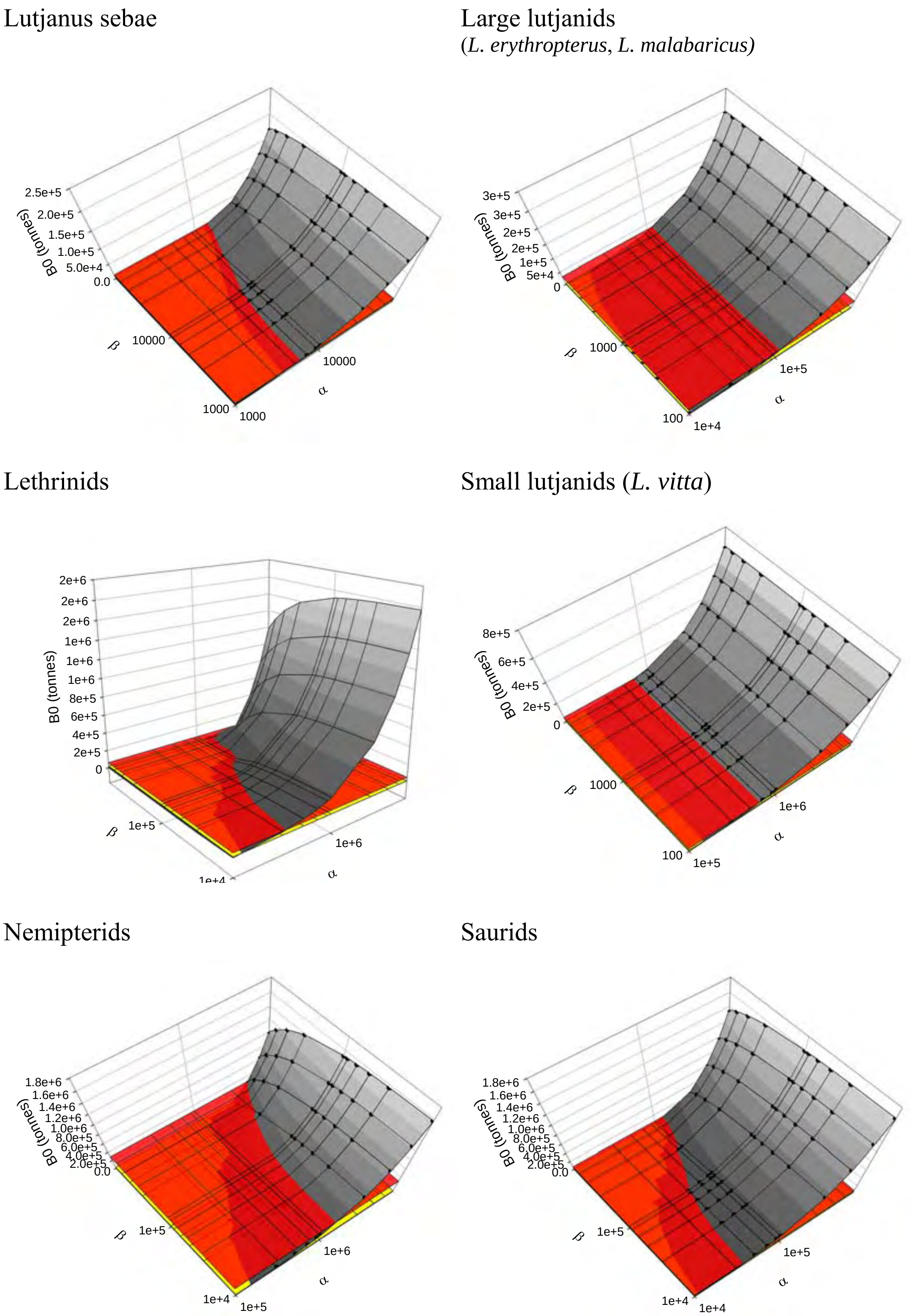

Figure 2.5.1: Initial available species or group biomasses for different values of α and β (grey), and the maximum (orange) and minimum (yellow) biomass estimated to be in the system based on Bulman (2006). The intersection (red) represents parameter combinations that fall within the range.

Prawn biomass estimates

The initial conditions and carrying capacity estimates for the prawn stocks were calculated using catch data and biological information taken from the WA Department of Fisheries (2002) submission to Environment Australia regarding the Exmouth Gulf Prawn Fishery. This information was converted to total stock sizes using the assessment rule-of-thumb that catch at Maximum Sustainable Yield equals 12% of virgin biomass and cross checked using the methods outlined in Taylor and Dichmont (2001). This resulted in an upper bound on the estimate of maximum total biomass of 15 000 tonnes for western king prawns, with a lower bound of 8 000 tonnes and a median of 12 000 tonnes. For banana prawns the upper bound on biomass was again 15 000 tonnes, while the lower bound was 4 000 tonnes and the median was 8 000 tonnes. All other prawn biological parameters were based on Kailola et al. (1993) and Taylor and Dichmont (2001).

2.6 Contaminants

The MSE models included interactions of industrial contaminant plumes with local fauna. The specific sub-models used in simulating these interactions are described in Gray et al. (2006) along with strategies for developing more sophisticated models incorporating sublethal effects.

There are two fundamental aspects to modelling the interaction of contaminants with marine organisms, namely the way they come into contact with each other and what happens to them when they do. Direct contact with a contaminant occurs when the contaminant is suspended or dissolved in the water column, while indirect contact may occur through consuming organisms which have already come into contact. The MSE focused on simulating mortality due to direct contact, where the contaminant is ingested or taken in through the animal’s respiratory system. Allowance was also made for exposure to multiple contaminants.

Plumes were represented as relative concentration fields, decaying from unit value at the source to a low threshold (0.0001 units) at the furthest contour. These fields were then converted to a set of concentrate ions for each of the the contaminants associated with the source by multiplying by the reputed source concentration and a factor that can account for uncertainty or misreporting of concentrations. This approach allows contours calculated for a unit source to be used for all contaminant types and concentrations from that source. It also provides a convenient framework in which to model management strategies that adaptively adjust contaminant inputs in response to monitoring of the system.

Data on the effects of particular contaminants on particular organisms are very limited, particularly with regard to sublethal effects on behaviour or reproductive capacity. The modelling was therefore focused on lethal impacts through either acute exposure or chronic exposure leading to more gradual accumulation in the tissue until a lethal level was reached. Uptake rates were specified for each impacted species by using the model to replicate outcomes of a study by Hashmi et al. (2002), in which heavy metal concentrations in tiger prawn tissue samples and their water environment were taken from two prawn farms subject to different contaminant loads. The optimistic, base-case and pessimistic interpretations were defined in terms of the exposure levels as determined by the the contaminant plume dynamics and the distribution of impacted organisms.

Plume dynamics

The MSE modelling included three scenarios for currents patterns and contaminant dispersion, each spanning four decades. These scenarios were loosely defined as:

- "high winds" simulating the potential effect of stronger than normal winds;
- "normal" simulating similar wind patterns to those currently experienced; and
- "low winds" simulating the potential effect of weaker than normal winds.

The contaminant plumes were generated for each of these scenarios using a contour advection and diffusion algorithm that incorporated a contour surgery approach (Dritschel 1989). The currents used to advect contours were estimated by a statistical model that was calibrated against outputs from a regional circulation model developed as part of NWSJEMS (Condie et al. 2006). It was not practical to use the circulation model outputs directly due to the limited time period modelled (six years at the regional scale and less than two years at finer coastal scales) and the high computational costs associated with searching large data files.

Development of the statistical model for the currents was based on the recognition that on inner-shelf, where contaminant plumes are of most concern, currents are primarily driven by tides and winds (Condie et al. 2006). Calibration of the statistical model was therefore based on the tide and wind datasets (table 2.6.1, figure 2.6.1) which all covered the period August 1996 to May 1998.

Table 2.6.1: Time-series data used in developing the statistical model for currents. While the NCEP wind fields were only available at 12 hourly intervals, they were interpolated to one hourly for the analysis. The currents were available on a regional grid (10 km resolution) and a coastal grid around the Dampier Archipelago (1 km resolution) as shown in figure 2.6.1 and described by Condie et al. (2006).

Description	Start Date/Time	End Date/Time	Resolution
Tidal height	3/8/96 18:00	31/5/98 18:00	1 hour
NCEP wind data @10 m	1/1/82 06:00	31/12/01 06:00	12 hours
Surface currents	3/8/96 18:00	31/5/98 18:00	1 hour
Depth-averaged currents	3/8/96 18:00	31/5/98 18:00	1 hour

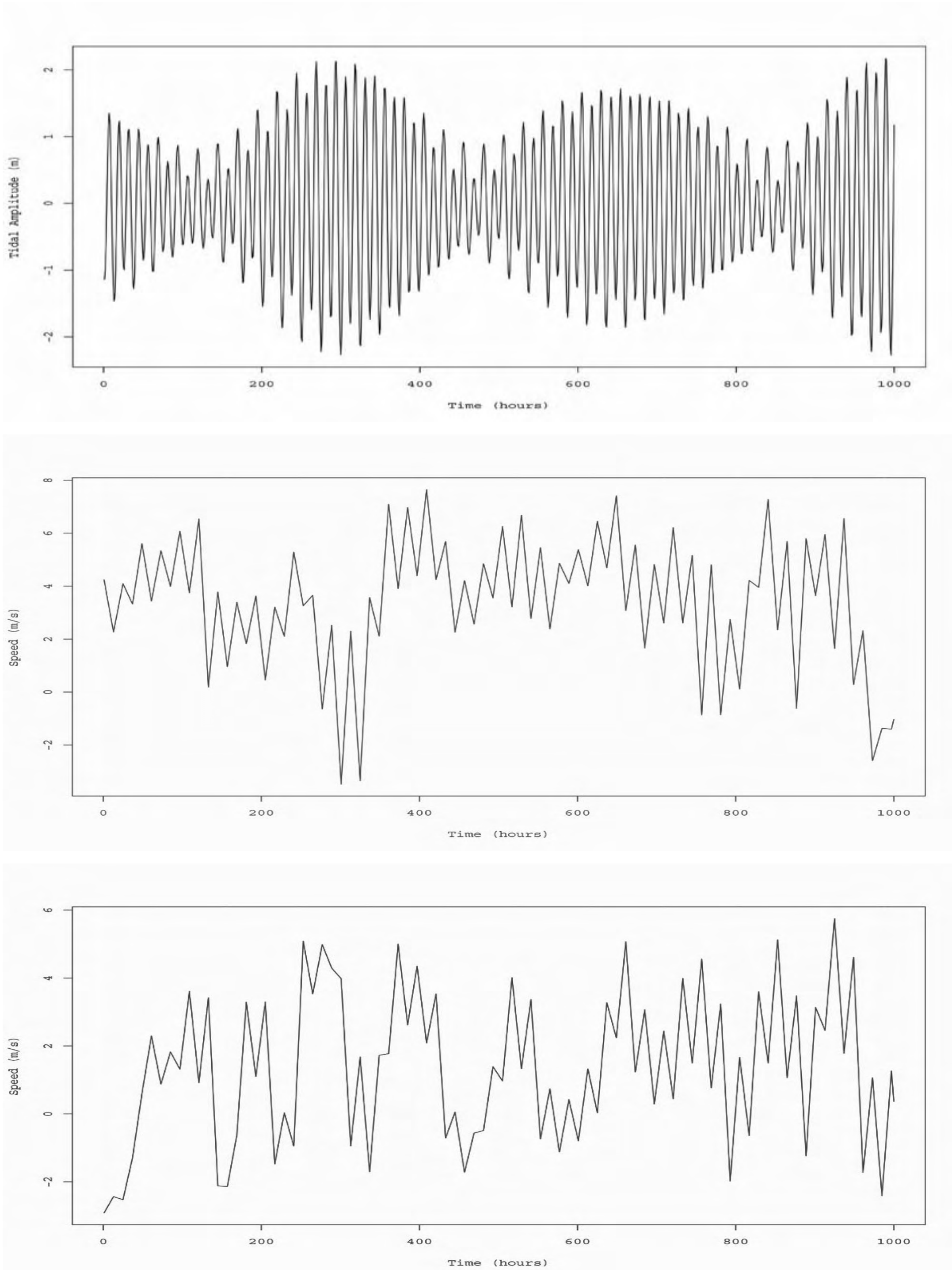

Figure 2.6.1: Example time-series of data used to calibrate the statistical model: tidal height (top), eastward wind component (centre) and northward wind component (bottom). Time is in hours since 18:00 on 3 August 1996.

A number of alternate statistical models were considered including linked spatio-temporal models. The over-riding requirements for speed, efficiency and accuracy were satisfied by fitting low-order polynomial models for the currents at each station. While this approach required all currents to be calculated during run-time from stored polynomial coefficients, the storage and computation costs were very small compared to alternative approaches.

The statistical model used was a generalised linear model of third-order polynomials in tide, lagged-tide and NCEP winds. This was calibrated against the eastward and northward components of both the surface and depth-averaged currents derived from the circulation models (using the higher resolution Dampier Archipelago model when inside that domain – figure 2.6.2). The influence of spring-neap cycles and seasonal factors affecting wind and current regimes were considered, but preliminary analyses (e.g. additive and multiplicative models in spring-neap amplitude and phase) did not provide improved predictions. Inclusion of the lagged tide time-series (lagged by one time step) provided an indication of the phase of the tide (rising or falling) and substantially improved the predictions of the model.

Examples of the statistical fits are provided in table 2.6.2 and figure 2.6.3. These results indicate that the fit deteriorates offshore as the influence of regional currents (not accounted for in the model) increases. Nonetheless, 60 to 80% of the variance is explained near the coast for the example stations used. Example of the statistical parameters for one site are listed in table 2.6.3. On completion of the statistical fits, a database of station locations and the polynomial coefficients were incorporated into the *InVitro* system. These fits allowed efficient simulations of currents over any period that tide and wind data were available.

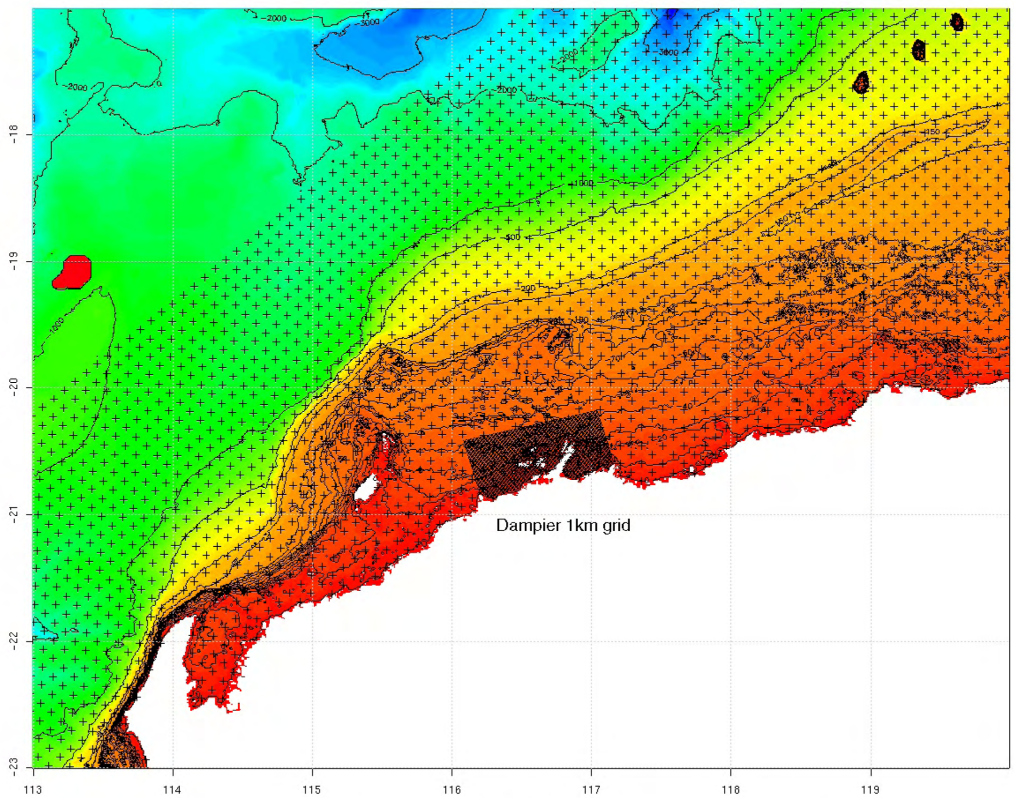

Figure 2.6.2: Map showing the location of the grid points for the 10km grid (marked with crosses) and the 1km grid (above label "Dampier 1km grid") superimposed on a contoured image of the bathymetry.

Table 2.6.2: Example listing of stations to illustrate variation of statistical model fits with depth.

Index	Longitude	Latitude	Depth (m)	Eastward current variance explained (%)	Northward current variance explained (%)
1720	116.4508	-20.8002	-5	63.2	62.4
2090	116.4476	-20.6023	-10	68.7	78.1
2206	116.4510	-20.5518	-20	72.2	80.5
2316	116.4477	-20.4781	-40	73.2	72.9
1478	116.5409	-19.6682	-58	14.5	29.2
1515	116.4691	-19.4551	-120	8.3	2.0
1587	116.4734	-19.1723	-236	10.5	28.9
1659	116.4777	-18.8895	-410	16.7	24.2
1770	116.4840	-18.4654	-1126	59.3	79.2
2006	116.4963	-17.6171	-2141	12.6	31.8

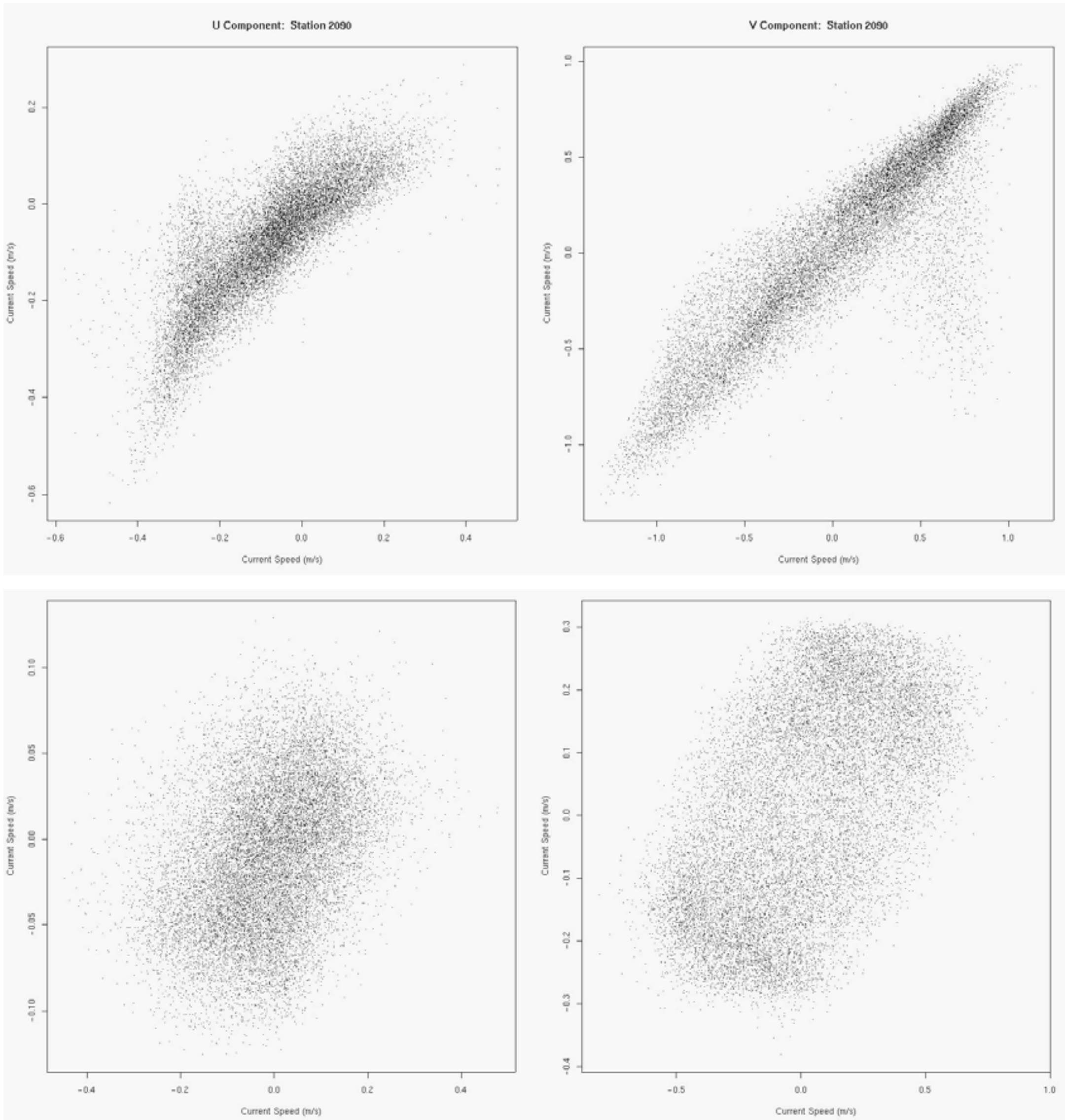

Figure 2.6.3: Example scatter plots for eastward (U) and northward (V) currents for to a shallow water station (upper, index 2090) and deep water station (lower, index 2006).

Table 2.6.3: Example statistical parameters related to the model for the two velocity components for Index 2090 (116.45°E, 20.60°S). The x1's are the tidal polynomial coefficients, x2's are the lagged tide and x3's and x4's are the NCEP wind components. The last digit in each set of polynomial coefficients denotes the polynomial power of the exponent for the independent variable. Note that in this example, the V velocities had higher variance and the statistical fits were better than the less energetic U component.

```
Eastward velocity for Station g1_2090 (1 km grid)

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -6.621e-02  1.317e-03 -50.290  < 2e-16 ***
x11          9.967e-02  1.977e-03  50.413  < 2e-16 ***
x12         -9.703e-03  8.860e-04 -10.952  < 2e-16 ***
x13         -1.653e-02  6.529e-04 -25.312  < 2e-16 ***
x21         -1.626e-01  1.977e-03 -82.252  < 2e-16 ***
x22         -4.755e-02  8.861e-04 -53.656  < 2e-16 ***
x23          1.626e-02  6.529e-04  24.909  < 2e-16 ***
x31          1.614e-02  3.056e-04  52.815  < 2e-16 ***
x32          2.316e-04  3.463e-05   6.687 2.35e-11 ***
x33          3.596e-05  5.709e-06   6.299 3.07e-10 ***
x41          9.626e-03  4.041e-04  23.820  < 2e-16 ***
x42          8.935e-04  7.614e-05  11.734  < 2e-16 ***
x43         -1.232e-04  1.455e-05  -8.471  < 2e-16 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1
(Dispersion parameter for gaussian family taken to be 0.00711901)

    Null deviance: 360.25  on 15850  degrees of freedom
Residual deviance: 112.75  on 15838  degrees of freedom
AIC: -33385
Number of Fisher Scoring iterations: 2

Northward velocity for Station g1_2090 (1 km grid)

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  6.215e-02  3.907e-03  15.908  < 2e-16 ***
x11          2.434e-01  5.866e-03  41.487  < 2e-16 ***
x12         -7.080e-03  2.629e-03  -2.693 0.007082 **
x13         -4.025e-04  1.937e-03  -0.208 0.835408
```

Table 2.6.4 continued: Example statistical parameters related to the model for the two velocity components for Index 2090 (116.45°E, 20.60°S). The x1's are the tidal polynomial coefficients, x2's are the lagged tide and x3's and x4's are the NCEP wind components. The last digit in each set of polynomial coefficients denotes the polynomial power of the exponent for the independent variable. Note that in this example, the V velocities had higher variance and the statistical fits were better than the less energetic U component.

```
x21          2.495e-01  5.866e-03  42.526  < 2e-16 ***
x22         -4.622e-02  2.629e-03 -17.581  < 2e-16 ***
x23         -6.128e-03  1.937e-03  -3.163 0.001562 **
x31          1.304e-02  9.068e-04  14.384  < 2e-16 ***
x32          4.631e-04  1.027e-04   4.507 6.62e-06 ***
x33          3.419e-05  1.694e-05   2.018 0.043599 *
x41          1.096e-02  1.199e-03   9.140  < 2e-16 ***
x42         -8.186e-04  2.259e-04  -3.623 0.000292 ***
x43          9.562e-05  4.317e-05   2.215 0.026774 *
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1
(Dispersion parameter for gaussian family taken to be 0.06267413)

    Null deviance: 4523.78  on 15850  degrees of freedom
Residual deviance:  992.63  on 15838  degrees of freedom
AIC: 1094.0
Number of Fisher Scoring iterations: 2
```

Modelling and extrapolation of contaminants

Following the method of *Contour Dynamics* developed by Dritschel (1989) and adapted for contaminant dispersal by Lyne et al. (1994), contaminants were modelled as nested sets of polygons representing plumes of differing concentrations spreading from their source. Nodes of the polygons were advected by the currents and "diffused" at each time step until the contour became so dilute that it could be neglected. Nodes of the plume were also excised if the plume became so thin that the nodes were almost touching. The main extension of the work reported here was in relation to the behaviour of the plumes as they interacted with the coast or islands.

The coastal boundary condition was difficult to specifiy as the behaviour of the plume in this situation depends critically on the nature of the contaminant. Surface slicks can be expected to partially stick to the boundary and possibly accumulate or evaporate. Likewise, particulate contaminants can be expected to accumulate in zones of low disturbance. The behaviour of dissolved contaminants would depend on the complex distortions of the currents as they interact with elements of the boundary. For example, rocky cliffs would affect the concentration fields very differently from sandy beaches. In the latter case, the large tides of the North West Shelf would carry contaminants over an extensive intertidal zone where they might be retained in sediments or surface pools and possibly returned within future tidal cycles.

Dependencies on contaminant properties and coastline structure represented significant impediments to the modelling of contaminant plumes and necessitated the adoption of two simplifying assumptions:

1. Mass was conserved as far as possible so that concentrations did not increase at the coast. The velocity field was constrained to be mass conserving at the coast by applying the mass conservation filter of Lyne et al. (1994).
2. Contour nodes advected onto the coast were returned to their previous position in the water and, where necessary, nodes were excised in order that the concentration within the contour did not increase.

While the applicability of these assumptions requires further investigation, the resulting solutions were considered adequate for the comparative analyses required for the study (but perhaps not for absolute estimates).

Each contaminant source was modelled individually using contour dynamics forced first by surface currents (appropriate for floating substances) and then by depth-averaged currents (appropriate for suspended solids or dissolved substances). Circular plumes of area approximately 1 km^2 (centred on the source) and unit concentration were added to the existing concentration field every 20 simulated minutes. For computational efficiency, the total number of nodes defining a plume contour was limited to 2000 (by merging close neighbouring nodes), while plumes of area less than 10^4 m^2 or concentration less than 10^{-4} were neglected. Results from the unit concentration sources (figure 2.6.4) were later scaled to match the required contaminant source concentrations for particular applications.

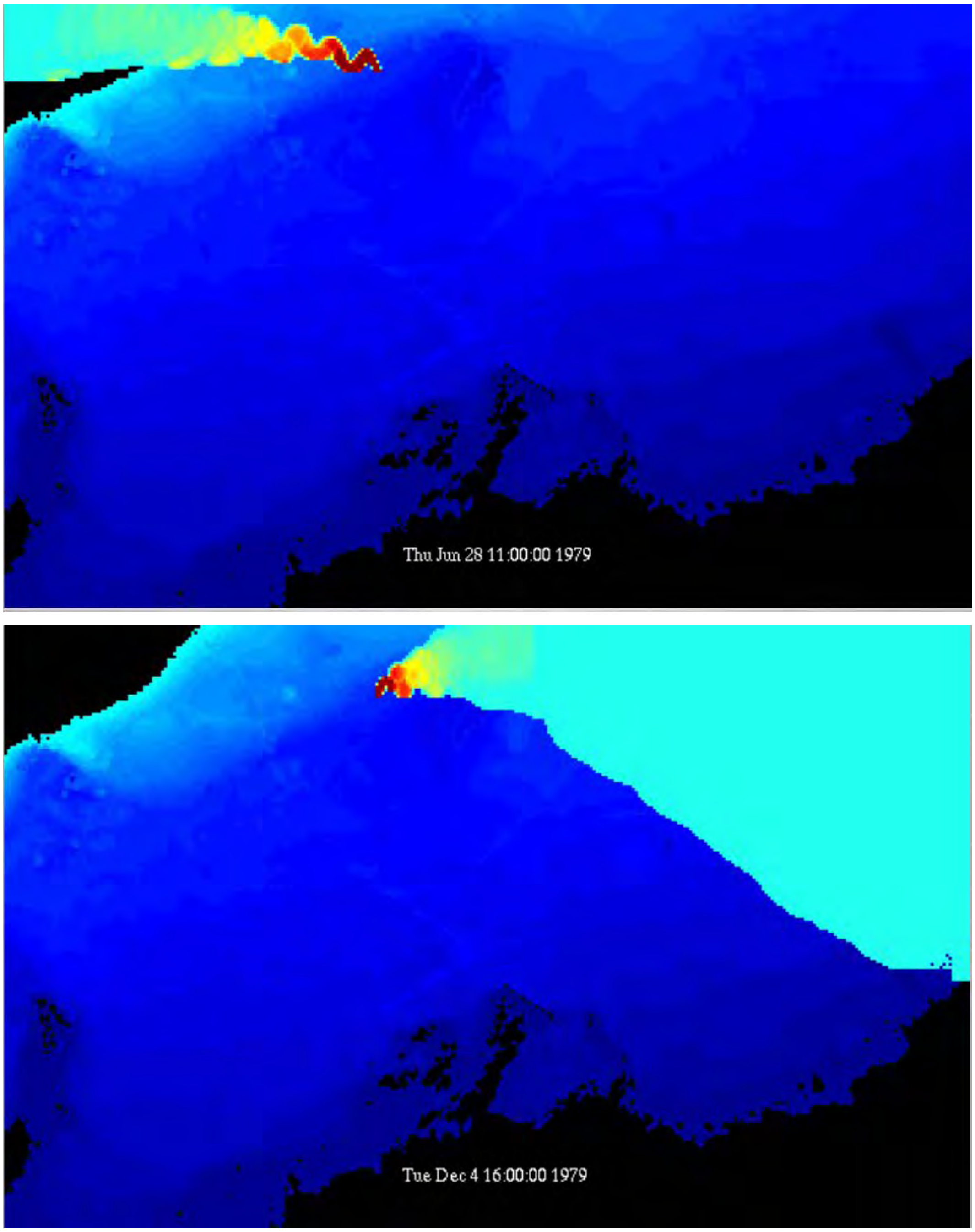

Figure 2.6.4: Example simulations of contaminant dispersal from an offshore platform. In these cases the minimum concentration was set at 10^{-6} of the source concentration in order to illustrate the far-field dispersion pattern.

The contour dynamics approach allowed unit concentration plumes from 14 of the most significant contaminant outfall sites on the North West Shelf to be modelled over a relatively wide range of conditions. However, with the available computing capacity (a cluster of 20 PCs) a few weeks of run-time still only produced a 12 month long simulation, far short of the required 40 year simulations. Hence, alternate statistical and pattern matching approaches were investigated. Away from the immediate source area, statistical approaches faired very poorly because of the sparse and sporadic nature of contaminant signal (less than 30% of the variance explained). Fortunately, pattern matching approaches proved somewhat more reliable.

Segments from the available 12 months of plume simulations were matched to other periods within the 40 year simulation by comparing the wind conditions (which largely control dispersion on the shelf over periods much longer than a tidal excursion). A simple lagged-window pattern matching was employed by taking a segment of wind from the period under consideration and matching it to a segment from the plume simulations. A bonus of this method is that all 14 sites could be modelled with one statistical matching. The method was trialled by comparing simulated plumes (from the 12 month simulation) with one generated for the same period by pattern matching (figure 2.6.5). The assessment is that these results are quite adequate for current requirements and that the technique may be useful more broadly for scenario generation where long sequences of complex contamination plumes need to be simulated.

Scenarios corresponding to high and low wind years were generated as follows:

- Monthly means of squared U and V components of the winds were computed for the 40 years sequence and these were scaled by the overall sum of squares of the winds for the entire sequence. (The squared of the winds was used to provide matches on wind energy rather than speed);
- Yearly means (of the scaled monthly means) were then used to rank the years on the overall degree of wind energy; and
- *High* wind years were defined as being the top nine years, while *low* wind years were defined as being the bottom nine years.

For the High and Low years, monthly ratios of these were computed using the overall monthly means (from the entire series) as the denominator. This provided monthly relative ratios of the high and low wind year groups for the two velocity components as shown in figure 2.6.6.

These monthly component ratios were then used to scale the 40 year wind sequence to provide the respective high and low wind scenarios.

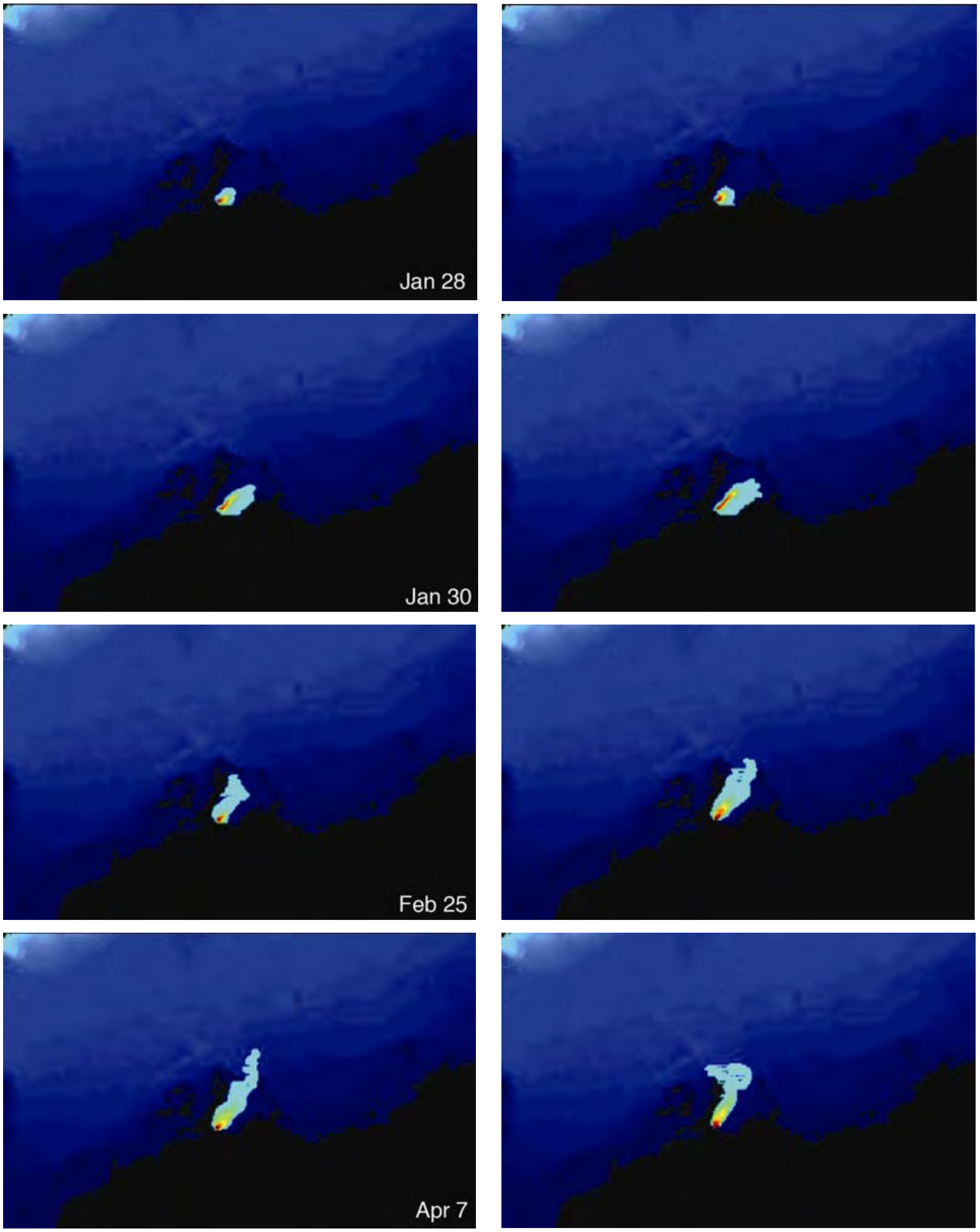

Figure 2.6.5: Snapshots of a movie sequence showing on the left a directly simulated contaminant plume in Nickol Bay and on the right the best “match” of that plume selected from an independent sequence by the statistical pattern matching algorithm.

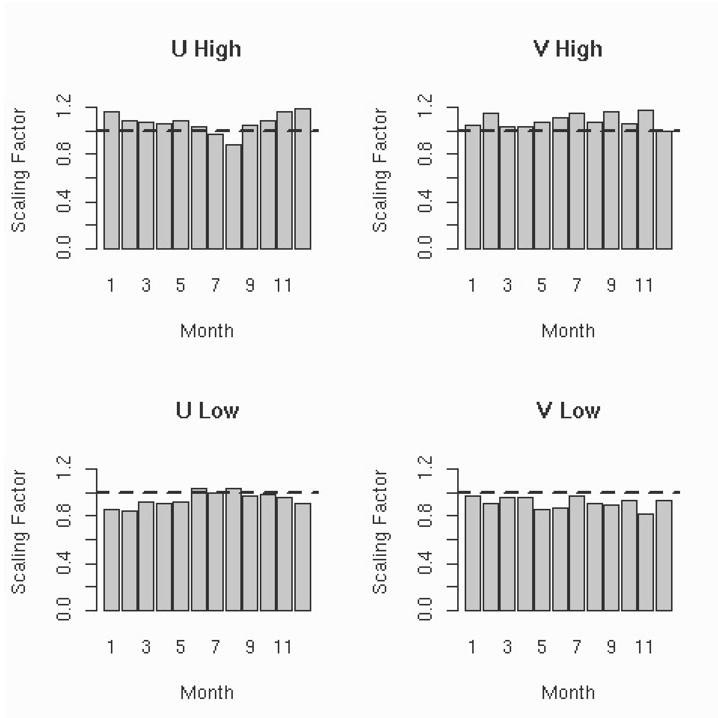

Figure 2.6.6: Normalised monthly ratios of the squared of the wind speeds for high wind years (upper plots) and low wind years (lower plots) (see text for definitions of high and low) relative to that for the entire sequence. U and V are eastward and northward components respectively.

Contaminant time series

The time series of contaminant concentrations at each location were constructed using the contaminants inventory (table 2.6.3). During the historical years of the model runs actual recorded values were used. During the projected period alternative time series reflecting potential changes due to altered production levels were constructed. These alternative time series were put together by considering the increase in release during past production shifts (a non-linear function due to increasing efficiency and the introduction of new technologies) and applying corresponding increases in step with the production scenarios. Time series of contaminants in plots are shown in section 3.2.

Table 2.6.3: Sources and quantities of contaminant outfalls represented in the model (Fandry et al. 2006). The on-shore treatment plant is at Mermaid Sound.

Location	Year	Calcium (t/yr)	Cadmium (kg/yr)	Copper (kg/yr)	Magnesium (t/yr)	Oil (kg/yr)	Sulphate (t/yr)
Dampier Salt Ponds	1997	317	0	0	136485	0	184985
Dampier Salt Ponds	1998	1463	0	0	101679	0	145155
Dampier Salt Ponds	1999	2821	0	0	84448	0	122910
Dampier Salt Ponds	2000	231	0	0	216160	0	274060
Dampier Salt Ponds	2001	231	0	0	216160	0	274060
On-shore Treatment Plant	1986	0	0.4	0	0	156	37.85
On-shore Treatment Plant	1997	0	5.5	12	0	549	57.65
On-shore Treatment Plant	1998	0	1.9	3.7	0	182	47.32
On-shore Treatment Plant	1999	0	2.1	4.1	0	150	42.69
On-shore Treatment Plant	2000	0	0.8	0.8	0	261	23.48
On-shore Treatment Plant	1992	0	6	0	0	1015	59.01
On-shore Treatment Plant	1993	0	0	0	0	394	89.02
On-shore Treatment Plant	1994	0	5	13	0	541.6	42.92
On-shore Treatment Plant	1995	0	4.9	10.7	0	772	80.89
On-shore Treatment Plant	1987	0	0.5	0	0	313	13.65
On-shore Treatment Plant	1988	0	0.6	0	0	1485	12.71
On-shore Treatment Plant	1989	0	1	0	0	1365	16.36
On-shore Treatment Plant	1990	0	3.3	0	0	565	21.99
On-shore Treatment Plant	1996	0	4.15	10.4	0	612	35.28
On-shore Treatment Plant	1985	0	0.02	0	0	101	17.66
On-shore Treatment Plant	1991	0	2.5	0	0	165	9.34
Hamersley Iron Power St	2000		252	450			

Contaminant uptake

The main example of contaminant uptake was in relation to commercial prawns in Nickol Bay, which are exposed to localised contamination from bitterns, a by-product of salt production. This contamination was modelled as a plume emanating from the point of release into the bay. Prawns were modelled as schools moving according to habitat preferences, prevailing currents and spawning requirements. The response of prawns to the bittern plumes was assumed to be neutral in the sense that they were neither repelled nor attracted to the plume.

Measurements of contaminant levels in the water and prawns from two aquaculture ponds (referred to as A and B) recorded over six years by Hashmi et al. (2002) were used to calibrate uptake by the modelled prawns. The contaminants selected were lead, cadmium and copper. Nonlinear uptake rate parameters were chosen for each metal that produced profiles comparable to those in the prawn samples over a six year simulation.

2.7 Human behaviour

Human behaviour and the effects of human activities on the marine environment were represented in the MSE using a combination of analytical decision models, response functions, specified rules, historical data and scenarios. Whether the decisions are modelled explicitly or are specified as feedback rules or scenarios, uncertainty plays an important part in determining whether human activities interact with biota and produce an environmental effect. The representation of real ecosystem behaviour and response used in the MSE (Gray et al. 2006) preserves the uncertainty that truly exists when humans attempt to achieve particular objectives (e.g. catching fish) but may fail because their observations are subject to error and because animals move or natural events (e.g. tropical cyclones) change circumstances unpredictably. Human effects are therefore represented in terms of potential interaction between humans and the environmental entities affected by, and affecting, humans.

Analytical decision models were developed for economic activities in the oil and gas industries and in the fisheries. Initially an economic model was developed for petroleum exploration and production, but could not be implemented because data needed for calibration and validation were commercially confidential. Instead, oil and gas production was introduced to the analysis by way of the development scenarios specified in section 3 below. Development scenarios were also used to specify impacts of recreational fishers, changes to port capacity, industrial production and associated contaminants, dredging, and human population dynamics.

A Bayesian decision model was used to represent finfish trawl fishing (Gray et al. 2006). This model emulated fishers' decisions on where to fish and when to return to port. These decisions utilised historical fishing data (as a proxy for fishers' knowledge) and the current catch to select target fishing locations, reference points and decision rules for changing location or returning to port. Each vessel spatially allocated their fishing effort based on their own internal representation of the spatial distribution of the state of the fish resource (modelled on a 1 degree grid). Within the grid cell that was deemed to have the highest expected catch rate, trawl shot and trap placement locations and vectors were selected randomly from a record of previous trawl shots that started in the grid cell. The state of the fish resource in each cell internal to each fishing operator was maintained and updated using a Kalman filter. Updates (using the numerical likelihood) were made on each occasion that the grid cell was fished.

Detailed decision modelling was also done for the fishery management authority (FMA) represented in the model (Gray et al. 2006). This involved formal stock assessments and specified decision rules for the FMA to adjust fishing effort quotas in the various fishing zones so as to serve the objectives of sustaining fish stocks and the commercial viability of the fishing industry. Formal models were not developed for other human decisions, although feedback rules were developed for port authorities, the EPA, conservation managers and shipping vessels (Gray et al. 2006).

As noted above, the impacts captured by the model included habitat damage and fish catch (sections 2.3 to 2.5), which were represented respectively as percentage of habitat destroyed and as catchability and fishing mortality of fish schools and iconic species that come into contact with the nets. In the case of industrial production, impact is by way of the effects of contaminants on biota (section 2.6) and the effects of shipping and port development.

2.8 Physical data inputs

This section describes a range of additional physical data that was used in the MSE modelling.

Bathymetry

The Auslig 250k series 1 topograpic data (Geoscience Australia, 2000) was used along with a North West Shelf coastline contour to generate a 0.008 degree grid using the ArcInfo *topogrid* command. This was merged with the AGSO bathymetric 30 second grid (Geoscience Australia, 1998) to form a complete bathymetric and topographic grid at 0.008 degree resolution for the complete North West Shelf study area (figure 2.8.1). Finally, this grid was projected to a Lambert Conformal Conic projection for use by the model. Conformal projections, ensuring that scale was invariant in all directions locally, although large grids tended to be distorted because of differential stretching of areas across large scales.

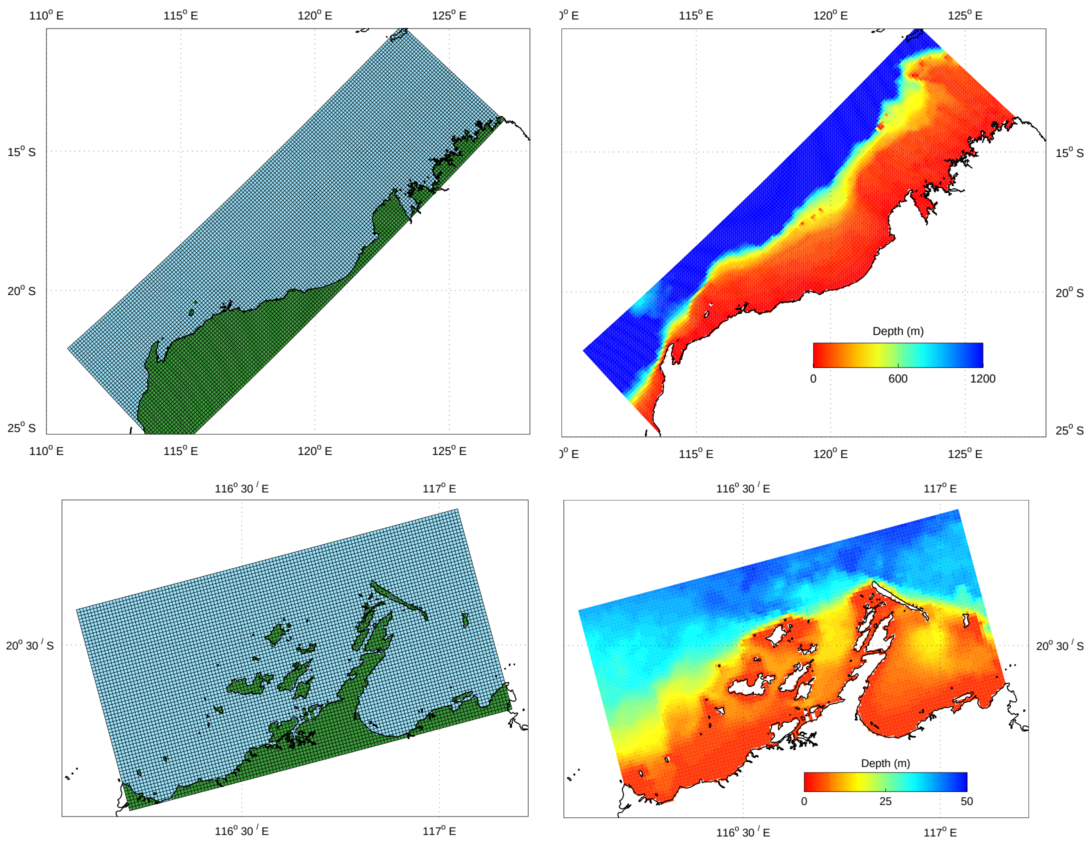

Figure 2.8.1: Model grids (left) and model bathymetry (right) for the larger Northwest region (top) and the Dampier region (bottom). In each case, the model bathymetry was derived by averaging the Geosciences Australia product within each model grid.

Winds

Wind is the predominant driver of low frequency (sub-tidal) currents on the shelf, particularly in near-surface waters. The stress τ exerted on the water surface by the wind is a quadratic function of wind speed and was estimated as:

$$\tau = \rho C_D U_{10}^2 ,$$

where ρ is the density of air (1.3 kg/m^3), U_{10} is wind speed at 10 metres above sealevel, and C_D is the drag coefficient. The wind speed data where taken from a 40-year reanalysis of global atmospheric model fields produced by NCEP and NCAR (Kalnay et al. 1996). From this zonal and meridonal wind-stress fields on the North West Shelf were calculated for the period 1965 to 1997.

Cyclones

Cyclone tracks were constructed using data supplied by the National Climate Centre in the Head Office of the Bureau of Meteorology (http://www.bom.gov.au/). These records contained information on the timing, route and intensity of cyclones, with high quality data available subsequent to the advent of GPS and automated monitoring. The final footprint of the cyclone used by the *catastrophe agents* in *InVitro* was constructed by mapping a polygon over each leg of a cyclone's route, with the track as the centreline and a width of 30 km on either side of that central track. These footprints and an intensity index (from the original record) were stored and accessed as needed.

Rainfall

The daily rainfall time series were constructed from records at Karratha and Port Hedland airports supplied by the National Climate Centre in the Bureau of Meteorology (P. Reid pers. comm.). These data sets ran from 14/12/1971 for Karratha and from 17/7/1942 for Port Hedland. These data sets were merged using:

- an average where a valid entry existed for both time series;
- the data as supplied if only one valid entry was present;
- the long term average for that day of the year if no valid entry was present in either time series.

The resulting combined rainfall time-series was then converted into 90-day running sums. Sums rather than averages were used as overall input to the system. These data were of particular significance to recruitment in the prawn fisheries of the region.

Light

Light time series were not used within this implementation of *NWS-InVitro*. In its place a simple equation was used to give average light levels derived from the output of the biogeochemical model of Herzfeld et al. (2006). The formulation used for photosynthetically active radiation (PAR) at the depth of the primary producers was:

$$I_{bot} = I_{top} \cdot \exp(-\gamma \cdot m) \;;$$

where m is depth in metres, the PAR at the seas surface (I_{top}) is set to 170 Wm^{-2} (the long-term average taken from representative runs of the Herzfeld et al. (2006) model) and the extinction coefficient is given by

$$\gamma = \phi_{w,m} + 0.0038 * \phi_{m,d} + 0.0035 * \phi_{m,p} \;;$$

with $\phi_{w,m}$ the coefficient of background light absorption due to water, dissolved organic nutrients and inorganic suspended sediment combined (set to 0.055 for offshore waters and 0.1 for turbid inshore waters (Frost 1987; Murray & Parslow 1997)); 0.0038 is the coefficient of light absorption due to labile detritus (highly turbid values from Murray & Parslow 1997); 0.0035 is the coefficient of light absorption due to particulate matter (Tett 1990); $\phi_{m,p}$ is the average concentration of particulate matter (plankton) in the water column at depth m (mg N m^{-3}); and $\phi_{m,d}$ is the average concentration of labile detritus in the water column at depth at depth m (mg N m^{-3}). These average concentrations were estimated from the model of Herzfeld et al. (2002):

$$\phi_{m,d} = \begin{cases} 7 & \text{depth} > 50\text{m} \\ 6.5 & \text{otherwise} \end{cases}$$

$$\phi_{m,p} = \begin{cases} 1.1 & \text{depth} > 50\text{m} \\ 6.8 & \text{otherwise} \end{cases}$$

3. DEVELOPMENT SCENARIOS

Three industrial development scenarios were specified to account for uncertainty in the future level of industrial activity in the North West Shelf region:

1. The first scenario assumed that infrastructure, residential and industrial development and environmental protection are fixed at 2002 levels. This is unrealistic, but provides a reference point corresponding to our current understanding of the state of the ecosystem. It is referred to as the *zero pulse* scenario.
2. The second scenario included the large developments under construction or envisaged for 2002 to 2007, with no additional development after 2007. This is referred to as the *single pulse* scenario.
3. The third scenario included the 2002 to 2007 developments, followed a second five year cycle of development similar in magnitude to the first. This is referred to as the *double pulse* scenario.

Each development scenario consists of a component for each of the four industry sectors *oil and gas, coastal development, fishing* and *conservation*. The following sections address each sector and outline the basis for each of the development scenarios. A list of the data files cited is provided in Appendix A.

3.1 Oil and gas

Increases in production are expected on the North West Shelf due to Woodside's planned expansions of condensate and LPG for export and domestic use. There are currently three production trains on the North West Shelf with a fourth announced in April 2001 which is expected to process 4.2 million tonnes of LNG. Woodside has predicted that production will continue to increase with six trains operating by 2012 (Woodside April 2001).

As a baseline, scenario (i) ignored these developments with increased production relying on 2002 infrastucture such as platforms, pipelines and shipping traffic (figure 3.1.1). The single pulse development scenario (ii) assumed that expansion ceased after commissioning of the fourth production train in 2005. The two pulse development scenario (iii) had a repeat of this fourth train expansion after a further five years.

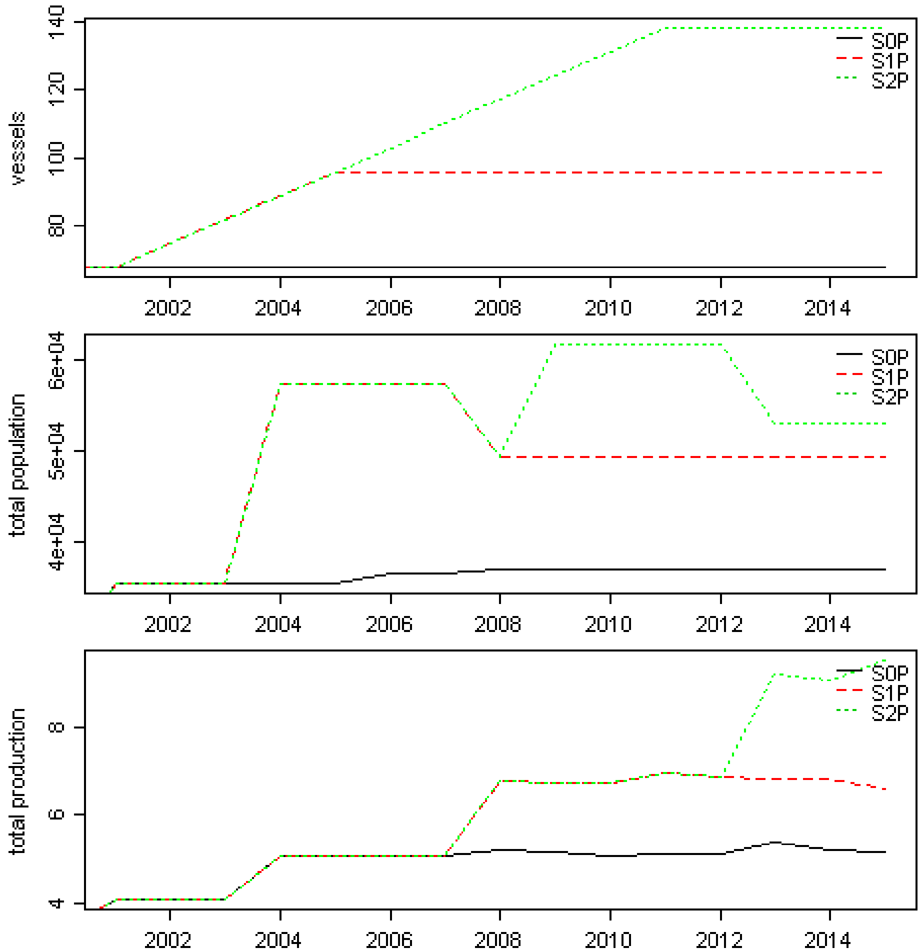

Figure 3.1.1: Oil and gas production time series corresponding to the three development scenarios (S0P = zero pulse scenario, S1P = single pulse scenario, and S2P = double pulse scenario). The top panel is the total number of vessels (related to the oil and gas sector); the middle panel is the total human population; and the bottom panel is the total production multiplier used to estimate oil and gas production.

3.2 Coastal development

For the purposes of this project coastal development includes, port facilities and shipping traffic, iron ore, salt and gas freight, on-shore gas processing plants, population, salt production, residential development, public and private infrastructure and electricity generation.

Port facilities and shipping traffic capacity

Vessel traffic at the ports was based on the Dampier Port Authority cargo statistics and number of vessels. It was assumed that both Port Hedland and Dampier had the same vessel traffic at the start of the projection period. For the zero pulse scenario, vessel traffic using the port remained stable at the 2000 levels. Under the single pulse scenario traffic increased 50% by 2005, and under the double pulse scenario it increased 200% by 2012 (figure 3.1.1). Shipping routes were derived from densities of ship locations for Dampier and Port Hedland (figure 3.2.1).

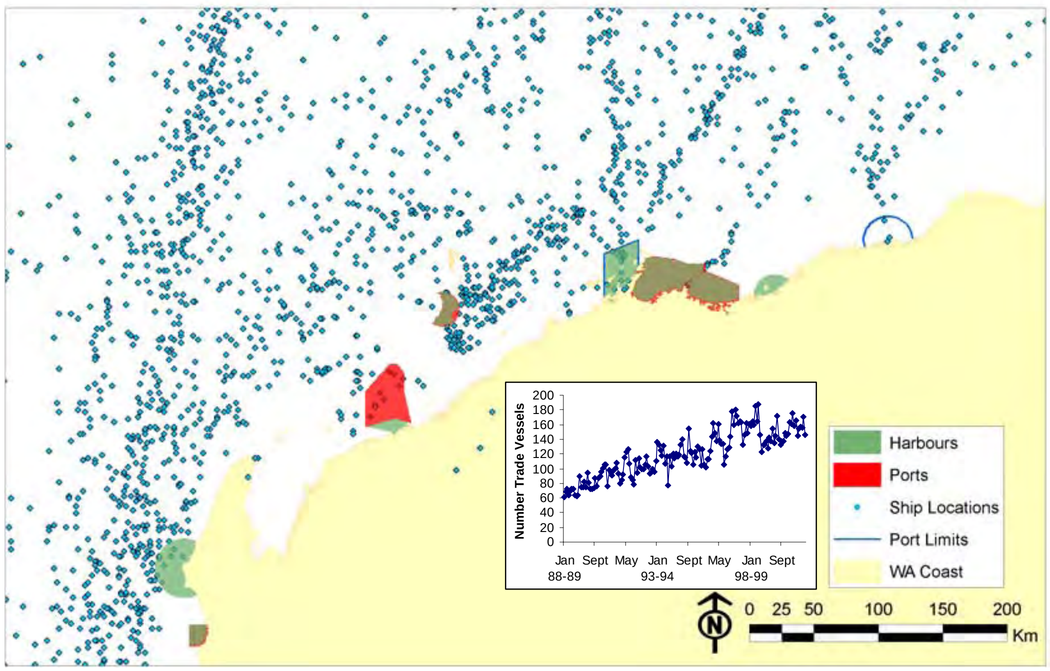

Figure 3.2.1: Ports, harbours and ship locations based on 12 hourly reports for 1999 (coutesy of the Australian Maritime Safety Authority). Inset is a time-series of the number of trade vessels using the Port of Dampier (Dampier Port Authority).

Dredge footprints were constructed in a similar way to the cyclone footprints using the vessel route defined in the port waypoint lists as the centreline of the footprint. The width of the footprint was set to 3 km for dredging so as to capture not only the channel itself but also the spread of resuspended sediments on either side of the dredge path. This was a very approximate way of representing the dredge plume, but more detailed modelling was computationally impractical and probably not warranted from a regional impacts perspective.

On-shore gas processing plant

Woodside’s on-shore gas processing plant located at Mermaid Sound near Karratha is Australia’s largest gas plant, producing natural gas, liquefied natural gas, liquid petroleum gas and condensate. The associated effluents include copper, cadmium, lead, oil, petroleum hydrocarbons, sulphate and tin. Examples for the double pulse scenario are shown in figure 3.2.2. The derivation of the contaminant time series was described previously in section 2.6.

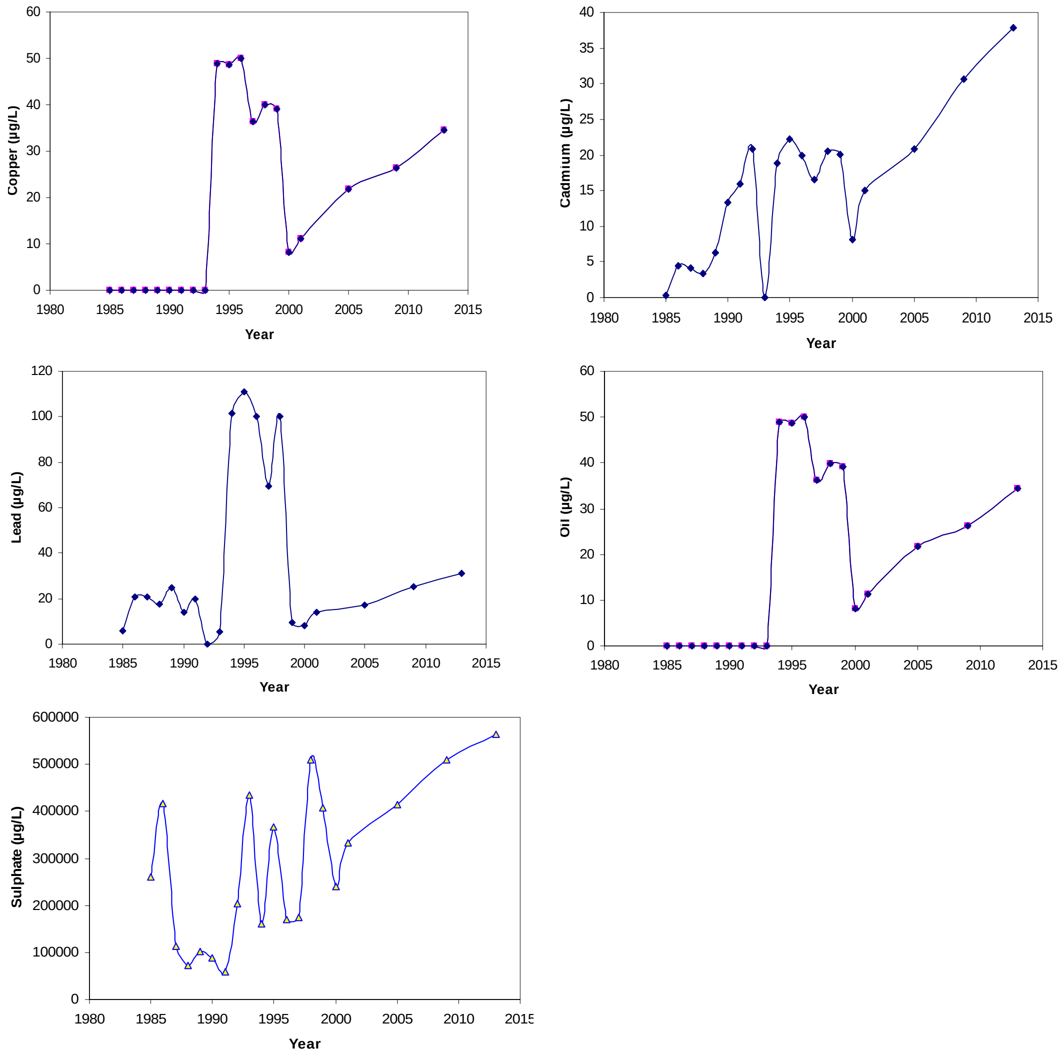

Figure 3.2.2: Time-series from Mermaid Sound of annually-averaged contaminant concentrations at source for copper, cadmium, lead, oil, and sulphate for the double pulse scenario. Levels are constant from 2002 for the zero pulse scenario and constant from 2007 for the single pulse scenario.

Salt production

The Pilbara salt ponds are a major producer of commercial sodium chloride producing seven million tonnes per year. The two producers are Dampier Salt, operating at Port Hedland and Dampier, and Onslow Salt. The residual brine is called bitterns and contains calcium, sulphate chloride of magnesium, bromine, iodine and potassium. The magnesium is used here as an indicator for bitterns.

For the single pulse scenario salt production is assumed to increase over the five year period from 2002 to 2007 then remains constant till 2012. For the double pulse scenario the projected increase is extended until 2012. The projected increases for each development scenario were derived from actual increases experienced by the industry in the period prior to 2002.

Iron ore and electricity generation

The impacts of increased electricity and iron ore production can be linked to increased effluents. The effluents from these industries include zinc, lead, copper, chromium and cadmium (Revill, 2002; Fandry et al. 2006). However, this study looked only at the copper discharged from these industries because it has the highest potential ecological impact. From 2002 copper discharges increased following the same scenario trends as described above for gas processing and salt production (figure 3.2.3).

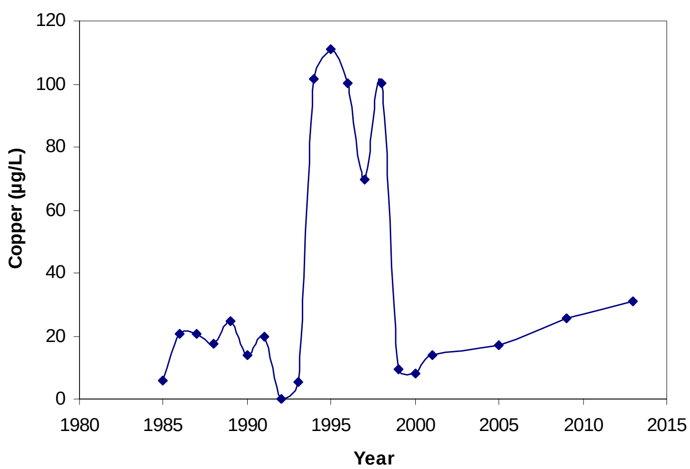

Figure 3.2.3: Copper contaminant time-series from Hammersley Iron.

Human Populations

The population distribution in the Pilbara region based on the 2001 census is shown in figures 3.2.4 and 3.2.5. Human population time series and projections for each population centre along the Pilbara coast were downloaded from the Australia Bureau of Statistics Census website (http://www.abs.gov.au). The ports included explicitly in the model were Dampier, Exmouth, Onslow, Point Samson, and Port Hedland. However, due to the potential for pressures (e.g. recreational fishing) to flow from locations further inland (e.g. Karratha), their populations were factored into the population time series of the adjacent port site. Figure 3.2.6 shows the example of Port Hedland population growth for the three development scenarios.

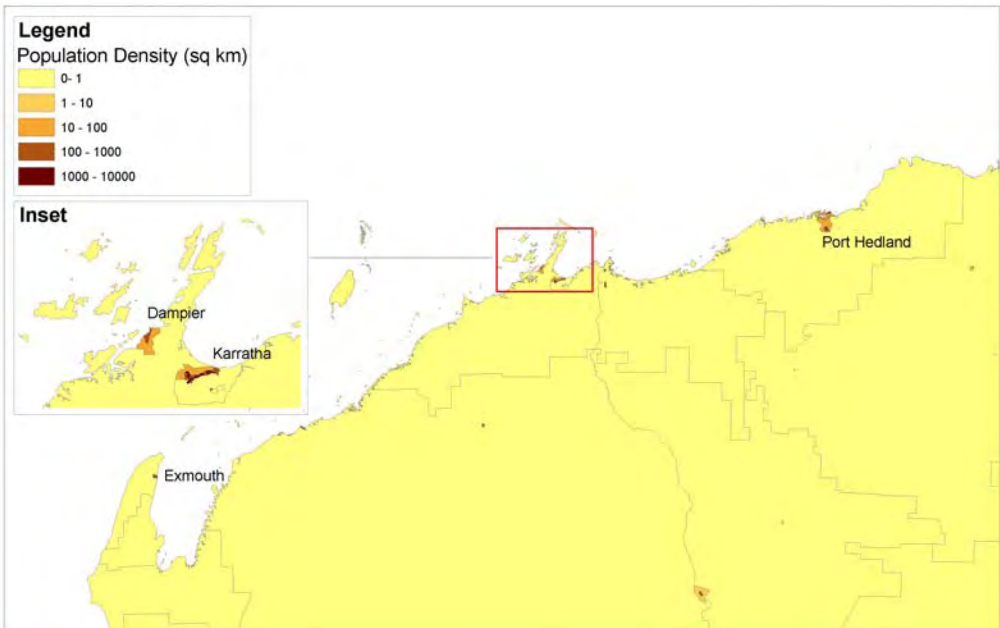

Figure 3.2.4: Population density by census collector district in persons per square km (Australian Bureau of Statistics 2001).

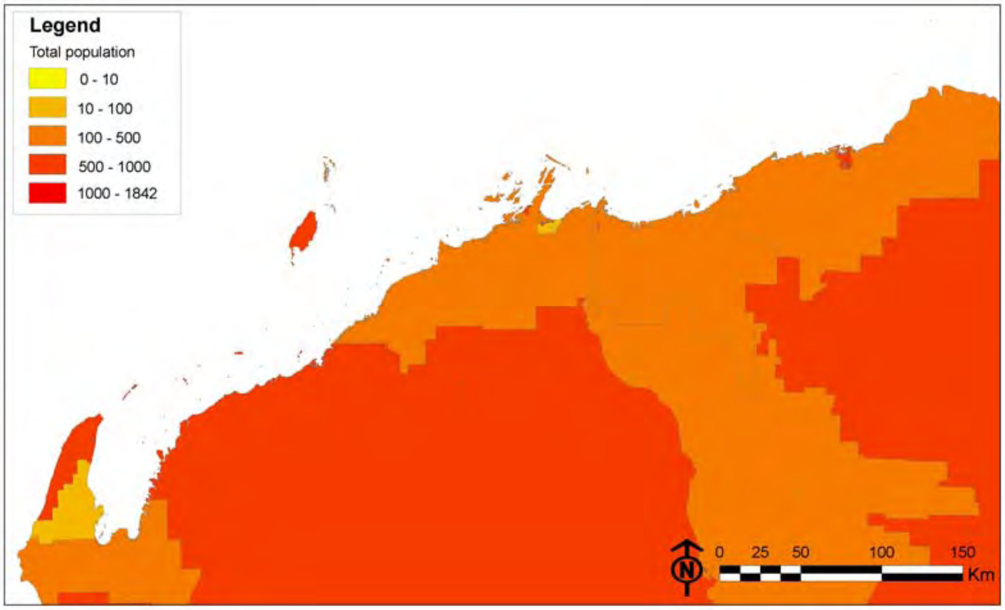

Figure 3.2.5: Total population by census collector district (Australian Bureau of Statistics 2001).

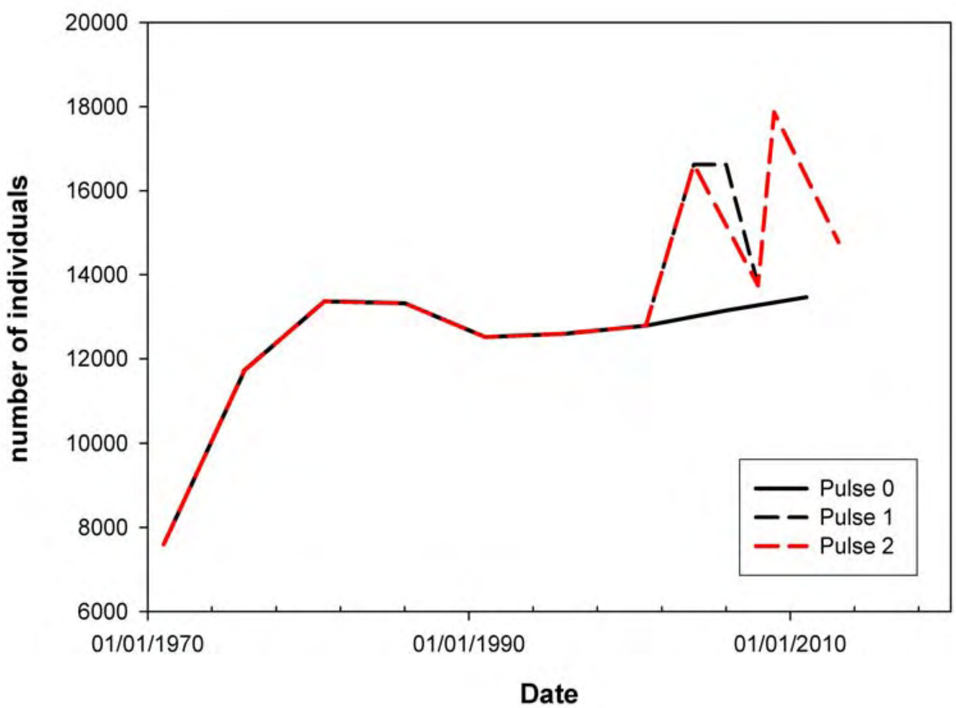

Figure 3.2.6: Time series of Port Hedland human population for the three development scenarios.

3.3 Fishing sector

The fishing sector is made up of commercial and recreational fishing. The form of management in this sector means that only relatively modest changes in pressure would be plausible. Consequently, this study considered just one development scenario for the fishing sector with the number of vessels being:

- six trawlers located at Point Sampson;
- one trap fisher located at Point Sampson;
- 28 prawn trawlers located in Exmouth;
- 16 prawn fishers located in Onslow; and
- 26 prawn fishers located in Dampier.

The fishing effectiveness of the vessels was constant throughout the study period.

Recreational fishing in the MSE was represented using a simple constant proportion agent (Gray et al. 2006). The extent of the access of this agent to fish stocks was dependent on the road network. At any known boat ramp or any point where the road network came within one kilometre the recreational fishers were assumed to have an access point. The mortality imposed on the fish groups was inversely proportional to the distance from a human settlement site (e.g. a port) to the access point and the distance from the access point out to the fish (figure 3.9). This model was then tuned to the data from the national creel survey (Henry & Lyle, 2003) so that the numbers of fish taken in the historical part of the model matched that recorded in the creel survey.

The numbers of fish taken in the creel survey were calculated by summing the effort recorded in the tropical part of Western Australia (44693 hr/yr) and determining the proportion of that effort due to fishers in the Pilbara region (0.3625). The total catch of Red emperor (*Lutjanus sebae*), Lethrininds and Lutjanids were calculated as:

pilbara_catch = total WA catch x proportionof effort in pilbara

This gave monthly catches of 544 for L. Sebae, 6024 for Lethrinids and 2079 for Lutjanids.

There was no direct modification to the recreational fishing model under any management strategy or development scenario. The only changes realised in relation to recreational fishing were as a result of:

- extra pressure that ensued from higher human population levels under the alternative development scenarios; and
- additional fisheries management actions (e.g. closed areas) under the alternative management strategies.

In the single pulse development scenario recreational fishing effectiveness (including the range of access from ports) increased by 3% per annum from 2002 to 2007. This rate of increase was maintained for a further five years for the double pulse scenario.

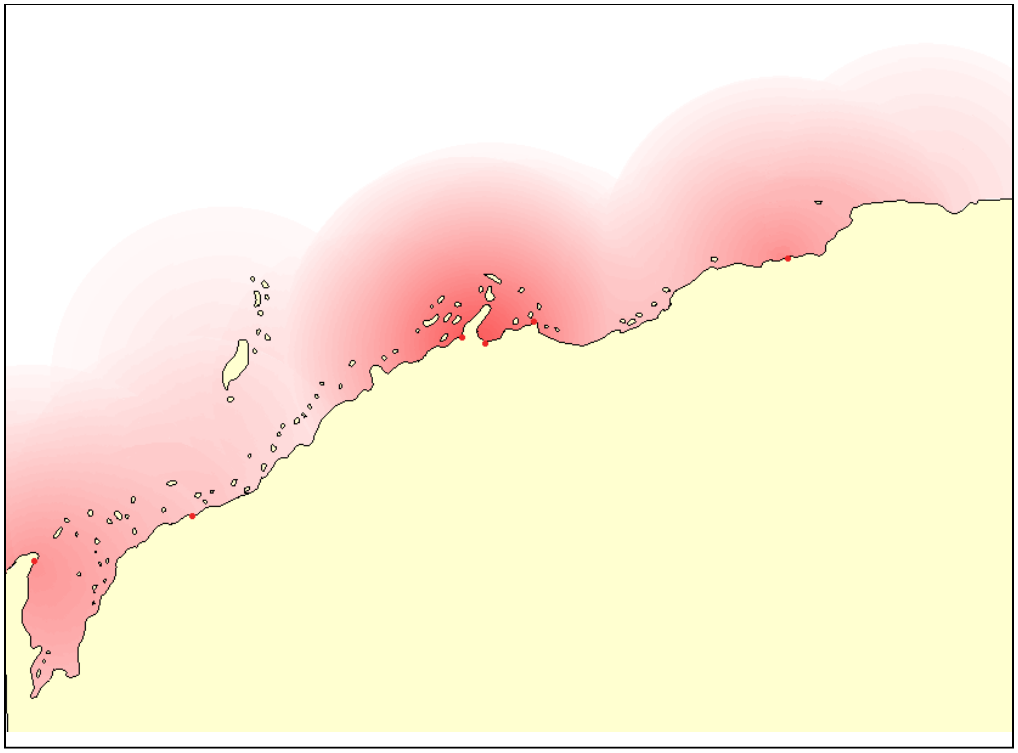

Figure 3.3.1: Distribution of recreational fishing on the North West Shelf. The dark red regions are areas of high recreational fishing density.

3.4 Conservation sector

The passage of the CALM Act (1984) provided statutory provision for the declaration of marine reserves for nature conservation and public recreation purposes. In the period 1987 through 1990 there were seven CALM Act marine reserves declared and one special legislation marine reserve. However none of these were located in the region of this study.

The development scenario considered for the period of the study was the region as it was in July 2002. There were no marine or coastal reserves. However, fishing zone three, prawn nursery grounds and exclusion zones around oil and gas facilities were closed to fishing and remained closed for the duration of the model runs. Many of these closed regions overlapped with the areas identified by the Wilson report (figure 3.4.1).

Additional closures to fishing occurred through the implementation of the enhanced and integrated management strategies (see sections 4.2 and 4.3). These management driven closures were in response to the stocks of turtles or sharks falling below 20% of initial biomass (see section 2.4).

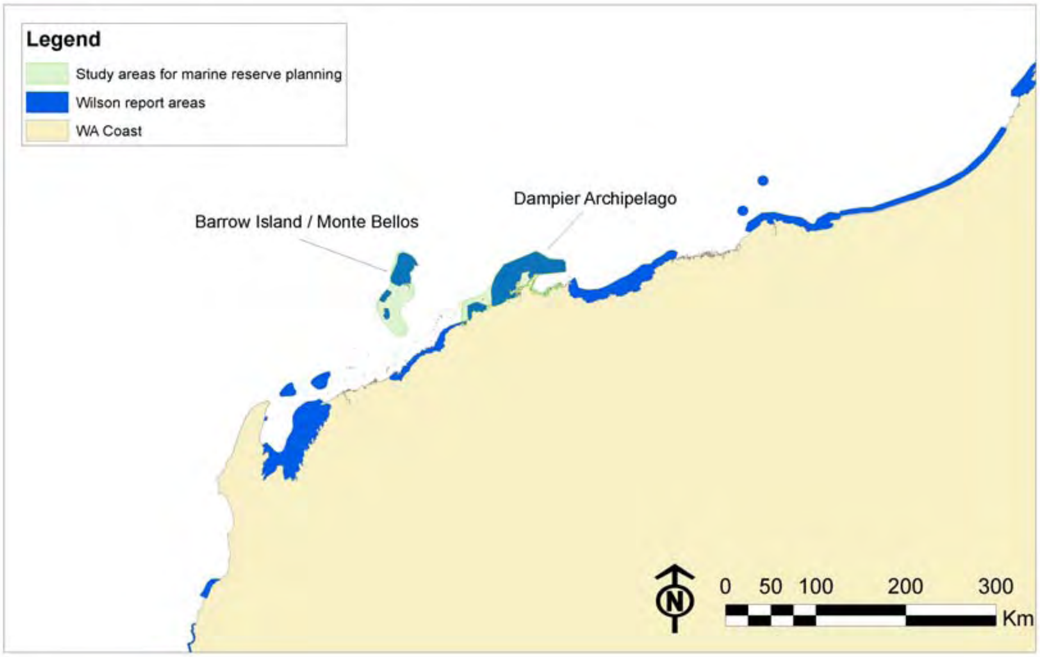

Figure 3.4.1: Wilson report areas to be considered for marine park reservation and the Barrow Island-Monte Bello Islands and Dampier Archipelago proposed marine park study areas.

4. MANAGEMENT STRATEGIES

The three management strategies chosen for evaluation are closely aligned to existing sector-by-sector legislative requirements. The first management strategy is referred to as the *status quo* because it broadly represents the combination of sectoral management strategies in place in 2002. These are detailed in gazetted legislation and associated regulations for departments and local authorities (Gordon, 2006).

The second management strategy examined is referred to as the *enhanced management strategy* because it includes potential modifications to the existing sectoral strategies that might allow some management objectives to be met more effectively. In particular the enhanced strategies make increased use of monitoring to measure the condition of the environment and resource used by each sector, and of remedial action if this monitoring indicates undesirable outcomes.

The third and final strategy examined is referred to as the *regionally co-ordinated sectoral strategy*. It is based on the existence of a regional mechanism to establish indicators and benchmarks, to coordinate monitoring, to enable the results of monitoring and assessment to be shared across sectors, and to facilitate a multi-sectoral management response if undesirable trends were detected in monitored indicators. Otherwise sectoral strategies operated as per the enhanced strategies above.

The objectives of all sectoral management strategies include the achievement of Ecologically Sustainable Development, as outlined in the Inter-governmental Agreement on the Environment (IGAE) (Commonwealth of Australia 1992) and the National Strategy for ESD (Commonwealth of Australia 1992), as well as the requirements of numerous pieces of relevant legislation (see, for example, the review of legislation affecting human activities related to the North West Shelf marine ecosystem by Gordon, 2006). The objective of ESD is "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased" (Commonwealth of Australia 1992). The principles of ESD as expressed in the IGAE include:

- international competitiveness should be maintained and enhanced in an environmentally sound manner;
- environmental considerations will be integrated into all government decision making, and this should include proper and cost-effective examination of matters that significantly affect the environment;
- conservation of biological diversity and ecological integrity are fundamental considerations in decision making;
- the precautionary approach should be applied in decision making;
- inter-generational equity is provided through ensuring the health, diversity and productivity of the environment; and
- there should be valuation, pricing and incentive mechanisms to achieve environmental goals.

These are taken to be the over-arching objectives and principles that management strategies are seeking to meet. The effectiveness of implementation of management measures was assumed to be imperfect, but the same under all strategies for each sector. For each sector this imperfect implementation comprised:

- oil and gas effluent limits were adhered to on 80% of the occasions when operationally they could be exceeded;
- coastal development effluent limits were adhered to on 80% of the occasions when operationally they could be exceeded;
- commercial fisheries catch records were provided accurately on 80% of occasions, while recreational fishing bag limits were adhered to on 75% of occasions when operationally they could be exceeded. Both commercial and recreational fishing operations were located within appropriate zones (e.g. fishery management zones and exclusion zones for management of other sectors) on 95% of occasions; and
- conservation controls on icon species and MPA conditions were adhered to by 80% of operations that could violate the conditions or controls.

The three strategies will now be described for each of the sectors *oil and gas, coastal development, fishing* and *conservation.* However, all sectors will treated together when describing the regionally coordinated sectoral strategy.

4.1 Oil and gas

Management of oil and gas production is the joint responsibility of the Australian Federal Government (Commonwealth of Australia (1967) Petroleum (Submerged Lands) Act 1967) and Western Australian state government (Government of Western Australia (1982) Petroleum (Submerged Lands) Act 1982). This extends from exploration activities through to construction of production and processing facilities, as well as ongoing activities related to resource extraction, processing and transport.

Exploration and production were initially represented as sequential joint production processes within the MSE modelling (NWSJEMS interim report 2002). This involved modelling the economic decisions of petroleum firms so that company responses to management changes could be included in the MSE. Unfortunately, commercial confidentiality prevented adequate calibration and testing of this model component, so it was excluded from the analysis. Instead oil and gas production were treated as scenarios and it was assumed that compliance with production and environmental regulations is a natural and voluntary part of the productive activities of petroleum firms.

Status quo strategy

As of July 2002, management of the production phase of oil and gas extraction was principally concerned with occupational and public safety and the release of contaminants into the environment. The Environmental Protection Authority has the responsibility for preventing, controlling and abating environmental pollution (Government of Western Australia (1986-93) Environmental Protection Act 1986-93). In addition there is a social welfare or resource rents aspect that requires petroleum firms to use procedures and technologies that maximise the quantity of oil and gas extracted from each proven reserve.

Release of contaminants of various types is regulated by volume and concentration. Discharges of this type include produced formation water (PFW) which is a by-product from natural gas extraction at a platform or rig. PFW contains oil and other hydrocarbons, water and a mix of various other contaminants listed in the contaminants inventory (Fandry et al. 2006) This PFW amounts to less than 40 m^3 per well per day and is treated by passing it through a skimmer vessel to a drain sump caisson. It is held there until free oil can be recovered (for sale) and the remaining water is discharged to the sea at a depth of 40 metres.

There was no statutory limit on the annual discharge of PFW as of July 2002, although the concentration of petroleum in released PFW must remain lower than 50 mg/l and must average less than 30 mg/l every calendar day. Detailed environmental plans, monitoring and monthly reporting are requirements for all petroleum leases. All violations of the petroleum concentrations must therefore be reported and penalties are applied at the rate of $440 per well per day until the concentration limits are no longer breached. The penalties are capped at $44 000 per well per annum. The other legislated management response to continued violation, which has not yet been exercised, is a review of lease conditions and possible cancellation of the lease.

The other major environmental discharge that triggers management response is an oil spill. All oil spills resulting from production, loading and transportation activities must be reported if greater than 80 litres, although most companies choose to report spills greater than 20 litres. All reportable spills must be dispersed or recovered as per the petroleum company's registered contingency plan.

The other management measure relating to exploration, development and ongoing production is the establishment of exclusion zones (table 4.1.1). These zones are declared to prevent non-company shipping traffic, including fishing vessels, from approaching any platform, rig, well head or pipeline. This is an occupational and public safety measure designed to avoid catastrophic intrusion by unauthorised persons.

Table 4.1: Size of exclusion zones around oil and gas installations.

Buffer around	Fisher	Fishing Survey	NTQ Fisher	Prawn fisher	Trap fisher
Pipe line	2000m	2000m	2000m	2000m	500m
Well	5000m	5000m	5000m	5000m	500m

While other management measures can be represented in the model, they were considered beyond the scope of the current work. These include compulsory use of water-based drilling muds and fluids to provide hydraulic pressure to the drilling apparatus; restrictions on the deposition of cuttings; removal of underwater obstacles when well heads are decommissioned and sealed; and restrictions on the timing of seismic activities and the colour-filtering of gas flares to minimise potential impacts on marine mammals and reptiles.

Enhanced management strategy

The monitoring component of the enhanced management strategy entails measurement of the accumulation of key contaminants in oysters within 1 km of installations (Cu, $CaSO_4$, lead, oil as an indictor for PFW, and magnesium as an indictor for bitterns), as well as monitoring species richness. Management responses were triggered at half the ANZECC guidelines (with the aim of avoiding reaching the guideline levels) or by a rapid decline in turtle or shark populations.

The management response was a requirement that contaminant outputs be reduced by 50%. The cost of this improvement was A$25M over the first five years and A$2M pa thereafter. Success in achieving the target reductions in contaminant output after five years was assumed, in even intervals of reduction. The management response could be repeated at five year intervals if monitoring continued to show undesirable outcomes. While production levels were not changed by triggered remedial actions, the effective production was reduced by EPA restrictions regarding contaminant outflows.

4.2 Coastal Development

Status quo strategy

Management of the coastal zone is conducted through a combination of uniform ANZECC/ARMCANZ (2000) water quality standards (http://www.deh.gov.au/water/quality/nwqms/index.html) and zoning for industrial, residential and recreational development (Government of Western Australia (1985) Western Austrlain planning Commission Act 1985). As at July 2002 the Department of Environmental Protection (DEP) (Government of Western Australia (1986-93) Environmental Protection Act 1986-93) adopted ANZECC/ ARMCANZ (2000) guidelines for water quality, food quality and sediment composition. These were incorporated into all development plans approved for industrial, residential, tourism and recreational purposes. In addition to these standards, industrial zones were developed for Maitland (on the Burrup Peninsula), Hedland and Onslow

The Department of Marine and Harbours (Government of Western Australia (1981) Marine and Harbours Act 1981; Government of Western Australia (1967) Shipping and Pilotage Act 1967; Government of Western Australia (1982) Western Australia Marine Act 1982; Government of Western Australia (1981) Prevention of a Collision at Sea regulations 1983) and local port authorities (Government of Western Australia (1985) Dampier Port Authority Act 1985) monitor and regulate shipping transport. Their main responsibility is to monitor port usage and profit, ensuring port facilities can handle the traffic demanded by the economic conditions.

Safety incidents are also investigated and records maintained of near misses. The number of times vessels in the model needed to take evasive manoeuvres to prevent a collision was similarly recorded and used as an indicator of the likelihood of a vessel collision and possible spill. However, under the status quo management strategy this data did not trigger any management action, with port capacity being held constant.

Enhanced management strategy

In the enhanced management option, the status quo guidelines for water quality, food quality and sediment composition were retained. However, management of port expansion was significantly enhanced. If an over-capacity threshold was exceeded in any given month, a port expansion was triggered to accommodate for the extra capacity. Port expansion involved doubling the port capacity, and also adding new shipping lanes (and incurring the associated environmental costs). Model shipping lanes with and without port capacity expansion are shown in figure 4.2.1 (details are provided in Gray et al. 2006).

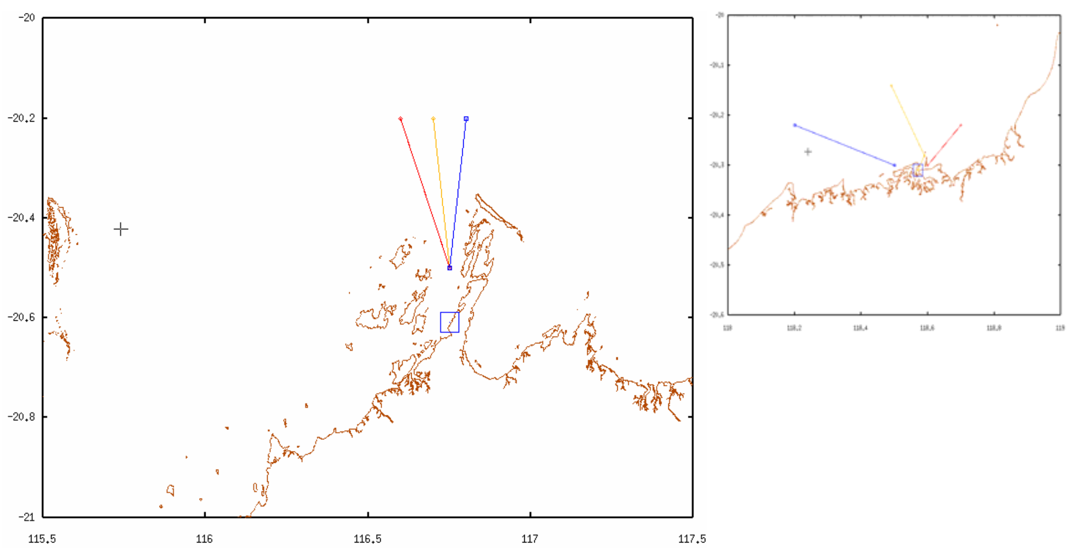

Figure 4.2.1: Maps showing location of ports (square boxes) at Dampier (left) and Port Hedland (right). Also shown is the shipping route into and out of the port at the beginning of the projection period (yellow line), and the shipping route into the port (red line) and out of the port (blue line) under port capacity expansion.

4.3 Fishing

Status quo management for fisheries

Decision procedures for the status quo management strategy were based on the requirements of the Fisheries Act (Government of Western Australia (1994) Fish Resources Management Act (FRMA) 1994; Pilbara Fish Trawl Fishery (Interim) Management Plan 1997, Pilbara Trap Management Plan 1992). These procedures include zoning and effort control for trawl and trap finfish fisheries, and zoning, seasonal closures and effort control for prawn fisheries. In the case of the finfish fisheries, managers respond to their assessment of fish stocks by adjusting effort quotas in commercial fishing zones (figure 4.3.1) to ensure sustainability of the fish stock and to promote the long-term economic viability of commercial fishing in the region. In the case of the prawn fisheries, stock assessments have not been feasible, so managers have responded directly to catch rates in deciding when fishing zones are open.

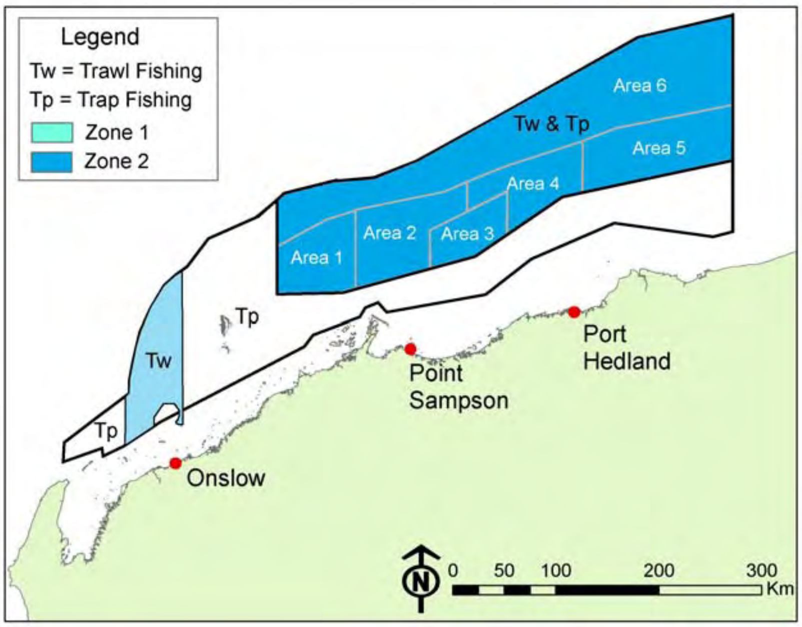

Figure 4.3.1: Zoning of the commercial trawl and trap fisheries on the North West Shelf.

Finfish management

Trap fishing is permitted in most areas on the North West Shelf deeper than about 30 m, while trawling is restricted to mid-shelf and outer-shelf zones (figure 4.3.1). Trawling is permitted in one area adjacent to Barrow Island (Zone 1) where trap fishing is excluded. Management is by fishing effort units, with allocations of the number of trap days (zone limits not specified) or hours trawled (zone limits specified). The number of vessels licensed to operate is limited to six in both the trap and trawl fisheries.

Catch (measured by the weight of various categories of commercial fish) and effort (measured by trap days or trawl hours) are recorded in industry completed logbooks by month and on a 30 minute spatial grid. Additional research logbooks are filled in by some operators giving actual trap or trawl location and catch of selected target species. Satellite based Vessel Monitoring System (VMS) information on trap or trawl location is also available for some vessels.

Annual assessments of the population status of one fishery target species (*Lutjanus sebae*) are conducted using the logbook data from both trap and trawl fishing, along with auxiliary information collected periodically by research sampling. *Lutjanus sebae* was selected as an indicator species because it is both commercially valuable and expected to be among the most vulnerable to overfishing. Population status is calculated for each fishing zone separately. A limit reference point for the spawning stock biomass is set at 30% of the level in 1972 for each fishing zone, and 40% over all fishing zones, with management aiming to keep the spawning stock above this level with high probability. There is no formal agreement of how the fishing effort units should be changed as a result of the annual assessment of the spawning stock in relation to the reference point. At present the process is that reductions in effort are recommended in the stock assessment if the population is assessed to be close to or below the reference point, and this recommendation is then considered by the management agency. In the recent past, recommendations have been broadly followed with implementation of significant effort reductions in 1999 and a redistribution of effort among zones in 2001.

Finfish stock assessments

The finfish stock assessment is conducted annually using commercial logbook data. In the model this entailed projecting the estimated stock assessment model many times (typically 1000) under the current management arrangements (i.e. current area closures and area effort quotas) and generating a distribution of spawning biomass representing the uncertainty associated with the fishery. Based on current actual management decision procedures, a management review is triggered when either of the following apply:

the probability of the spawning biomass falling below 30% for any one area is greater than 25%, i.e.

$$P(X_{\gamma} < 0.3) > 0.25$$

the probability of all areas combined falls below 40% is greater than 50%, i.e.

$$P(X_{\gamma=all} < 0.4) > 0.5\,,$$

where $P_{\gamma}(X)$ is the distribution of relative spawning biomasses ($X = S^{\gamma}_{final} / S^{\gamma}_{initial}$) for γ, including all areas combined, i.e.

$$X = \sum_{\gamma} S^{\gamma}_{final} / \sum_{\gamma} S^{\gamma}_{initial}\,.$$

Reviews triggered by condition (i) indicate local over-exploitation. In this case, the simulated management response is to reduce the effort in the over-exploited area by 10% until the condition for this zone is met. The effort removed is then evenly allocated to the other areas, as long as condition (ii) continues to be met. Reviews triggered by condition (ii) indicate broader-scale over-exploitation. In this case, the simulated management response is to reduce the effort over the entire zone (i.e. all management areas) by 10% until the condition is met. Any effort that cannot be allocated to an area without meeting the condition is disregarded.

Prawn management

The three North West Shelf prawn fisheries are the Exmouth Gulf Prawn Fishery, the Onslow Prawn Fishery and the Nickol Bay Prawn Fishery. In reality, each fishery is spatially managed with openings and closures of multiple zones (figure 4.3.2). The fisheries are not independent, with effort levels in the Onslow and Nickol Bay fisheries being dependent on the Exmouth Gulf fishery.

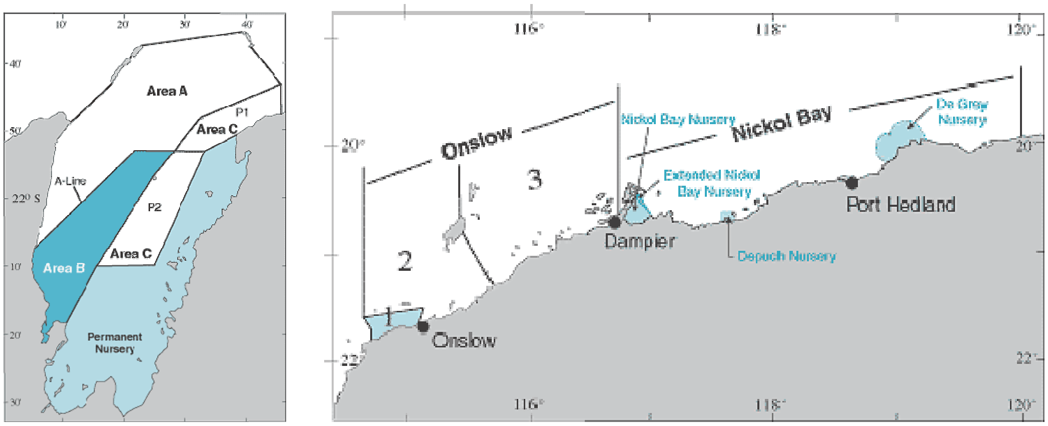

Figure 4.3.2: Prawn fishery management zones for Exmouth Gulf (left), Onslow and Nickol Bay (right).

Onslow and Nickol Bay have generally produced lower catches than Exmouth (table 4.3.1) and have not required much management intervention beyond setting acceptable catch limits (table 4.3.2). In contrast, Exmouth has had a history of not only setting acceptable catch limits, but also experienced a temporary closure in 1999–2000 due to low catch rates. Reference limits in the Exmouth fishery also include acceptable catch ranges that are calculated based on historical data.

Prawn fishery management in the model consists of a decision procedure based on the total catch coming from each fishery as a performance indicator, and the projected or acceptable range limits. The procedure acts on the fishery when the performance indicators, in this case total catch, are outside of the reference limits of acceptable catch range. In reality, actual management action has not always been taken under such a circumstance, as environmental conditions have been used to explain the outlying catch record. The only instance were action has been taken was in the Exmouth Gulf fishery in 1999–2000, where areas were closed for three years following two consecutive years of low catches. The model decision procedure implemented similar restrictions, closing a randomly selected area for three years in any fishery that displayed two consecutive years of total catches below acceptable ranges.

Table 4.3.1: Historical prawn species catch data.

Actual catch data (tonnes)						
Year	**Fishery**	**king**	**tiger**	**endeavour**	**banana**	**total**
98-99	Exmouth	508	377	170	3	1058
	Onslow	35	14	11	2	61
	Nickol Bay	50	3	1	36	89
99-00	Exmouth	471	451	543	2	1467
	Onslow	38	26	20	9	93
	Nickol Bay	69	13	5	171	259
00-01	Exmouth	299	82	122	62	565
	Onslow	12	18	6	51	87
	Nickol Bay	31	13	1	467	512

Table 4.3.2: Comparison of acceptable catch ranges for actual and modelled management of prawn fisheries (see Appendix C for further details).

Fishery		**Actual acceptable catch (tonnes)**	**Model acceptable catch (tonnes)**
Exmouth	king	350-500	
	tiger	250-550	
	endeavour	120-300	
	banana	-	
	total	771-1276	350-500
Onslow	king	10-55	
	tiger	5-40	
	endeavour	5-20	
	banana	2-90	
	total	60-130	57-100
Nickol Bay	king	20-70	
	tiger	2-40	
	endeavour	1-10	
	banana	40-220	
	total	90-300	110-240

Recreational fishing

The management procedures for recreational fishing, under all management strategies, included rules on discarding rates, legal size limits, prohibited species and spatial management zones. A fish could only be retained by the recreational fisher if all of these management measures allow it (i.e. it is a species that is both desirable and unprotected, of a desirable and legal size and not in a "no-take" marine protected area). The model did not provide for monitoring or assessment of stocks, and there was no planned management intervention.

Enhanced sectoral management strategy for fisheries

The enhanced sectoral management strategy involved additional monitoring in the form a fishing vessel that lands a commercial catch while simultaneously providing key scientific data. In addition, for the prawn fishery, fishing ceased if CPUE fell below the lowest fishery specific CPUE in the ten years prior to the projection period of the model. This already exists on a voluntary basis in the real prawn fishery with a minimum CPUE of 16 kg/hr.

Enhanced finfish stock assessments

The operations of the additional fishing vessel involved randomly selecting a trawl area and then a location within this area subject to the same constraints as regular trawl vessels. The age distributions of the catch obtained by this vessel were recorded and used to improve the biomass estimates of the stock assessment model by updating the log-likelihood of the commercial CPUE data with the log-likelihood of the age distributions:

$$\lambda_{age} = \frac{n_3}{2} \sum_y \sum_s \sum_a p_{a,y}^{s,\gamma} \ln\left(\frac{\hat{p}_{a,y}^{s,\gamma}}{p_{a,y}^{s,\gamma}}\right),$$

where n_3 is the number of years which the survey have been performed; $p_{a,y}^{s,\gamma}$ is the *observed* proportion of individuals in the catch of the survey vessel of sex s in year y that are age a; and $\hat{p}_{a,y}^{s,\gamma}$ is the *estimated* proportion of individuals in the catch of the survey vessel of sex s in year y that are age a; i.e.

$$\hat{p}_{a,y}^{s,\gamma} = \frac{N_{a,y}^s V_y^s}{\sum_s \sum_a N_{a,y}^s V_a^s}$$

The new overall log-likelihood is then $\lambda = \lambda_{CPUE} - \lambda_{age}$.

4.4 Conservation

Direct responsibility for conservation management rests with the Western Australian Department of Conservation and Land Management (CALM) (Government of Western Australia (1994) Conservation and Land Management Act 1994 [CALM], Government of Western Australian (1997), Acts Amendment (Marine Reserves) Act 1997, Government of Western Australian Government (1950) Wildlife Conservation Act 1950), which is responsible for protection of both terrestrial and marine fauna and flora.

As at 31 December 2002 the main instruments of conservation management were terrestrial and coastal reserves and the protection of individual species beyond these reserves. The region of North West Shelf considered by this study did not contain any coastal and marine reserves. However, fishing zone three, prawn nursery grounds, and exclusion zones around oil and gas facilities (see figure 1.2.1) were closed to fishing and remained closed for the duration of the model runs. Additional closures to fishing occurred through the implementation of the enhanced and integrated management strategies (see section 4.3). These management driven closures were in response to the stocks of turtles or sharks falling below 20% of initial biomass (see section 2.4).

4.5 Regionally coordinated sectoral management

The status quo and enhanced management strategies have been described for each sector. The regionally coordinated management strategy will now be described considering all sectors simultaneously.

The regionally coordinated strategy was based on the existence of a regional mechanism to establish indicators and benchmarks, to coordinate monitoring, to enable the results of monitoring and assessment to be shared across sectors, and to facilitate a multi-sectoral management response if undesirable trends were detected in monitored indicators. Otherwise sectoral strategies operated as per the enhanced strategies described above.

The regional management response was conducted through modification of the sectoral management arrangements, rather than a requirement for new kinds of arrangements. For each indicator it is envisaged that there is prior agreement about which sectors are likely to be relevant if undesirable trends are detected, and that a multi-sector response by those sectors has been identified. A decision tree for regionally coordinated management decisions is shown in figure 4.5.1.

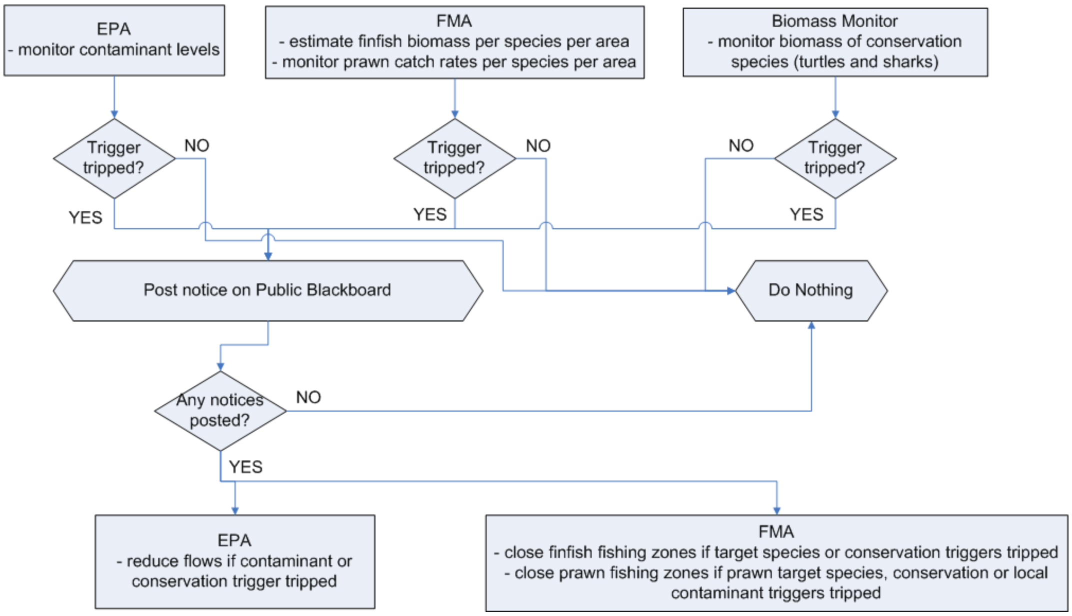

Figure 4.5.1: Regional coordinated management decision tree.

The regional indicators were monitored by a regional monitoring program made up of the sectoral monitoring activities augmented as necessary to give regional coverage. For each indicator there was a trigger level for regional management responses by the sectors that were identified as relevant to that indicator. The management response by each sector involved implementation of the enhanced sectoral management strategies described previously. A two year period of negotiation was assumed each time a trigger was reached, followed by a coordinated implementation of the enhanced sectoral management strategy by the relevant sectors. Costs were passed on to industries to cover remediation, compensation, or government fines.

This is a very simplistic approach to regionally coordinated management, but it allows some exploration of alternatives to strictly sectoral management. Alternative approaches yet to be explored might involve the specification of economic instruments (e.g. rights that are tradeable across sectors) or detailed objectives and management strategies being provided for the region as a whole.

Oil and gas

The regionally coordinated sectoral management used the same procedures as the enhanced management, but shared its monitoring results with other sectors.

Coastal development

Contaminant outflows were monitored and controlled according to ANZECC/ARMCANZ guidelines for contaminant concentration in sea water (ANZECC & ARMCANZ 2000). The management of port facilities and shipping traffic in the regionally coordinated management strategy was the same as that described for the status quo management strategy.

Fishing

The regionally coordinated sectoral management used similar procedures to the enhanced management, except that it could be influenced by the findings of other management agents. Thus, instead of relying on catch rates alone to determine which fishing zones were open, under the regionally coordinated management fishing areas were (potentially) closed to fishing whenever:

- the target stocks or the biomass of turtles and sharks fell below limit reference points; or
- the EPA put out a notification of excessive contaminant levels within an area covered by a fishing zone (e.g. prawn fishery in Nickol Bay).

Conservation

Monitoring and controls were based on stock levels of species of conservation value (turtles and sharks) and monitored contaminant levels. When populations dropped below a trigger point (e.g. 20% fall in biomass from initial levels) then a range of sector management option were implemented:

- fishing effort quotas reduced;
- prawn areas closed;
- EPA notified for further action.

4.6 Indicators of environmental quality and economically sustainable development

The fourth critical element of the MSE specification is a set of *indicators*. The term indicator is used in this report to refer to a quantity which reflects the state, pressures, or changes in a property that is of management relevance (Sainsbury et al. 2000; Fletcher et al. 2002). For example indicators could relate to environmental or ecosystem conditions, economic flows, or social values. If benchmarks or reference points (i.e. desirable or undesirable values) are specified for an indicator then performance measures can be calculated from the indicator value that reflect current status in relation to those benchmarks. Also, in an MSE context indicators are of two general types:

- those potentially or actually measured in the field, which might be used to trigger management actions, to report management performance, or to recognise and account for external drivers of system dynamics (e.g. physical oceanographic indicators of ENSO condition);

- those used internally to the MSE process to allow comparison the performance of the alternative strategies (potentially including aspects of a system that are important but that can not be easily measured directly in the real world).

A wide range of indicators have been proposed and evaluated for use in monitoring and managing ecosystem components. Ecological indicators are usually scale-dependent and relevant to one of the following hierarchical levels:

- individuals (behavioural and metabolic responses);
- populations (behavioural, demographic, metabolic and genetic responses of certain species);
- communities (species richness, diversity and habitat structure); and
- ecosystems (ecosystem production or trophic structure).

It has been shown that community and ecosystem level indicators are generally the most useful for monitoring ecosystem-level impacts of human activities (Frost et al. 1992; Fulton et al. 2006). However, there are notable exceptions, such as contaminant levels in individuals having broader ecological implications.

Species with particular roles or vulnerabilities (e.g. harvested, bycatch, key-stone, pest, and threatened species) may all be useful indicators (Carignan & Villard 2002; Fulton et al. 2004). Other species may be used as indicators if they are easily sampled, readily identified, cosmopolitan, or characterise system state or causes of change in a system. Any of these species are known as “indicator species”. Groups often found to be useful indicator species include seagrass, benthic invertebrates, piscivorous and planktivorous fish, and high-level predators (e.g. birds, sharks and marine mammals). Selection of key species to be monitored in any specific system must be done carefully and must span a suite of species with a range of properties, habitat requirements, sensitivities and rates of response (Whitfield & Elliott 2002; Fulton et al. 2006).

The MSE modelling used a wide range of indicators to describe outcomes and compare alternative management strategies. These are detailed below under categories such as environmental, ecological, fisheries, economic and social indicators.

Environmental indicators

The environmental indicators included in the study were:

- water quality in selected zones (primarily contaminant concentrations);
- sediment contamination in selected zones;
- contaminant concentrations in tissues (of oysters at monitored sites, prawns, sharks and turtles); and
- total contaminant exposure per unit time (of the monitored taxa).

These were monitored in specific coastal and off-shore development zones.

Ecological indicators

Ecological indicators came from the evaluation of Fulton et al. (2004, 2005):

- regional habitat diversity (total count of groups at a location and high and low order Réyni and Shannon diversity measures, so both richness and evenness are considered);
- population status of k-selected indicator species (i.e. long lived species with low reproductive rates – turtles and sharks in this case);
- ratio of r-selected (short-lived with high reproduction rates) to k-selected biomass in the catch;
- status of expected sensitive or vulnerable habitat forming taxa (seagrass, mangroves, corals and sponges in this case);
- fragmentation by habitat type; and
- primary productivity (satellite monitoring of Chla with some ground truthing) with benchmarks set relating to expected eutrophication and pristine levels.

Fisheries indicators

Fisheries have a long history of using indicators for monitoring and managing sector activities. The classical fisheries indicators were used here:

- catch (per fleet, including recreational);
- effort (per fleet, including recreational);
- catch per unit effort (CPUE) (per fleet, including recreational);
- target stock biomass;
- bycatch rates;
- bycatch stock biomass (k-selected group in the model); and
- area affected by fishing (i.e. area trawled).

Economic indicators

The economic indicators chosen for use in the MSE are typically widely used and well accepted:

- value of production by sector and for all sectors combined;
- return (gross revenue) on investment by sector and for all sectors combined;
- flow of government royalties;
- employment level;
- per capita gross income;
- throughput of ships for each port; and
- number of vessel evasive manoeuvres preventing a collision.

The last of these indicators was included amongst the economic indices because of the close relationship between economic development and density of shipping traffic, as well as the large economic costs associated with potential spills.

The economic analysis of the finfish fisheries was done using cost data from AFMA logbooks and ABARE survey statistics from the Southeast Trawl Fishery (table 4.6.1). Fish price data were based on the Sydney Fish Market monthly price report data for 2004 for six species (table 4.6.2). Gross margins were calculated as:

$$\pi_y = (1 - c_l)\sum_s C_{y,s} p_s - E_y c_c$$

where π_y is the gross margin in year y; $C_{y,s,}$ is the total trawl catch of species s in year y; p_s is the price ($/kg) of fish of species s; c_l is the average labor and other costs per unit revenue; c_c is the average fuel costs per unit effort; and E_y is the total trawl effort expended (h) in year y. For the analysis, c_l was set to 0.37, and c_c was 137.25. Gross margin was scaled to fixed costs. Fixed costs were calculated from the average of the capital and gear costs, multiplied by the average annual effort E_y.

Table 4.6.1: Cost data of the Southeast Trawl Fishery used as a guide to costs in the North West Shelf trawl fishery (courtesy of T. Kompas).

Costs	Unit	Method			Average
		Inshore	Offshore	Danish	
Share of labour costs / revenue	$ per $	0.31	0.27	0.35	
Share of other / revenue	$ per $	0.06	0.06	0.05	
Total		0.37	0.33	0.40	0.37
Average fuel cost / effort	$/hour	103.44	244.65	63.66	137.25
Average capital cost / effort	$/hour	94.4	115.05	80.87	
Average gear cost / effort	$/hour	19.19	68.20	18.56	
Total		113.59	183.25	99.43	66.05

Table 4.6.2: Average Sydney Fish Market price in 2004 for six species of Western Australian fish.

Species	price ($/kg)
red emperor	10.18
blue-spotted emperor	3.10
spangled emperor	6.79
average	4.95
scarlet sea perch	4.94
red snapper	4.54
average	4.74
threadfin bream	5.08

Social indicators

Social indicators chosen were selected for their ability to reflect aesthetic value, personal health, and other desirable attributes the general public look for in the system:

- recreational fishing experience quality (catch rate of large species such as *Lutjanus sebae* and desirable coastal species);
- water quality suitability for swimming (surrogate for several other aesthetic uses);
- quality and area of recreationally used habitats (coral reefs, seagrass meadows, sandy beach access, fractionation of coastal access for walks and camping, rubbish levels at main recreational sites);
- wildlife sightings (turtles);
- human population stability (variance in three year running average of population size, combined industry investment).

Unlike some of the other indicators discussed above, the social indicators related to recreational value were treated qualitatively. Hence they could be used to judge the success of the strategies with respect to socially based management objectives, but not included in the models, dynamic feedback loops.

Management responsibility

Not all sectors affect every indicator. A list of indicators and the sectors which impact upon or use them is given in table 4.6.3.

Table 4.6.3: List of indicators and relevant sectors that may impact upon or use them.

Indicator	Sectors
Regional habitat diversity	All sectors
Water quality in selected zones - offshore	Oil and gas production
Water quality in selected zones - inshore	Coastal development
Sediment contamination - offshore	Oil and gas production
Sediment contamination - inshore	Coastal development
Population status of K-selected indicator species	All sectors
Status of expected sensitive or vulnerable habitats	Conservation, fisheries (commercial), coastal development
Primary productivity	Oil and gas production, coastal development
Recreational values: recreational fishing experience	Fisheries, (commercial and recreational), conservation
Recreational values: water quality suitability for swimming	Coastal development
Recreational values: quality and area of recreationally used habitats	Coastal development, conservation
Recreational values: observing wildlife	Conservation, fisheries (commercial), coastal development
Return (gross revenue) on investment by sector	Relevant sector
Value of production by sector*	Relevant sector and overall
Employment level*	All sectors
Human population stability*	All sectors
Flow of government royalties, combined gross production for all sectors*	All sectors
Per capita gross income*	All sectors

* Indices that were not necessarily dynamic in all sectors.

5. CONCLUSION

This report has documented the model specifications, development scenarios and management strategies that constitute the three dimensions of an MSE analysis for the North West Shelf. A technical description of the MSE model can be found in the companion report of Gray et al. (2006), while the results of the analysis are reported in Little et al. (2006).

The three model specifications spanned a range of model structures representing both biophysical processes and human impacts. Model structures and parameter values were identified that best matched available historical data (within the 80% confidence intervals). Three of these combinations were then selected for detailed analysis based respectively on an optimistic, a pessimistic and an intermediate interpretation of the system's productivity and resilience to human impacts.

The three development scenarios aimed to account for uncertainty in the future level of industrial activity in the North West Shelf region. The first development scenario represented recent (i.e. 2002) levels of infrastructure, residential and industrial development and environmental protection. The second development scenario represented the planned development over the next five years with no subsequent development, while the third allowed for a repeated cycle of development of the type planned for the next five years after a further five years. Each scenario included developments in each of the four industry sectors: oil and gas, coastal development, fishing, and conservation.

The three management strategies chosen for evaluation focused on the same four sectors and were closely aligned to existing sector-by-sector legislative requirements. The first management strategy broadly represented the combination of sectoral management strategies in place in 2002. The second management strategy included potential modifications to existing sectoral strategies that might allow some management objectives to be met more effectively, while the third was a set of co-ordinated sectoral strategies, with shared monitoring and the potential for integrated multi-sectoral management responses.

The fourth element of the specification was a set of indicators. A set of the potentially most informative indicators was selected based on previous experience and applications. They were intended to be comprehensive and the final list included indicators relating to environmental, ecological, fisheries, economic and social values.

This report has demonstrated the magnitude and complexity of the task of developing models of ecosystem dynamics, human uses and management responses needed to comprehensively address the issue of managing multiple-uses across a large marine region. Placing these models within an MSE framework has added further complexity, but is seen as an essential step in incorporating the large inherent uncertainties associated with the dynamics of the system. While many improvements can be made, with respect to both specific process models and the broader framework, the study has successfully demonstrated the feasibility of the multiple-use MSE approach within a regional context.

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APPENDIX A: LIST OF INVITRO INPUT DATA SETS

abbrev_pilb_traps.xy.pt
abbrev_pilbara-prawns.xy.pt
abbrev_pipelines_new.xy.pt
abbrev_wells.xy.pt
AirlieIsA_Oil.ts
irlieIsA_ProducedFormationWater.ts
BananaprawnNODAT.SAD
BananaPrawnSpatialCatch.his
Burrup-bbox.ll.pt
bycatch.ll.pt
bycatch.xy.pt
C-Lambert-in.pt
C-Lambert-out.pt
condensate-prod.ts
condensate-prod-1p.ts
condensate-prod-2p.ts
Cossack_Oil.ts
Cossack_ProducedFormationWater.ts
currents.data
Cyclones.data
D_003_Prawn.BB
Dampier-in.pt
Dampier-out.pt
Dampier-Overflow-in.pt
Dampier-Overflow-out.pt
Dampier-pop.ts
Dampier-pop-1p.ts
Dampier-pop-2p.ts
Dampier-prod.ts
Dampier-prod-1p.ts
Dampier-prod-2p.ts
deep.xy.pt
Disasters.data
Dredge.data
Dredge_enhanced_1p.data
Dredge_enhanced_2p.data
East-intercourse-island-in.pt
East-intercourse-island-out.pt
effort.his
effortTrap.his
Exmouth-pop.ts
Exmouth-pop-1p.ts
Exmouth-pop-2p.ts
Exmouth-prawn.xy.pt
Exmouth-prod.ts
Exmouth-prod-1p.ts
Exmouth-prod-2p.ts
ExtraDisasters.data
F_015_Prawn.BB
F_024_Prawn.BB
F_358_Prawn.BB
F_424_Prawn.BB
F_447_Prawn.BB
F_454_Prawn.BB
F_465_Prawn.BB
F_474_Prawn.BB
F_477_Prawn.BB
F_479_Prawn.BB
F_501_Prawn.BB
F_543_Prawn.BB
F_550_Prawn.BB
F_556_Prawn.BB
F_561_Prawn.BB
F_630_Prawn.BB
F_814_Prawn.BB
F_824_Prawn.BB
file.txt
G_142_Prawn.BB

G_223_Prawn.BB
G_350_Prawn.BB
gas-net.ts
gas-prod.ts
gas-prod-1p.ts
gas-prod-2p.ts
GoodwynA_Oil.ts
GoodwynA_ProducedFormationWater.ts
Griffin_Oil.ts
Griffin_ProducedFormationWater.ts
HammersleyWTP_Copper.ts
HammersleyWTP_Copper_1p.ts
HammersleyWTP_Copper_2p.ts
HammersleyWTP_Copper1p.ts
HammersleyWTP_Copper2p.ts
HammersleyWTP_flow.ts
HammersleyWTP_flow-1p.ts
HammersleyWTP_flow1p.ts
HammersleyWTP_flow-2p.ts
HammersleyWTP_flow2p.ts
HarrietA_Bitterns.ts
HarrietA_Lead.ts
HarrietA_Oil.ts
HarrietA_ProducedFormationWater.ts
HarrietB_ProducedFormationWater.ts
HarrietC_Oil.ts
HarrietC_ProducedFormationWater.ts
HeavyExtraDisasters.data
KingprawnNODAT.SAD
KingPrawnSpatialCatch.his
leth.his
lethTrap.his
llut.his
llutTrap.his
lsebae.his
LSebaeNODAT.SAD
LSebaeNODATB.SAD
lsebaeTrap.his
M_135_Prawn.BB
macrophytegrids.ll.pt
mangrovegrids.ll.pt
map.rc
merged_xy.pfm
MermaidSound_Cadmium.ts
MermaidSound_Cadmium-1p.ts
MermaidSound_Cadmium1p.ts
MermaidSound_Cadmium-2p.ts
MermaidSound_Cadmium2p.ts
MermaidSound_Copper.ts
MermaidSound_Copper-1p.ts
MermaidSound_Copper1p.ts
MermaidSound_Copper-2p.ts
MermaidSound_Copper2p.ts
MermaidSound_flow.ts
MermaidSound_flow-1p.ts
MermaidSound_flow1p.ts
MermaidSound_flow-2p.ts
MermaidSound_flow2p.ts
MermaidSound_Lead.ts
MermaidSound_Lead-1p.ts
MermaidSound_Lead1p.ts
MermaidSound_Lead-2p.ts
MermaidSound_Lead2p.ts
MermaidSound_Oil.ts
MermaidSound_Oil-1p.ts
MermaidSound_Oil1p.ts
MermaidSound_Oil-2p.ts
MermaidSound_Oil2p.ts
MermaidSound_PetroleumHydrocarbons.ts
MermaidSound_PetroleumHydrocarbons-1p.ts
MermaidSound_PetroleumHydrocarbons1p.ts
MermaidSound_PetroleumHydrocarbons-2p.ts
MermaidSound_PetroleumHydrocarbons2p.ts
MermaidSound_Sulphate.ts
MermaidSound_Sulphate-1p.ts
MermaidSound_Sulphate1p.ts
MermaidSound_Sulphate-2p.ts
MermaidSound_Sulphate2p.ts

MermaidSound_Tin.ts
MermaidSound_Tin-1p.ts
MermaidSound_Tin1p.ts
MermaidSound_Tin-2p.ts
MermaidSound_Tin2p.ts
nemip.his
nemipTrap.his
NEW_C45.BB
NEW_F105.BB
NEW_F248.BB
NEW_F550.BB
NEW_F661.BB
NEW_F711.BB
NEW_F841.BB
NEW_G296.BB
NEW_PS10.BB
NEW_PS14.BB
NEW_PS19.BB
NEW_PS20.BB
NEW_PS21.BB
NEW_PS7.BB
NEW_Z430.BB
NickolBay_Bitterns.ts
NickolBay_Bitterns-1p.ts
NickolBay_Bitterns1p.ts
NickolBay_Bitterns-2p.ts
NickolBay_Bitterns2p.ts
NickolBay_Calcium.ts
NickolBay_Calcium-1p.ts
NickolBay_Calcium1p.ts
NickolBay_Calcium-2p.ts
NickolBay_Calcium2p.ts
NickolBay_flow.ts
NickolBay_flow-1p.ts
NickolBay_flow1p.ts
NickolBay_flow-2p.ts
NickolBay_flow2p.ts
NickolBay_Sulphate.ts
NickolBay_Sulphate-1p.ts
NickolBay_Sulphate1p.ts
NickolBay_Sulphate-2p.ts
NickolBay_Sulphate2p.ts
Nickol-prawn.xy.pt
NRankinA_Oil.ts
NRankinA_ProducedFormationWater.ts
nws_dem_xy.pfm
NWS-bbox.ll.pt
NWS-bbox.xy.pt
nwscoast.ll
nwscoast.ll.pt
nwscoast.xy
nwscoast.xy.pt
nws-cyclones.ll.pt
nws-cyclones.xy.pt
oil_wells.ll
oil-data.0
oil-facilities.pgm
oil-net.ts
oil-prod.ts
oil-prod-1p.ts
oil-prod-2p.ts
oil-revenue.ts
Onslow-prawn.xy.pt
Parker-point-in.pt
Parker-point-out.pt
pilbara-closed.xy.pt
pilbara-roads.xy.pt
pilbara-zones.xy.pt
Point-Samson-pop.ts
Point-Samson-prod.ts
Point-Samson-prod-1p.ts
Point-Samson-prod-2p.ts
porifera_grown.ll.pt
port-hed-in.pt
Port-Hedland-in.pt
Port-Hedland-in.txt
Port-Hedland-out.pt
Port-Hedland-out.txt

Port-Hedland-Overflow-in.pt
Port-Hedland-Overflow-out.pt
Port-Hedland-pop.ts
Port-Hedland-pop-1p.ts
Port-Hedland-pop-2p.ts
Port-Hedland-prod.ts
Port-Hedland-prod-1p.ts
Port-Hedland-prod-2p.ts
port-hed-out.pt
portLineCossack.pt
portLineCossack.rt
portLineN_Rankin_A.pt
portLineN_Rankin_A.rt
portLineOre.pt
portLineOre.rt
portLineOre2.pt
portLineOre2.rt
portLineOre3.pt
portLineOre3.rt
portLineOre4.rt
portLineRigs.pt
PrawnEffortSpatial.his
PS017_Prawn.BB
PS019_Prawn.BB
PtSamson-in.pt
PtSamson-out.pt
rainfall_60.ts
rigs-cadastre.xy.pt
Salt-prod.pt
saur.his
saurTrap.his
sed381.xy.pt
slut.his
slutTrap.his
Stag_Oil.ts
Stag_ProducedFormationWater.ts
ThevenardIs_Oil.ts
ThevenardIs_ProducedFormationWater.ts
tuv_mh.data
tuv_ml.data
tuv_mn.data
vesNothing.BB
Wandoo_Oil.ts
Wandoo_ProducedFormationWater.ts
wind.data

APPENDIX B: SELECTED MODEL PARAMETERS

Table B.1: Base case parameters set for continental shelf reef habitat (sponges, soft corals, etc) in North West Shelf benthic habitat model. Those entries marked with an asterisk are transformed in the calculation dependent on size of habitat patches, activity/event footprint and fragmentation index for that cell of the benthic habitat model.

Parameter	**Value**	**Notes**
Small reef habitat		
Horizontal growth rate (μ_s)	0.103	estimated
Index of spread for growth (λ)	1.0	Fixed (based on expert knowledge)
Inflexion point for growth (ν)	4.0	Fixed (based on expert knowledge)
Recruitment rate (ξ)	0.05	estimated
Natural mortality rate (κ_s)	0.012	estimated
Index of spread for mortality (θ)	1.0	Fixed (based on expert knowledge)
Inflexion point for mortality (φ)	11.0	Fixed (based on expert knowledge)
Vulnerability to trawling	0.09*	Fixed (based on Hall (1999))
Vulnerability to dredging	1.0*	Fixed (based on Roberts (1998) and Newell et al. (2004)
Vulnerability to cyclones	0.4*	Fixed (based on Augustin et al. (1997))
Transition (vertical growth) rate (ω)	0.05	Fixed (based on Harrison & Cowden (1976), Barnes (1987), Garrabou & Zabala (2001) and Bell (2002))
Index of spread for transition (θ)	1.5	Fixed
Inflexion point for transition (φ)	9.0	Fixed
Number of age-size classes (χ)	10.0	Fixed (computationally efficient while still capturing the typical span of size and ages for sponges less than 20cm in height, from information in Barnes (1987)).

Table B.2: Base-case parameters set for seagrass habitat in North West Shelf benthic habitat model. Those entries marked with an asterisk are transformed in the calculation dependent on size of habitat patches, activity/event footprint and fragmentation index for that cell of the benthic habitat model.

Parameter	Value	Notes
Horizontal growth rate (μ_L)	0.5	Fixed (based on Cambridge et al. (2002) and Campbell (2003))
Growth coefficient for depth effect (ϖ)	0.1	estimated - simple least squares estimation
Growth coefficient for sediment effect (ζ)	1.0	estimated - simple least squares estimation
Natural mortality rate (κ_s)	0.2	Fixed (based on van Tussenbroek (2002) and Biber et al. (2004))
Vulnerability to trawling	0.8*	Fixed (based on Hall (1999) and Meyer et al. (1999))
Vulnerability to dredging	1.0*	Fixed (based on Cheshire & Miller (1996))
Vulnerability to cyclones	0.4*	Fixed (based on Preen et al. (1995))

Table B.3: Base-case parameters set for macroalgae in North West Shelf benthic habitat model. Those entries marked with an asterisk are transformed in the calculation dependent on size of habitat patches, activity/event footprint and fragmentation index for that cell of the benthic habitat model.

Parameter	Value	Notes
Horizontal growth rate (μ_L)	0.1	Fixed (based on Creed et al. (1998))
Growth coefficient for depth effect (ϖ)	0.1	estimated - simple least squares estimation
Growth coefficient for sediment effect (ζ)	1.0	estimated - simple least squares estimation
Natural mortality rate (κ_s)	0.2	Fixed (based on Aberg (1992) and Solidoro et al. (1997))
Vulnerability to trawling	0.7*	Fixed (based on Hall (1999))
Vulnerability to dredging	1.0*	Fixed (based on Roberts (1998) & Newell et al. (2004)
Vulnerability to cyclones	0.3*	Fixed (based on Augustin et al. (1997))

Table B.4: Base-case parameters set for mangroves in North West Shelf benthic habitat model. Those entries marked with an asterisk are transformed in the calculation dependent on size of habitat patches, activity/event footprint and fragmentation index for that cell of the benthic habitat model.

Parameter	Value	Notes
Small mangroves		
Horizontal growth rate (μ_s)	0.01	Fixed (based on Robertson & Alongi (1992))
Index of spread for growth (λ)	0.15	estimated - simple least squares estimation
Inflection point for growth (ν)	1.0	estimated - simple least squares estimation
Recruitment rate (ξ)	0.01	Fixed (based on Robertson & Alongi (1992) and McGuinness (1997))
Natural mortality rate (κ_s)	0.01	Fixed (based on Robertson & Alongi (1992))
Index of spread for mortality (θ)	1.0	estimated - simple least squares estimation
Inflection point for mortality (φ)	7.0	estimated - simple least squares estimation
Vulnerability to clearing	1.0*	Fixed (based on Semeniuk (1994), Semeniuk & Semeniuk (1995, 1997))
Vulnerability to cyclones	0.7*	Fixed (based on Grove et al. (2000) and Kathiresan & Bingham (2001))
Transition (vertical growth) rate (ω)	0.09	Fixed (based on Robertson & Alongi (1992))
Index of spread for transition (θ)	0.8	estimated - simple least squares estimation
Inflection point for transition (φ)	12.0	estimated - simple least squares estimation
Number of age-size classes (χ)	10.0	Fixed (computationally efficient while still capturing the typical span of size and ages for mangroves less than 100cm in height, from information in Robertson & Alongi (1992))
Large mangroves		
Horizontal growth rate (μ_L)	0.0005	Fixed (based on Robertson & Alongi (1992))
Growth coefficient for depth effect (ϖ)	1.0	estimated - simple least squares estimation
Growth coefficient for sediment effect (ζ)	1.0	estimated - simple least squares estimation
Natural mortality rate (κ_s)	0.001	Fixed (based on Robertson & Alongi (1992))
Vulnerability to clearing	1.0*	Fixed (based on Semeniuk (1994), Semeniuk & Semeniuk (1995, 1997))
Vulnerability to cyclones	0.7*	Fixed (based on Grove et al. (2000) and Kathiresan & Bingham (2001))

Table B.5: Limits of available biomass for the different species groups (based on Bulman, 2006).

Species group	min	max
Lutjanus sebae	2,500 t	6,500 t
large lutjanids	1,000 t	16,000 t
L. erythropterus, L. malabaricus		
lethrinids	6,500 t	220,000 t
small lutjanids	20,000 t	590,000 t
L. vitta		
nemipterids	12,000 t	70,000 t
saurids	7,000 t	35 000 t

Table B.6: Stock recruitment parameters for optimistic, base-case and pessimistic model specifications.

		Specification		
Species group	Parameter	Optimistic	Base case	Pessimistic
Lutjanus sebae	α	3000	3000	3000
	β	1000	5000	9000
Large lutjanids:	α	30000	30000	30000
L. erythropterus, L. malabaricus				
	β	100	5000	10000
lethrinids	α	300000	30000	300000
	β	10000	30000	50000
small lutjanids	α	900000	100000	300000
L. vitta				
	β	100000	10000	90000
nemipterids	α	700000	700000	700000
	β	70000	90000	100000
saurids	α	30000	30000	30000
	β	10000	50000	60000

APPENDIX C: HISTORY OF PERFORMANCE INDICATORS, REFERENCE LIMITS AND MANAGEMENT ACTIONS IN THE THREE PRAWN FISHERIES ON THE NORTH WEST SHELF

Table C.1: History of performance indicators, reference limits and management actions in the three prawn fisheries on the North West Shelf. (Source WA Dept Fisheries State of Fisheries Report, table of Stock Exploitation Status and Catch Ranges for Major Commercial Fisheries for the indicated years).

Fishery	Year	Indicator catch (t)	Expected catch (t)	reference limits: projected catch (t)	within range	comments	management action taken
Nickol Bay	92-93	84	-	100	-		
	93-94	143	100	170			
	94-95	130	170	100-150			
	95-96	115	100-150	75-150	yes		
	96-97	164	75-150	n/a	higher than expected	environmental conditions favourable to banana prawns	none
	97-98	237	n/a	10-100 banana prawns	-	high summer rain fall	none
	98-99	89	10-100 banana prawns	150-250 banana prawns	yes	low summer rainfall	
	99-00	259	150-250 banana prawns	300-500 banana prawns	higher than expected	high summer rain fall	none
	00-01	512 (467t of banana prawns)	300-500 banana prawns	90-300	yes	high summer rain fall	

Fishery	Year	Indicator catch (t)	Expected catch (t)	reference limits: projected catch (t)	within range	comments	management action taken
	01-02	11	90-300	90-300	lower than expected	below acceptable range due to environmental conditions	none
Onslow	92-93	56	-	50			
	93-94	138	50	120		catch taken from beyond traditional fishing area	
	94-95	178	120	80-100	higher than expected	favourable conditions for tiger prawns	none
	95-96	97	80-100	80-100	yes		
	96-97	94	80-100	n/a	yes		
	97-98	120	n/a	30-265	-	high rainfall	
	98-99	61	30-265	61-132	yes	low summer rainfall	
	99-00	93	61-132	61-132	yes	low summer rainfall gave low banana prawn catches	
	00-01	87	61-132	60-130	yes	high summer rainfall gave higher banana prawn catches	
	01-02	63	60-130	60-130	yes		

Fishery	Year	Indicator catch (t)	Expected catch (t)	reference limits: projected catch (t)	within range	comments	management action taken
Exmouth Gulf	92-93	1,036	-	1,100			
	93-94	1,020	1,100	1,100			
	94-95	1276	1,100	1,000-1,200			
	95-96	1192	1,000-1,200	850-1,100			
	96-97	771	850-1,100	850-1,100	lower than expected	unfavourable conditions for tiger prawns	none, but a low breeding stock of tiger prawns was recognised
	97-98	815	850-1,100	771-1,276	lower than expected	tiger prawn catches rebuilding from low levels due to cyclones	reduced acceptable limits
	98-99	1,058	771-1,276	771-1,276	yes	tiger prawn catches responding to rebuilding measures	
	99-00	1,467	771-1,276	771-1,276	higher than expected	tiger prawn catches increased due to cyclone benefit, but concern over them in some areas because CPUE<16kg/h	temporary closure
	00-01	565	771-1,276	771-1,276	lower than expected	lower tiger prawn catches due to previous cyclones, catches reduced by temporary closures	temporary closure
	01-02	670	771-1,276	771-1,276	lower than expected	lower tiger prawn catches due to previous cyclones, catches reduced by temporary closures	none

APPENDIX D: SUMMARY NOTES FROM EIA REPORTS – INPUTS AND OUTPUTS BY SITE

Site	Notes	Project Life	Construction Period	Workforce Construction; Operation	Water	Gas	Power
Industry							
Oil and Gas Report 1: Bulletin 985 - Proposed Gas to Synthetic Hydrocarbons Plant - Syntroleum Sweetwater LLC		25+ years	Not Provided	Not Available	Approximately 3 million litres per day	Nominal 135 terajoules per day from the Woodside On-shore Gas Plant	Operational power generated internally
Mehtanol Report 2: Bulletin 1075 - Methanol Plant and Product Export, Burrup Peninsula - Australian Methanol Company Pty Ltd	Uses WaterCorp outfall – must comply to ANZECC guidelines at the plant boundary	Over 25 years	Approx 23 months 30 month construction period	An estimated 500 strong construction workforce	Supply of up to 36 ML/day of raw seawater for operation of the seawater cooling (tower) system and for operation of the desalination plant	Approx 4.33 TJ/h (approx 65 tph) from the Dampier to Bunbury gas pipeline	Onsite electrical power generation will be via 8 MW steam turbine generator (primary) and 600 kVA emergency diesel power generator.
Methanol Report 3: Bulletin 1077 - Methanol Complex, Burrup Peninsula - Methanex Corporation		Over 25 years	27 months for the first plant	1000 at peak construction; up to 150 for normal operation.	Seawater - Up to 55 megalitres per day Desalination for up to 15 megalitres per-day of fresh water for potable, steam systems and cooling tower make-up. Demineralisation systems to produce high pressure steam quality water	About 400 terajoules per day for two plants	30 megawatt/plant primary and 5 megawatt emergency generation

Site	Notes	Project Life	Construction Period	Workforce Construction; Operation	Water	Gas	Power
Amonia Report 4: Bulletin 1036 - Ammonia Plant, Burrup Peninsula – Burrup Fertilisers Pty Ltd		25+ years	Approximately 20 months	operational (Karratha-based) workforce of 50 people.	Potable Water - 7-10 kilolitres per hour Seawater - Approximately 1.6 megalitres per hour; 38 megalitres per day	Approximately 74 terajoules per day	Internal generation. Two (1 x operating 100% capacity and 1 x operating 25% capacity) 20 megawatts steam turbine generators. Supply of energy (approx 4 megawatts of electricity) to the desalination plant
Amonia Report 5: Bulletin 1065 - Ammonia-Urea Plant, Burrup Peninsula - Dampier Nitrogen Pty Ltd			Not Provided	Not Provided	Seawater for cooling Process Plant - 2,300-3,000 kL/h from the Water Corporation (to be drawn from Mermaid Sound) Desalination plant - 3500 kL/h from the Water Corporation	93 TJ/day from LNG Plant Also Urea formaldehyde - 11 000tpa approximately. To be trucked	Internal generation, with some export. Supplied by two combined cycle 15MW gas turbines, steam boiler and emergency generators (to be specified)
Infrastructure							
Upgrade marine services Report 6: Bulletin 964 – Upgrade of Marine Service Facilities, King Bay, Dampier – Mermaid Marine Australia Ltd				Not Provided			
Upgrade marine services Report 9:			8 Months	30 (peak);?			

Site	Notes	Project Life	Construction Period	Workforce Construction; Operation	Water	Gas	Power
Bulletin 1042 - Dampier Public Wharf Expansion – Load-out Facility and Lay-down Area, Port of Dampier - Western Stevedores Pty Ltd							
Desalination Report 7: Bulletin 1014 - Desalination and Seawater Supplies Project, Burrup Peninsula - Water Corporation		25 + years	Approximately 15 months.	Peak 50 persons; estimated 6 persons.	Seawater Initially – approximately 18 megalitres/day (winter) to approximately 38 megalitres/day (summer). Finally - up to 100 megalitres/day		Approximately 1MW to 1.5MW, supplied from Syntroleum.
Desalination Report 8: Bulletin 1044 - Upgrade of multi-user seawater supply and introduction of wastewater to ocean outfall, Burrup Peninsula, Change to Environmental Conditions Water Corporation		25 +years	Approximately 20 months	Peak 50 persons; estimated 6 persons.	The proponent estimates the total seawater demand 280 ML/d		Pump station . ultimately, approximately 3 MW, supplied from process plants

APPENDIX E: InVitro AGENT FILES

The following table contains documented agent files. Each table contains the parameters used for that agent-type and taxon (e.g. species). Where data is hierarchical the lower layers are listed under the higher level title. A description of the parameter and notes on the source of the values used are also provided. An “&include” entry indicates the parameters from the specificed agents file were also loaded when loading the base file.

Table E.1: anzecc file - used to set trigger levels for contaminant concentrations. Taken from ANZECC guidelines ISBN: 09578245 0 5 Vol 2, pp 101-302, Australian and New Zealand Guidelines for fresh and marine water quality (2000) - only a subset of the contaminants listed are present in the model. Some of the values are low in reliability, but typically the 95% ANZECC has usually gone in as the “default” unless otherwise noted. Note that all levels are in ug/l unless otherwise specified and that the default value was typically used.

Parameter	Value	Notes
global_callback		program control parameter - controls the form of management model interactions
integrated-management	1	
default	0	
AdjustmentLag	3	Management scenario parameter
AdjustmentInterval	quarterly	Management scenario parameter
OutflowControl	1	
lethal_contaminants		
Bitterns		Not present in ANZECC
conc		
default	700000	
protective	500000	MGMT Parameter: trigger level for epa action
industrial	990000	MGMT Parameter: trigger level for epa action
rate		
default	0.65	
strong_reaction	0.5	MGMT Parameter controls EPA throttle rate

Table E.1: Continued

Parameter	Value	Notes	Parameter
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
conc			
	default	8000	
	protective	2000	MGMT Parameter: trigger level for epa action
	industrial	10000000	MGMT Parameter: trigger level for epa action
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Cadmium			
conc			
	default	0.7	99% protection
	protective	0.2	MGMT Parameter: trigger level for epa action ; recommended for prawn areas
	industrial	5.5	MGMT Parameter: trigger level for epa action ; 95% protection at this level
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Chromium			
conc			
	default	4.4	for Cr(VI) @ 95%
	protective	1.1	MGMT Parameter: trigger level for epa action
	industrial	10	for Cr(III) @ 95%; MGMT Parameter: trigger level for epa action

Table E.1: Continued

Parameter		Value	Notes
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Cobalt			
conc			
	default	1	95% protection
	protective	0.03	MGMT Parameter: trigger level for epa action
	Industrial	3	MGMT Parameter: trigger level for epa action
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Copper			
conc			
	default	1.3	95% protection
	protective	0.04	MGMT Parameter: trigger level for epa action
	industrial	4	MGMT Parameter: trigger level for epa action
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate

Table E.1: Continued

Parameter			Value	Notes
Lead				
	conc			
		default	4.4	for Cr(VI) @ 95%
		protective	1.1	MGMT Parameter: trigger level for epa action
		industrial	10	for Cr(III) @ 95%; MGMT Parameter: trigger level for epa action
	rate			
		default	0.65	
		strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
		mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Manganese				
	conc		80	low reliability
	rate			
		default	0.65	
		strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
		mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
	conc		3	low reliability
		default	0.65	
		strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
		mild_reaction	0.8	MGMT Parameter controls EPA throttle rate

Table E.1: Continued

Parameter	Value	Notes
Mercury		
conc		
default	0.4	95% protection
protective	0.1	99% recommended for disturbed systems MGMT Parameter: trigger level for epa action
industrial	10	MGMT Parameter: trigger level for epa action
rate		
default	0.65	
strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Nickel		
conc		
default	70	95% protection
protective	7	99% recommended for disturbed systems; MGMT Parameter: trigger level for epa action
industrial	100	MGMT Parameter: trigger level for epa action
rate		
default	0.65	
strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Zinc		

Table E.1: Continued

Parameter		Value	Notes
conc			
	default	15	95% protection
	protective	7	MGMT Parameter: trigger level for epa action
	Industrial	45	MGMT Parameter: trigger level for epa action
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Silver			
conc			
	default	1.4	95% protection
	protective	0.05	MGMT Parameter: trigger level for epa action
	industrial	2	MGMT Parameter: trigger level for epa action
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
TBT			
conc			
	default	0.006	95% protection
	protective	0.001	MGMT Parameter: trigger level for epa action
	industrial	0.01	MGMT Parameter: trigger level for epa action

Table E.1: Continued

Parameter		Value	Notes
rate			
	default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Tin			
conc			
	default	6	95% protection
	protective	1	MGMT Parameter: trigger level for epa action
	industrial	10	MGMT Parameter: trigger level for epa action
Tin			
rate			
	Default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
	mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Oil			
conc			
	Default	7000	low reliability
	Protective	5000	MGMT Parameter: trigger level for epa action
	Industrial	21000	MGMT Parameter: trigger level for epa action
rate			
	Default	0.65	
	strong_reaction	0.5	MGMT Parameter controls EPA throttle rate

Table E.1: Continued

Parameter	Value	Notes
mild_reaction	0.8	MGMT Parameter controls EPA throttle rate
Condensate		
conc		
Default	500	low reliability
Protective	200	MGMT Parameter: trigger level for epa action
Industrial	1500	MGMT Parameter: trigger level for epa action
rate		
Default	0.65	
strong_reaction	0.5	MGMT Parameter controls EPA throttle rate
mild_reaction	0.8	MGMT Parameter controls EPA throttle rate

Table E.2: contamination-prawns file (LC levels, uptake and decay rates). The values in this file were taken from the ASEAN documents unless otherwise specified. Not all the data in this file is used. Not all contaminants in the file are present in the simulation. The best values reported in the source documents were used.

Parameter		Value	Notes
logs_contamination			program control parameter - sets whether this species writes contamination date to disk
	default	1	
	NoContaminants	0	
	Intensive_tracking	1	
contamination_track_interval	daily		program control parameter - determines how frequently tissueloads are written to file
tracks_contamination			controls whether or not species interacts with contaminants
	NoContaminants	0	
	default	0	
	fish	1	
	population	0	
	larva	0	
	blastula	0	
contaminants			
AccumToxin			
conc		0	
LDT		3.46E+08	duration of LC trial from ASEAN document
LD50		4.60E+20	LC50 in ug/L*10e8 from ASEAN document
LD100		1.00E+21	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
Nbins		50	
L_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.003587	/day

Table E.2: Continued

Parameter		Value	Notes
	low_uptake	0.003	/day
AccumToxin	mid_uptake	0.003587	/day
L_Uptake			
	high_uptake	0.004	/day
			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
NL_Uptake			
	default	1.00E-08	
	low_uptake	1.00E-09	
	high_uptake	1.00E-07	
Halflife		10*year	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Bitterns			
LDT		Day	duration of LC trial from ASEAN document
LD50		4.00E+07	LC50 in ug/L*10e8 from ASEAN document
LD100		1.20E+08	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	
L_Uptake		0	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.000464	
	low_uptake	0.000164	
	high_uptake	0.000464	

Table E.2: Continued

Parameter		Value	Notes
Halflife		12*hour	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Nbins		50	
			Sulphate levels for freshwater species exist in
			http:// wlapwww.gov.bc.ca/wat/wq/BCguidelines/sulphate.htm
Table E.: Continued			
Parameter		Value	Notes
Sulphate			
LDT		Day	duration of LC trial from ASEAN document
LD50		1.20E+05	LC50 in ug/L*10e8 from ASEAN document
LD100		4.00E+05	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	
Nbins		50	
NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	1.00E-06	
	low_uptake	1.00E-07	
	high_uptake	1.00E-05	
L_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.000358	/day
	low_uptake	0.0003	/day
	mid_uptake	0.000358	/day
	high_uptake	0.0004	/day

Table E.2: Continued

Parameter		Value	Notes
halflife			halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
	default	36*hour	
	low_uptake	40*hour	
	mid_uptake	36*hour	
	high_uptake	29*hour	
Cadmium			calibrated to reflect Hashmi, Mustafa and Tariq (2002)
conc		0	
LDT		345600	duration of LC trial from ASEAN document
LD50		4.60E+10	LC50 in ug/L*10e8 from ASEAN document
LD100		3.00E+11	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
nbins		50	
Controlled_Uptake		110	concentration level at which the uptake slope changes (estimated from Hashmi et al. 2000)
Controlled_Slope		0.000005	/day rate of uptake at lower concentrations (estimated from Hashmi et al. 2000)
Uncontrolled_Slope		0.0001625	/day rate of uptake at higher concentrations (estimated from Hashmi et al. 2000)
halflife		Year	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Copper			calibrated to reflect Hashmi, Mustafa and Tariq (2002)
LDT		172800	duration of LC trial from ASEAN document
LD50		1.40E+10	LC50 in ug/L*10e8 from ASEAN document
LD100		3.00E+10	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	

Table E.2: Continued

Parameter	Value	Notes
NL_Uptake	0.00047	/day Linear and NonLinear uptake rates, calibrated to provide observable effect over time
L_Uptake	0.00035	/day Linear and NonLinear uptake rates, calibrated to provide observable effect over time
lambda	4.38E-08	decay rate of contaminant in the absence of additional input (unused)
Lead		calibrated to reflect Hashmi, Mustafa and Tariq (2002)
LDT	345600	duration of LC trial from ASEAN document
LD50	2.85E+10	LC50 in ug/L*10e8 from ASEAN document
LD100	6.00E+10	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc	0	
Controlled_Uptake	80	concentration level at which the uptake slope changes (estimated from Hashmi et al. 2000)
Controlled_Slope	0.000005	/day rate of uptake at lower concentrations (estimated from Hashmi et al. 2000)
Uncontrolled_Slope	0.0001825	/day rate of uptake at higher concentrations (estimated from Hashmi et al. 2000)
halflife	1.5*year	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Zinc		
LDT	345600	duration of LC trial from ASEAN document
LD50	1850	LC50 in ug/L*10e8 from ASEAN document
LD100	4000	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc	0	
Zinc	0.3	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
NL_Uptake		
L_Uptake	1.00E-05	Linear and NonLinear uptake rates, calibrated to provide observable effect over time

Table E.2: Continued

Parameter	Value	Notes
lambda	4.38E-08	decay rate of contaminant in the absence of additional input (unused)
Oil		
LDT	day	duration of LC trial from ASEAN document
LD50	10	LC50 in ug/L*10e8 from ASEAN document
LD100	100	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc	0	
NL_Uptake	0.1	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
L_Uptake	1.00E-05	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
lambda	1.00E-06	decay rate of contaminant in the absence of additional input (unused)
PFW		
LDT	day	duration of LC trial from ASEAN document
LD50	100	LC50 in ug/L*10e8 from ASEAN document
LD100	1000	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc	0	
NL_Uptake	0.1	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
L_Uptake	1.00E-05	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
Lambda	1.00E-06	decay rate of contaminant in the absence of additional input (unused)

Table E.3: contamination-oysters file (LC levels, uptake and decay rates). The values in this file were taken from the ASEAN documents unless otherwise specified. Not all the data in this file is used. Not all contaminants in the file are present in the simulation. The best values reported in the source documents were used.

Parameter		Value	Notes
logs_contamination			program control parameter - sets whether this species writes contamination date to disk
	NoContaminants	0	
	default	1	
contamination_track_interval	daily		program control parameter - determines how frequently tissueloads are written to file
tracks_contamination			controls whether or not species interacts with contaminants
	NoContaminants	0	
	default	0	
	fish	1	
	population	0	
	larva	0	
	blastula	0	
contaminants			
AccumToxin			
conc		0	
LDT		3.46E+08	duration of LC trial from ASEAN document
LD50		4.60E+20	LC50 in ug/L*10e8 from ASEAN document
LD100		1.00E+21	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
nbins		50	
L_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.003587162	/day
	low_uptake	0.003	/day

Table E.3: Continued.

Parameter		Value	Notes
	mid_uptake	0.003587162	/day
	high_uptake	0.004	/day
AccumToxin NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	1.00E-08	
	low_uptake	1.00E-09	
	high_uptake	1.00E-07	
Halflife		10*year	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
lethal_contaminants			
Bitterns			
LDT		day	duration of LC trial from ASEAN document
LD50		0.04	LC50 in ug/L*10e8 from ASEAN document
LD100		0.12	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	
L_Uptake		0	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.000464	
	low_uptake	0.000164	
	high_uptake	0.000464	
Halflife		12*hour	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Nbins		50	
			Sulphate levels for freshwater species exist in

Parameter		Value	Notes
			http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/sulphate.html
Sulphate			
LDT		day	duration of LC trial from ASEAN document
LD50		5900	LC50 in ug/L*10e8 from ASEAN document
LD100		20000	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	
Nbins		50	
NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	1.00E-06	
	low_uptake	1.00E-07	
	high_uptake	1.00E-05	
L_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.0003587162	/day
	low_uptake	0.0003	/day
	mid_uptake	0.0003587162	/day
	high_uptake	0.0004	/day
halflife			halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
	default	36*hour	
	low_uptake	40*hour	
	mid_uptake	36*hour	
	high_uptake	29*hour	
Cadmium			
conc		0	

Table E.3: Continued.

Parameter		Value	Notes
LDT		345600	duration of LC trial from ASEAN document
LD50		2210	LC50 in ug/L*10e8 from ASEAN document
LD100		1000	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
nbins		50	
L_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	0.003587162	/day
	low_uptake	0.003	/day
	mid_uptake	0.003587162	/day
	high_uptake	0.004	/day
NL_Uptake			Linear and NonLinear uptake rates, calibrated to provide observable effect over time
	default	1.00E-08	
	low_uptake	1.00E-09	
	high_uptake	1.00E-07	
halflife		10*year	halflife of contaminant in the absence of additional input only relevant to prawns (estimated from Hashmi et al. 2000)
Copper			
LDT		172800	duration of LC trial from ASEAN document
LD50		2440	LC50 in ug/L*10e8 from ASEAN document
LD100		4840	LC100 in ug/L*10e8 (An upper bound - not necessarily the least upper bound)
conc		0	
NL_Uptake		0.3	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
L_Uptake		1.00E-05	Linear and NonLinear uptake rates, calibrated to provide observable effect over time
lambda		4.38E-08	decay rate of contaminant in the absence of additional input (unused)

Table E.4: banana prawn (*Penaeus merguiensis*) parameter file.

Parameter		Value	Notes	
agent_cap			program control parameter	
	default	400		
	Intensive_tracking	300		
	NoContaminants	0		
fast_maturing		1	program control param - allows agents to breed quickly after juvenile stage	
eggmortality			Determines pre-larval mortality applied to number of eggs produced	
	default	1/1.1e6	The ratio of eggs surviving to settlement to the number originally spawned. Calculated by solving for the rate that lead to a stable population level.	
may_nest			program control parameter - allows for nesting of this agent type within other agents	
	fish	1		
	default	1		
	blastula	0		
cull_period	week*4		periodicity of natural mortality (tuned to match runtime resolution)	
Carrying_capacity			estimated based on stock assessments from the Northern Prawn Fishery (NPF). Based on	
	default	1.50E+07	consultation with Cathy Dichmont (CSIRO) and Mervi Kangas (WA fisheries) the carrying capacity was set to a third of the NPF value. This was then revised down using the rule of thumb that catch at MSY is roughly 0.2*0.6*Biomass (from NPF assessments).	
	low	4.00E+06		
	medium	8.00E+06		
	high	1.50E+07		
Maximum_Age		2	years	Kailola et al. (1993)
t_zero		0.05	years	Age of maturity (used in mortality calculations); from Kailola et al. (1993)
Rate_Mortality		0.4	/ year	based on Taylor and Dichmont (2001)

Table E.4: Continued

Parameter	Value		Notes
Catastrophic_Mortality		Mortality rate during catastrophic storm event	
default	0.15	/ event	Guesstimate based on expert opinion and information in Taylor and Dichmont (2001) and Kailola et al. (1993)
low	0.3	/ event	Maximum value from guesstimate's credible range
medium	0.15	/ event	Guesstimate based on expert opinion and information in Taylor and Dichmont (2001) and Kailola et al. (1993)
high	0.07	/ event	Minimum value from guesstimate's credible range
Speed	0.08	metres / second	Cruising speed; Hill (1985)
MaxSpeed	1.8	metres / second	Hill (1985)
SearchRadiusExponent	2	governs how far afield we assume organisms can detect conditions (estimated based on velocity)	
Directional_variability	0.2	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability	0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time	1	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t	0.15	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t)))	
Mass_t	0.03	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t)))	
IndividualMass	0.03	Typical mass (kg) of an individual; direct measurement	
Width_a	0.015	dimensions of organism; directly measured	
Gape/Width	0.005	ratio of gape to width (estimated from direct measurements)	
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)	

Table E.4: Continued

Parameter		Value	Notes	
Metabolism		0	kg of food burned per second	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
Max_mass			Upper limit of mass	
	default	0.07	kg	Kailola et al. (1993)
mass_lambda		0.6	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)	
Safe_Range		6	six times the cruising speed	estimated from visibility ranges; not used when adequate food assumed
Neighbourhood		0		
Perception_Range		20	times the cruising speed	The range at which prey may be detected; estimated from visibility ranges; not used when adequate food assumed
Eating_Range		1	seconds	How close it must get seconds to it's prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
spatialLarvalFactor		1E-11	calibrated to give a plausible stock-recruit relationship	
Fecundity_rate		1200000	mass based correction to maximum fecundity (calibrated to match field spawning rates – as opposed to laboratory determined maximum egg production)	
Fecundity			eggs / female at maximum size	Maximum potential fecundity rate; Kailola et al. (1993)
	default	7200000		
	low	5500000		
	medium	7200000		
	high	8500000		
	testing	2000		

Table E.4: Continued

Parameter		Value	Notes
Fecundity			
	referencename	rainfall	environmental scalar to fecundity – from expert opinion Mervi Kangas (WA fisheries)
	referencelevel	50	reference level for environmental scalar - mean rainfall value over 60 day period prior to median banana prawn recruitment (as calculated from catch time series)
	referencename2	NoScaling	secondary environmental scalar to fecundity – not in effect here
	referencelevel2	1	reference level for secondary environmental scalar – not in effect here
Breeding			
age		week*26	breeding age; from Kailola et al. (1993)
start		week*6	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset		0	allows for continuous breeding – not needed for this species
period		week*26	time between individual breeding seasons; Kailola et al. (1993)
duration		week*13	length of breeding season ; from Kailola et al. (1993)
fallow_period		week*13	time time between breeding events; from Kailola et al. (1993)
habitat		seagrass	location of breeding; from Kailola et al. (1993)
scale		0.5	habitat scalar on realised fecundity (calibrated)
radius		800	metres distance from habitat patch that spawning behaviour may begin
Group_Size			program control parameter – dictates maximum school size (above this the school splits)
	default	1500000	
	testing	1000	
Group_Stddev		50	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion		300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)

Table E.4: Continued

Parameter		Value	Notes
Group_Terminal			when schools drop below this they are culled (if they can not merge first)
	default	2000	group size below which school disperses
	testing	20	
Group_Must_Merge			program control parameter dictating at what points schools try to merge with other schools of same taxon
	default	20000	group must try and merge if it gets this low
	testing	10	
merge_radius_scale		200	merge radius (to merge must be within this radius in m) – typically set to about 20000x speed
Bored_Tick			Maximum standard time step length
	default	week	
	very_fast	day	
	fast	week	
	slow	week*4	
Tick_Length			Typical time step length
	default	week	
	very_fast	3600	seconds
	fast	day	
	moderate	week	
	slow	2*week	
Excited_Tick			Standard time step length if in active state
	default	1.5*hour	seconds
	very_fast	60	seconds

Table E.4: Continued

Parameter	Value	Notes	
fast	3600	seconds	
slow	600	seconds	
Minimum_Depth	-0.5	metres	minimum preferred depth; Kailola et al. (1993)
Best_Depth	-20	metres	median preferred depth; Kailola et al. (1993)
Maximum_Depth	-40	metres	maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-1	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth		maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)	
default	-50		
very_shallow	-18	used when retaining them within Nickol Bay (for contaminant trials)	
shallow	-20		
large_range	-70	metres	
full_range	-90	metres	Kailola et al. (1993)
radius	10000	metres	school extent
trawl_efficiency	0.1	efficiency of trawlers against species (analogous to selectivity in the population agents); set using expert opinion	
spatialCatchFactor	0.05	calibrated to minimise differences between observed and predicted catches	
selMass	0.05	kg	mass juveniles when first susceptible to fishing (estimated)
assess_environment	1	flag to show whether species seeks favourable environments	
Awareness_type	0	0 for fine scale awareness, 1 for large scale	program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. 2005)

Table E.4: Continued

Parameter	Value	Notes
ScalingBestSeaDepth		
default	0.0001	Weighting for influence of preferred depth in guiding habitat selection
Mass0	0.001	kg mass of individual fish larvae at notional hatching point
FastMaturation	1	1 = can reproduce soon after recruiting to adult population
Larva		Juvenile parameters
MetabolismType	4	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)
tick_length	1200	seconds Typical time step length for juvenile age stages
bored_tick	81400	seconds Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency	0	efficiency of trawlers against juveniles of this species (expert opinion, Neil Lonergan pers. comm.)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	10000	metres Radius of juvenile patch / school (estimated from aerial photographs)
spatialLarvalFactor	1E-11	settlement "stock-recruit" relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		Parameters for first age phase of larval agents
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)
Current_K	0.4	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen

Table E.4: Continued

Parameter	Value	Notes
Wind_K	0.1	metres / second — coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second — average based on slicks
RadialDiffusion	0.005	metres / second — average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
Second		Parameters for second age phase of larval agents
Current_K	0	metres / second — coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second — coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second — average based on slicks
RadialDiffusion	0.001	metres / second — average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
CarryingCapacityAlpha	0.3	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Taylor and Dichmont (2001) and Bulman (2006)
CarryingCapacityBeta	3	mnimum square metres required to support a kg of settled juveniles; calculated from Taylor and Dichmont (2001) and Bulman (2006)
Third		Parameters for third age phase of larval agents
Current_K	1	metres / second — coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second — coefficient for movement of unsettled larva with winds; set to zero as directed movement

Table E.4: Continued

Parameter		Value	Notes	
Settling				
age		1814400	seconds	age when begin settling; Kailola et al. (1993)
radius		10000	metres	distance from centre of bed of suitable habitat type that will settle
scale		0.5	scalar on habitat quality for settling	
offset		1	offset on habitat quality for settling	
habitat		seagrass	suitable settling habitat	
habitat_type		4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)	
direction_travel		1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage	
Recruitment				
age		0.75 * year	age when begin recruiting to adult population; Kailola et al. (1993)	
radius		10000	distance from centre of bed of suitable habitat type that will recruit	
temporal_radius			time in blastula queue when "close enough" to recruit; calibrated to give realistic settlement patterns	
	default	day * 13		
	short	week		
	long	4 * week		
scale		0.5	scalar on recruitment habitat preferences	
offset		1	offset on recruitment habitat quality	
habitat		none	identifies suitable recruiting habitat (none indicates no preference)	
habitat_type		5	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)	
direction_travel		0	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage	

Table E.4: Continued

Parameter		Value	Notes
aggregate_rate		0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Fish	0.9	
	Tuna	0.9	
	Shark	0.9	
habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Seagrass	0.9	
	Seabed	0.1	
	Seagrass_thresh	300000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
			&include Include/contamination-prawns

Table E.5: king prawn (Penaeus latisulcatus, Penaeus longistylus and Metapenaeus endeavouri, Metapenaeus ensis, Penaeus esculentus) parameter file.

Parameter	Value	Notes
agent_cap		program control parameter
Default	400	
NoContaminants	0	
Intensive_tracking	300	
fast_maturing	1	program control param - allows agents to breed quickly after juvenile stage
eggmortality		Determines pre-larval mortality applied to number of eggs produced
Default	1/2e6	The ratio of eggs surviving to settlement to the number originally spawned. Calculated by solving for the rate that lead to a stable population level.
may_nest		program control parameter - allows for nesting of this agent type within other agents
Fish	1	
Default	1	
Blastula	0	
cull_period week*4		periodicity of natural mortality (tuned to runtime resolution)
Carrying_capacity		estimated based on stock assessments from the Northern Prawn Fishery (NPF). Based on consultation with Cathy Dichmont (CSIRO) and Mervi Kangas (WA fisheries) the carrying capacity was set to a third of the NPF value. This was then revised down using the rule of thumb that catch at MSY is roughly 0.2*0.6*Biomass (from NPF assessments).
Default	1.67E+07	
Low	8.00E+06	
Medium	1.20E+07	
High	1.60E+07	
Maximum_Age	4	years Kailola et al. (1993)
t_zero	0.05	years Age of maturity (used in mortality calculations); from Kailola et al. (1993)
Rate_Mortality	0.35	/ year based on Taylor and Dichmont (2001)

Table E.5: Continued

Parameter	Value	Notes
Catastrophic_Mortality		Mortality rate during catastrophic storm event
Default	0.2	/ event Guesstimate based on expert opinion and information in Taylor and Dichmont (2001) and Kailola et al. (1993)
Low	0.15	/ event Maximum value from guesstimate's credible range
Medium	0.2	/ event Guesstimate based on expert opinion and information in Taylor and Dichmont (2001) and Kailola et al. (1993)
High	0.15	/ event Minimum value from guesstimate's credible range
Speed	0.08	metres / second Crusing speed; Hill (1985)
MaxSpeed	1.8	metres / second Hill (1985)
SearchRadiusExponent	2	governs how far afield we assume organisms can detect conditions (estimated based on velocity)
Directional_variability	0.2	degree to which they remain moving in a single facing (direction); calibrated
Speed_variability	0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)
Length_t	0.15	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Mass_t	0.03	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
IndividualMass	0.03	Typical mass (kg) of an individual; direct measurement
Width_a	0.015	dimensions of organism; directly measured
Gape/Width	0.005	ratio of gape to width (estimated from direct measurements)
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)
Metabolism	0	kg of food burned per second determines if organisms must hunt or adequate food is assumed (later assumed for MSE runs here)

Table E.5: Continued

Parameter	Value	Notes
Max_mass		Upper limit of mass
default	0.1	kg Kailola et al. (1993)
mass_lambda	0.6	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
Safe_Range	6	six times the cruising speed estimated from visibility ranges; not used when adequate food assumed
Neighbourhood	0	
Perception_Range	20	times the cruising speed range at which prey may be detected
Eating_Range	1	seconds How close it must get seconds to its prey (assuming the prey isn't “safe”) – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
spatialLarvalFactor		calibrated to give a plausible stock-recruit relationship
default	1E-11	
low	4.5E-06	
medium	2.5E-06	
high	5.5E-07	
Fecundity_rate	1000000	mass based correction to maximum fecundity (calibrated to match field spawning rates – as opposed to laboratory determined maximum egg production)
Fecundity		eggs / female at maximum size Maximum potential fecundity rate; Kailola et al. (1993)
default	7500000	
low	6000000	
medium	7500000	
high	10000000	
testing	2000	

Table E.5: Continued

Parameter	Value	Notes
referencename	NoScaling	environmental scalar to fecundity – not in effect here
referencelevel	1	reference level for environmental scalar – not in effect here
referencename2	NoScaling	secondary environmental scalar to fecundity – not in effect here
referencelevel2	1	reference level for secondary environmental scalar – not in effect here
Breeding		
age	week*26	breeding age; from Kailola et al. (1993)
start	week*32	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset	0	allows for continuous breeding – not needed for this species
period	week*52	time between individual breeding seasons; Kailola et al. (1993)
duration	week*26	
fallow_period	week*26	time time between breeding events; from Kailola et al. (1993)
habitat	seagrass	
scale	0.5	habitat scalar on realised fecundity (calibrated)
radius	800	metres distance from habitat patch that spawning behaviour may begin
Group_Size		program control parameter – dictates maximum school size (above this the school splits)
default	2000000	
testing	1000	
Group_Stddev	50	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion	300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Terminal		when schools drop below this they are culled (if they can not merge first)

Table E.5: Continued

Parameter	Value	Notes
default	2000	group size below which school disperses
testing	20	
Group_Must_Merge		program control parameter dictating at what points schools try to merge with other schools of same taxon
default	20000	group must try and merge if it gets this low
testing	10	
merge_radius_scale	200	merge radius (to merge must be within this radius in m) – typically set to about 20000x speed
Bored_Tick		Maximum standard time step length
default	week	
very_fast	day	
fast	week	
slow	week*4	
Tick_Length		Typical time step length
default	week	
very_fast	3600	seconds
fast	day	
moderate	week	
slow	2*week	
Excited_Tick		Standard time step length if in active state
default	1.5*hour	
very_fast	60	seconds
fast	3600	seconds

Table E.5: Continued

Parameter	Value	Notes
slow	600	seconds
Minimum_Depth	-0.1	metres minimum preferred depth; Kailola et al. (1993)
Best_Depth	-10	metres median preferred depth; Kailola et al. (1993)
Maximum_Depth	-40	metres maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-0.1	metres minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth		maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
default	-120	
very_shallow	-18	used when retaining them within Nickol Bay (for contaminant trials)
shallow	-20	
large_range	-70	metres
full_range	-90	metres Kailola et al. (1993)
radius	10000	metres school extent
trawl_efficiency	0.1	efficiency of trawlers against species (analogous to selectivity in the population agents); set using expert opinion
spatialCatchFactor	0.05	calibrated to minimise differences between observed and predicted catches
selMass	0.05	kg mass juveniles when first susceptible to fishing (estimated)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	0	0 for fine scale awareness, 1 for large scale program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth		
default	0.0001	Weighting for influence of preferred depth in guiding habitat selection
Mass0	0.001	kg mass of individual fish larvae at notional hatching; must be greater than zero

Table E.5: Continued

Parameter	Value	Notes
FastMaturation	1	1 = can reproduce soon after recruiting to adult population
Larva		Juvenile parameters
MetabolismType	4	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
tick_length	1200	seconds Typical time step length for juveniles
bored_tick	81400	seconds Maximum standard time step length fore juveniles
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency	0	efficiency of trawlers against juvenile stages (expert opinion Neil Loneragan pers. comm.)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	10000	metres Radius of juvenile patch / school (estimated from aerial photographs)
spatialLarvalFactor	0.00002	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		Parameters for first age phase of larval agents
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)
Current_K	0.4	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second average based on slicks
RadialDiffusion	0.005	metres / second average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced

Table E.5: Continued

Parameter	Value	Notes
Second		Parameters for second age phase of larval agents
Current_K	0	metres / second coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second average based on slicks
RadialDiffusion	0.001	metres / second average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
CarryingCapacityAlpha	0.3	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Taylor and Dichmont (2001) and Bulman (2006)
CarryingCapacityBeta	3	mnimum square metres required to support a kg of settled juveniles; calculated from Taylor and Dichmont (2001) and Bulman (2006)
Third		Parameters for third age phase of larval agents
Current_K	1	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling		
age	1814400	age when begin settling; Kailola et al. (1993)
radius	10000	distance from centre of bed of suitable habitat type that will settle
scale	0.5	scalar on habitat quality for settling
offset	1	offset on habitat quality for settling
habitat	seagrass	identifies suitable settling habitat

Table E.5: Continued

Parameter	Value	Notes
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Recruitment		
age	0.3 * year	age when begin recruiting to adult population; Kailola et al. (1993)
radius	10000	distance from centre of bed of suitable habitat type that will recruit
temporal_radius		time in blastula queue when "close enough" to recruit; calibrated to give realistic settlement patterns
default	day * 13	
middle	day * 9	
short	week	
long	4 * week	
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	none	identifies suitable recruiting habitat (none indicates no preference)
habitat_type	5	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel	0	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
aggregate_rate	0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition
Fears		relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
Fish	0.9	
Tuna	0.9	
Shark	0.9	

Table E.5: Continued

Parameter	Value	Notes
Habitat		relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
seagrass	0.9	
Seabed	0.5	
Seagrass_thresh	300000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
		&include Include/contamination-prawns

Table E.6: lethrinid (leth) file.

Parameter		Value	Notes
Assess_environment		1	flag to show whether species seeks favourable environments
restricted_area		pilbara-closed	zones fisheries targeting this species must avoid
control_area		pilbara-zones	zones fisheries targeting this species must be aware of
Carrying_capacity			estimated from Bulman (2006) and gradient parameter search
	default	1.50E+07	in kg
	Standard	35000000	in kg
Maximum_Age		14	years FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero		1	years Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality		0.25	/ year FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality		0	/event mortality rate during catastrophic storm event
Speed		0.7	metres / second cruising speed from FISHBASE (2005)
SpeedScale		0.1	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)
MaxSpeed		1.8	metres / second from FISHBASE (2005)
SearchRadiusExponent		2	governs how far afield we assume organisms can detect conditions (estimated on velocity)
Directional_variability		0.5	degree to which they remain moving in a single facing (direction); calibrated
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)
Traverse_Time		10	months Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		0.5	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Mass_t		2	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))

Table E.6: Continued

Parameter	Value	Notes	
Width_a	0.1	dimensions of organism; directly measured	
Width_b	0.17	dimensions of organism; directly measured	
Gape/Width	0.9	ratio of gape to width (estimated from direct measurements)	
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)	
Metabolism	0	kg of food burned per second	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
propMale	0.5	proportion male (from WA fisheries stock assessments, P. Stephenson 2003)	
Mlinf	31.52	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mlength_lambda	0.716	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mvbt0	-0.472	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthA	1.28E-08	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthB	3.0881	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flinf	29.31	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flength_lambda	0.742	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Fvbt0	-0.471	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthA	1.29E-08	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthB	3.0881	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Safe_Range	6	six times the cruising speed	estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed	range at which prey may be detected

Table E.6: Continued

Parameter		Value	Notes	
Eating_Range		1	seconds	How close it must get seconds to its prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
ScalingMult		0.65	calibrated	
BHa			Beverton-Holt alpha in numbers not biomass - estimated from fisheries data from WAFMA and logbooks	
	default	3.00E+05		
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks	
	default	3.00E+04		
	low	5.00E+04		
	medium	3.00E+04		
	high	1.00E+04		
sel50		35	(~3.5years); expert opinion, P. Stephenson pers. comm.	
sel25		12.76	expert opinion, P. Stephenson pers. comm.	
linesel50		22.5	a guestimate based on GBR take rates and overall fish lengths	
linesel25		15.5	a guestimate based on GBR take rates and overall fish lengths	
fec50		34.5	expert opinion, P. Stephenson pers. comm.	
fec95		25.5	expert opinion, P. Stephenson pers. comm.	
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al. (1998)	
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)	
minLegalLength		35	Minimum legal length - so recreational fishers know what they can toss back; WA fisheries regulations	
selMass		0.2	kg	mass juveniles when first susceptible to fishing (estimated)

Table E.6: Continued

Parameter	Value	Notes
spatialCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)
default	1.00E-02	
spatialTrapCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
default	1.00E-02	
numberParms	4	number of parms to estimate in stock assessment (if performed for this species)
Max_mass	8.5	kg Upper limit of mass; Kailola et al. (1993) and FISHBASE (2005)
mass_lambda	0.03	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity	1000000	how many larvae it may engender - if fish agent not population agent; from Kailola et al. (1993)
Breeding		
age	week*208	breeding age; from Kailola et al. (1993)
Start	week*17	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset	0	allows for continuous breeding – not needed for this species
Period	year	time between individual breeding seasons; Kailola et al. (1993)
fallow_period	0	time time between breeding events; from Kailola et al. (1993)
Group_Size		program control parameter – dictates maximum school size (above this the school splits)
default	7.00E+05	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))

Table E.6: Continued

Parameter	Value	Notes
Standard	10000000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))
Group_Stddev	500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion	300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Terminal	300	group size below which school disperses when schools drop below this they are culled (if they can not merge first)
Excited_Tick	604800	seconds Standard time step length if in active state
Alarmed_Tick	604800	seconds Standard time step length if in active state
Bored_Tick	7862400	seconds Maximum standard time step length
Tick_Length	7862400	seconds Typical time step length
Minimum_Depth	-1	metres minimum preferred depth; Kailola et al. (1993)
Best_Depth	-40	metres median preferred depth; Kailola et al. (1993)
Maximum_Depth	-200	metres maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-15	metres minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth	-6000	metres maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
CarryingCapacityAlpha	0.001	mass (kg) of fish supported per kg/m2 of habitat; calculated from Bulman (2005)
CarryingCapacityBeta	100	min square metres required to support a kg of fish; calculated from Bulman (2006)
Masslarva	1	for population this is mass of individual juvenile in kg; direct measurement
radius	25000	metres school extent

Table E.6: Continued

Parameter	Value	Notes
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	1	0 for fine scale awareness, 1 for large scale program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth	0.0001	Weighting for influence of preferred depth in guiding habitat selection
Larva		Juvenile parameters
tick_length	7862400	seconds Typical time step length for juvenile age phases
bored_tick	7862400	seconds Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
suppress_wander	1	Prevents blastula wandering from original position
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency	0	efficiency of trawlers against juvenile age stages (expert opinion, Keith Sainsbury CSIRO pers. comm.)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	25000	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		Parameters for first age phase of larval agents
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)
Current_K	0.4	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen

Table E.6: Continued

Parameter	Value	Notes
AreaIDiffusion	1	metres / second average based on slicks
RadialDiffusion	0.005	metres / second average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
Second		Parameters for second age phase of larval agents
Current_K	0	metres / second coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second average based on slicks
RadialDiffusion	0.001	metres / second average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
CarryingCapacityAlpha	12880000	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)
CapacityRadius	13000	metres
mortality	0.3	juvenile mortality rate
LarvaType	1	type of spawnling/juveniles to use - larva agents0 or blastula agents1
MetabolismType	1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)
Third		Parameters for third age phase of larval agents

Table E.6: Continued

Parameter	Value	Notes
Current_K	1	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling		
age	31449600	age when begin settling; Kailola et al. (1993)
radius	200000	distance from centre of bed of suitable habitat type that will settle
scale	0.5	scalar on habitat quality for settling
offset	1	offset on habitat quality for settling
habitat	sponge	identifies suitable settling habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Recruitment		
age	31622400	age when begin recruiting to adult population; Kailola et al. (1993)
temporal_radius	604800	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns
radius	10000	distance from centre of bed of suitable habitat type that will recruit
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	sponge	identifies suitable recruiting habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)

Table E.6: Continued

Parameter		Value	Notes
direction_travel		-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Mass0		0.05	kg UNUSED
aggregate_rate		1	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	benthos	0.9	
	fish	0.05	
	bycatch	0.1	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	sponge	0.7	
	self	0.01	If prefer/detest to be with conspecifics then include them in the preferred habitat definition
	Sponge_thresh	160000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	self_thresh	350000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellant
	self_scalar	-10	If < 1 then find high density of conspecifics a repellant
&include Include/contamination-finfish			

Table E.7: large lutjanids (llut) file.

Parameter		Values	Notes	
restricted_area	pilbara-closed		zones fisheries targeting this species must avoid	
control_area	pilbara-zones		zones fisheries targeting this species must be aware of	
Carrying_capacity			estimated from Bulman (2006) and gradient parameter search	
	default	1.50E+07	in kg	
	Standard	7500000	in kg	
Maximum_Age		20	years	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero		1	years	Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality		0.3	/ year	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality		0	/event	mortality rate during catastrophic storm event
Speed		0.7	metres / second	Cruising speed from FISHBASE (2005)
SpeedScale		0.0001	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)	
MaxSpeed		1.8	metres / second	FISHBASE (2005)
SearchRadiusExponent		2	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.5	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time		0.8	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		0.7	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	
Mass_t		6	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	

Table E.7: Continued

Parameter	Values	Notes	
Width_a	0.15	dimensions of organism; directly measured	
Width_b	0.23	dimensions of organism; directly measured	
Gape/Width	0.9	ratio of gape to width (estimated from direct measurements)	
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)	
Metabolism	0	kg of food burned per second	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
propMale	0.5	proportion male (from WA fisheries stock assessments, P. Stephenson 2003)	
Mlinf	68.6	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mlength_lambda	0.18	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mvbt0	-0.33	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthA	2.51E-08	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.); using *Lutjanus malabaricus*	
MlengthB	2.916	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flinf	56.6	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flength_lambda	0.262	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Fvbt0	-0.09	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthA	2.51E-08	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthB	2.919	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Safe_Range	6	six times the cruising speed	estimated from visibility ranges; not used when adequate food assumed

Table E.7: Continued

Parameter		Values	Notes
Perception_Range		20	times the cruising speed range at which prey is detected
Eating_Range		1	seconds How close it must get seconds to it's prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
ScalingMult		1	calibrated
BHa			Beverton-Holt alpha in numbers not biomass - estimated from fisheries data from WAFMA and logbooks
	default	3.00E+04	
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks
	default	5.00E+03	
	low	1.00E+04	
	medium	5.00E+03	
	high	1.00E+02	
sel50		38.5	(~3.5years); expert opinion, P. Stephenson pers. comm.
sel25		34.21	expert opinion, P. Stephenson pers. comm.
linesel50		32.5	using coral trout selectivity (Fulton et al. 1999)
linesel25		30.5	using coral trout selectivity (Fulton et al. 1999)
fec50		38.5	expert opinion, P. Stephenson pers. comm.
fec95		42	expert opinion, P. Stephenson pers. comm.
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al.(1998)
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)
minLegalLength		41	Minimum legal length - so recreational fishers know what they can toss back; WA fisheries regulations
selMass		0.2	kg mass juveniles when first susceptible to fishing (estimated)

Table E.7: Continued

Parameter	Values	Notes
spatialCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)
default	1.00E-02	
spatialTrapCatchFactor		
		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
Default	1.00E-02	
numberParms	4	number of parms to estimate in stock assessment (if performed for this species)
Max_mass	8.4	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda	0.03	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity	100000	how many larvae it may engender – if fish agent not population agent; from Kailola et al. (1993)
Breeding		
age	week*208	breeding age; from Kailola et al. (1993)
start	week*39	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset	0	allows for continuous breeding – not needed for this species
period	year	time between individual breeding seasons; Kailola et al. (1993)
fallow_period	0	time time between breeding events; from Kailola et al. (1993)
Group_Size		program control parameter – dictates maximum school size (above this the school splits)

Table E.7: Continued

Parameter	Values	Notes	
default	1.00E+05	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))	
Standard	100000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)) (500000)	
Group_Stddev	500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)	
Group_Dispersion	300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)	
Group_Terminal	300	group size below which school disperses	when schools drop below this they are culled (if they can not merge first)
Excited_Tick	604800	seconds	Standard time step length if in active state
Alarmed_Tick	604800	seconds	Standard time step length if in active state
Bored_Tick	7862400	seconds	Maximum standard time step length
Tick_Length	7862400	seconds	Typical time step length
Minimum_Depth	-1	metres	minimum preferred depth; Kailola et al. (1993)
Best_Depth	-90	metres	median preferred depth; Kailola et al. (1993)
Maximum_Depth	-200	metres	maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-15	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth	-6000	metres	maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
CarryingCapacityAlpha	0.005	mass (kg) of fish supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	200	min square metres required to support a kg of fish; calculated from Bulman (2006)	

Table E.7: Continued

Parameter	Values	Notes
Masslarva	1	for population this is mass of individual juvenile in kg; direct measurement
radius	25000	metres school extent
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	1	0 for fine scale awareness, 1 for large scale program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth		
default	0.0001	Weighting for influence of preferred depth in guiding habitat selection
Larva		Juvenile parameters
tick_length	7862400	seconds Typical time step length for juvenile age stages
bored_tick	7862400	seconds Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
suppress_wander	1	Prevents blastula wandering from original position
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency	0	efficiency of trawlers against juvenile age stages (expert opinion, Keith Sainsbury CSIRO pers. comm.)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	25000	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		Parameters for first age phase of larval agents
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)

Table E.7: Continued

Parameter	Values		Notes
Current_K	0.4	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second	coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second	average based on slicks
RadialDiffusion	0.005	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
Second		Parameters for second age phase of larval agents	
Current_K	0	metres / second	coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second	coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second	average based on slicks
RadialDiffusion	0.001	metres / second	average based on slicks
RadialProportion	0.5	unused	
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
CarryingCapacityAlpha	2.23E+08	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)	
CapacityRadius	13000	metres	
mortality	0.35	juvenile mortality rate	
LarvaType	1	type of spawnling/juveniles to use – larva agents0 or blastula agents1	
MetabolismType	1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)	

Table E.7: Continued

Parameter	Values	Notes
Third		Parameters for third age phase of larval agents
Current_K	1	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling		
age	15724800	age when begin settling; Kailola et al. (1993)
radius	10000	distance from centre of bed of suitable habitat type that will settle
scale	0.5	scalar on habitat quality for settling
offset	1	offset on habitat quality for settling
habitat	sponge	identifies suitable settling habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	0	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Recruitment		
age	31622400	age when begin recruiting to adult population; Kailola et al. (1993)
temporal_radius	604800	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns
radius	10000	distance from centre of bed of suitable habitat type that will recruit
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	sponge	identifies suitable recruiting habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)

Table E.7: Continued

Parameter		Values	Notes
direction_travel		-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Mass0		0.05	kg unused
aggregate_rate		0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	benthos	0.9	
	fish	0.05	
	bycatch	0.1	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Sponge	0.7	
	Self	0.01	If prefer/detest to be with conspecifics then include them in the preferred habitat definition
	Sponge_thresh	300000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat; the magnitude here is due to the size of the gridcells used by sponge and assumption of large lutjanids liking at least 40% cover
	self_thresh	250000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellant
	self_scalar	-10	If < 1 then find high density of conspecifics a repellent
&include Include/contamination-finfish			

Table E.8: *Lutjanus sebae* (lsebae) file.

Parameter		Values	Notes	
restricted_area	pilbara-closed		zones fisheries targeting this species must avoid	
control_area	pilbara-zones		zones fisheries targeting this species must be aware of	
Carrying_capacity			estimated from Bulman (2006) and gradient parameter search	
	default	1.50E+07	in kg	
	Standard	6000000	in kg	
Maximum_Age		25	years	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero		1	years	Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality		0.13	/ year	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality		0	/ event	mortality rate during catastrophic storm event
Speed		0.7	metres / second	cruising speed from FISHBASE (2005)
SpeedScale		0.0001	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)	
MaxSpeed		1.8		
SearchRadiusExponent		2	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.5	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time		10	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		0.7	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	
Mass_t		6	Coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	

Table E.8: Continued

Parameter	Values	Notes
Width_a	0.15	dimensions of organism; directly measured
Width_b	0.23	dimensions of organism; directly measured
Gape/Width	0.9	ratio of gape to width (estimated from direct measurements)
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)
Metabolism	0	kg of food burned per second determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
propMale	0.5	proportion male (from WA fisheries stock assessments, P. Stephenson ref)
Mlinf	69.89	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Mlength_lambda	0.165	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Mvbt0	-1.496	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
MlengthA	1.31E-08	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
MlengthB	3.0841	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Flinf	54.89	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Flength_lambda	0.235	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Fvbt0	-1.57	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
FlengthA	1.31E-08	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
FlengthB	3.0841	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Safe_Range	6	six times the cruising speed estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed range at which prey is detecte
Eating_Range	1	seconds How close it must get seconds to it's prey (assuming the prey isn't “safe”) – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)

Table E.8: Continued

Parameter		Values	Notes
ScalingMult		1	calibrated
BHa			Beverton-Holt alpha in numbers not biomass - estimated from fisheries data from WAFMA and logbooks
	default	3.00E+03	
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks
	default	5.00E+03	
	Low	9.00E+03	
	medium	5.00E+03	
	High	1.00E+03	
sel50		38.5	(~3.5years); expert opinion, P. Stephenson pers. comm.
sel25		34.21	(~3.5years); expert opinion, P. Stephenson pers. comm.
linesel50		30.5	using coral trout selectivity (Fulton et al. 1999) - adjusted down a little to reflect different sized fish
linesel25		28.5	using coral trout selectivity (Fulton et al. 1999) - adjusted down a little to reflect different sized fish
fec50		38.5	expert opinion, P. Stephenson pers. comm.
fec95		42	expert opinion, P. Stephenson pers. comm.
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al. (1998)
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)
minLegalLength		41	Minimum legal length - so recreational fishers know what they can toss back; WA fisheries regulations (set same as for large lutjanids)
selMass		0.2	kg mass juveniles when first susceptible to fishing (estimated)
spatialCatchFactor			estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)

Table E.8: Continued

Parameter	Values	Notes
default	1.00E-02	
spatialTrapCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
default	1.00E-02	
numberParms	4	number of parms to estimate in stock assessment (if performed for this species)
Max_mass	8.4	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda	0.03	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity	100000	how many larvae it may engender - if fish agent not population agent; from Kailola et al. (1993)
Breeding		
age	week*208	breeding age; from Kailola et al. (1993)
start	week*39	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset	0	allows for continuous breeding – not needed for this species
period	year	time between individual breeding seasons; Kailola et al. (1993)
fallow_period	0	time time between breeding events; from Kailola et al. (1993)
Group_Size		program control parameter – dictates maximum school size (above this the school splits)
default	1.00E+05	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))
Standard	100000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)) (500000)
Group_Stddev	500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)

Table E.8: Continued

Parameter	Values	Notes
Group_Dispersion	300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Terminal	300	group size below which school disperses; when schools drop below this they are culled (if they can not merge first)
Excited_Tick	604800	seconds; Standard time step length if in active state
Alarmed_Tick	604800	seconds; Standard time step length if in active state
Bored_Tick	7862400	seconds; Maximum standard time step length
Tick_Length	7862400	seconds; Typical time step length
Minimum_Depth	-1	metres; minimum preferred depth; Kailola et al. (1993)
Best_Depth	-90	metres; median preferred depth; Kailola et al. (1993)
Maximum_Depth	-200	metres; maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-15	metres; minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth	-6000	metres; maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
CarryingCapacityAlpha	0.005	mass (kg) of fish supported per kg/m2 of habitat; calculated from Bulman (2006)
CarryingCapacityBeta	200	min square metres required to support a kg of fish; calculated from Bulman (2006)
Masslarva	1	for population this is mass of individual larva in kg, for fish it is a scalar for recruits
radius	25000	metres; school extent
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	1	0 for fine scale awareness, 1 for large scale; program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))

Table E.8: Continued

Parameter	Values	Notes	
ScalingBestSeaDepth			
default	0.0001	weighting for influence of preferred depth in guiding habitat selection	
Larva		juvenile parameters	
tick_length	7862400	seconds	Typical time step length for juvenile age stages
bored_tick	7862400	seconds	Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds	Standard time step length if in active state for juvenile age stages
suppress_wander	1	prevents blastula wandering from original position	
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)	
trawl_efficiency	0	efficiency of trawlers against juvenile age phases (expert opinion, Keith Sainsbury CSIRO pers. comm.)	
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)	
radius	25000	metres	Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship	
First		parameters for first age phase of larval agents	
tracer_minor	3	to advect centroid only, 3 to advect vertices	
Current_K	0.4	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second	coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second	average based on slicks
RadialDiffusion	0.005	metres / second	average based on slicks

Table E.8: Continued

Parameter	Values	Notes	
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
Second		parameters for second age phase of larval agents	
Current_K	0	metres / second	coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second	coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second	average based on slicks
RadialDiffusion	0.001	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
CarryingCapacityAlpha	2.23E+08	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)	
CapacityRadius	13000	metres	
mortality	0.18	juvenile mortality rate	
LarvaType	1	type of spawnling/juveniles to use - larva agents0 or blastula agents1	
MetabolismType	1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)	
Third		parameters for third age phase of larval agents	
Current_K	1	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second	coefficient for movement of unsettled larva with winds; set to zero as directed movement

Table E.8: Continued

Parameter	Values	Notes
Settling		
age	15724800	age when begin settling; Kailola et al. (1993)
radius	10000	distance from centre of bed of suitable habitat type that will settle
scale	0.5	scalar on habitat quality for settling
offset	1	offset on habitat quality for settling
habitat	sponge	identifies suitable settling habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	0	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Recruitment		
age	31622400	age when begin recruiting to adult population; Kailola et al. (1993)
temporal_radius	604800	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns
radius	10000	distance from centre of bed of suitable habitat type that will recruit
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	sponge	identifies suitable recruiting habitat
habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel	-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Mass0	0.05	kg unused
aggregate_rate	0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition

Table E.8: Continued

Parameter		Values	Notes
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	benthos	0.9	
	Fish	0.05	
	bycatch	0.1	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Sponge	0.7	
	Self	0.01	if prefer/detest to be with conspecifics then include them in the preferred habitat definition
	Sponge_thresh	150000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	Self_thresh	250000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellant
	self_scalar	-10	if < 1 then find high density of conspecifics a repellent
&include Include/contamination-finfish			

Table E.9: mangroves file - parameters taken from literature or tuned to reflect understanding of system.

Parameter	Values	Notes
Awareness_type	1	0 for fine scale awareness, 1 for large scale — program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
tick_length	604800	seconds — Typical time step length
bored_tick	1728000	seconds — Maximum standard time step length
alarmed_tick	1200	seconds — Standard time step length if in active state
really_verbose_vectors	1	put titles in monitor file
RecruitmentOption		flag indicating recruitment model used (dictates contribution of external source of larvae and the influence of sediment and depth on recruitment success – 0 for based on depth and sediment quality, 1 for based on depth and proportional to are of NWS colonised, 2 for proportion of suitable habitat on NWS, 3 for recruitment based on suitable habitat plus sediment quality and constant supply of external recruits, 4 for recruitment based on proportional habitat cover on the NWS plus sediment quality and constant supply of external recruits , and 5 for recruitment based on suitable habitat colonised plus proportional cover plus sediment quality and constant supply of external recruits)
default	0	
altrecruit1	1	
altrecruit2	1	
RecruitmentScalar	100	used to scale recruitment weightings; calibrated
RecruitmentCoefficient	1	steepness of curvature of recruitment curve; calibrated
ClearingDamageRate	0.1	rate of general damage to gridcell due to coastal development clearing; based on Semeniuk (1994), Semeniuk and Semeniuk (1995, 1997)
AcidGrowthReduction	0.05	reduction in growth rate due to acid sulphate leaching
Small		
AverageMass	20	kg / square metre — based on Robertson and Alongi (1992)
AverageHeight	0.5	metres — based on Robertson and Alongi (1992), McGuinness (1997) and Paling (1996)
RecruitRate	0.01	recruitment rate; based on Robertson and Alongi (1992), McGuinness (1997) and Paling (1996)
SpreadRate	0.01	horizontal growth rate per year; estimated - simple least squares estimation
DepthCoefficient	1	depth related recruitment parameter
SedimentCoefficient	1	sediment related recruitment parameter (set to 1.0 as no effect)

Table E.9: continued

Parameter	Values	Notes
Trawl		
DamageRate	0	trawls don't interact with mangroves
Coastal development		
DamageRate	1.0	based on Semeniuk (1994), Semeniuk and Semeniuk (1995, 1997)
Cyclone		
DamageRate	0.7	based on Grove et al. (2000) and Kathiresan and Bingham (2001)
Dredge		
DamageRate	0	dredges don't interact with mangroves
MortalityRate	0.01	/ year Based on Robertson and Alongi (1992)
Large		
AverageMass	48.6	kg / square metre
AverageHeight	15	in m
SpreadRate	0.0005	horizontal growth rate 0.05; based on Robertson and Alongi (1992)
DepthCoefficient	1	depth related horizontal growth parameter; estimated - simple least squares estimation
SedimentCoefficient	1	sediment related horizontal growth parameter (set to 1.0 always as no effect in this case)
Trawl		
DamageRate	0	trawls don't interact with mangroves
Coastal development		
DamageRate	1.0	based on Semeniuk (1994), Semeniuk and Semeniuk (1995, 1997)
Cyclone		

Table E.9: continued

Parameter		Values	Notes	
DamageRate		0.7	based on Grove et al. (2000) and Kathiresan and Bingham (2001)	
Dredge				
DamageRate		0	dredges don't interact with mangroves	
MortalityRate		0.001	estimated - simple least squares estimation	
SedimentModel	1		set to 0 for shallow-water/hard-bottom growth modified by *SedimentCoefficient to give final growth rates, set to 1 for depth and sediment related expression	
ThresholdLongitude		118	longitude in degrees	Threshold location for step function in growth and recruitment rates (simplest recruitment model)
ThresholdDepthLeft		100	depth (metres) silt starts to left of threshold longitude	
ThresholdDepthRight		160	depth (metres) silt starts to right of threshold longitude	
PreferredHabitatName	muddy			
ManmadeHabitat				
	default	0	increment to succesful proportion of sedimentatation rate due to manmande habitats	
GridedHabitat		0	set this to one if the habitat file is grided data	
minimumdepth		2	metres	minimum preferred depth; based on Robertson and Alongi (1992)
maximumdepth		-2	metres	based on Robertson and Alongi (1992)
SpreadGrow		0.15	estimated - simple least squares estimation	
MiddleGrow		1	estimated - simple least squares estimation	
SpreadDie		1	estimated - simple least squares estimation	
MiddleDie		7	estimated - simple least squares estimation	
SpreadBig		0.8	estimated - simple least squares estimation	
MiddleBig		12	estimated - simple least squares estimation	

Table E.9: continued

Parameter	Values	Notes
ProbabilityGrowBig	0.09	based on Robertson and Alongi (1992)
NumberAgeGroups	10	computationally efficient while still capturing the typical span of size and ages for mangroves less than 100cm in height, from information in Robertson and Alongi (1992)
HistoricalEffortCoefft	1	scalar on historical fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
GridedAgent	1	
HabitatComplexity	2	indicates how complex the CSurface environment as percived by other agents: 0 for standard flat grid, 1 for polyorganism, 2 for grided benthics
&include Include/contamination-mangroves		

Table E.10: nemipterid (nemip) file.

Parameter		Values	Notes	
restricted_area	pilbara-closed		zones fisheries targeting this species must avoid	
control_area	pilbara-zones		zones fisheries targeting this species must be aware of	
Carrying_capacity			estimated from Bulman (2006) and gradient parameter search	
	default	1.50E+07	in kg	
	Standard	30000000	in kg	
Maximum_Age		8	years	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero		1	years	Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality		0.25	/ year	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality		0	/ event	mortality rate during catastrophic storm event
Speed		0.7	metres / second	cruising speed from FISHBASE (2005)
SpeedScale		0.00009	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)	
MaxSpeed		1.8	metres / second	from FISHBASE (2005)
SearchRadiusExponent		2	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.5	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time		0.8	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		0.3	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	
Mass_t		0.4	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	
Width_a		0.04	dimensions of organism; directly measured	
Gape/Width		0.15	ratio of gape to width (estimated from direct measurements)	

Table E.10: continued

Parameter	Values	Notes
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)
Metabolism	0	kg of food burned per second — determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
propMale	0.5	proportion male (from WA fisheries stock assessments, P. Stephenson ref)
Mlinf	27.16	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Mlength_lambda	0.475	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Mvbt0	-2	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
MlengthA	3.40E-08	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
MlengthB	2.8826	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Flinf	25.4	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Flength_lambda	0.483	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Fvbt0	-2	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
FlengthA	3.40E-08	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
FlengthB	2.8826	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Safe_Range	6	six times the cruising speed — estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed — range at which prey may be detected
Eating_Range	1	seconds — How close it must get seconds to it's prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
ScalingMult	1	calibrated

Table E.10: continued

Parameter		Values	Notes
BHa			Beverton-Holt alpha in numbers not biomass - estimated from fisheries data from WAFMA and logbooks
	default	7.00E+05	
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks
	default	9.00E+04	
	low	1.00E+05	
	medium	9.00E+04	
	high	7.00E+04	
sel50		18.8	assuming 70mm mesh for Nemipterus nemtopus; Liu et al. (1985)
sel25		17.6	assuming 70mm mesh for Nemipterus nemtopus; Liu et al. (1985)
linesel50		17.5	a guesstimate based off minimum size of fish captured on GBR
linesel25		15.5	a guesstimate based off minimum size of fish captured on GBR
fec50		11.8	expert opinion, P. Stephenson pers. comm.
fec95		15	expert opinion, P. Stephenson pers. comm.
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al. (1998)
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)
minLegalLength		0	minimum legal length - so recreational fishers know what they can toss back; WA fisheries regulations
selMass		0.2	kg mass juveniles when first susceptible to fishing (estimated)
spatialCatchFactor			estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)
	default	1.00E-02	

Table E.10: continued

Parameter		Values	Notes
spatialTrapCatchFactor			estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
	default	1.00E-02	
numberParms		4	number of parms to estimate in stock assessment (if performed for this species)
Max_mass		3	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda		0.03	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
spatialLarvalFactor		1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity		1000000	how many larvae it may engender - if fish agent not population agent; from Kailola et al. (1993)
Breeding			
	age	week*208	breeding age; from Kailola et al. (1993)
	start	week*17	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
	offset	0	allows for continuous breeding – not needed for this species
	period	year	time between individual breeding seasons; Kailola et al. (1993)
	fallow_period	0	time time between breeding events; from Kailola et al. (1993)
Group_Size			program control parameter – dictates maximum school size (above this the school splits)
	default	1.00E+06	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))
	Standard	800000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)) (5000000)
Group_Stddev		500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion		300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)

Table E.10: continued

Parameter	Values	Notes		
Group_Terminal	300	group size below which school disperses		when schools drop below this they are culled (if they can not merge first)
Excited_Tick	604800	seconds	Standard time step length if in active state	
Alarmed_Tick	604800	seconds	Standard time step length if in active state	
Bored_Tick	7862400	seconds	Maximum standard time step length	
Tick_Length	7862400	seconds	Typical time step length	
Minimum_Depth	-1	metres	minimum preferred depth; Kailola et al. (1993)	
Best_Depth	-60	metres	median preferred depth; Kailola et al. (1993)	
Maximum_Depth	-180	metres	maximum preferred depth; Kailola et al. (1993)	
Minimum_Sea_Depth	-15	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)	
Maximum_Sea_Depth	-6000	metres	maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)	
CarryingCapacityAlpha	0.003	mass (kg) of fish supported per kg/m2 of habitat; calculated from Bulman (2006)		
CarryingCapacityBeta	300	min square metres required to support a kg of fish; calculated from Bulman (2006)		
Masslarva	1	for population this is mass of individual larva in kg		
radius	25000	metres	school extent	
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)		
assess_environment	1	flag to show whether species seeks favourable environments		
Awareness_type	1	0 for fine scale awareness, 1 for large scale		program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth	0.0001	weighting for influence of preferred depth in guiding habitat selection		
Larva		juvenile parameters		

Table E.10: continued

Parameter	Values		Notes
tick_length	7862400	seconds	Typical time step length
bored_tick	7862400	seconds	Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds	Standard time step length if in active state for juvenile age stages
suppress_wander	1	prevents blastula wandering from original position	
head_for	1	when recruiting or settling move to : 1 = closest, 0 = random	
trawl_efficiency	0	efficiency of trawlers against juvenile phases (expert opinion, Keith Sainsbury CSIRO pers. comm.)	
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)	
radius	25000	metres	Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement "stock-recruit" relationship scalar – calibrated to give plausible overall stock-recruit relationship	
First		parameters for first age phase of larval agents	
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)	
Current_K	0.4	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second	coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second	average based on slicks
RadialDiffusion	0.005	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
Second		parameters for second age phase of larval agents	
Current_K	0	metres / second	coefficient for movement of settled juveniles with currents; set to zero as settled

Table E.10: continued

Parameter	Values	Notes	
Wind_K	0	metres / second	coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second	average based on slicks
RadialDiffusion	0.001	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
CarryingCapacityAlpha	12880000	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)	
CapacityRadius	13000	metres	
mortality	0.3	juvenile mortality rate	
LarvaType	1	type of spawnling/juveniles to use - larva agents0 or blastula agents1	
MetabolismType	1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)	
Third		parameters for third age phase of larval agents	
Current_K	1	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second	coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling			
age	15724800	age when begin settling; Kailola et al. (1993)	
radius	10000	distance from centre of bed of suitable habitat type that will settle	
scale	0.5	scalar on habitat quality for settling	
offset	1	offset on habitat quality for settling	

Table E.10: continued

Parameter		Values	Notes
habitat		sponge	identifies suitable settling habitat
habitat_type		4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel		-1	identifies whether swimming on-shore (1) or offshore (-1) or herever (0) at this life stage
Recruitment			
age		31622400	age when begin recruiting to adult population; Kailola et al. (1993)
temporal_radius		604800	seconds; time in blastula queue when "close enough" to recruit; calibrated to give realistic settlement patterns
radius		200000	distance from centre of bed of suitable habitat type that will recruit
scale		0.5	scalar on recruitment habitat preferences
offset		1	offset on recruitment habitat quality
habitat		sponge	identifies suitable recruiting habitat
habitat_type		5	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel		-1	identifies whether swimming on-shore (1) or offshore (-1) or herever (0) at this life stage
Mass0		0.05	kg unused
aggregate_rate		1	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	benthos	0.9	
	Fish	0.05	
	bycatch	0.1	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)

Table E.10: continued

Parameter		Values	Notes
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Sponge	0.1	
	seagrass	0.1	
	Self	0.01	If prefer/detest to be with conspecifics then include them in the preferred habitat definition
	Sponge_thresh	150000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	seagrass_thresh	80000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	Self_thresh	750000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellant
	Self_scalar	-10	If < 1 then find high density of conspecifics a repellent
&include Include/contamination-finfish			

Table E.11: oysterlease file – specifies parameters for commercial oyster production.

Parameter	Values		Notes
monitor_environments	Bitterns, Calcium, Sulphate, Zinc, Cadmium, Copper, Lead, Oil, PetroleumHydrocarbons, Tin		selects environmental contaminants to monitor
Suppress_Wander	1	used to prevent oysters wandering	
Suppress_Breeding	1	used to prevent oyster leases breeding; renders all members of the species sterile and disinterested	
Excited_Tick	604800	seconds	Standard time step length if in active state
Alarmed_Tick	604800	seconds	Standard time step length if in active state
Bored_Tick	7862400	seconds	Maximum standard time step length
Tick_Length	7862400	seconds	Typical time step length
&include Include/contamination-oysters			

Table E.12: saurid (saur) file.

Parameter	Values	Notes
restricted_area	pilbara-closed	zones fisheries targeting this species must avoid
control_area	pilbara-zones	zones fisheries targeting this species must be aware of
Carrying_capacity		estimated from Bulman (2006) and gradient parameter search
default	1.50E+07	in kg
Standard	30000000	in kg
Maximum_Age	40	years FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero	1	years Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality	0.1	/ year FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality	0	/ event mortality rate during catastrophic storm event
Speed	0.7	metres / second cruising speed from FISHBASE (2005)
SpeedScale	0.0001	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)
MaxSpeed	1.8	metres / second from FISHBASE (2005)
SearchRadiusExponent	2	governs how far afield we assume organisms can detect conditions (estimated on velocity)
Directional_variability	0.5	degree to which they remain moving in a single facing (direction); calibrated
Speed_variability	0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)
Traverse_Time	10	months Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t	0.4	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Mass_t	1.2	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Width_a	0.08	dimensions of organism; directly measured
Gape/Width	0.15	ratio of gape to width (estimated from direct measurements)

Table E.12: Continued

Parameter	Values	Notes	
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)	
Metabolism	0	kg of food burned per second	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
propMale	0.5		
Mlinf	74	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mlength_lambda	0.1	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mvbt0	-0.5	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthA	0.000162	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthB	1.5	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flinf	74	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flength_lambda	0.1	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Fvbt0	-0.5	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthA	0.000162	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthB	1.5	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Safe_Range	6	six times the cruising speed	estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed	range at which prey may be detected
Eating_Range	1	seconds	How close it must get seconds to its prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship	

Table E.12: Continued

Parameter		Values	Notes
ScalingMult		0.9	calibrated
BHa			Beverton-Holt alpha in numbers not biomass – estimated from fisheries data from WAFMA and logbooks
	default	3.00E+04	
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks
	default	5.00E+04	
	low	6.00E+04	
	medium	5.00E+04	
	high	1.00E+04	
sel50		21.01	assuming 55mm mesh size for *Saurida undosquamis*; Liu et al. (1985)
sel25		15.6	assuming 55mm mesh size for *Saurida undosquamis*; Liu et al. (1985)
linesel50		75.5	set so that not impossible to catch them, but rare (as more a trawl than a line fish)
linesel25		68.5	set so that not impossible to catch them, but rare (as more a trawl than a line fish)
fec50		21	expert opinion, P. Stephenson pers. comm.
Fec95		24	expert opinion, P. Stephenson pers. comm.
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al.(1998)
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)
minLegalLength		0	minimum legal length – so recreational fishers know what they can toss back; WA fisheries regulations
selMass		0.2	kg mass juveniles when first susceptible to fishing (estimated)
spatialCatchFactor			estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)

Table E.12: Continued

Parameter		Values	Notes
	default	1.00E-02	
spatialTrapCatchFactor			estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
	default	1.00E-02	
numberParms		3	number of parms to estimate in stock assessment (if performed for this species)
Max_mass		3	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda		0.03	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
Fecundity		1000000	how many larvae it may engender - if fish agent not population agent; from Kailola et al. (1993)
Breeding			
	age	week*208	breeding age; from Kailola et al. (1993)
	start	week*30	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
	offset	0	allows for continuous breeding – not needed for this species
	period	year	time between individual breeding seasons; Kailola et al. (1993)
	fallow_period	0	time time between breeding events; from Kailola et al. (1993)
Group_Size			program control parameter – dictates maximum school size (above this the school splits)
	default	5.00E+05	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))
	Standard	1000000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))
Group_Stddev		500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion		300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)

Table E.12: Continued

Parameter	Values	Notes
Group_Terminal	300	group size below which school disperses — when schools drop below this they are culled (if they can not merge first)
Excited_Tick	604800	seconds — Standard time step length if in active state
Alarmed_Tick	604800	seconds — Standard time step length if in active state
Bored_Tick	7862400	seconds — Maximum standard time step length
Tick_Length	7862400	seconds — Typical time step length
Minimum_Depth	-1	metres — minimum preferred depth; Kailola et al. (1993)
Best_Depth	-90	metres — median preferred depth; Kailola et al. (1993)
Maximum_Depth	-200	metres — maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth	-15	metres — minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth	-6000	metres — maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
Masslarva	1	for population this is mass of individual larva in kg, for fish it is a scalar for recruits (defaul value 1.0)
radius	40000	metres — school extent
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	1	0 for fine scale awareness, 1 for large scale — program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth	0.0001	weighting for influence of preferred depth in guiding habitat selection
Larva		juvenile parameters
tick_length	7862400	seconds — Typical time step length for juvenile age stages
bored_tick	7862400	seconds — Maximum standard time step length for for juvenile age stages

Table E.12: Continued

Parameter	Values	Notes
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
suppress_wander	1	prevents blastula wandering from original position
head_for	1	when recruiting or settling: 1 head for closest, 0 head for random
trawl_efficiency	0	efficiency of trawlers against species – trawlers do not have an affect on larvae
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	40000	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		parameters for first age phase of larval agents
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)
Current_K	0.4	metres / second coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second average based on slicks
RadialDiffusion	0.005	metres / second average based on slicks
RadialProportion	0.5	calibrated
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
Second		parameters for second age phase of larval agents
Current_K	0	metres / second coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second average based on slicks

Table E.12: Continued

Parameter	Values	Notes	
RadialDiffusion	0.001	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-14		
CarryingCapacityAlpha	2.23E+08	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)	
CarryingCapacityBeta	300	mnimum square metres required to support a kg of settled juveniles	
CapacityRadius	13000	metres	
mortality	0.2	juvenile mortality rate	
LarvaType	1	type of spawnling/juveniles to use - larva agents0 or blastula agents1	
MetabolismType	1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)	
Third		Parameters for third age phase of larval agents	
Current_K	1	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K	0	metres / second	coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling			
age	15724800	age when begin settling; Kailola et al. (1993)	
radius	10000	distance from centre of bed of suitable habitat type that will settle	
scale	0.5	scalar on habitat quality for settling	
offset	1	offset on habitat quality for settling	

Table E.12: Continued

Parameter	Values	Notes
habitat	sponge	identifies suitable settling habitat
habitat_type	5	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	0	identifies whether swimming on-shore (1) or offshore (-1) or □herever (0) at this life stage
Recruitment		
age	31622400	age when begin recruiting to adult population; Kailola et al. (1993)
temporal_radius	604800	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns
radius	200000	distance from centre of bed of suitable habitat type that will recruit
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	sponge	identifies suitable recruiting habitat
habitat_type	5	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel	-1	identifies whether swimming on-shore (1) or offshore (-1) or □herever (0) at this life stage
Mass0	0.05	kg UNUSED
aggregate_rate	1	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers		relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
benthos	0.9	
fish	0.05	
bycatch	0.1	
Fears		relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)

Table E.12: Continued

Parameter		Values	Notes
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Sponge	0.1	
	seagrass	0.1	
	Self	0.01	if prefer/detest to be with conspecifics then include them in the preferred habitat definition
	Sponge_thresh	30	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	seagrass_thresh	20	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
	self_thresh	2500000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellant
	self_scalar	-10	if < 1 then find high density of conspecifics a repellent
&include Include/contamination-finfish			

Table E.13: seagrass file - parameters taken from literature or tuned to reflect understanding of system.

Parameter	Values		Notes
tick_length	604800	seconds	Typical time step length
bored_tick	1728000	seconds	Maximum standard time step length
alarmed_tick	1200	seconds	Standard time step length if in active state
ClearingDamageRate	0	rate of damage to gridcell due to coastal development clearing	
AcidGrowthReduction	0	reduction in growth rate due to acid sulphate leaching	
Small			
AverageMass	0.2	kg / square metre	based on Bulman (2006)
AverageHeight	0.2	metres	Clayton and King (1990)
RecruitRate	0.3	recruitment rate; Campbell (2003)	
SpreadRate	0.5	horizontal growth rate ; based on Cambridge et al. (2002) and Campbell (2003)	
DepthCoefficient	0.1	depth related recruitment parameter; estimated	
SedimentCoefficient	1	sediment related recruitment parameter; estimated	
Trawl			
DamageRate	0.8	vulnerability to trawling; based on Hall (1999) and Meyer et al. (1999)	
Cyclone			
DamageRate	0.4	vulnerability to cyclones; based on Preen et al. (1995)	
Dredge			
DamageRate	1	vulnerability to dredging; based on Cheshire and Miller (1996)	
MortalityRate	0.2	/ year	based on van Tussenbroek (2002) and Biber et al., (2004)
Large			
AverageMass	1	kg / square metre	Based on Bulman (2006)
AverageHeight	0.5	in m	Creed et al. (1998), Alberg (1992)

Table E.13: continued

Parameter		Values	Notes
SpreadRate		0.1	recruitment rate per year; based on Creed et al. (1998)
DepthCoefficient		0.1	depth related horizontal growth parameter; estimated
SedimentCoefficient		1	sediment related horizontal growth parameter; estimated
Trawl			
DamageRate		0.7	vulnerability to trawling; based on Hall (1999)
Cyclone		0.3	vulnerability to cyclones; based on Augustin et al. (1997)
Dredge		1	vulnerability to dredging; based on Roberts (1998) and Newell et al. (2004)
MortalityRate		0.2	/ year based on Aberg (1992) and Solidoro et al. (1997)
RecruitmentOption			flag indicating recruitment model used (dictates contribution of external source of larvae and the influence of sediment and depth on recruitment success – 0 for based on depth and sediment quality, 1 for based on depth and proportional to are of NWS colonised, 2 for proportion of suitable habitat on NWS, 3 for recruitment based on suitable habitat plus sediment quality and constant supply of external recruits, 4 for recruitment based on proportional habitat cover on the NWS plus sediment quality and constant supply of external recruits , and 5 for recruitment based on suitable habitat colonised plus proportional cover plus sediment quality and constant supply of external recruits)
	default	0	
	altrecruit1	1	
	altrecruit2	1	
	altrecruit3	1	
RecruitmentScalar			
	default	1	used to scale recruitment weightings; calibrated
RecruitmentCoefficient			
	default	1	steepness of curvature of recruitment curve; calibrated
RecruitmentConstant			external recruitment contribution; calibrated
	default	0	
	altrecruit3	0.3	

Table E.13: continued

Parameter	Values	Notes
SedimentModel	0	det to 0 for shallow-water/hard-bottom growth modified by *SedimentCoefficient to give final growth rates, set to 1 for depth and sediment related expression
ThresholdLongitude	118	longitude in degrees Threshold location for step function in growth and recruitment rates (simplest recruitment model)
ThresholdDepthLeft	100	depth (metres) silt starts to left of threshold longitude
ThresholdDepthRight	160	depth (metres) silt starts to right of threshold longitude
ManmadeHabitat	0	increment to sedimentatation rating due to manmande habitats
Current_K	0	no movement in this case
Wind_K	0	no movement in this case
ArealDiffusion	0	no diffusion in this case
RadialDiffusion	0.00016	metres / second average based on slicks
RadialProportion	1	calibrated
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced
HeightLambda	1.00E-07	calibrated so realistic growth form reproduced
trawl_height_lambda	1.00E-14	calibrated so realistic depletion reproduced
SpreadGrow	1	single age class only
MiddleGrow	1	single age class only
SpreadDie	1	single age class only
MiddleDie	1	single age class only
SpreadBig	1	single age class only

Table E.13: continued

Parameter	Values	Notes	
MiddleBig	1	single age class only	
ProbabilityGrowBig	0	single age class only so no transition necessary	
NumberAgeGroups	2	single age class only for seagrass and macroalgae	
HistoricalEffortCoefft	0.0001	scalar on historical fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)	
GridedAgent	1		
HabitatComplexity	2	indicates how complex the CSurface environment as percived by other agents: 0standard flat grid, 1polyorganism, 2grided benthics	
PreferredHabitatName	sandy		
SuitableHabitatFile	sed381.xy.pt		
minimum_depth	-1.0	metres	minimum preferred depth; Clayton and King (1990)
maximum_depth	-50.0	metres	maximum preferred depth; Clayton and King (1990)
&include Include/contamination-seagrass			

Table E.14: small lutjanids (slut) file.

Parameter		Values	Notes	
restricted_area	pilbara-closed		zones fisheries targeting this species must avoid	
control_area	pilbara-zones		zones fisheries targeting this species must be aware of	
Carrying_capacity			estimated from Bulman (2006) and gradient parameter search	
	Default	1.50E+07	in kg	
	Standard	15000000	in kg	
Maximum_Age		12	years	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
t_zero		1	years	Age of maturity (used in mortality calculations); FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Rate_Mortality		0.25	/ year	FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)
Catastrophic_Mortality		0	/ event	mortality rate during catastrophic storm event
Speed		0.7	metres / second	cruising speed from FISHBASE (2005)
SpeedScale		0.00009	scale cruising speed by this when dealing to populations; Wall and Przeworski (2000)	
MaxSpeed		1.8	metres / second	from FISHBASE (2005)
SearchRadiusExponent		2	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.5	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time		10	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		0.55	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	
Mass_t		1.7	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	

Table E.14: Continued

Parameter	Values	Notes	
Width_a	0.14	dimensions of organism; directly measured	
Width_b	0.25	dimensions of organism; directly measured	
Gape/Width	0.9	ratio of gape to width (estimated from direct measurements)	
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)	
Metabolism	0	kg of food burned per second	determines if organisms must hunt or assume adequate food
propMale	0.5	proportion male (from WA fisheries stock assessments, P. Stephenson ref)	
Mlinf	30.19	male asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mlength_lambda	0.706	years; male parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Mvbt0	-0.333	male Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthA	1.19E-08	male length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
MlengthB	3.0645	male length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flinf	29.29	female asymptotic maximum length; from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Flength_lambda	0.661	years; female parameter used in age-mass relationship (growth equation); from FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Fvbt0	-0.801	female Von Bertalanfy t_o; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthA	1.19E-08	female length-weight coefficient; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
FlengthB	3.0645	female length-weight exponent; FISHBASE (2005) and expert opinion (P. Stephenson pers. comm.)	
Safe_Range	6	six times the cruising speed	Estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed	range at which prey may be detected

Table E.14: Continued

Parameter		Values	Notes	
Eating_Range		1	seconds	How close it must get seconds to it's prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
ScalingMult		0.9	calibrated	
BHa			Beverton-Holt alpha in numbers not biomass - estimated from fisheries data from WAFMA and logbooks	
	Default	1.00E+05		
	Low	3.00E+05		
	Medium	1.00E+05		
	High	9.00E+05		
BHb			Beverton-Holt beta (larvae it may engender) – estimated from fisheries data from WAFMA and logbooks	
	Default	1.00E+04		
	Low	9.00E+04		
	Medium	1.00E+04		
	High	3.00E+05		
sel50		28.5	(~3.5years); expert opinion, P. Stephenson pers. comm.	
sel25		24.21	(~3.5years); expert opinion, P. Stephenson pers. comm.	
linesel50		15.5	a guesstimate based off minimum size of fish captured on GBR	
linesel25		12.5	a guesstimate based off minimum size of fish captured on GBR	
fec50		18.5	expert opinion, P. Stephenson pers. comm.	
fec95		22	expert opinion, P. Stephenson pers. comm.	
trapSelMean		52.25	Moran and Jenke (1990) and Milton et al. (1998)	
trapSelSig		68.5	Moran and Jenke (1990) and Milton et al. (1998)	

Table E.14: Continued

Parameter	Values	Notes
minLegalLength	30	minimum legal length - so recreational fishers know what they can toss back; WA fisheries regulations
selMass	0.2	kg mass juveniles when first susceptible to fishing (estimated)
spatialCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trawl catches)
default	1.00E-02	
spatialTrapCatchFactor		estimated from fisheries data from WAFMA and logbooks (to minimise differences between observed and predicted trap catches)
default	1.00E-02	
numberParms	4	number of parms to estimate in stock assessment (if performed for this species)
Max_mass	7.9	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda	0.03	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity	1000000	how many larvae it may engender - if fish agent not population agent; from Kailola et al. (1993)
Breeding		
age	week*208	breeding age; from Kailola et al. (1993)
start	week*17	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset	0	allows for continuous breeding – not needed for this species
period	year	time between individual breeding seasons; Kailola et al. (1993)

Table E.14: Continued

Parameter		Values	Notes	
	fallow_period	0	time time between breeding events; from Kailola et al. (1993)	
Group_Size			program control parameter – dictates maximum school size (above this the school splits)	
	default	4.00E+05	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))	
	Standard	1000000	size of groups (dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE))	
Group_Stddev		500	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)	
Group_Dispersion		300	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)	
Group_Terminal		300	group size below which school disperses	when schools drop below this they are culled (if they can not merge first)
Excited_Tick		604800	seconds	Standard time step length if in active state
Alarmed_Tick		604800	seconds	Standard time step length if in active state
Bored_Tick		7862400	seconds	Maximum standard time step length
Tick_Length		7862400	seconds	Typical time step length
Minimum_Depth		-1	metres	minimum preferred depth; Kailola et al. (1993)
Best_Depth		-40	metres	median preferred depth; Kailola et al. (1993)
Maximum_Depth		-200	metres	maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth		-15	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth		-6000	metres	maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
CarryingCapacityAlpha		0.001	mass (kg) of fish supported per kg/m2 of habitat; estimated from Bulman (2006)	
CarryingCapacityBeta		100	min square metres required to support a kg of fish; calculated from Bulman (2006)	

Table E.14: Continued

Parameter	Values	Notes
Masslarva	1	for population this is mass of individual juvenile in kg; direct measurement (1.0e-9default)
radius	25000	metres school extent
trawl_efficiency	0.1	efficiency of trawlers against species on juvenile stages (expert opinion; P. Stephenson pers. comm.)
assess_environment	1	flag to show whether species seeks favourable environments
Awareness_type	1	0 for fine scale awareness, 1 for large scale program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth		
default	0.0001	weighting for influence of preferred depth in guiding habitat selection
Larva		juvenile parameters
tick_length	7862400	seconds Typical time step length for juvenile age phases
bored_tick	7862400	seconds Maximum standard time step length for juvenile age phases
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
suppress_wander	1	prevents blastula wandering from original position
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: 1=heading for closest, 0=heading for random
trawl_efficiency	0	efficiency of trawlers against juvenile stages (expert opinion, Keith Sainsbury CSIRO pers. comm.)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	25000	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement "stock-recruit" relationship scalar – calibrated to give plausible overall stock-recruit relationship
First		parameters for first age phase of larval agents

Table E.14: Continued

Parameter	Values	Notes	
tracer_minor	3	flag to indicate form of advection used (3 means vertices are advected)	
Current_K	0.4	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
Wind_K	0.1	metres / second	coefficient for movement of unsettled larva with winds; calibrated so that observed time from spawning to settlement obtained and correct movement patterns seen
ArealDiffusion	1	metres / second	average based on slicks
RadialDiffusion	0.005	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-08	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
Second		parameters for second age phase of larval agents	
Current_K	0	metres / second	coefficient for movement of settled juveniles with currents; set to zero as settled
Wind_K	0	metres / second	coefficient for movement of settled juveniles with wind; set to zero as settled
ArealDiffusion	0.5	metres / second	average based on slicks
RadialDiffusion	0.001	metres / second	average based on slicks
RadialProportion	0.5	calibrated	
BiomassLambda	1.00E-14	growth coefficient for exponential growth equation; calibrated so realistic growth form reproduced	
CarryingCapacityAlpha	12880000	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)	
CarryingCapacityBeta	380	min square metres required to support a kg of settled juveniles; calculated from Bulman (2006)	
CapacityRadius	13000	metres	
mortality	0.3	juvenile mortality rate	

Table E.14: Continued

Parameter		Values	Notes	
LarvaType		1	type of spawnling/juveniles to use - larva agents0 or blastula agents1	
MetabolismType		1	type of metabolism used: 1for cull if biomass is greater than carrying capacity, 2 for false metabolism, 3 for true animal metabolism and 4 for false metabolism and periodic density dependent cull (i.e. basically determines if organisms must hunt or we assume adequate food – the later assumed for MSE runs here)	
Third			Parameters for third age phase of larval agents	
Current_K		1	metres / second	coefficient for movement of unsettled larva with currents; calibrated so that observed movement patterns are reproduced
Wind_K		0	metres / second	coefficient for movement of unsettled larva with winds; set to zero as directed movement
Settling				
	age	15724800	age when begin settling; Kailola et al. (1993)	
	radius	10000	distance from centre of bed of suitable habitat type that will settle	
	scale	0.5	scalar on habitat quality for settling	
	offset	1	offset on habitat quality for settling	
	habitat	sponge	identifies suitable settling habitat	
	habitat_type	4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)	
	direction_travel	-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage	
Recruitment				
age		31622400	age when begin recruiting to adult population; Kailola et al. (1993)	
temporal_radius		604800	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns	
radius		200000	distance from centre of bed of suitable habitat type that will recruit	

Table E.14: Continued

Parameter		Values	Notes
scale		0.5	scalar on recruitment habitat preferences
offset		1	offset on recruitment habitat quality
habitat		sponge	identifies suitable recruiting habitat
habitat_type		4	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel		-1	identifies whether swimming on-shore (1) or offshore (-1) or whereever (0) at this life stage
Mass0		0.05	kg unused
aggregate_rate		1	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	benthos	0.9	
	fish	0.05	
	bycatch	0.1	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Tuna	0.9	
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Sponge	0.7	

Table E.14: Continued

Parameter	Values	Notes
seagrass	0.5	
Self	0.01	if prefer/detest to be with conspecifics then include them in the preferred habitat definition
Sponge_thresh	140000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
seagrass_thresh	8000	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
self_thresh	350000	total biomass (kg) in habitat grid cell; threshold biomass below which density of conspecifics is insufficient to act as a true attractant/repellent
self_scalar	-10	if < 1 then find high density of conspecifics a repellent
&include Include/contamination-finfish		

Table E.15: shark file - parameters taken from literature or tuned to reflect understanding of system.

Parameter		Values	Notes	
may_nest			program control parameter - allows for nesting of this agent type within other agents	
	fish	1		
	default	1		
	blastula	0		
eggmortality			determines pre-larval mortality applied to number of eggs produced	
	default	1	the ratio of eggs surviving to settlement to the number originally spawned. Calculated by solving for the rate that leads to a stable population level.	
cull_period		week*4	periodicity of natural mortality (tuned to runtime resolution)	
Carrying_capacity		330000	in kg	Estimated from Bulman (2006)
Maximum_Age		65	years	FISHBASE (2005)
t_zero		1	years	Age of maturity (used in mortality calculations);
Rate_Mortality		0.095	/ year	expert opinion, Fred Pribac pers. comm.
Catastrophic_Mortality		0	/ event	mortality rate during catastrophic storm event
Speed		0.02	metres / second	cruising speed; from FISHBASE (2005)
MaxSpeed		0.05	metres /second	from FISHBASE (2005)
SearchRadiusExponent		4	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.8	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in FISHBASE (2005)	
Traverse_Time		0.1	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length_t		3	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))	

Table E.15: Continued

Parameter	Values	Notes
Mass_t	100	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Width_a	0.5	"eccentricity" of cylindrical fish dimensions of organism; directly measured
Gape/Width	0.5	ratio of gape to width (estimated from direct measurements)
Capacity	0.3	gut capacity as a proportion of length (estimate from direct measurements)
Metabolism	0	kg of food burned per second determines if organisms must hunt or we have adequate food
Max_mass	250.0	kg Upper limit of mass; Kailola et al. (1993) and and FISHBASE (2005)
mass_lambda	0.01	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
length_C	5.00E+10	specified using mm length and kg mass for length*pow(mass/C, 1/mroot)/1000.0
mass_root	2.9	
Safe_Range	6	six times the cruising speed Estimated from visibility ranges; not used when adequate food assumed
Neighbourhood	0	
Perception_Range	20	times the cruising speed range at which prey may be detected
Eating_Range	1	seconds How close it must get seconds to it's prey (assuming the prey isn't "safe") – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity_rate	0.03	mass based correction to maximum fecundity (calibrated to match field spawning rates – as opposed to laboratory determined maximum egg production)
Fecundity		eggs / female at maximum size Maximum potential fecundity rate; Kailola et al. (1993) and Last and Stevens (1994)
default	9	

Table E.15: Continued

Parameter		Values	Notes
	low	9	
	medium	12	
	high	15	
Breeding			
age		week*676	breeding age; from Kailola et al. (1993)
Start		week*40	start time of first cycle after the start of the Julian year; from Kailola et al. (1993)
offset		0.5	allows for continuous breeding – not needed for this species
Period		year	time between individual breeding seasons; Kailola et al. (1993)
Duration		week*9	
fallow_period		week*40	time time between breeding events; from Kailola et al. (1993)
habitat		seagrass	
scale		0.5	habitat scalar on realised fecundity (calibrated)
radius		800	metres distance from habitat patch that spawning behaviour may begin
Group_Size			program control parameter – dictates maximum school size (above this the school splits)
	default	100	
	testing	1000	
Group_Stddev		2	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Dispersion		10	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)
Group_Terminal			when schools drop below this they are culled (if they can not merge first)

Table E.15: Continued

Parameter		Values	Notes	
	default	5	group size below which school disperses	
Group_Must_Merge			program control parameter dictating at what points schools try to merge with other schools of same taxon	
	default	20	group must try and merge if it gets this low	
merge_radius_scale	200000		merge radius (to merge must be within this radius in m) – typically set to about 20000x speed	
Bored_Tick			maximum standard time step length	
	default	year/3.0		
	fast	fortnight		
	slow	week*12		
Tick_Length			typical time step length	
	default	quarter		
	fast	week		
	slow	month		
Excited_Tick			standard time step length if in active state	
	default	week		
	fast	day		
	slow	week		
Minimum_Depth		-0.1	metres	minimum preferred depth; Kailola et al. (1993)
Best_Depth		-50	metres	median preferred depth; Kailola et al. (1993)
Maximum_Depth		-550	metres	maximum preferred depth; Kailola et al. (1993)
Minimum_Sea_Depth		-15	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)

Table E.15: Continued

Parameter		Values	Notes
Maximum_Sea_Depth		-6000	metres maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
radius		400	metres
BycatchSpecies		1	if set1 then will be depleted by historical fishing (via incidental mortality)
trawl_efficiency			efficiency of trawlers against species (Stephenson & Chidlow 2003 and Fred Pribac CSIRO pers. comm.)
	default	0.1	analogous to selectivity in the populations file
	low	0.45	very susceptible to trawling
	medium	0.3	
	high	0.15	can avoid trawls
selMass		1	kg mass juveniles when first susceptible to fishing (estimated)
HistoricalEffortCoefft		0.2	scalar on historical fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
spatialCatchFact		5.00E-09	calibrated to minimise differences between observed and predicted catches
assess_environment		1	flag to show whether species seeks favourable environments
Awareness_type		1	0 for fine scale awareness, 1 for large scale program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. 2006)
ScalingBestSeaDepth			
	default	0.0001	weighting for influence of preferred depth in guiding habitat selection
Mass0		1	kg mass of individual pups at hatching or birth; expert opinion Ross Daley CSIRO pers. comm.
Larva			juvenile parameters

Table E.15: Continued

Parameter	Values	Notes
MetabolismType	4	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
tick_length	1200	seconds Typical time step length for juvenile age stages
bored_tick	81400	seconds Maximum standard time step length for juvenile age stages
alarmed_tick	600	seconds Standard time step length if in active state for juvenile age stages
head_for	1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency	0	baby sharks too small to be caught in trawls (as not born yet really but lets skip the "if caught mum" complication for now)
projection_efficiency_scalar	1	scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
radius	400	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor	1E-11	settlement "stock-recruit" relationship scalar – calibrated to give plausible overall stock-recruit relationship
CarryingCapacityAlpha	0.00012	mass (kg) of settled juveniles supported per kg/m2 of habitat; calculated from Bulman (2006)
CarryingCapacityBeta	6000	mnimum square metres required to support a kg of settled juveniles; calculated from Bulman (2006)
CapacityRadius	13000	metres
mortality	0.3	juvenile mortality rate
Settling		
age	86400	age when begin settling; Kailola et al. (1993) and Last and Stevens (1994)
radius	10000	distance from centre of bed of suitable habitat type that will settle
scale	0.5	scalar on habitat quality for settling
offset	1	offset on habitat quality for settling
habitat		identifies suitable settling habitat

Table E.15: Continued

Parameter		Values	Notes
habitat_type		6	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel		0	identifies whether swimming on-shore (1) or offshore (-1) or wherever (0) at this life stage
Recruitment			
age		¾ * year	age when begin recruiting to adult population; Kailola et al. (1993) and Last and Stevens (1994)
radius		10000	distance from centre of bed of suitable habitat type that will recruit
temporal_radius		259200	seconds; time in blastula queue when "close enough" to recruit; calibrated to give realistic settlement patterns
scale		0.5	scalar on recruitment habitat preferences
offset		1	offset on recruitment habitat quality
habitat		none	identifies suitable recruiting habitat (none indicates no preference)
Recruitment			
habitat_type		6	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel		0	identifies whether swimming on-shore (1) or offshore (-1) or wherever (0) at this life stage
aggregate_rate		0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers			relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
	Fish	0.9	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	seabed	0.5	

Table E.15: Continued

Parameter	Values	Notes
seagrass	0.5	
sponge	0.5	
llut	0.5	this was used to keep the sharks around “reef fish” communities, so they didn’t wander into deep water a lot
&include Include/contamination-K		

Table E.16: sponge file - parameters taken from literature or tuned to reflect understanding of system.

Parameter	Values	Notes	
Awareness_type	1	0 for fine scale awareness, 1 for large scale	program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
tick_length	604800	seconds	Typical time step length
bored_tick	1728000	seconds	Maximum standard time step length
alarmed_tick	1200	seconds	Standard time step length if in active state
RecruitmentOption		flag indicating recruitment model used (dictates contribution of external source of larvae and the influence of sediment and depth on recruitment success – 0 for based on depth and sediment quality, 1 for based on depth and proportional to are of NWS colonised, 2 for proportion of suitable habitat on NWS, 3 for recruitment based on suitable habitat plus sediment quality and constant supply of external recruits, 4 for recruitment based on proportional habitat cover on the NWS plus sediment quality and constant supply of external recruits , and 5 for recruitment based on suitable habitat colonised plus proportional cover plus sediment quality and constant supply of external recruits)	
Default	0		
Altrecruit1	4		
Altrecruit2	4		
Altrecruit3	5		
Altrecruit4	5		
RecruitmentScalar		used to scale recruitment weightings; calibrated	
Default	1		
Altrecruit1	1000		
Altrecruit2	1000		
RecruitmentCoefficient		steepness of curvature of recruitment curve; calibrated	
Default	1		
Altrecruit1	100000		
Altrecruit2	50000000		

Table E.16: Continued

Parameter	Values	Notes	
RecruitmentConstant		external recruitment contribution; calibrated	
Default	0		
altrecruit3	0.3		
altrecruit4	0.4		
ClearingDamageRate	0	rate of damage to gridcell due to coastal development clearing	
AcidGrowthReduction	0	reduction in growth rate due to acid sulphate leaching	
Small			
AverageMass	0.4	kg / square metre	based on Bulman (2006)
AverageHeight	0.05	in m	Barnes (1987)
RecruitRate		/ year	recruitment rate; estimated
Default	0.05		
SpreadRate		horizontal growth rate per year; estimated	
Default	0.103		
Low	0.05		
Medium	0.103		
High	0.2		
DepthCoefficient	0.49379	depth related recruitment parameter; estimated	
SedimentCoefficient	0.994923	sediment related recruitment parameter; estimated	
Trawl			
DamageRate		vulnerability to trawling; based on Hall (1999) and Moran and Stephenson (2000)	
Default	5E-09		

Table E.16: Continued

Parameter	Values	Notes
Low	5E-08	
Medium	5E-09	
High	5E-11	
Cyclone		vulnerability to cyclones; based on Augustin et al. (1997)
DamageRate	0.4	
Dredge		vulnerability to dredging; based on Roberts (1998) and Newell et al. (2004)
DamageRate	1	
MortalityRate	0.012	/ year estimated
Large		
AverageMass	1	kg / square metre Based on Bulman (2006)
AverageHeight	0.2	in m Harrison and Cowden (1976); Barnes (1987)
SpreadRate		horizontal growth rate per year; mostly estimated
Default	0.05	
Low	0.045	
Medium	0.05	
High	0.1	Harrison and Cowden (1976); Bell (2002)
DepthCoefficient	0.49379	depth related horizontal growth parameter; estimated
SedimentCoefficient	0.994923	sediment related horizontal growth parameter; estimated
Trawl		vulnerability to trawling; based on Hall (1999)
DamageRate		

Table E.16: Continued

Parameter	Values	Notes
Default	9E-09	
Low	9E-08	
Medium	9E-09	
High	9E-11	
Cyclone		vulnerability to cyclones; based on Augustin et al. (1997)
DamageRate	0.5	
Dredge		vulnerability to dredging; based on Roberts (1998) and Newell et al. (2004)
DamageRate	1	
MortalityRate	0.0048	/ year estimated
SedimentModel	2	set to 0 for shallow-water/hard-bottom growth modified by *SedimentCoefficient to give final growth rates, set to 1 for depth and sediment related expression
ThresholdLongitude	118	longitude in degrees Threshold location for step function in growth and recruitment rates (simplest recruitment model)
ThresholdDepthLeft	-100	depth (metres) silt starts to left of threshold longitude
ThresholdDepthRight	-160	depth (metres) silt starts to left of threshold longitude
PreferredHabitatName	rocky	
SuitableHabitatFile	sed381.xy.pt	
ManmadeHabitat		
default	0.05	increment to successful proportion of sedimentatation rate due to manmande habitats
GridedHabitat	0	set this to one if the habitat file is grided data
minimumdepth	-10	metres Barnes (1987)
maximumdepth	-2000	metres Barnes (1987)

Table E.16: Continued

Parameter	Values	Notes
minFishedDepth	-50	metres From observations and logbooks
SpreadGrow	1	estimated
MiddleGrow	4	estimated
SpreadDie	1	estimated
MiddleDie	11	estimated
SpreadBig	1.5	estimated
MiddleBig	9	estimated
ProbabilityGrowBig	0.05	based on Harrison and Cowden (1976), Barnes (1987), Garrabou and Zabala (2001) and Bell (2002)
NumberAgeGroups	10	computationally efficient while still capturing the typical span of size and ages for sponges less than 20cm in height, from information in Barnes (1987)
HistoricalEffortCoefft		scalar on historical fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
default	1	
GridedAgent	1	
HabitatComplexity	2	indicates how complex the CSurface environment as percived by other agents: 0 for standard flat grid, 1for polyorganism, 2 for grided benthics
GrowthRate	0.1	growth rate per year
&include Include/contamination-sponge		

Table E.17: turtle file - parameters taken from literature or tuned to reflect understanding of system.

Parameter		Values	Notes
agent_cap			program control parameter
	NoContaminants	0	
	default	400	
	Intensive_tracking	300	
logs_contamination			program control parameter -sets whether this species writes contamination date to disk
	NoContaminants	0	
	default	0.2	
	Intensive_tracking	1	
contamination_track_interval	daily		program control parameter - determines how frequently tissueloads are written to file
eggmortality		1	determines pre-larval mortality applied to number of eggs produced; it is the ratio of eggs surviving to settlement to the number originally spawned. Calculated by solving for the rate that lead to a stable population level.
tracks_contamination			program control parameter - controls whether or not species interacts with contaminants
	NoContaminants	0	
	default	1	
	reptile	1	
	fish	1	
	population	0	
	larva	0	
may_nest			program control parameter - allows for nesting of this agent type within other agents
	reptile	1	
	fish	1	
	default	1	
	blastula	0	

Table E.17: Continued

Parameter		Values	Notes	
cull_period		week*4	periodicity of natural mortality (tuned to runtime resolution)	
Carrying_capacity		1500000	in kg	estimated from Limpus et al. (1984), Marsh and Saalfield (1989), Environment Australia (2000), Chaloupka (2003), Marsh et al. (2004) and Bulman (2006)
Maximum_Age		100	years	Limpus and Reed (1985), Chaloupka and Musick (1997), Environment Australia (2000)
t_zero		1	years	Age of establishment (maturity in other species, but time when first pulse of mortality drops in the case of turtles; used in mortality calculations); Chaloupka and Musick (1997)
Rate_Mortality				
	default	0.01	/ year	Limpus et al. (1994)
	highmort	0.05		Chaloupka and Limpus (2002), Chaloupka (2003)
Catastrophic_Mortality		0.03	/ event	Mortality rate during catastrophic storm event; guesstimate based on Chaloupka (2003)
Speed		0.02	metres / second	cruising speed from FISHBASE (2005)
MaxSpeed		0.05	metres / second	from FISHBASE (2005)
SearchRadiusExponent		4	governs how far afield we assume organisms can detect conditions (estimated on velocity)	
Directional_variability		0.8	degree to which they remain moving in a single facing (direction); calibrated	
Speed_variability		0.07	stochastic variability in wandering speed; calculated by comparing crusing and maximum speeds in Eckert (2002)	
Traverse_Time		0.1	months	Time taken to cross the entire NWS if swimming directly; calculated from swimming speed, weighted by degree of aggregation (of agent – so populations took longer than fish)
Length/Mass		0.5	estimated	

Table E.17: Continued

Parameter	Values	Notes
Length_t	2	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Mass_t	6	coefficient in length-weight relationship (using length = pow(mass,ln(Length_t)/ln(Mass_t))))
Width/Length	0.52	estimated
Gape/Length	0.15	estimated
Capacity	0.3	gut capacity as a proportion of length (estimated)
Metabolism	0	kg of food burned per second — determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
Max_mass	100.0	kg — Upper limit of mass; Limpus et al. (1994), Chaloupka and Musick (1997) and Environment Australia (2000)
mass_lambda	0.022	specified in years; for age-mass equation (tuned to give realistic age spans given known masses)
length_C	5.00E+10	specified using mm for for length and kg mass (used in equation for length = pow(mass/C, 1/mroot)/1000.0)
mass_root	2.9	calibrated
Safe_Range	6	six times the cruising speed — estimated from visibility ranges; not used when adequate food assumed
Perception_Range	20	times the cruising speed — range at which prey may be detected
Eating_Range	1	seconds — How close it must get seconds to it's prey (assuming the prey isn't “safe”) – the temporal range at which prey may be detected (a time not a distance measure as have known lunge speed for attack – see Gray et al. (2006) for formulation)
spatialLarvalFactor	1E-11	calibrated to give a plausible stock-recruit relationship
Fecundity_rate	0.08	mass based correction to maximum fecundity (calibrated to match field spawning rates – as opposed to laboratory determined maximum egg production)
Fecundity		eggs / female at maximum size — Maximum potential fecundity rate; Chaloupka and Musick (1997) and Environment Australia (2000)
default	4	

Table E.17: Continued

Parameter		Values	Notes
	low	15	
	medium	17	
	high	19	
Breeding			
age		week*1560	breeding age; from Chaloupka and Musick (1997) and Environment Australia (2000)
start		week*40	start time of first cycle after the start of the Julian year; from Environment Australia (2000)
offset		0	allows for continuous breeding – not needed for this species
period		year	time between individual breeding seasons; Environment Australia (2000)
duration		week*9	length of breeding season ; from Environment Australia (2000)
fallow_period			time time between breeding events; from Environment Australia (2000)
low		week*260	
medium		week*208	
high		week*156	
habitat		seagrass	location of breeding; from Environment Australia (2000) and Limpus et al. (1994)
scale		0.5	habitat scalar on realised fecundity (calibrated)
offset		1	offset on relaised fecundity (calibrated)
radius		800	radius; distance from habitat patch that spawning behaviour may begin
Group_Size			program control parameter – dictates maximum school size (above this the school splits)
	default	150	
Group_Stddev		1	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)

Table E.17: Continued

Parameter		Values	Notes	
Group_Dispersion		2	dictates distributions in schools; calibration parameter (only used in fine scale simulations during development, not regional scale MSE)	
Group_Terminal			when schools drop below this they are culled (if they can not merge first)	
	default	5	group size below which school disperses	
Group_Must_Merge			program control parameter dictating at what points schools try to merge with other schools of same taxon	
	default	20	group must try and merge if it gets this low	
merge_radius_scale		200000	merge radius (to merge must be within this radius in m) – typically set to about 20000x speed	
Bored_Tick			maximum standard time step length	
	default	week*12		
	fast	week		
	slow	week*12		
Tick_Length			typical time step length	
	default	quarter		
	fast	week		
	slow	month		
Excited_Tick			standard time step length if in active state	
	default	week		
	fast	day		
	slow	week		
Minimum_Depth		5	metres	minimum preferred depth; Environment Australia (2000)
Best_Depth		-50	metres	median preferred depth; Environment Australia (2000)

Table E.17: Continued

Parameter		Values	Notes	
Maximum_Depth		-550	metres	maximum preferred depth; Environment Australia (2000)
Minimum_Sea_Depth		-1	metres	minimum depth typically used in marine waters (used to constrain locations in scenarios)
Maximum_Sea_Depth		-6000	metres	maximum depth typically reached in marine waters (often used to constrain the populations to specific locations for fine scale simulations)
radius		4000	metres	school extent
BycatchSpecies		1	if set1 then will be depleted by historical fishing (via incidental mortality)	
trawl_efficiency			efficiency of trawlers against species (based on sharks)	
	default	0.1	analogous to selectivity in the populations file	
	low	0.45	very susceptible to trawling	
	medium	0.35		
	high	0.3	can avoid trawls	
HistoricalEffortCoefft		0.006	calibrated so that predicted catch of turtles matches observations (Prince pers. comm.; WA Fisheries)	
spatialCatchFact		5.00E-09	calibrated to minimise differences between observed and predicted catches	
selMass		1	kg	mass juveniles when first susceptible to fishing (estimated)
assess_environment		1	flag to show whether species seeks favourable environments	
Awareness_type		1	0 for fine scale awareness, 1 for large scale	program control parameter – dictating resolution of adviser agent interrogation (see Gray et al. (2006))
ScalingBestSeaDepth			Weighting for influence of preferred depth in guiding habitat selection	
	default	0.0001	Weighting for influence of preferred depth in guiding habitat selection	
Mass0		0.4	kg	mass of individual turtle hatchlings; based on Environment Australia (2000) and Chaloupka (2003)
Larva			juvenile parameters	

Table E.17: Continued

Parameter		Values	Notes
MetabolismType		4	determines if organisms must hunt or we assume adequate food (later assumed for MSE runs here)
tick_length		1200	seconds Typical time step length for juvenile age stages
bored_tick		81400	seconds Maximum standard time step length for juvenile age stages
alarmed_tick		600	seconds Standard time step length if in active state for juvenile age stages
head_for		1	flag setting whether they head for random spot or closest when recruiting or settling: (1 for heading for closest, 0 for heading for random)
trawl_efficiency			efficiency of trawlers against species (based on sharks and corrected for size)
	default	0.05	analogous to selectivity in the populations file
	low	0.1	very susceptible to trawling
	medium	0.09	
	high	0.085	can avoid trawls
projection_efficiency_scalar			scalar on fishing efficiency so no discontinuity from historical to projection treatement (given different spatial scales of operation)
	default	200	
radius		200000	metres Radius of juvenile patch / school (calibrated to give credible juvenile dynamics)
spatialLarvalFactor		1E-11	settlement “stock-recruit” relationship scalar – calibrated to give plausible overall stock-recruit relationship
Settling			
age		13 * year	age when begin entering pelagic phase; Chaloupka (2003)
radius		10000	distance from centre of bed of suitable habitat type that will settle
scale		0.5	scalar on habitat quality for settling
offset		1	offset on habitat quality for settling

Table E.17: Continued

Parameter	Values	Notes
habitat	seagrass	identifies suitable settling habitat
habitat_type	6	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent settlement)
direction_travel	1	identifies whether swimming on-shore (1) or offshore (-1) or □herever (0) at this life stage
Recruitment		
age		age when begin recruiting to adult population; Chaloupka (2003)
default	16 * year	
low	16 * year	maximum given in Environment Australia 2000
medium	14 * year	
high	12 * year	minimum given in Environment Australia 2000
radius	10000	distance from centre of bed of suitable habitat type that will recruit
temporal_radius	259200	seconds; time in blastula queue when “close enough” to recruit; calibrated to give realistic settlement patterns
scale	0.5	scalar on recruitment habitat preferences
offset	1	offset on recruitment habitat quality
habitat	seagrass	identifies suitable recruiting habitat
habitat_type	6	habitat agent type (1 for data grid in file, 2 for habitat tracer agents, 3 for polyorganism agents, 4 for benthic agents, 5 for no agent type set and 6 for carrying capacity dependent recruitment)
direction_travel	-1	identifies whether swimming on-shore (1) or offshore (-1) or □herever (0) at this life stage
aggregate_rate	0.5	rate of polygon contraction when recruiting; calibrated to give smooth transition
Prefers		relative prey ranking (arbitary, with main prey given maximum ranking of about 0.9)
Fish	0.9	

Table E.17: Continued

Parameter		Values	Notes
	benthos	0.9	
Fears			relative fear ranking (arbitary, with main predators given maximum ranking of about 0.9)
	Shark	0.9	
Habitat			relative adult habitat ranking (arbitary, with most preferred habitat given maximum ranking of about 0.9)
	Seagrass	0.5	
	Seagrass_thresh	10649880	total biomass (kg) in habitat grid cell; threshold biomass below which the animal is less interested in the habitat
&include Include/contamination-finfish			

Table E.18: Outfall file -all outflow data is from the contaminants inventory, this file sets basic properties.

Parameter	Values	Notes
immutable	1	program control parameter
capacity	0	
epsilon	1.00E-06	Concentrations below this level are deemed to be zero
forcing_conc	0	program control parameter
is_a_contaminant	1	program control parameter

Table E.19: Aster file – specifies destination for vessels.

Parameter	Values	Notes
Name	Aster.rig	
capacity	3	
location		
longitude	116.597	
latitude	-19.5056	

Table E.20: Barrow file - specifies destination for vessels also specifies a source of recreational fishing effort based on population.

Parameter	Values	Notes
Name	Barrow Is	
capacity	3	
location		
longitude	115.3837	
latitude	-20.8247	
latitude	-20.8247	
tick	28800	program control parameter - regulates size of time steps, tuned for runtime resolution
radius	100	metres radius of effect beyond island edge

Table E.21: Bombay file - specifies destination for vessels.

Parameter	Values	Notes
name	Bombay	
neighbours	20	determines max number of neighbours considered
capacity	1000	
location		
longitude	114.1	
latitude	-20.5	
radius	10	radius of effect beyond port edge

Table E.22: Calcutta file - specifies destination for vessels.

Parameter	Values	Notes
name	Calcutta	
capacity	1000	
location		
longitude	114.5	
latitude	-17.5	

Table E.23: Cossack_port file - specifies destination for vessels.

Parameter	Values	Notes
name	Cossack	
neighbours	20	determines max number of neighbours considered
capacity	3	
location		
longitude	116.5	
latitude	-19.55	
radius	1000	radius of effect beyond port edge

Table E.24: Dampier file - specifies destination for vessels also specifies source of recreational fishing effort based on population.

Parameter	Values	Notes
Name	Dampier	
neighbours	20	determines max number of neighbours considered
capacity	5	
increased_capacity	2	
threshold		
default	1000	
enhanced	50	
location		
longitude	116.75	
latitude	-20.608	
radius	4000	radius of effect beyond port edge
waypoint		
longitude	116.75	
latitude	-20.608	
inbound	Dampier-in.pt	postulated transit corridor
outbound	Dampier-out.pt	postulated transit corridor
Overflow		
inbound	Dampier-Overflow-in.pt	postulated transit corridor
outbound	Dampier-Overflow-out.pt	postulated transit corridor
township		
longitude	116.7133	

Table E.24: Continued

Parameter	Values	Notes
latitude	-20.66	
price		prices for commodities (spot prices, not kept up to date)
fuel	1.2	
Shark	12	
Fish	7	
forcing_invoked		program control parameter - selects development scenario
default	0	
1p	1	
2p	2	
forcing_system		program control parameter - selects timeseries to be used
population	Dampier-pop.ts	
population1p	Dampier-pop-1p.ts	
population2p	Dampier-pop-2p.ts	
production	Dampier-prod.ts	
production1p	Dampier-prod-1p.ts	
production2p	Dampier-prod-2p.ts	

Table E.25: Exmouth file - specifies destination for vessels also specifies a source of recreational fishing effort based on population.

Parameter	Values	Notes
Name	Exmouth	
capacity	20	
location		
longitude	114.127	
latitude	-21.933	
radius	4000	radius of effect beyond port edge
price		prices for commodities (spot prices, not kept up to date)
fuel	1.2	
Shark	12	
Fish	7	
forcing_invoked		program control parameter - selects development scenario
default	0	
1p	1	
2p	2	
forcing_system		program control parameter - selects timeseries to be used
population	Exmouth-pop.ts	
population1p	Exmouth-pop-1p.ts	
population2p	Exmouth-pop-2p.ts	
production	Exmouth-prod.ts	
production1p	Exmouth-prod-1p.ts	
production2p	Exmouth-prod-2p.ts	

Table E.26: Hammersley_WTP file - Outflows - all data is from the contaminants inventory. NO LD, Uptake or decay data is taken from this file.

Parameter		Values	Notes
tag		HammersleyWTP_control	
base_taxon	Outfall		program control parameter - selects parent taxon to init parameters
scale			
	default	1	
	Low	0.8	
	Lower	0.6	
	Lowest	0.4	
	High	2	
	Rabid	4	
forcing_conc			program control parameter
	default	0	
	1p	1	
	2p	2	
lethal_contaminants			
AccumToxin			
			for arguments sake 288.484 ug/L
conc		288.484	
conc1p		288.484	
conc2p		288.484	

Table E.26: Continued

Parameter	Values	Notes
Copper		
conc	HammersleyWTP_Copper.ts@t@1e9	
conc1p	HammersleyWTP_Copper1p.ts@t@1e9	
conc2p	HammersleyWTP_Copper2p.ts@t@1e9	
contaminants		
flow		
conc	HammersleyWTP_flow.ts@t@1e9	
conc1p	HammersleyWTP_flow1p.ts@t@1e9	
conc2p	HammersleyWTP_flow2p.ts@t@1e9	

Table E.27: epa_Hammersley_WTP - The following trigger the outflow controls based on “anzecc”.

Parameter	Values	Notes
		uses rate of release as a control rather than concentration
AdjustmentInterval	quarterly	Management scenario parameter
OutflowControl	1	
lethal_contaminants		
Copper		
conc	-1	
rate	0.8	
contaminants		
flow		
conc	-1	
rate	0.8	
&include anzecc		

Table E.28: Hammersley_WTP_logger - Loggers at Outflows - locations chosen to be near outflow. Loggers sample water concentrations at set intervals and are used as input to epa controls.

Parameter	Values	Notes
base_taxon	logger	program control parameter - selects parent taxon to init parameters
tag	HammersleyWTP*	
monitor_environments	Copper,flow	selects environmental attributes/contaminants to monitor

Table E.29: Kabul file - specifies destination for vessels.

Parameter	Values	Notes
name	Kabul	
capacity	1000	
location		
longitude	114.5	
latitude	-17.5	

Table E.30: Mermaid Sound file - all outflow data is from the contaminants inventory. No LD, Uptake or decay data is taken from this file.

Parameter	Values	Notes
Tag	MermaidSound_control	
base_taxon	Outfall	program control parameter - selects parent taxon to init parameters
scale		
default	1	
Low	0.8	
Lower	0.6	
Lowest	0.4	
High	2	
Rabid	4	
forcing_conc		program control parameter
default	0	
1p	1	
2p	2	
lethal_contaminants		
AccumToxin		
conc	288.484	for arguments sake 288.484 ug/L
conc1p	288.484	
conc2p	288.484	
Cadmium		
conc	MermaidSound_Cadmium.ts@t@1e9	
conc1p	MermaidSound_Cadmium1p.ts@t@1e9	

Table E.30: Continued

Parameter	Values	Notes
conc2p	MermaidSound_Cadmium2p.ts@t@1e9	
Copper		
conc	MermaidSound_Copper.ts@t@1e9	
conc1p	MermaidSound_Copper1p.ts@t@1e9	
conc2p	MermaidSound_Copper2p.ts@t@1e9	
Lead		
conc	MermaidSound_Lead.ts@t@1e9	
conc1p	MermaidSound_Lead1p.ts@t@1e9	
conc2p	MermaidSound_Lead2p.ts@t@1e9	
Oil		
conc	MermaidSound_Oil.ts@t@1e9	
conc1p	MermaidSound_Oil1p.ts@t@1e9	
conc2p	MermaidSound_Oil2p.ts@t@1e9	
PetroleumHydrocarbons		
conc	MermaidSound_PetroleumHydrocarbons.ts@t@1	
conc1p	MermaidSound_PetroleumHydrocarbons1p.ts@t@1	
conc2p	MermaidSound_PetroleumHydrocarbons2p.ts@t@1	
Sulphate		
conc	MermaidSound_Sulphate.ts@t@1e9	
conc1p	MermaidSound_Sulphate1p.ts@t@1e9	
conc2p	MermaidSound_Sulphate2p.ts@t@1e9	

Table E.30: Continued

Parameter	Values	Notes
Tin		
conc	MermaidSound_Tin.ts@t@1	
conc1p	MermaidSound_Tin1p.ts@t@1	
conc2p	MermaidSound_Tin2p.ts@t@1	
contaminants		
flow		
conc	MermaidSound_flow.ts@t@1000	
conc1p	MermaidSound_flow1p.ts@t@1000	
conc2p	MermaidSound_flow2p.ts@t@1000	

Table E.31: epa_MermaidSound file - The following trigger the outflow controls based on “anzecc” - uses rate of release as a control rather than concentration.

Parameter	Values	Notes
AdjustmentInterval	quarterly	Management scenario parameter
OutflowControl	1	
lethal_contaminants		
Cadmium		
conc	-1	
rate	0.8	
Copper		
conc	-1	
rate	0.8	
Lead		
conc	-1	
rate	0.8	
Oil		
conc	-1	
rate	0.8	
PetroleumHydrocarbons		
conc	-1	
rate	0.8	
Sulphate		
conc	-1	
rate	0.8	

Table E.31: Continued

Parameter	Values	Notes
Tin		
conc	-1	
rate	0.8	
contaminants		
flow		
conc	-1	
rate	0.8	
&include anzecc		

Table E.32: MermaidSound_loggerfile - Loggers at Outflows - locations chosen to be near outflow. Loggers sample water concentrations at set intervals and are used as input to epa controls.

Parameter	Values	Notes
base_taxon	logger	program control parameter - selects parent taxon to init parameters
tag	MermaidSound*	
monitor_environments	Cadmium, Copper, Lead, Oil, PetroleumHydrocarbons, Sulphate, Tin, flow	selects environmental attributes/contaminants to monitor

Table E.33: NRA_port file - specifies destination for vessels.

Parameter	Values	Notes
name	North Rankin A	
neighbours	20	determines max number of neighbours considered
capacity	3	
location		
longitude	116.15	
latitude	-19.5	
radius	1000	radius of effect beyond platform edge

Table E.34: Nauru - specifies destination for vessels.

Parameter	Values	Notes
name	Nauru	
neighbours	20	determines max number of neighbours considered
capacity	1000	
location		
longitude	119	
latitude	-17	

Table E.35: NickolBay - Outflows - all data is from the contaminants inventory Basic properties of an outflow No LD, Uptake or decay data is taken from this file.

Parameter	Values	Notes
tag	NickolBay_control	
base_taxon	Outfall	program control parameter - selects parent taxon to init parameters
location		
longitude	116.8147	
latitude	-20.6954	
scale		
default	1	
Low	0.8	
Lower	0.6	
Lowest	0.4	
High	2	
Rabid	4	
forcing_conc		program control parameter
default	0	
1p	1	
2p	2	
lethal_contaminants		
AccumToxin		
conc	288.484	for arguments sake 288.484 ug/L
conc1p	288.484	
conc2p	288.484	
		recall that we use magnesium as the marker for Bitterns

Table E.35: Continued

Parameter	Values	Notes
Bitterns		
conc	NickolBay_Bitterns.ts@t@1e12	
conc1p	NickolBay_Bitterns1p.ts@t@1e12	
conc2p	NickolBay_Bitterns2p.ts@t@1e12	
Calcium		
conc	NickolBay_Calcium.ts@t@1e12	
conc1p	NickolBay_Calcium1p.ts@t@1e12	
conc2p	NickolBay_Calcium2p.ts@t@1e12	
Sulphate		
conc	NickolBay_Sulphate.ts@t@1e12	
conc1p	NickolBay_Sulphate1p.ts@t@1e12	
conc2p	NickolBay_Sulphate2p.ts@t@1e12	
contaminants		
flow		
conc	NickolBay_flow.ts@t@1000	
conc1p	NickolBay_flow1p.ts@t@1000	
conc2p	NickolBay_flow2p.ts@t@1000	

Table E.36: epa_NickolBay file - The following trigger the outflow controls based on “anzecc” uses rate of release as a control rather than concentration.

Parameter	Values	Notes
AdjustmentInterval	quarterly	management scenario parameter
OutflowControl	1	
lethal_contaminants		
Bitterns		
conc	-1	
rate	0.8	
Calcium		
conc	-1	
rate	0.8	
Sulphate		
conc	-1	
rate	0.8	
contaminants		
flow		
conc	-1	
rate	0.8	
&include anzecc		

Table E.37: NickolBay_logger file - Loggers at Outflows - locations chosen to be near outflow Loggers sample water concentrations at set intervals and are used as input to epa controls.

Parameter	Values	Notes
base_taxon	logger	program control parameter - selects parent taxon to init parameters
tag	NickolBay*	
monitor_environments	Bitterns,Calcium,Sulphate,flow	selects environmental attributes/contaminants to monitor

Table E.38: Onslow file - specifies destination for vessels also specifies source of recreational fishing effort based on population.

Parameter	Values	Notes
name	Onslow	
capacity	20	
location		
longitude	115.135	
latitude	-21.688	
radius	3000	radius of effect beyond port edge
price		prices for commodities (spot prices, not kept up to date)
fuel	1.2	
Shark	12	
Fish	7	

Table E.39: Osaka file - specifies destination for vessels.

Parameter	Values	Notes
name	Osaka	
neighbours	20	Determines max number of neighbours considered
capacity	1000	
location		
longitude	117.21	
latitude	-17.5	

Table E.40: Point-Samson file - specifies destination for vessels also specifies source of recreational fishing effort based on population.

Parameter	Values	Notes
name	Point Samson	
neighbours	20	determines max number of neighbours considered
capacity	20	
location		
longitude	117.21	
latitude	-20.583	
radius	2000	radius of effect beyond port edge
waypoint		
longitude	117.21	
latitude	-20.583	
inbound	PtSamson-in.pt	postulated transit corridor
outbound	PtSamson-out.pt	postulated transit corridor
outwaypoint		
longitude	117.4	
latitude	-20.477	
township		
longitude	117.1966	
latitude	-20.6266	

Table E.40: Continued

Parameter	Values	Notes
price		prices for commodities (spot prices, not kept up to date)
fuel	1.2	
Shark	12	
Fish	7	
forcing_invoked		program control parameter - selects development scenario
default	0	
1p	1	
2p	2	
forcing_system		program control parameter - selects timeseries to be used
population	Point-Samson-pop.ts	
population1p	Point-Samson-pop.ts	
population2p	Point-Samson-pop.ts	
production	Point-Samson-prod.ts	
production1p	Point-Samson-prod.ts	
production2p	Point-Samson-prod.ts	

Table E.41: Port-Hedland - specifies destination for vessels also specifies a source of recreational fishing effort based on population.

Parameter	Values	Notes
neighbours	20	Determines max number of neighbours considered
location		
longitude	118.57	
latitude	-20.31	
radius	4000	metres radius of effect beyond port edge
capacity	5	
increased_capacity	2	
threshold		
default	1000	
enhanced	50	
waypoint		
longitude	118.57	
latitude	-20.31	
inbound	Port-Hedland-in.pt	postulated transit corridor
outbound	Port-Hedland-out.pt	postulated transit corridor
Overflow		
inbound	Port-Hedland-Overflow-in.pt	postulated transit corridor
outbound	Port-Hedland-Overflow-out.pt	postulated transit corridor
township		
longitude	118.6	
latitude	-20.31	

Table E.41: Continued

Parameter	Values	Notes
price		prices for commodities (spot prices, out of date)
fuel	1.2	
Shark	12	
Fish	7	
forcing_invoked		program control parameter - selects development scenario
default	0	
1p	1	
2p	2	
forcing_system		program control parameter - selects timeseries to be used
population	Port-Hedland-pop.ts	
population1p	Port-Hedland-pop-1p.ts	
population2p	Port-Hedland-pop-2p.ts	
production	Port-Hedland-prod.ts	
production1p	Port-Hedland-prod-1p.ts	
production2p	Port-Hedland-prod-2p.ts	

Table E.42: US file - specifies destination for vessels.

Parameter	Values	Notes
name	US	
neighbours	20	determines max number of neighbours considered
capacity	1000	
location		
longitude	119	
latitude	-17.5	

Table E.43: logger file -Used in calibration. Loggers at Outflows - locations chosen to be near outflow. Loggers sample water concentrations at set intervals and are used as input to epa controls.

Parameter	Values	Notes	
tick_length	259200	seconds	typical time step length
little_tick	259200	seconds	
big_tick	2592000	seconds	maximum standard time step length
normal_tick	259200	seconds	typical time step length
monitor_current	0		
monitor_environments	Outfall	selects environmental attributes/contaminants to monitor	
env_samplesize	3		
sample_mode	2	max	
Current_K	0	anchored	
Wind_K	0	anchored	
track	1		
avian	1		
terrestrial	1		
marine	1		

Table E.44: logger file - Loggers at Outflows - locations chosen to be near outflow Loggers sample water concentrations at set intervals and are used as input to epa controls.

Parameter	Values	Notes
base_taxon	Logger	program control parameter - selects parent taxon to init parameters
monitor_environments	Bitterns,accumtoxin*	selects environmental attributes/contaminants to monitor
tag	NBlogger	

Table E.45: dot file - Department of Transport.

Parameter	Values	Notes	
	Department of Transport - no parameters		
name	dot		
tick_length	86400	seconds	typical time step length

Table E.46: stdvessel file – parameters for standard shipping vessels.

Parameter	Values	Notes	
tick_length	4800	seconds	typical time step length
bored_tick	172800	seconds	maximum standard time step length
alarmed_tick	1200	seconds	standard time step length if in active state
neighbours	20	determines max number of neighbours considered	
TimeInPort	21600	time between fishing excursions – assumes six hours to load/unload	
SpeedInPort	0	limits vessel speed in port – must be zero while "in port"	
speed	8		
maxspeed	8		
FuelCapacity	15000	adequate for duration of transits – need not be true value	
FuelEfficiency	0.01 s-1	estimated from capacity and duration	
VoyageLength	30 days		
Percpetion_Range	20		
ExclusionZone	50		
min_depth	-10	minimum ocean depth for vessels – adequate for a physical constraint in the model runs	

Table E.47: fisher file – parameters for a normal finfish trawler. Vessel data from David McDonald, historical data from WAFMA and logbooks.

Parameter	Values	Notes	
BackgroundCPUE	700		
wellbuffer	5000	MGMT parameter - regulated buffer zone	
pipelinebuffer	2000	MGMT parameter - regulated buffer zone	
Track	1		
tick_length	21600	seconds	Typical time step length
bored_tick	172800	seconds	Maximum standard time step length
alarmed_tick	4800	seconds	Standard time step length if in active state
min_depth	-3	minimum ocean depth for vessels – provides a physical constraint	
max_depth	-200	maximum ocean depth for vessels - keeps them inshore	
ExclusionZone	50		
set_time	0		
set_speed	1.5		
catchmemoryhysteresis	0.4		
neighbours	200	determines max number of neighbours considered	
Trawler	1	program control param - allows vessel to trawl	
TimeInPort	21600	time between fishing excursions – assumes six hours to load/unload	
SpeedInPort	0	limits vessel speed in port – must be zero when “in port”	
TimeToDeploy	600	time to deploy fishing gear – assumes ten minutes to deploy nets	
SpeedToDeploy	1.6	boat speed at which fishing gear is deployed (VMS & David McDonald pers. comm.)	
FOPtime	14400	seconds	amount of time spent towing trawl nets etc (estimated)

Table E.47: Continued

Parameter	Values	Notes
FOPspeed	1.75	boat speed at which the nets are towed (VMS & David McDonald pers. comm.)
HaulingTime	1200	How long it takes to haul the gear in – assumed to be twenty minutes
HaulingSpeed	1.6	boat speed at which the gear are hauled -- assumed to be the same as deployment
ProcessingTime	1800	time it takes to stow fish – taken to be half an hour
ProcessingSpeed	0	vessel speed which processing – ship is taken to be stationary during processing
speed	3	
maxspeed	4	
HoldCapacity	4500	Consensus value (David McDonald pers. comm.*m.)*
FuelCapacity	40000	Consensus value (David McDonald pers. comm.*m.)*
FuelPrice	1	
vmsEffortRatio	0.68	
FuelEfficiency	0.01 s-1	estimated from capacity and duration
Mesh	0.12	Somewhere between 4 & 4.5 inches net mesh (consensus value, David McDonald pers. comm.)
Efficiency		efficiency of gear – Not used on Populations
default	0.1	
HighEfficiency	0.5	
BenthicEfficiency	0.05	Landing efficiency of gear (Hall 2000)
HookCount	0	
VoyageLength	14 days	

Table E.47: Continued

Parameter	Values	Notes
TrawlWidth	90	Effective width of net for calculations
BottomWidth	33	width of net on the bottom
SightingRange	3000.0 meters	distance at which suface effects of schools can be sighted (including birds)
HighGrading	0	Does not allow vessel to discard bycatch
FishingGrid		establishes origin of the grid which ranks areas likely CPUE
Longitude	114.5	
latitude	-21.5	
Prefers		relative targeting ranking (arbitary, with most preferred target species given highest ranking)
lsebae	40	Lutjanus sebae
llut	40	large lutjanids
slut	40	Small lutjanids
leth	20	Lethrinids
nemip	5	Nemipterids
saur	1.0	Saurids (not targeted per se, but given a notice here so know to interact)
Fish	7	Fish in general

Table E.48: ntq-fisher file – parameters for a normal finfish trawler which high-grades catch. Vessel data from David McDonald, historical data from WAFMA and logbooks.

Parameter	Values	Notes	
BackgroundCPUE	700		
wellbuffer	5000	MGMT parameter - regulated buffer zone	
pipelinebuffer	2000	MGMT parameter - regulated buffer zone	
track	1		
tick_length	4800	seconds	typical time step length
bored_tick	172800	seconds	maximum standard time step length
alarmed_tick	1200	seconds	standard time step length if in active state
min_depth	-3	minimum ocean depth for vessels – provides a physical constraint	
max_depth	-200	maximum ocean depth for vessels - keeps them inshore & controlled zones	
ExclusionZone	50		
set_time	0		
set_speed	1.5		
catchmemoryhysteresis	0		
neighbours	200	determines max number of neighbours considered	
Trawler	1	program control param - allows vessel to trawl	
TimeInPort	21600	assumed to need 6 hours for unloading/loading	
SpeedInPort	0	limits vessel speed in port – must be zero hen berthed	
TimeToDeploy	600	time to deploy fishing gear – taken to be ten minutes	
SpeedToDeploy	1.6	boat speed at which fishing gear is deployed (VMS & Consensus data via D. McDonald pers. comm.)	
FOPtime	10800	amount of time spent towing trawl nets etc (estimated)	

Table E.48: Continued

Parameter		Values	Notes
FOPspeed		1.75	boat speed at which the nets are towed (VMS & Consensus data via D.McDonald pers. comm.)
HaulingTime		1200	how long it takes to haul the gear in – taken to be 20 mins
HaulingSpeed		1.75	boat speed at which the gear are hauled – taken to be the same as deployment
ProcessingTime		1800	time it takes to stow fish – taken to be half an hour
ProcessingSpeed		0	vessel speed which processing – taken to be zero during processing
speed		3	
maxspeed		4	
HoldCapacity		4500	consensus value via David McDonald pers. comm.*m.*
FuelCapacity		40000	consensus value
FuelEfficiency		0.005 s-1	estimated from capacity and duration
Mesh		0.12	somewhere between 4 & 4.5 inches net mesh size – Consensus value
Efficiency			efficiency of gear – NOT USED for Populations
	default	0.1	
	HighEfficiency	0.5	
BenthicEfficiency	0.05		landing efficiency of gear (Hall 2000)
HookCount	0		
VoyageLength	7 days		
TrawlWidth	90		effective width of net

Table E.48: Continued

Parameter		Values	Notes
BottomWidth	33		width of net on the bottom
SightingRange	3000 meters		distance at which suface effects of schools can be sighted (incl. birds)
HighGrading		1	Allows vessel to discard bycatch
FishingGrid			establishes origin of the grid which ranks areas likely CPUE
longitude		114.5	
latitude		-21.5	
Prefers			relative targeting ranking (arbitary, with most preferred target species given highest ranking)
	lsebae	40	Lutjanus sebae
	llut	40	Large lutjanids
	slut	40	Small lutjanids
	leth	20	Lethrinids
	nemip	5	Nemipterids
	saur	1.0	Saurids (not targeted per se, but given a ranking here so know to interact)

Table E.49: prawnfisher file – parameters for a normal prawn trawler. Vessel data from David McDonald, historical data from WAFMA and logbooks.

Parameter	Values	Notes
BackgroundCPUE	700	
wellbuffer	5000	MGMT parameter - regulated buffer zone
pipelinebuffer	2000	MGMT parameter - regulated buffer zone
track	1	
tick_length	21600	seconds typical time step length
bored_tick	172800	seconds maximum standard time step length
alarmed_tick	4800	seconds standard time step length if in active state
min_depth	-2.5	minimum ocean depth for vessels – provides a physical constraint
max_depth	-200	maximum ocean depth for vessels - keeps them inshore
ExclusionZone	3	
set_time	0	
set_speed	1.5	
catchmemoryhysteresis	0.4	
neighbours	200	determines max number of neighbours considered
Trawler	1	program control param - allows vessel to trawl
TimeInPort	43200	time between fishing excursions -- only spend 12 hours out at a time.
SpeedInPort	0	limits vessel speed in port – berthed
TimeToDeploy	600	time to deploy fishing gear – taken to be 10 mins
SpeedToDeploy	1.6	boat speed at which fishing gear is deployed
FOPtime	7200	amount of time spent towing trawl nets etc (estimated)

Table E.49: Continued

Parameter	Values	Notes
FOPspeed	1.75	boat speed at which the nets are towed
HaulingTime	1200	how long it takes to haul the gear in – taken to be 20 mins
HaulingSpeed	1.6	boat speed at which the gear is hauled in
ProcessingTime	1800	time it takes to stow fish – taken to be half an hour
ProcessingSpeed	0	vessel speed which processing – boat is taken to be stationary during sorting
speed	3	
maxspeed	4	
HoldCapacity	4500	taken to be the same as the finfish
FuelCapacity	40000	taken to be the same as the finfish – not critical, since the prawn trawlers have shorter trips
FuelEfficiency	0.05 s-1	estimated from capacity and duration
Mesh	0.01	it is *really* 2cm, but the prawns manage to get through :-(
Efficiency		landing efficiency of gear
Default	0.1	
HighEfficiency	0.5	
BenthicEfficiency	0.1	landing efficiency of gear
HookCount	0	
VoyageLength	7 days	
TrawlWidth	90	effective width of net
BottomWidth	33	width of net on the bottom

Table E.49: Continued

Parameter	Values	Notes
SightingRange	100000.0 meters	distance at which suface effects of schools can be sighted 10k with spotter planes (now 100k)
HighGrading	0	does not allow vessel to discard bycatch
FishingGrid		establishes origin of the grid which ranks areas likely CPUE
lowerleft		
longitude	114	
latitude	-23	
upperright		
longitude	119.5	
latitude	-17.5	
Prefers		relative targeting ranking (arbitary, with most preferred target species given highest ranking)
bananaprawn	50	Banana prawns
kingprawn	40	King prawns
		plane parameters
UseSpotterPlane	1	
SpotterTolerance	1000	
Plane		
tick_length	86400	seconds typical time step length for planes
bored_tick	604800	seconds maximum standard time step length for planes
alarmed_tick	4800	seconds standard time step length if in active state

Table E.50: fishing_survey file – parameters for a normal stock survey trawler.

Parameter	Values	Notes
BackgroundCPUE	700	
wellbuffer	5000	MGMT parameter - regulated buffer zone
pipelinebuffer	2000	MGMT parameter - regulated buffer zone
track	1	
tick_length	4800	seconds typical time step length
bored_tick	172800	seconds maximum standard time step length
alarmed_tick	1200	seconds standard time step length if in active state
min_depth	-3	minimum ocean depth for vessels -- provides physical constraint
max_depth	-200	maximum ocean depth for vessels - keeps them inshore
ExclusionZone	50	
set_time	0	
set_speed	1.5	
CatchMemoryHysteresis	0.4	
neighbours	200	determines max number of neighbours considered
Trawler	1	program control param - allows vessel to trawl
TimeInPort	21600	time between fishing excursions – load/unload
SpeedInPort	0	limits vessel speed in port – berthed
TimeToDeploy	600	time to deploy fishing gear – taken to be ten minutes
SpeedToDeploy	1.6	boat speed at which fishing gear is deployed – same as for finfish trawl
FOPtime	10800	amount of time spent towing trawl nets etc (estimated in finfish trawl)
FOPspeed	1.75	boat speed at which the nets are towed – same as finfish trawl
HaulingTime	1200	how long it takes to haul the gear in -- taken to be 20 minutes, as for commercial trawl

Table E.50: Continued

Parameter	Values	Notes
HaulingSpeed	1.6	boat speed at which the gear are hauled – taken to mimic finfish trawl
ProcessingTime	1800	time it takes to stow fish, probably should be longer, but taken to tbe the same as for the commercial trawl
ProcessingSpeed	0	vessel speed which processing, taken to be the same as for the finfish trawl
speed	3	
maxspeed	4	
HoldCapacity	4500	arbitrarily the same as the finfish trawl
FuelCapacity	40000	adequate for the surveys
FuelEfficiency	0.005 s-1	estimated from capacity and duration
Mesh	0.12	somewhere between 4 & 4.5 inches net mesh size – consensus value
Efficiency		landing efficiency of gear, Hall (2000)
default	0.1	
HighEfficiency	0.5	
HookCount	0	
VoyageLength	7 days	
TrawlWidth	90	effective width of net
BottomWidth	33	width of net on the bottom
SightingRange	3000.0 meters	distance at which suface effects of schools can be sighted (including birds)
HighGrading	0	allows vessel to discard bycatch

Table E.50: Continued

Parameter	Values	Notes
FishingGrid		establishes origin of the grid which ranks areas likely CPUE
longitude	114.5	
latitude	-21.5	
Prefers		
tuna	40	
llut	40	
lsebae	40	
slut	40	
leth	20	
nemip	5	
saur	1	

Table E.51: trap-fisher file – parameters for a normal trap fishing vessels. Vessel data from David McDonald, historical data from WAFMA and logbooks.

Parameter	Values	Notes
BackgroundCPUE	700	
wellbuffer	500	MGMT parameter - regulated buffer zone
pipelinebuffer	500	MGMT parameter - regulated buffer zone
MaximumFishingDepth	-200	
track	1	
tick_length	4800	seconds typical time step length
bored_tick	172800	seconds maximum standard time step length
alarmed_tick	1200	seconds standard time step length if in active state
min_depth	-3	minimum ocean depth for vessels – establishes physical constraint
max_depth	-200	maximum ocean depth for vessels - keeps them inshore
ExclusionZone	50	
set_time	0	
set_speed	1.5	
catchmemoryhysteresis	0.4	
neighbours	20	dtermines max number of neighbours considered
#Trawler	1	program control param - defaults to zero: does not allow vessel to trawl
Trapper	1	program control param - allows vessel to set traps
TimeInPort	21600	time between fishing excursions – taken to be 6 hours
SpeedInPort	0	limits vessel speed in port – berthed
TimeToDeploy	600	time to deploy fishing gear – taken to be ten minutes
SpeedToDeploy	0	boat speed at which fishing gear is deployed – boat stops to deploy traps

Table E.51: Continued

Parameter	Values	Notes
FOPtime	0	amount of time spent towing trawl nets etc -- traps are not towed
FOPspeed	0	boat speed at which the nets are towed
HaulingTime	1200	how long it takes to haul the gear (estimated)
HaulingSpeed	0	boat speed at which the gear are hauled – stationary hauling traps in
ProcessingTime	1800	time it takes to stow fish – taken to be half an hour
ProcessingSpeed	0	vessel speed which processing – taken to be stationary
speed	3	
maxspeed	4	
HoldCapacity	4500	taken to be similar to trawl fishery
FuelCapacity	40000	taken to be similar to trawl fishery
FuelEfficiency	0.05 s-1	estimated from capacity and duration
VoyageLength	7 days	
SightingRange	3000.0 meters	distance at which suface effects of schools can be sighted (incl. birds)
HighGrading	0	does not allow vessel to discard bycatch
trapSoakTime	7200	
circuits_per_trip	2	
Prefers		
lsebae	40	
llut	40	
slut	40	
leth	20	
nemip	5	
saur	1	

Table E.52: leghold file – specifies the parameters which are associated with fish traps.

Parameter	Values	Notes
tick_length	4800	seconds Typical time step length
capacity	25	kilos of fish trap will hold
influence_radius	100000	metres radius of total effect (population-scale parameterisation; would be fine if fish-scale)
neighbours	20	Determines max number of neighbours considered from fisher

Table E.53: fishWAFMA file – Management Authority for the prawn fisheries.

Parameter		Values	Notes
global_callback			program control parameter
	integrated-management	1	program control parameter - controls mgmt mode
	default	0	

Table E.54: popWAFMA file – Management Authority for the finfish fisheries.

Parameter	Values	Notes
global_callback		program control parameter
integrated-management	1	program control parameter - controls mgmt mode
default	0	

Table E.55: popBiomass file – specifies the periodicity of the population reporting from within the model. PopBiomass also applies historical mortality.

Parameter	Values	Notes
schedule	@01/15	

Table E.56: popage file – specifies when the juvenile finfish populations are recruited to the adult population (program parameter).

Parameter	Values	Notes
schedule	@12/15	

Table E.57: sharkesky file – sets parameters for tracking shark biomass and triggering management actions in scenarios with integrated management.

Parameter		Values	Notes
global_callback			program control parameter
	integrated-management	1	program control parameter - controls mgmt mode
	default	0	
epa_trigger			
	numbers	-1	take the value from the end of the historical period
	biomass	0	don't use biomass
	mean_mass	0	or mean_mass

Table E.58: turtleesky file – sets parameters for tracking turtle biomass and triggering management actions in scenarios with integrated management population trackers.

Parameter		Values	Notes
global_callback			program control parameter
	integrated-management	1	program control parameter - controls mgmt mode
	default	0	
epa_trigger			
	numbers	-1	take the value from the end of the historical period
	biomass	0	don't use biomass
	mean_mass	0	or mean_mass

APPENDIX F: INVITRO CONFIGURATION FILES

These tables contain the configuration files used in the NWSJEMS MSE runs. The format for these files is:

<agent type> <taxon or agent name> <start time> <end time> <configuration parameters>

A start or end time of 0 indicates that the agent will commence (or end) with the entire simulation rather than on a specific date.

The configuration parameters typically include the latitude and longitude of their starting position or extent, whether they are to be tracked, their periodicity of output and a sting list of other agent types they may be interested in.

Class	Name	Start	End	Location in Model Space				Size	Proj DB	Projection	Cell No	Suppress Output	Period	Sm. scale Report period	Lg. scale Report period	Report file	Targets
Adviser	adv1:	0	0	-720643	-2.20E+06	-619999	-2.08E+06	0.1	map.rc	none	1	0	quarterly	quarterly	Yearly	adv1.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv2:	0	0	-720643	-2.08E+06	-619999	-1.97E+06	0.1	map.rc	none	2	0	quarterly	quarterly	yearly	adv2.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv3:	0	0	-720643	-1.97E+06	-619999	-1.85E+06	0.1	map.rc	none	3	0	quarterly	quarterly	yearly	adv3.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv4:	0	0	-720643	-1.85E+06	-619999	-1.74E+06	0.1	map.rc	none	4	0	quarterly	quarterly	yearly	adv4.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease

Class	Name	Start	End	Location in Model Space				Size	Proj DB	Projection	Cell No	Suppress Output	Period	Sm. scale Report period	Lg. scale Report period	Report file	Targets
Adviser	adv5:	0	0	-720643	-1.74E+06	-619999	-1.63E+06	0.1	map.rc	none	5	0	quarterly	quarterly	yearly	adv5.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv6:	0	0	-619999	-2.20E+06	-519355	-2.08E+06	0.1	map.rc	none	6	0	quarterly	quarterly	yearly	adv6.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv7:	0	0	-619999	-2.08E+06	-519355	-1.97E+06	0.1	map.rc	none	7	0	quarterly	quarterly	yearly	adv7.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv8:	0	0	-619999	-1.97E+06	-519355	-1.85E+06	0.1	map.rc	none	8	0	quarterly	quarterly	yearly	adv8.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv9:	0	0	-619999	-1.85E+06	-519355	-1.74E+06	0.1	map.rc	none	9	0	quarterly	quarterly	yearly	adv9.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv10:	0	0	-619999	-1.74E+06	-519355	-1.63E+06	0.1	map.rc	none	10	0	quarterly	quarterly	yearly	adv10.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv11:	0	0	-519355	-2.08E+06	-418711	-1.97E+06	0.1	map.rc	none	11	0	quarterly	quarterly	yearly	adv11.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease

Class	Name	Start	End	Location in Model Space				Size	Proj DB	Projection	Cell No	Suppress Output	Period	Sm. scale Report period	Lg. scale Report period	Report file	Targets
Adviser	adv12:	0	0	-519355	-1.97E+06	-418711	-1.85E+06	0.1	map.rc	none	12	0	quarterly	quarterly	yearly	adv12.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv13:	0	0	-519355	-1.85E+06	-418711	-1.74E+06	0.1	map.rc	none	13	0	quarterly	quarterly	yearly	adv13.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv14:	0	0	-519355	-1.74E+06	-418711	-1.63E+06	0.1	map.rc	none	14	0	quarterly	quarterly	yearly	adv14.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv15:	0	0	-418711	-2.08E+06	-318067	-1.97E+06	0.1	map.rc	none	15	0	quarterly	quarterly	yearly	adv15.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv16:	0	0	-418711	-1.97E+06	-318067	-1.85E+06	0.1	map.rc	none	16	0	quarterly	quarterly	yearly	adv16.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv17:	0	0	-418711	-1.85E+06	-318067	-1.74E+06	0.1	map.rc	none	17	0	quarterly	quarterly	yearly	adv17.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv18:	0	0	-418711	-1.74E+06	-318067	-1.63E+06	0.1	map.rc	none	18	0	quarterly	quarterly	yearly	adv18.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease

Class	Name	Start	End	Location in Model Space				Size	Proj DB	Projection	Cell No	Suppress Output	Period	Sm. scale Report period	Lg. scale Report period	Report file	Targets
Adviser	adv19:	0	0	-318067	-1.97E+06	-217423	-1.85E+06	0.1	map.rc	none	19	0	quarterly	quarterly	yearly	adv19.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv20:	0	0	-318067	-1.85E+06	-217423	-1.74E+06	0.1	map.rc	none	20	0	quarterly	quarterly	yearly	adv20.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv21:	0	0	-318067	-1.74E+06	-217423	-1.63E+06	0.1	map.rc	none	21	0	quarterly	quarterly	yearly	adv21.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv22:	0	0	-217423	-1.97E+06	-116779	-1.85E+06	0.1	map.rc	none	22	0	quarterly	quarterly	yearly	adv22.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv23:	0	0	-217423	-1.85E+06	-116779	-1.74E+06	0.1	map.rc	none	23	0	quarterly	quarterly	yearly	adv23.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease
Adviser	adv24:	0	0	-217423	-1.74E+06	-116779	-1.63E+06	0.1	map.rc	none	24	0	quarterly	quarterly	yearly	adv24.mon.pt	Mangroves Seagrass llut lsebae Slut nemip leth saur Sponge kingprawn bananaprawn shark turtle oysterlease

Bruce.cfg

Configures the recreational fishing effort.

Class	Name	Starts	Ends	Road network	Periodicity	Report file	Q:trawl_Q	Size:MaxSize Ratio for keepers	Radius of influence	Tithe	Max depth fished	Participation Rate	
recfisher	Bruce:	1/01/2001	0	pilbara-roads.xy.pt	monthly	anglers.tbl	0.0005	2	50000	0.3	-20	0.47	Llut lsebae slut leth nemip saur shark Kingprawn Bananaprawn turtle

EContLateStart.cfg

This file is just a list of the component configuration files which should be used for the Enhanced run with contaminants.

```
&include    ../configs/world.cfg
&include    ../configs/Advisers.cfg

&include    ../configs/Ports.cfg
&include    ../configs/Govt.cfg
&include    ../configs/Zones.cfg

&include    ../configs/Habitat.cfg
&include    ../configs/FishPopulations.cfg
&include    ../configs/PrawnStocksLateStart.cfg
```

```
&include    ../configs/Sharks.cfg
&include    ../configs/Turtles.cfg
&include    ../configs/Oysterlease.cfg
# Turn on the contaminants
&include    ../configs/inshore-outfalls

&include    ../configs/HistoricalPrawnLate.cfg

&include    ../configs/Bruce.cfg
&include    ../configs/TrawlBoats.cfg
&include    ../configs/trapper.cfg
&include    ../configs/PrawnFleet.cfg

&include    ../configs/SurveyVessel.cfg

&include    ../configs/Vessels.cfg
&include    ../configs/Rigs.cfg

polyorganism    Ponyfish:    0        bycatch.xy.pt    map.rc    none    0        0
```

EContLateStart2p.cfg

This file is just a list of the component configuration files which should be used for the Enhanced run with contaminants and the two pulse development.

```
&include    ../configs/world.cfg
&include    ../configs/Advisers.cfg

&include    ../configs/Ports.cfg
&include    ../configs/Govt.cfg
&include    ../configs/Zones.cfg

&include    ../configs/Habitat.cfg
&include    ../configs/FishPopulations.cfg
&include    ../configs/PrawnStocksLateStart.cfg
&include    ../configs/Sharks.cfg
&include    ../configs/Turtles.cfg
&include    ../configs/Oysterlease.cfg
# Turn on the contaminants
&include    ../configs/inshore-outfalls

&include    ../configs/HistoricalPrawnLate.cfg

&include    ../configs/Bruce.cfg
```

&include ../configs/TrawlBoats.cfg
&include ../configs/trapper.cfg
&include ../configs/PrawnFleet.cfg

&include ../configs/SurveyVessel.cfg

&include ../configs/Vessels2p.cfg
&include ../configs/Rigs.cfg

Class	Taxon	Track?	Presence data	Projection DB	Projection	Start	End
polyorganism	ponyfish:	0	bycatch.xy.pt	map.rc	none	0	0

FishPopulations.cfg

This file configures the fish Populations

Class	Taxon	Start	End	Period	Report file	TargetType	Unused	Trawl history files	Trap history files
POPbiomass	popBiomass:	0	0	yearly	pop.tbl	-1	emperor	hist: lsebae.his llut.his slut.his nemip.his leth.his saur.his effort.his	trap: lsebaeTrap.his llutTrap.his slutTrap.his nemipTrap.his lethTrap.his saurTrap.his effortTrap.his

Class	Taxon	Start	End	Period	Targets
GraduatePop	popage:	0	0	yearly	Llut slut nemip saur leth lsebae

&include ../configs/LlutPopulations.cfg

&include ../configs/LethPopulations.cfg

&include ../configs/LsebaePopulations.cfg

&include ../configs/SlutPopulations.cfg

&include ../configs/SaurPopulations.cfg

&include ../configs/NemipPopulations.cfg

Govt.cfg

Specifies "infrastructure" with an impact on the system

Class	Taxon	Start	End	Report file	Input file	Targets
catastrophe	sandpit:	0	0	Dredged.dat	Dredge.data	Benthic animal

Habitat.cfg

This file configures the benthic habitat agents and Monitors which track their state.

Class	Taxon	Track?	Presence data	Projection DB	Projection	Start	End
benthic	mangroves:	0	mangrovegrids.ll.pt	map.rc	nws	0	0
benthic	seagrass:	0	macrophytegrids.ll.pt	map.rc	nws	0	0
benthic	sponge:	0	porifera_grown.ll.pt	map.rc	nws	0	0

Class	Taxon	Start	End	Period	Report file	Target
tracker	shoreplants:	3/01/1970	0	Yearly	mangroves	mangroves
tracker	benthicplants:	3/01/1970	0	Yearly	seagrass	seagrass
tracker	poriferas:	3/01/1970	0	Yearly	sponge	sponge

HistoricalPrawn.cfg

Configures the agent which applies historical effort to prawn fishery.

Class	Taxon	Start	End	Period	Report file	Target type	Unused	Targets
FishBiomass	fishBiomass:	0	0	monthly	fishpop.tbl	-1	emperor	hist: KingPrawnSpatialCatch.his BananaPrawnSpatialCatch.his PrawnEffortSpatial.his

HistoricalPrawnLate.cfg

Configures the agent which applies historical effort to prawn fishery.

Class	Taxon	Start	End	Period	Report file	Target type	Unused	Targets
FishBiomass	fishBiomass:	1/01/1995	1/01/2020	monthly	fishpop.tbl	-1	emperor	hist: KingPrawnSpatialCatch.his BananaPrawnSpatialCatch.his PrawnEffortSpatial.his

IntManEnhancesLateStart.cfg

Includes configuration files for a run with integrated management and enhanced options.

```
&include    ../configs/world.cfg
&include    ../configs/Advisers.cfg

&include    ../configs/Ports.cfg
&include    ../configs/Govt.cfg
&include    ../configs/Zones.cfg

&include    ../configs/Bruce.cfg
&include    ../configs/TrawlBoats.cfg
&include    ../configs/trapper.cfg
&include    ../configs/PrawnFleet.cfg
```

&include ../configs/HistoricalPrawnLate.cfg

&include ../configs/SurveyVessel.cfg

&include ../configs/Vessels.cfg
&include ../configs/Rigs.cfg

&include ../configs/Habitat.cfg
&include ../configs/FishPopulations.cfg
&include ../configs/PrawnStocksLateStart.cfg
&include ../configs/Sharks.cfg
&include ../configs/Turtles.cfg
&include ../configs/Oysterlease.cfg

Class	Taxon	Track?	Presence data	Projection DB	Projection	Start	End
polyorganism	ponyfish:	0	bycatch.xy.pt	map.rc	none	0	0

Oysterlease.cfg

Configures agents used to represent oyster leases.

Class	Taxon	Track?	Start	End	Location			Velocity			Age	Mass	Contaminants tracked
thing	oysterlease:	1	0	0	114.21	-22.42	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.23	-22.45	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.33	-22.4	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.37	-22.19	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.3	-22.21	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.9	-20.41	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.86	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.92	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.85	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.87	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.1	-22.19	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.11	-22.1	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin

thing	oysterlease:	1	0	0	115.51	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.48	-20.44	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.48	-20.41	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.48	-20.42	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	114.36	-22.25	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.48	-20.38	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.63	-20.39	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.64	-20.4	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.61	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.64	-20.45	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	118.93	-19.88	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	118.92	-19.86	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.3	-20.78	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.63	-20.5	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.65	-20.39	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin

thing	oysterlease:	1	0	0	115.64	-20.39	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	117.19	-20.6	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	118.49	-20.31	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.61	-20.39	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.62	-20.42	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.44	-20.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.45	-20.63	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.47	-20.64	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.18	-20.84	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	116.56	-20.55	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.52	-20.62	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.62	-20.39	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	117.67	-20.65	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.49	-21.43	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin
thing	oysterlease:	1	0	0	115.68	-20.6	-1	0	0	0	0	0	Bitterns Calcium Sulphate Zinc Cadmium Copper Lead Oil PetroleumHydrocarbons Tin

Ports.cfg

Selects ports to include in status quo run.

Name	Scenario configuration
Exmouth:	Exmouth
Point-Samson:	Point-Samson
Port-Hedland:	Port-Hedland
Dampier:	Dampier
Osaka:	Osaka
Calcutta:	Calcutta
US:	US
Bombay:	Bombay
NRA_port:	NRA_port
Cossack_port:	Cossack_port
Onslow:	Onslow

Ports_1p.cfg

Selects ports to include in run with one development pulse.

Name	Scenario configuration
Exmouth:	Exmouth_1p
Point-Samson:	Point-Samson
Port-Hedland:	Port-Hedland_1p
Dampier:	Dampier_1p
Osaka:	Osaka
Calcutta:	Calcutta
US:	US
Bombay:	Bombay
NRA_port:	NRA_port
Cossack_port:	Cossack_port
Onslow:	Onslow_1p

Ports_2p.cfg

Selects ports to include in run with two development pulses.

Name	Scenario configuration
Exmouth:	Exmouth_2p
Point-Samson:	Point-Samson
Port-Hedland:	Port-Hedland_2p
Dampier:	Dampier_2p
Osaka:	Osaka
Calcutta:	Calcutta
US:	US
Bombay:	Bombay
NRA_port:	NRA_port
Cossack_port:	Cossack_port
Onslow:	Onslow_2p

PrawnFleet.cfg

Configures the management authority and includes the spotter planes and fishing fleets for the status quo runs.

Class	Management Authority	Start	End	Period	Trawl zones	Trap zones	Prawn zones	Report file	Target class	Stock assessment data files
FMA	fishWAFMA:	0	0	monthly	pilbara-zones	pilbara-trap-zones	prawn-zones	fishWAFMA.rpt	T: boat	SAD: KingprawnNODAT.SAD

&include ../configs/planes.cfg

&include ../configs/ExmouthBoats.cfg
&include ../configs/OnslowBoats.cfg
&include ../configs/DampierBoats.cfg

PrawnFleet_1p.cfg

Configures the management authority and includes the spotter planes and fishing fleets for the runs with one development pulse.

Class	Management Authority	Start	End	Period	Trawl zones	Trap Zones	Prawn zones	Report file	Enh. Mgmnt.	Targets	Stock assessment data files
FMA	fishWAFMA:	0	0	monthly	pilbara-zones	pilbara-trap-zones	prawn-zones	fishWAFMA.rpt	0	T: boat	SAD: KingprawnNODAT.SAD BananaprawnNODAT.SAD

```
&include    ../configs/planes.cfg

&include    ../configs/ExmouthBoats_1p.cfg
&include    ../configs/OnslowBoats_1p.cfg
&include    ../configs/DampierBoats_1p.cfg
```

PrawnStocks.cfg

Includes the king prawn and banana brawn stock files.

```
&include    ../configs/Kingprawns.cfg
&include    ../configs/Bananaprawns.cfg
```

PrawnStocksLateStart.cfg

Includes the king prawn and banana brawn stock files.

```
&include    ../configs/KingprawnsLateStart.cfg
&include    ../configs/BananaprawnsLateStart.cfg
```

Rigs.cfg

Configures the platforms for Vessels to use as part of their itinerary.

Class	Taxon	Controller	State of Production	Start	End	Unused	Ununsed	Unused	Fishing Restriction
oilco	Ampule:	0							
rig	N_Rankin_A:	Ampule	2	0	0	1.00E+12	1.00E+10	300	10000
rig	Cossack:	Ampule	2	0	0	1.00E+12	1.00E+10	300	10000

Sharks.cfg

Configures agents which represent the shark population and agents to monitor them.

Class	Taxon	Starts	Ends	Sample interval	Report file	Target type	Include blastula	Only recruits	Targets
biomass	sharkesky:	0	0	monthly	shark_bio.tbl	0	0	0	shark

Class	Taxon	Starts	Ends	Sample interval	Report file	Targets
tracker	sharks:	0	0	monthly	sharkmap	shark

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass
blastula	shark:	1	0	0	114.5	-21.5	0	0	0	0	0	0.001
blastula	shark:	1	0	0	115.6	-19.9	0	0	0	0	0	0.001
blastula	shark:	1	0	0	116	-20.25	0	0	0	0	0	0.001
blastula	shark:	1	0	0	116.9	-19.9	0	0	0	0	0	0.001
blastula	shark:	1	0	0	118.2	-19.7	0	0	0	0	0	0.001
blastula	shark:	1	0	0	119	-19.2	0	0	0	0	0	0.001
blastula	shark:	1	0	0	119.5	-19.2	0	0	0	0	0	0.001

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	120.002	-19.4367	0	0	0	0	0	85.878632	0.8	15
fish	shark:	1	0	0	117.0959	-20.0543	0	0	0	0	0	106.133728	0.8	12
fish	shark:	1	0	0	119.5107	-19.2237	0	0	0	0	0	100.569725	0.8	15
fish	shark:	1	0	0	115.2302	-21.5482	0	0	0	0	0	99.968025	0.8	13
fish	shark:	1	0	0	118.5895	-18.7052	0	0	0	0	0	99.476097	0.8	19
fish	shark:	1	0	0	116.8145	-20.0416	0	0	0	0	0	85.935997	0.8	11
fish	shark:	1	0	0	118.1368	-19.8954	0	0	0	0	0	82.06456	0.8	18
fish	shark:	1	0	0	114.6304	-21.5754	0	0	0	0	0	119.443916	0.8	12
fish	shark:	1	0	0	115.3266	-20.1534	0	0	0	0	0	63.351952	0.8	11
fish	shark:	1	0	0	117.8482	-18.3479	0	0	0	0	0	63.351952	0.8	18
fish	shark:	1	0	0	115.9436	-19.0271	0	0	0	0	0	63.351952	0.8	23
fish	shark:	1	0	0	117.3272	-20.4502	0	0	0	0	0	63.351952	0.8	36
fish	shark:	1	0	0	119.6269	-18.1057	0	0	0	0	0	62.849514	0.8	34

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.7441	-19.5313	0	0	0	0	0	60.346157	0.8	25
fish	shark:	1	0	0	118.2556	-19.6129	0	0	0	0	0	60.346157	0.8	17
fish	shark:	1	0	0	119.8787	-19.3509	0	0	0	0	0	60.346157	0.8	18
fish	shark:	1	0	0	118.9035	-17.6088	0	0	0	0	0	60.346157	0.8	27
fish	shark:	1	0	0	117.9114	-18.4388	0	0	0	0	0	60.346157	0.8	16
fish	shark:	1	0	0	115.8507	-20.1111	0	0	0	0	0	60.346157	0.8	17
fish	shark:	1	0	0	119.2918	-19.3417	0	0	0	0	0	58.824387	0.8	15
fish	shark:	1	0	0	117.4845	-20.2108	0	0	0	0	0	58.824387	0.8	24
fish	shark:	1	0	0	119.291	-19.0697	0	0	0	0	0	58.824387	0.8	28
fish	shark:	1	0	0	114.5649	-21.5161	0	0	0	0	0	58.210415	0.8	29
fish	shark:	1	0	0	119.9001	-18.3057	0	0	0	0	0	58.210415	0.8	18
fish	shark:	1	0	0	119.1814	-19.2817	0	0	0	0	0	58.210415	0.8	26
fish	shark:	1	0	0	119.7607	-19.0187	0	0	0	0	0	58.210415	0.8	32
fish	shark:	1	0	0	116.8309	-18.9823	0	0	0	0	0	55.742508	0.8	10
fish	shark:	1	0	0	119.3422	-18.0505	0	0	0	0	0	55.742508	0.8	29
fish	shark:	1	0	0	118.4656	-19.0188	0	0	0	0	0	55.742508	0.8	21
fish	shark:	1	0	0	117.536	-19.9403	0	0	0	0	0	55.742508	0.8	19
fish	shark:	1	0	0	119.5919	-17.5282	0	0	0	0	0	55.742508	0.8	23
fish	shark:	1	0	0	115.7294	-20.4154	0	0	0	0	0	54.182186	0.8	11
fish	shark:	1	0	0	119.6146	-18.3839	0	0	0	0	0	54.182186	0.8	30
fish	shark:	1	0	0	118.8989	-18.8051	0	0	0	0	0	54.182186	0.8	15
fish	shark:	1	0	0	115.0073	-20.9704	0	0	0	0	0	54.182186	0.8	21
fish	shark:	1	0	0	118.1389	-19.5197	0	0	0	0	0	50.379314	0.8	27

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	116.8683	-20.1819	0	0	0	0	0	49.422482	0.8	36
fish	shark:	1	0	0	114.2135	-21.7871	0	0	0	0	0	49.422482	0.8	18
fish	shark:	1	0	0	117.4632	-20.2049	0	0	0	0	0	49.422482	0.8	45
fish	shark:	1	0	0	119.3028	-18.1487	0	0	0	0	0	48.576935	0.8	15
fish	shark:	1	0	0	119.3941	-18.6227	0	0	0	0	0	48.576935	0.8	12
fish	shark:	1	0	0	117.8045	-19.4329	0	0	0	0	0	48.576935	0.8	14
fish	shark:	1	0	0	119.5401	-17.9087	0	0	0	0	0	48.576935	0.8	23
fish	shark:	1	0	0	119.7424	-18.8365	0	0	0	0	0	48.576935	0.8	26
fish	shark:	1	0	0	114.3651	-21.8609	0	0	0	0	0	46.182594	0.8	16
fish	shark:	1	0	0	116.1608	-20.6089	0	0	0	0	0	46.182594	0.8	12
fish	shark:	1	0	0	119.0563	-19.79	0	0	0	0	0	46.182594	0.8	22
fish	shark:	1	0	0	119.6136	-19.7177	0	0	0	0	0	44.542305	0.8	25
fish	shark:	1	0	0	119.9711	-17.6275	0	0	0	0	0	43.576527	0.8	19
fish	shark:	1	0	0	118.476	-19.899	0	0	0	0	0	43.576527	0.8	23
fish	shark:	1	0	0	118.3335	-17.9338	0	0	0	0	0	41.220371	0.8	25
fish	shark:	1	0	0	118.1118	-18.2672	0	0	0	0	0	41.220371	0.8	17
fish	shark:	1	0	0	118.3315	-18.452	0	0	0	0	0	41.220371	0.8	20
fish	shark:	1	0	0	117.4507	-20.2414	0	0	0	0	0	41.220371	0.8	26
fish	shark:	1	0	0	117.0706	-20.6029	0	0	0	0	0	39.539227	0.8	16
fish	shark:	1	0	0	118.3879	-20.2359	0	0	0	0	0	39.539227	0.8	19
fish	shark:	1	0	0	118.4992	-20.0295	0	0	0	0	0	38.449528	0.8	16
fish	shark:	1	0	0	116.2447	-19.8815	0	0	0	0	0	38.449528	0.8	17
fish	shark:	1	0	0	114.8738	-21.1162	0	0	0	0	0	38.449528	0.8	20

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	118.652	-19.3325	0	0	0	0	0	37.983631	0.8	26
fish	shark:	1	0	0	117.624	-19.7288	0	0	0	0	0	37.983631	0.8	32
fish	shark:	1	0	0	117.1627	-20.1932	0	0	0	0	0	37.983631	0.8	29
fish	shark:	1	0	0	115.7665	-20.0564	0	0	0	0	0	37.983631	0.8	24
fish	shark:	1	0	0	115.5464	-20.9375	0	0	0	0	0	37.983631	0.8	25
fish	shark:	1	0	0	114.551	-21.6328	0	0	0	0	0	37.983631	0.8	25
fish	shark:	1	0	0	116.1684	-20.8117	0	0	0	0	0	37.743969	0.8	20
fish	shark:	1	0	0	119.2431	-19.8212	0	0	0	0	0	37.743969	0.8	20
fish	shark:	1	0	0	118.3269	-18.2015	0	0	0	0	0	37.743969	0.8	20
fish	shark:	1	0	0	118.095	-19.684	0	0	0	0	0	37.743969	0.8	16
fish	shark:	1	0	0	115.583	-20.584	0	0	0	0	0	36.132534	0.8	25
fish	shark:	1	0	0	116.4735	-19.2776	0	0	0	0	0	36.132534	0.8	30
fish	shark:	1	0	0	118.8795	-19.5798	0	0	0	0	0	36.132534	0.8	20
fish	shark:	1	0	0	117.7623	-20.4718	0	0	0	0	0	36.184269	0.8	19
fish	shark:	1	0	0	118.9234	-19.3776	0	0	0	0	0	35.971828	0.8	15
fish	shark:	1	0	0	118.1877	-18.2582	0	0	0	0	0	35.971828	0.8	15
fish	shark:	1	0	0	119.8503	-18.1877	0	0	0	0	0	34.397064	0.8	15
fish	shark:	1	0	0	119.1467	-17.4931	0	0	0	0	0	34.397064	0.8	15
fish	shark:	1	0	0	117.153	-20.2367	0	0	0	0	0	34.397064	0.8	15
fish	shark:	1	0	0	115.1793	-20.3425	0	0	0	0	0	34.397064	0.8	15
fish	shark:	1	0	0	117.3984	-20.5921	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	115.5722	-20.5402	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	118.1918	-20.3326	0	0	0	0	0	34.217525	0.8	31

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.6679	-19.6695	0	0	0	0	0	34.217525	0.8	28
fish	shark:	1	0	0	117.0024	-20.4687	0	0	0	0	0	34.217525	0.8	30
fish	shark:	1	0	0	118.5176	-18.8704	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	118.2189	-19.0917	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	119.5806	-19.9832	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	119.8147	-18.0192	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	119.0979	-19.643	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	117.4421	-19.6944	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	119.8571	-18.5693	0	0	0	0	0	34.217525	0.8	16
fish	shark:	1	0	0	118.9172	-19.0411	0	0	0	0	0	34.217525	0.8	29
fish	shark:	1	0	0	118.7684	-20.0891	0	0	0	0	0	33.192726	0.8	13
fish	shark:	1	0	0	118.4965	-19.6322	0	0	0	0	0	33.192726	0.8	10
fish	shark:	1	0	0	118.4092	-19.5607	0	0	0	0	0	33.192726	0.8	10
fish	shark:	1	0	0	115.9887	-20.5286	0	0	0	0	0	33.192726	0.8	10
fish	shark:	1	0	0	115.8774	-20.2835	0	0	0	0	0	32.610325	0.8	11
fish	shark:	1	0	0	118.7481	-20.2347	0	0	0	0	0	32.610325	0.8	31
fish	shark:	1	0	0	119.6039	-18.9684	0	0	0	0	0	32.610325	0.8	31
fish	shark:	1	0	0	117.1463	-20.0234	0	0	0	0	0	32.610325	0.8	11
fish	shark:	1	0	0	117.6257	-20.2187	0	0	0	0	0	32.610325	0.8	31
fish	shark:	1	0	0	119.0467	-17.1565	0	0	0	0	0	32.610325	0.8	39
fish	shark:	1	0	0	117.7211	-19.1087	0	0	0	0	0	32.610325	0.8	20
fish	shark:	1	0	0	116.4066	-20.1082	0	0	0	0	0	32.610325	0.8	31
fish	shark:	1	0	0	116.3939	-20.7747	0	0	0	0	0	32.610325	0.8	31

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	115.1355	-20.9913	0	0	0	0	0	32.382988	0.8	31
fish	shark:	1	0	0	119.8325	-19.5564	0	0	0	0	0	32.382988	0.8	24
fish	shark:	1	0	0	116.76	-19.6334	0	0	0	0	0	32.382988	0.8	31
fish	shark:	1	0	0	118.0865	-18.7733	0	0	0	0	0	32.382988	0.8	31
fish	shark:	1	0	0	117.5836	-18.4952	0	0	0	0	0	32.382988	0.8	30
fish	shark:	1	0	0	116.2092	-19.58	0	0	0	0	0	32.382988	0.8	30
fish	shark:	1	0	0	116.4975	-20.3652	0	0	0	0	0	32.382988	0.8	27
fish	shark:	1	0	0	115.0098	-21.2211	0	0	0	0	0	32.382988	0.8	29
fish	shark:	1	0	0	114.7459	-20.8057	0	0	0	0	0	32.382988	0.8	29
fish	shark:	1	0	0	115.7726	-20.9985	0	0	0	0	0	30.806532	0.8	19
fish	shark:	1	0	0	119.6744	-18.3625	0	0	0	0	0	30.806532	0.8	19
fish	shark:	1	0	0	118.8756	-19.7525	0	0	0	0	0	30.806532	0.8	19
fish	shark:	1	0	0	117.9728	-19.1995	0	0	0	0	0	30.806532	0.8	33
fish	shark:	1	0	0	118.1819	-20.083	0	0	0	0	0	30.806532	0.8	29
fish	shark:	1	0	0	117.8028	-20.4167	0	0	0	0	0	30.806532	0.8	19
fish	shark:	1	0	0	118.7245	-19.0119	0	0	0	0	0	30.806532	0.8	33
fish	shark:	1	0	0	119.1359	-19.091	0	0	0	0	0	30.806532	0.8	18
fish	shark:	1	0	0	118.7984	-18.2686	0	0	0	0	0	28.972282	0.8	36
fish	shark:	1	0	0	119.4618	-17.4036	0	0	0	0	0	28.972282	0.8	36
fish	shark:	1	0	0	118.5937	-17.6361	0	0	0	0	0	28.972282	0.8	42
fish	shark:	1	0	0	117.4673	-20.3899	0	0	0	0	0	28.972282	0.8	41
fish	shark:	1	0	0	119.0921	-19.8983	0	0	0	0	0	28.972282	0.8	45
fish	shark:	1	0	0	118.4438	-18.4977	0	0	0	0	0	28.788021	0.8	36

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.7647	-19.6736	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	117.6373	-18.4822	0	0	0	0	0	28.788021	0.8	21
fish	shark:	1	0	0	114.7666	-21.2878	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	119.559	-18.15	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	115.9993	-20.8186	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	114.7209	-21.2984	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	118.379	-19.6575	0	0	0	0	0	28.788021	0.8	32
fish	shark:	1	0	0	118.7398	-20.0261	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	116.8722	-20.1832	0	0	0	0	0	28.788021	0.8	36
fish	shark:	1	0	0	118.336	-18.9263	0	0	0	0	0	28.788021	0.8	32
fish	shark:	1	0	0	115.5545	-20.7356	0	0	0	0	0	28.788021	0.8	32
fish	shark:	1	0	0	118.2241	-18.3924	0	0	0	0	0	28.788021	0.8	32
fish	shark:	1	0	0	117.6559	-18.8017	0	0	0	0	0	28.234297	0.8	31
fish	shark:	1	0	0	116.451	-19.5671	0	0	0	0	0	27.122686	0.8	39
fish	shark:	1	0	0	118.3622	-18.4304	0	0	0	0	0	27.122686	0.8	39
fish	shark:	1	0	0	119.3348	-19.7459	0	0	0	0	0	27.122686	0.8	39
fish	shark:	1	0	0	116.0878	-20.0398	0	0	0	0	0	27.122686	0.8	18
fish	shark:	1	0	0	118.2377	-19.2905	0	0	0	0	0	27.122686	0.8	34
fish	shark:	1	0	0	119.2856	-19.9403	0	0	0	0	0	27.122686	0.8	39
fish	shark:	1	0	0	117.486	-20.3578	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	119.8798	-19.4928	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	118.8215	-19.1958	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	119.3972	-19.2899	0	0	0	0	0	26.93688	0.8	38

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.6933	-19.3587	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	117.5246	-18.9017	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	119.9678	-19.4723	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	118.283	-18.6088	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	114.7847	-21.551	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	115.5075	-19.6394	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	118.3531	-18.7653	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	115.2746	-20.9342	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	119.5282	-19.5697	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	119.1812	-19.258	0	0	0	0	0	26.93688	0.8	30
fish	shark:	1	0	0	114.8874	-20.644	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	119.6514	-19.4967	0	0	0	0	0	26.93688	0.8	39
fish	shark:	1	0	0	116.6783	-19.3728	0	0	0	0	0	26.378531	0.8	31
fish	shark:	1	0	0	117.8754	-19.2067	0	0	0	0	0	26.378531	0.8	32
fish	shark:	1	0	0	119.7983	-18.2415	0	0	0	0	0	25.25762	0.8	42
fish	shark:	1	0	0	118.8839	-17.9025	0	0	0	0	0	25.25762	0.8	42
fish	shark:	1	0	0	119.1365	-19.7819	0	0	0	0	0	25.25762	0.8	42
fish	shark:	1	0	0	114.7391	-20.7481	0	0	0	0	0	25.25762	0.8	45
fish	shark:	1	0	0	114.6493	-21.6042	0	0	0	0	0	25.070255	0.8	39
fish	shark:	1	0	0	118.3914	-19.2639	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	117.3102	-20.4621	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	115.815	-20.9198	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	117.8208	-18.6478	0	0	0	0	0	25.070255	0.8	42

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	115.5055	-21.2702	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	113.7122	-22.8893	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	119.7824	-19.3468	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	118.8725	-19.6162	0	0	0	0	0	25.070255	0.8	23
fish	shark:	1	0	0	114.165	-22.0258	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	115.4497	-20.8572	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	117.8891	-19.7623	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	116.5971	-20.5617	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	117.9762	-19.1085	0	0	0	0	0	25.070255	0.8	42
fish	shark:	1	0	0	117.5351	-18.6928	0	0	0	0	0	25.070255	0.8	25
fish	shark:	1	0	0	119.0615	-18.6143	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	118.5365	-20.295	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	117.0688	-20.4305	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	117.668	-18.9773	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	119.8007	-19.892	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	114.1712	-22.1677	0	0	0	0	0	23.376945	0.8	45
fish	shark:	1	0	0	118.0082	-19.1426	0	0	0	0	0	23.188013	0.8	43
fish	shark:	1	0	0	117.279	-20.4136	0	0	0	0	0	23.188013	0.8	46
fish	shark:	1	0	0	118.2406	-19.6241	0	0	0	0	0	23.188013	0.8	41
fish	shark:	1	0	0	119.594	-18.6281	0	0	0	0	0	23.188013	0.8	46
fish	shark:	1	0	0	116.9036	-20.5291	0	0	0	0	0	23.188013	0.8	42
fish	shark:	1	0	0	114.3518	-21.7433	0	0	0	0	0	23.188013	0.8	45
fish	shark:	1	0	0	118.3612	-18.4251	0	0	0	0	0	23.188013	0.8	43

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.1582	-18.7959	0	0	0	0	0	23.188013	0.8	42
fish	shark:	1	0	0	118.9829	-18.679	0	0	0	0	0	23.188013	0.8	46
fish	shark:	1	0	0	117.2008	-19.5119	0	0	0	0	0	21.480524	0.8	49
fish	shark:	1	0	0	117.1112	-20.1294	0	0	0	0	0	21.480524	0.8	11
fish	shark:	1	0	0	114.4649	-21.885	0	0	0	0	0	21.480524	0.8	49
fish	shark:	1	0	0	117.4991	-20.1355	0	0	0	0	0	21.480524	0.8	11
fish	shark:	1	0	0	119.7821	-17.8264	0	0	0	0	0	21.480524	0.8	11
fish	shark:	1	0	0	119.8655	-19.428	0	0	0	0	0	21.480524	0.8	49
fish	shark:	1	0	0	115.3562	-21.4221	0	0	0	0	0	21.480524	0.8	11
fish	shark:	1	0	0	119.421	-17.8295	0	0	0	0	0	21.290009	0.8	27
fish	shark:	1	0	0	117.7829	-18.587	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	119.0669	-18.6755	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	116.5531	-20.5239	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	119.7934	-19.9239	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	119.5567	-19.3822	0	0	0	0	0	21.290009	0.8	27
fish	shark:	1	0	0	118.9485	-17.5193	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	119.3541	-19.3184	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	115.4619	-20.0165	0	0	0	0	0	21.290009	0.8	48
fish	shark:	1	0	0	116.4441	-20.2831	0	0	0	0	0	21.290009	0.8	27
fish	shark:	1	0	0	119.2601	-19.4638	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	115.6027	-20.73	0	0	0	0	0	21.290009	0.8	49
fish	shark:	1	0	0	115.4333	-19.8392	0	0	0	0	0	21.290009	0.8	27
fish	shark:	1	0	0	116.5066	-20.6297	0	0	0	0	0	20.71752	0.8	30

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	117.9706	-19.2466	0	0	0	0	0	19.568239	0.8	53
fish	shark:	1	0	0	119.1318	-18.8158	0	0	0	0	0	19.568239	0.8	10
fish	shark:	1	0	0	119.311	-18.2262	0	0	0	0	0	19.568239	0.8	50
fish	shark:	1	0	0	119.541	-19.9114	0	0	0	0	0	19.568239	0.8	10
fish	shark:	1	0	0	118.1473	-19.6178	0	0	0	0	0	19.568239	0.8	53
fish	shark:	1	0	0	119.4121	-17.8919	0	0	0	0	0	19.568239	0.8	53
fish	shark:	1	0	0	118.8301	-20.113	0	0	0	0	0	19.568239	0.8	46
fish	shark:	1	0	0	119.0781	-19.3355	0	0	0	0	0	19.568239	0.8	10
fish	shark:	1	0	0	115.6238	-20.043	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	115.062	-21.4816	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	118.9421	-18.9017	0	0	0	0	0	19.376127	0.8	29
fish	shark:	1	0	0	117.5134	-20.4163	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	115.6209	-20.1095	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	118.514	-17.8244	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	119.812	-18.3305	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	114.326	-22.1464	0	0	0	0	0	19.376127	0.8	29
fish	shark:	1	0	0	117.7399	-18.4483	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	117.0343	-19.8129	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	115.8965	-20.332	0	0	0	0	0	19.376127	0.8	25
fish	shark:	1	0	0	116.3799	-19.4965	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	119.3439	-19.4864	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	117.3055	-20.3922	0	0	0	0	0	19.376127	0.8	29
fish	shark:	1	0	0	118.6623	-19.7323	0	0	0	0	0	19.376127	0.8	53

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	115.2897	-20.9502	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	119.525	-17.5512	0	0	0	0	0	19.376127	0.8	29
fish	shark:	1	0	0	115.5272	-19.4935	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	118.9648	-17.9362	0	0	0	0	0	19.376127	0.8	53
fish	shark:	1	0	0	115.271	-21.0502	0	0	0	0	0	19.376127	0.8	29
fish	shark:	1	0	0	116.3261	-19.8535	0	0	0	0	0	17.639948	0.8	54
fish	shark:	1	0	0	119.9168	-18.5014	0	0	0	0	0	17.446236	0.8	29
fish	shark:	1	0	0	119.3731	-19.6822	0	0	0	0	0	17.446236	0.8	29
fish	shark:	1	0	0	119.2319	-18.5144	0	0	0	0	0	17.446236	0.8	29
fish	shark:	1	0	0	118.9297	-18.1482	0	0	0	0	0	17.446236	0.8	29
fish	shark:	1	0	0	116.9382	-20.5551	0	0	0	0	0	17.446236	0.8	29
fish	shark:	1	0	0	115.3706	-20.3688	0	0	0	0	0	16.864126	0.8	36
fish	shark:	1	0	0	115.1398	-21.3925	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	117.5297	-20.3992	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	118.3084	-19.9598	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	118.0463	-20.1944	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	116.5034	-19.8333	0	0	0	0	0	15.695527	0.8	46
fish	shark:	1	0	0	116.8371	-19.5543	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	119.7512	-19.2036	0	0	0	0	0	15.695527	0.8	58
fish	shark:	1	0	0	118.2091	-19.2086	0	0	0	0	0	15.500193	0.8	59
fish	shark:	1	0	0	115.9383	-20.7085	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	114.9485	-21.4181	0	0	0	0	0	15.500193	0.8	16
fish	shark:	1	0	0	114.3	-22.1252	0	0	0	0	0	15.500193	0.8	14

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	118.9016	-18.3053	0	0	0	0	0	15.500193	0.8	16
fish	shark:	1	0	0	114.539	-21.593	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	116.4811	-20.6426	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	118.5327	-19.6935	0	0	0	0	0	15.500193	0.8	16
fish	shark:	1	0	0	114.23	-21.1885	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	118.6752	-18.7744	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	114.2077	-22.2425	0	0	0	0	0	15.500193	0.8	16
fish	shark:	1	0	0	119.054	-18.6964	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	114.1694	-21.1074	0	0	0	0	0	15.500193	0.8	62
fish	shark:	1	0	0	115.0122	-21.365	0	0	0	0	0	15.500193	0.8	56
fish	shark:	1	0	0	114.3001	-21.9198	0	0	0	0	0	14.913207	0.8	49
fish	shark:	1	0	0	118.7512	-20.0318	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	116.4609	-20.0828	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	119.494	-18.7829	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	117.4797	-19.9956	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	114.6013	-21.4851	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	118.8216	-20.0278	0	0	0	0	0	13.734832	0.8	60
fish	shark:	1	0	0	118.1301	-18.9493	0	0	0	0	0	13.734832	0.8	52
fish	shark:	1	0	0	118.555	-19.9889	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	115.8567	-20.1287	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	115.6038	-21.0547	0	0	0	0	0	13.537864	0.8	17
fish	shark:	1	0	0	115.9707	-19.6101	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	115.8199	-20.0922	0	0	0	0	0	13.537864	0.8	67

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	115.6088	-20.102	0	0	0	0	0	13.537864	0.8	20
fish	shark:	1	0	0	118.4868	-19.0912	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	114.3535	-22.0745	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	116.5822	-19.7767	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	115.8879	-20.1423	0	0	0	0	0	13.537864	0.8	34
fish	shark:	1	0	0	117.3356	-20.3355	0	0	0	0	0	13.537864	0.8	64
fish	shark:	1	0	0	114.9166	-21.4804	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	114.2204	-21.6705	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	115.6061	-20.5993	0	0	0	0	0	13.537864	0.8	67
fish	shark:	1	0	0	117.5399	-18.9257	0	0	0	0	0	13.537864	0.8	27
fish	shark:	1	0	0	117.7553	-20.5681	0	0	0	0	0	12.945971	0.8	57
fish	shark:	1	0	0	118.1018	-20.3328	0	0	0	0	0	11.757728	0.8	53
fish	shark:	1	0	0	119.0825	-19.6819	0	0	0	0	0	11.757728	0.8	51
fish	shark:	1	0	0	119.5801	-17.9625	0	0	0	0	0	11.757728	0.8	53
fish	shark:	1	0	0	119.867	-17.6787	0	0	0	0	0	11.757728	0.8	53
fish	shark:	1	0	0	119.1907	-19.3809	0	0	0	0	0	11.757728	0.8	53
fish	shark:	1	0	0	115.3697	-20.1958	0	0	0	0	0	11.757728	0.8	53
fish	shark:	1	0	0	117.5879	-19.8831	0	0	0	0	0	11.559113	0.8	63
fish	shark:	1	0	0	116.667	-19.5505	0	0	0	0	0	11.559113	0.8	49
fish	shark:	1	0	0	118.8939	-19.9036	0	0	0	0	0	11.559113	0.8	72
fish	shark:	1	0	0	119.7657	-17.7599	0	0	0	0	0	11.559113	0.8	61
fish	shark:	1	0	0	117.7051	-18.893	0	0	0	0	0	11.559113	0.8	72
fish	shark:	1	0	0	118.3798	-20.2657	0	0	0	0	0	11.559113	0.8	61

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	117.8129	-18.975	0	0	0	0	0	11.559113	0.8	72
fish	shark:	1	0	0	119.8959	-18.043	0	0	0	0	0	11.559113	0.8	61
fish	shark:	1	0	0	118.6391	-19.0551	0	0	0	0	0	11.559113	0.8	55
fish	shark:	1	0	0	119.1477	-18.9082	0	0	0	0	0	11.559113	0.8	61
fish	shark:	1	0	0	116.8511	-19.59	0	0	0	0	0	11.559113	0.8	72
fish	shark:	1	0	0	117.186	-19.8473	0	0	0	0	0	11.559113	0.8	61
fish	shark:	1	0	0	116.962	-19.4591	0	0	0	0	0	11.559113	0.8	63
fish	shark:	1	0	0	119.345	-19.6046	0	0	0	0	0	10.962265	0.8	67
fish	shark:	1	0	0	117.3259	-20.158	0	0	0	0	0	10.363921	0.8	71
fish	shark:	1	0	0	117.3177	-19.6223	0	0	0	0	0	9.764084	0.8	70
fish	shark:	1	0	0	116.3065	-20.6302	0	0	0	0	0	9.764084	0.8	70
fish	shark:	1	0	0	115.8784	-20.5954	0	0	0	0	0	9.764084	0.8	70
fish	shark:	1	0	0	117.381	-18.8744	0	0	0	0	0	9.764084	0.8	67
fish	shark:	1	0	0	117.7261	-19.2353	0	0	0	0	0	9.764084	0.8	70
fish	shark:	1	0	0	115.9319	-20.7285	0	0	0	0	0	9.764084	0.8	70
fish	shark:	1	0	0	114.219	-21.9747	0	0	0	0	0	9.563805	0.8	78
fish	shark:	1	0	0	119.4044	-19.9433	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	119.3294	-17.8371	0	0	0	0	0	9.563805	0.8	78
fish	shark:	1	0	0	118.9278	-19.4835	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	118.9864	-18.5888	0	0	0	0	0	9.563805	0.8	77
fish	shark:	1	0	0	118.2108	-19.6978	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	115.9937	-20.2564	0	0	0	0	0	9.563805	0.8	75
fish	shark:	1	0	0	115.482	-19.5902	0	0	0	0	0	9.563805	0.8	57

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	119.6731	-18.5196	0	0	0	0	0	9.563805	0.8	78
fish	shark:	1	0	0	117.5981	-19.1723	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	114.2429	-22.2838	0	0	0	0	0	9.563805	0.8	78
fish	shark:	1	0	0	115.218	-19.9491	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	119.5001	-19.1964	0	0	0	0	0	9.563805	0.8	78
fish	shark:	1	0	0	119.5049	-19.1905	0	0	0	0	0	9.563805	0.8	57
fish	shark:	1	0	0	119.3877	-19.014	0	0	0	0	0	8.961961	0.8	34
fish	shark:	1	0	0	116.4361	-19.5876	0	0	0	0	0	8.559879	0.8	46
fish	shark:	1	0	0	113.5713	-22.4994	0	0	0	0	0	8.559879	0.8	46
fish	shark:	1	0	0	119.5277	-19.2236	0	0	0	0	0	8.559879	0.8	46
fish	shark:	1	0	0	118.8425	-20.1244	0	0	0	0	0	8.559879	0.8	46
fish	shark:	1	0	0	116.931	-20.5219	0	0	0	0	0	8.559879	0.8	46
fish	shark:	1	0	0	115.8682	-20.699	0	0	0	0	0	8.15716	0.8	46
fish	shark:	1	0	0	118.1837	-20.0406	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	119.8545	-19.7974	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	118.2189	-19.7179	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	119.0233	-19.2193	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	116.0065	-20.2648	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	117.1598	-20.3782	0	0	0	0	0	7.753753	0.8	70
fish	shark:	1	0	0	115.8322	-19.9801	0	0	0	0	0	7.551797	0.8	84
fish	shark:	1	0	0	115.0253	-21.1657	0	0	0	0	0	7.551797	0.8	81
fish	shark:	1	0	0	115.2977	-20.3194	0	0	0	0	0	7.551797	0.8	36
fish	shark:	1	0	0	116.0621	-19.9067	0	0	0	0	0	7.551797	0.8	84

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	117.4682	-20.5646	0	0	0	0	0	7.551797	0.8	48
fish	shark:	1	0	0	113.6062	-22.4782	0	0	0	0	0	7.551797	0.8	78
fish	shark:	1	0	0	116.7472	-20.4784	0	0	0	0	0	7.551797	0.8	48
fish	shark:	1	0	0	115.9844	-21.0139	0	0	0	0	0	7.551797	0.8	84
fish	shark:	1	0	0	115.8488	-19.5924	0	0	0	0	0	7.551797	0.8	48
fish	shark:	1	0	0	119.8479	-17.5922	0	0	0	0	0	7.551797	0.8	84
fish	shark:	1	0	0	117.7824	-19.623	0	0	0	0	0	7.551797	0.8	32
fish	shark:	1	0	0	116.0073	-20.256	0	0	0	0	0	7.551797	0.8	84
fish	shark:	1	0	0	116.0038	-20.2585	0	0	0	0	0	7.551797	0.8	48
fish	shark:	1	0	0	114.8916	-20.5508	0	0	0	0	0	6.539488	0.8	60
fish	shark:	1	0	0	116.9632	-19.5479	0	0	0	0	0	6.539488	0.8	60
fish	shark:	1	0	0	115.2844	-21.1235	0	0	0	0	0	6.539488	0.8	60
fish	shark:	1	0	0	116.9108	-19.9103	0	0	0	0	0	6.133383	0.8	75
fish	shark:	1	0	0	114.4142	-21.0505	0	0	0	0	0	6.133383	0.8	45
fish	shark:	1	0	0	115.6104	-19.9064	0	0	0	0	0	4.297508	0.8	62
fish	shark:	1	0	0	119.5254	-19.2328	0	0	0	0	0	4.297508	0.8	61
fish	shark:	1	0	0	118.2102	-19.7211	0	0	0	0	0	4.297508	0.8	62
fish	shark:	1	0	0	119.0252	-19.2233	0	0	0	0	0	4.297508	0.8	69
fish	shark:	1	0	0	114.5029	-21.5058	0	0	0	0	0	4.297508	0.8	62
fish	shark:	1	0	0	116.0069	-20.2607	0	0	0	0	0	4.297508	0.8	77
fish	shark:	1	0	0	116.909	-19.9151	0	0	0	0	0	4.297508	0.8	62
fish	shark:	1	0	0	114.4968	-21.5046	0	0	0	0	0	4.092671	0.8	45
fish	shark:	1	0	0	118.2	-19.7	0	0	0	0	0	3.682483	0.8	65

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	shark:	1	0	0	116.9	-19.9	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	115.6	-19.9	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	119.5	-19.2	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	119	-19.2	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	116	-20.25	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	114.5	-21.5	0	0	0	0	0	3.682483	0.8	65
fish	shark:	1	0	0	115.6	-19.9	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	114.5	-21.5	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	114.5	-21.5	0	0	0	0	0	3.477591	0.8	60
fish	shark:	1	0	0	119.5	-19.2	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	116.9	-19.9	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	116.9	-19.9	0	0	0	0	0	3.477591	0.8	60
fish	shark:	1	0	0	119	-19.2	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	116	-20.25	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	116	-20.25	0	0	0	0	0	3.477591	0.8	60
fish	shark:	1	0	0	118.2	-19.7	0	0	0	0	0	3.477591	0.8	97
fish	shark:	1	0	0	118.2	-19.7	0	0	0	0	0	3.477591	0.8	40

StatusQuo.cfg

Includes configuration files for a status quo run.

```
&include    ../configs/world.cfg
&include    ../configs/Advisers.cfg

&include    ../configs/Ports.cfg
&include    ../configs/Govt.cfg
&include    ../configs/Zones.cfg

&include     ../configs/Habitat.cfg
&include     ../configs/FishPopulations.cfg
&include     ../configs/PrawnStocks.cfg
&include     ../configs/Sharks.cfg
&include     ../configs/Turtles.cfg
#&include    ../configs/Oysterlease.cfg

&include    ../configs/HistoricalPrawn.cfg

&include    ../configs/Bruce.cfg
&include    ../configs/TrawlBoats.cfg
&include    ../configs/trapper.cfg
```

&include ../configs/PrawnFleet.cfg

&include ../configs/Vessels.cfg
&include ../configs/Rigs.cfg

Class	Taxon	Track?	Presence data	Projection DB	Projection	Starts	Ends
polyorganism	ponyfish:	0	bycatch.xy.pt	map.rc	none	0	0

StatusQuo_1p.cfg

Includes configuration files for a status quo run with one development pulse.

&include ../configs/world.cfg
&include ../configs/Advisers.cfg

&include ../configs/Ports_1p.cfg
&include ../configs/Govt.cfg
&include ../configs/Zones.cfg

&include ../configs/Bruce.cfg
#&include ../configs/TrawlBoats_1p.cfg
#&include ../configs/trapper.cfg

```
#&include     ../configs/PrawnFleet_1p.cfg

#&include     ../configs/HistoricalPrawn.cfg

&include     ../configs/Vessels_1p.cfg
&include     ../configs/Rigs.cfg

#&include     ../configs/Habitat.cfg
#&include     ../configs/FishPopulations.cfg
#&include     ../configs/PrawnStocks.cfg
#&include     ../configs/Sharks.cfg
#&include     ../configs/Turtles.cfg
#&include     ../configs/Oysterlease.cfg
```

StatusQuo_2p.cfg

Includes configuration files for a status quo run with two development pulses.

```
&include    ../configs/world.cfg
&include    ../configs/Advisers.cfg

&include    ../configs/Ports_2p.cfg
```

```
&include    ../configs/Govt.cfg
&include    ../configs/Zones.cfg

&include     ../configs/Bruce.cfg
#&include    ../configs/TrawlBoats.cfg
#&include    ../configs/trapper.cfg
#&include    ../configs/PrawnFleet.cfg

#&include    ../configs/HistoricalPrawn.cfg

&include     ../configs/Vessels_2p.cfg
#&include    ../configs/Rigs.cfg

#&include    ../configs/Habitat.cfg
#&include    ../configs/FishPopulations.cfg
#&include    ../configs/PrawnStocks.cfg
#&include    ../configs/Sharks.cfg
#&include    ../configs/Turtles.cfg
#&include    ../configs/Oysterlease.cfg
```

Trapper.cfg

Configures agents which represent the trap fishery. Mainly boats and traps.

boat	trap-fisher:	Titanic	Point-Samson	1/01/2001	0	0	5000	R: pilbara-closed	C: pilbara-trap-zones pilbara-zones	Line: trapLineAll.pt	KF: 0 0.01 vesNothing.BB 1 1 1 1 1

trap	leghold:	thefirst	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thesecond	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thethird	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thefourth	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thefifth	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thesixth	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	theseventh	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	theeighth	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thenineth	1/01/2001	0	Titanic	100	0.25	0.6	0.2
trap	leghold:	thetenth	1/01/2001	0	Titanic	100	0.25	0.6	0.2

TrawlBoats.cfg

Configures trawl fleet and fisheries management authority for normal run with no development.

FMA	popWAFMA:	0	0	monthly	pilbara-zones	pilbara-trap-zones	prawn-zones	popWAFMA.rpt	0	T:	boat	SAD:	LSebaeNODAT.SAD

equivalent to 7 full time vessels as stated in the 2002 SOF report

Class	Taxon	Name	HomePort	Starts	Ends	Kg in hold	Fuel remaining	Restricted Zones	Fisheries control zones	Kalman Filter data
boat	fisher:	Trawl_A	Point-Samson	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F711.BB 1 1 1 1 1
boat	fisher:	Trawl_B	Point-Samson	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_C45.BB 1 1 1 1 1
boat	fisher:	Trawl_C	Point-Samson	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F248.BB 1 1 1 1 1
boat	fisher:	Trawl_D	Port-Hedland	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F550.BB 1 1 1 1 1
boat	fisher:	Trawl_E	Port-Hedland	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F661.BB 1 1 1 1 1
boat	fisher:	Trawl_F	Dampier	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F841.BB 1 1 1 1 1
boat	fisher:	Trawl_G	Dampier	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F105.BB 1 1 1 1 1

TrawlBoats_1p.cfg

Configures trawl fleet and fisheries management authority for run with one development pulse.

FMA popWAFMA: 0 0 monthly pilbara-zones pilbara-trap-zones prawn-zones popWAFMA.rpt 0 T: boat SAD: LSebaeNODAT.SAD

equivalent to 7 full time vessels as stated in the 2002 SOF report

Class	Taxon	Name	HomePort	Starts	Ends	Kg in hold	Fuel remaining	Restricted Zones	Fisheries control zones	Kalman Filter data
boat	fisher:	Trawl_A	Point-Samson_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F711.BB 1 1 1 1 1
boat	fisher:	Trawl_B	Point-Samson_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_C45.BB 1 1 1 1 1
boat	fisher:	Trawl_C	Point-Samson_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F248.BB 1 1 1 1 1
boat	fisher:	Trawl_D	Port-Hedland_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F550.BB 1 1 1 1 1
boat	fisher:	Trawl_E	Port-Hedland_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F661.BB 1 1 1 1 1
boat	fisher:	Trawl_F	Dampier_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F841.BB 1 1 1 1 1
boat	fisher:	Trawl_G	Dampier_1p	1/01/2001	0	1	5000	R: pilbara-closed	C: pilbara-zones pilbara-zones	KF: 5 0.1 NEW_F105.BB 1 1 1 1 1

Turtles.cfg

Configures the agents which represent the turtle population.

Class	Taxon	Starts	Ends	Sample interval	Report file	Target type	Include blastula	Only recruits	Targets
biomass	turtleesky:	0	0	monthly	turtle_bio.tbl	1	0	0	turtle

Class	Taxon	Starts	Ends	Sample interval	Report file	Target type
tracker	turtles:	0	0	monthly	turtlemap	turtle

Class	Taxon	Track?	Starts	Ends	Location		Velocity			Age	Mass
blastula	turtle:	1	0	0	115.4	-21	0	0	0	0	0
blastula	turtle:	1	0	0	115.5	-20.4	0	0	0	0	0
blastula	turtle:	1	0	0	118	-20.3	0	0	0	0	0
blastula	turtle:	1	0	0	115.5	-20.4	0	0	0	0	0
blastula	turtle:	1	0	0	114.3	-21.75	0	0	0	0	0
blastula	turtle:	1	0	0	116.6	-20.45	0	0	0	0	0
blastula	turtle:	1	0	0	115.6	-20.6	0	0	0	0	0

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.626	-18.3408	0	0	0	0	0	77.373718	0.8	30
fish	turtle:	0	0	0	117.6453	-20.5794	0	0	0	0	0	60.449303	0.8	39
fish	turtle:	0	0	0	118.3991	-19.0293	0	0	0	0	0	69.318794	0.8	48
fish	turtle:	0	0	0	117.1682	-19.2809	0	0	0	0	0	64.598717	0.8	57
fish	turtle:	0	0	0	116.6878	-20.047	0	0	0	0	0	74.559196	0.8	51
fish	turtle:	0	0	0	115.5264	-20.3564	0	0	0	0	0	62.225616	0.8	36
fish	turtle:	0	0	0	116.5319	-20.3589	0	0	0	0	0	62.51004	0.8	33
fish	turtle:	0	0	0	115.3349	-21.3375	0	0	0	0	0	67.897362	0.8	28
fish	turtle:	0	0	0	119.7569	-18.8276	0	0	0	0	0	73.411179	0.8	28
fish	turtle:	0	0	0	115.2862	-20.4456	0	0	0	0	0	71.370979	0.8	57
fish	turtle:	0	0	0	118.7833	-20.0467	0	0	0	0	0	66.722237	0.8	42
fish	turtle:	0	0	0	119.5561	-19.5824	0	0	0	0	0	55.089573	0.8	72
fish	turtle:	0	0	0	118.7179	-19.9394	0	0	0	0	0	72.745392	0.8	60
fish	turtle:	0	0	0	119.8248	-17.7526	0	0	0	0	0	68.58651	0.8	42
fish	turtle:	0	0	0	117.7617	-20.5348	0	0	0	0	0	59.111237	0.8	66
fish	turtle:	0	0	0	119.91	-18.2863	0	0	0	0	0	72.207169	0.8	75
fish	turtle:	0	0	0	119.71	-17.2244	0	0	0	0	0	59.876133	0.8	54
fish	turtle:	0	0	0	115.7077	-19.7782	0	0	0	0	0	76.158577	0.8	33
fish	turtle:	0	0	0	119.3087	-19.8402	0	0	0	0	0	51.254185	0.8	78
fish	turtle:	0	0	0	119.6949	-19.7413	0	0	0	0	0	75.361786	0.8	24
fish	turtle:	0	0	0	118.1109	-19.5315	0	0	0	0	0	54.52739	0.8	49

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	115.6928	-20.1673	0	0	0	0	0	60.449303	0.8	45
fish	turtle:	0	0	0	119.2525	-18.1397	0	0	0	0	0	76.986641	0.8	42
fish	turtle:	0	0	0	118.1011	-19.8719	0	0	0	0	0	67.818466	0.8	27
fish	turtle:	0	0	0	118.9684	-19.5825	0	0	0	0	0	64.598717	0.8	29
fish	turtle:	0	0	0	119.2097	-19.1555	0	0	0	0	0	62.225616	0.8	56
fish	turtle:	0	0	0	119.4109	-19.8014	0	0	0	0	0	67.897362	0.8	33
fish	turtle:	0	0	0	116.9994	-20.6013	0	0	0	0	0	57.465912	0.8	48
fish	turtle:	0	0	0	119.7846	-19.8225	0	0	0	0	0	66.722237	0.8	72
fish	turtle:	0	0	0	119.7218	-19.4813	0	0	0	0	0	70.454063	0.8	48
fish	turtle:	0	0	0	119.5833	-18.427	0	0	0	0	0	71.117302	0.8	45
fish	turtle:	0	0	0	119.6101	-19.7884	0	0	0	0	0	64.170471	0.8	36
fish	turtle:	0	0	0	118.8591	-17.7155	0	0	0	0	0	54.64436	0.8	43
fish	turtle:	0	0	0	117.12	-19.7349	0	0	0	0	0	80.5	0.8	63
fish	turtle:	0	0	0	119.3437	-19.2151	0	0	0	0	0	80.9	0.8	84
fish	turtle:	0	0	0	119.4748	-18.5837	0	0	0	0	0	81.8	0.8	72
fish	turtle:	0	0	0	119.3687	-19.5884	0	0	0	0	0	81.56	0.8	33
fish	turtle:	0	0	0	119.8745	-17.7149	0	0	0	0	0	82.88	0.8	87
fish	turtle:	0	0	0	119.4416	-19.4521	0	0	0	0	0	82.59	0.8	36
fish	turtle:	0	0	0	118.0842	-19.6769	0	0	0	0	0	47.58	0.8	75
fish	turtle:	0	0	0	116.5331	-19.7409	0	0	0	0	0	47.68	0.8	78
fish	turtle:	0	0	0	115.5078	-20.4422	0	0	0	0	0	47.69	0.8	63
fish	turtle:	0	0	0	119.5749	-19.8616	0	0	0	0	0	47.6	0.8	78
fish	turtle:	0	0	0	119.5138	-18.2478	0	0	0	0	0	47.9	0.8	63

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	118.6171	-19.1976	0	0	0	0	0	47.82	0.8	57
fish	turtle:	0	0	0	119.2912	-19.4755	0	0	0	0	0	47.1	0.8	78
fish	turtle:	0	0	0	118.4534	-19.586	0	0	0	0	0	47.3	0.8	72
fish	turtle:	0	0	0	118.4802	-18.0028	0	0	0	0	0	47.22	0.8	75
fish	turtle:	0	0	0	119.3372	-19.4749	0	0	0	0	0	47.17	0.8	82
fish	turtle:	0	0	0	119.9627	-18.9181	0	0	0	0	0	47.99	0.8	75
fish	turtle:	0	0	0	119.6988	-19.5093	0	0	0	0	0	47.51	0.8	66
fish	turtle:	0	0	0	117.2118	-18.713	0	0	0	0	0	47.43	0.8	78
fish	turtle:	0	0	0	117.0192	-20.521	0	0	0	0	0	47.78	0.8	75
fish	turtle:	0	0	0	114.217	-21.5308	0	0	0	0	0	83.71	0.8	56
fish	turtle:	0	0	0	115.8824	-20.7013	0	0	0	0	0	83.79	0.8	72
fish	turtle:	0	0	0	118.9903	-17.8816	0	0	0	0	0	84.73	0.8	48
fish	turtle:	0	0	0	116.9083	-19.1776	0	0	0	0	0	84.7	0.8	48
fish	turtle:	0	0	0	118.7941	-18.0901	0	0	0	0	0	45.75	0.8	33
fish	turtle:	0	0	0	114.2091	-21.9235	0	0	0	0	0	45.91	0.8	99
fish	turtle:	0	0	0	117.2031	-19.1955	0	0	0	0	0	45.1	0.8	44
fish	turtle:	0	0	0	115.7037	-19.4642	0	0	0	0	0	45.13	0.8	63
fish	turtle:	0	0	0	115.4879	-20.6262	0	0	0	0	0	45.19	0.8	72
fish	turtle:	0	0	0	119.8872	-17.7442	0	0	0	0	0	45.03	0.8	36
fish	turtle:	0	0	0	114.8118	-20.5805	0	0	0	0	0	45.09	0.8	66
fish	turtle:	0	0	0	114.3091	-22.1919	0	0	0	0	0	45.97	0.8	87
fish	turtle:	0	0	0	119.5615	-19.3442	0	0	0	0	0	45.91	0.8	72
fish	turtle:	0	0	0	117.9185	-18.5186	0	0	0	0	0	45.93	0.8	90

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	118.5412	-18.3213	0	0	0	0	0	45.45	0.8	74
fish	turtle:	0	0	0	116.5969	-19.4525	0	0	0	0	0	45.62	0.8	99
fish	turtle:	0	0	0	117.979	-18.7888	0	0	0	0	0	45.94	0.8	72
fish	turtle:	0	0	0	119.5946	-18.8403	0	0	0	0	0	45.21	0.8	93
fish	turtle:	0	0	0	119.9001	-19.6549	0	0	0	0	0	45.34	0.8	73
fish	turtle:	0	0	0	118.5713	-20.1284	0	0	0	0	0	85.78595	0.8	78
fish	turtle:	0	0	0	118.4379	-18.827	0	0	0	0	0	85.78595	0.8	99
fish	turtle:	0	0	0	119.9705	-17.6217	0	0	0	0	0	86.78595	0.8	27
fish	turtle:	0	0	0	119.5605	-19.8156	0	0	0	0	0	86.78595	0.8	90
fish	turtle:	0	0	0	118.7944	-18.8991	0	0	0	0	0	87.78595	0.8	75
fish	turtle:	0	0	0	116.1555	-19.2854	0	0	0	0	0	87.78595	0.8	26
fish	turtle:	0	0	0	118.592	-19.8358	0	0	0	0	0	43.78595	0.8	80
fish	turtle:	0	0	0	115.9544	-20.5845	0	0	0	0	0	43.78595	0.8	66
fish	turtle:	0	0	0	118.5179	-19.6685	0	0	0	0	0	43.78595	0.8	65
fish	turtle:	0	0	0	119.536	-18.2607	0	0	0	0	0	43.78595	0.8	60
fish	turtle:	0	0	0	119.3247	-19.1898	0	0	0	0	0	43.78595	0.8	57
fish	turtle:	0	0	0	116.1383	-19.1431	0	0	0	0	0	43.78595	0.8	63
fish	turtle:	0	0	0	118.4504	-20.1998	0	0	0	0	0	43.78595	0.8	66
fish	turtle:	0	0	0	119.2679	-18.3855	0	0	0	0	0	43.78595	0.8	27
fish	turtle:	0	0	0	115.4651	-21.1667	0	0	0	0	0	43.78595	0.8	75
fish	turtle:	0	0	0	114.4099	-21.947	0	0	0	0	0	43.78595	0.8	90
fish	turtle:	0	0	0	119.8194	-18.5009	0	0	0	0	0	88.79335	0.8	67
fish	turtle:	0	0	0	117.9359	-19.1948	0	0	0	0	0	88.79335	0.8	96

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	117.7386	-19.392	0	0	0	0	0	89.79335	0.8	75
fish	turtle:	0	0	0	119.2582	-19.6599	0	0	0	0	0	89.79335	0.8	33
fish	turtle:	0	0	0	119.8178	-19.2181	0	0	0	0	0	90.79335	0.8	74
fish	turtle:	0	0	0	119.5596	-17.4348	0	0	0	0	0	90.79335	0.8	25
fish	turtle:	0	0	0	115.6964	-21.0028	0	0	0	0	0	41.79335	0.8	78
fish	turtle:	0	0	0	118.9671	-19.7084	0	0	0	0	0	41.79335	0.8	90
fish	turtle:	0	0	0	116.6052	-20.5268	0	0	0	0	0	41.79335	0.8	102
fish	turtle:	0	0	0	119.2677	-19.6768	0	0	0	0	0	41.79335	0.8	105
fish	turtle:	0	0	0	115.2586	-21.2397	0	0	0	0	0	41.79335	0.8	66
fish	turtle:	0	0	0	119.1275	-17.4474	0	0	0	0	0	41.79335	0.8	29
fish	turtle:	0	0	0	119.8746	-17.7971	0	0	0	0	0	41.79335	0.8	99
fish	turtle:	0	0	0	118.5803	-18.4509	0	0	0	0	0	41.79335	0.8	73
fish	turtle:	0	0	0	117.6858	-20.2878	0	0	0	0	0	41.79335	0.8	74
fish	turtle:	0	0	0	115.8336	-21.0363	0	0	0	0	0	91.730122	0.8	101
fish	turtle:	0	0	0	115.0901	-20.4574	0	0	0	0	0	91.730122	0.8	100
fish	turtle:	0	0	0	118.5981	-17.8672	0	0	0	0	0	47.730122	0.8	60
fish	turtle:	0	0	0	115.8294	-20.3563	0	0	0	0	0	47.730122	0.8	71
fish	turtle:	0	0	0	115.6418	-19.8654	0	0	0	0	0	47.730122	0.8	79
fish	turtle:	0	0	0	114.3599	-21.8103	0	0	0	0	0	39.730122	0.8	70
fish	turtle:	0	0	0	119.5917	-18.3214	0	0	0	0	0	39.730122	0.8	60
fish	turtle:	0	0	0	118.7747	-18.4145	0	0	0	0	0	39.730122	0.8	90
fish	turtle:	0	0	0	117.0332	-19.3279	0	0	0	0	0	39.730122	0.8	93
fish	turtle:	0	0	0	114.105	-22.0902	0	0	0	0	0	39.730122	0.8	93

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.6341	-19.688	0	0	0	0	0	39.730122	0.8	93
fish	turtle:	0	0	0	118.9752	-17.4564	0	0	0	0	0	39.730122	0.8	104
fish	turtle:	0	0	0	117.3208	-18.6784	0	0	0	0	0	39.730122	0.8	63
fish	turtle:	0	0	0	119.7186	-17.5088	0	0	0	0	0	39.730122	0.8	55
fish	turtle:	0	0	0	115.0509	-20.8063	0	0	0	0	0	39.730122	0.8	63
fish	turtle:	0	0	0	119.8945	-19.5357	0	0	0	0	0	39.730122	0.8	44
fish	turtle:	0	0	0	115.9956	-20.5191	0	0	0	0	0	39.730122	0.8	63
fish	turtle:	0	0	0	116.5091	-18.849	0	0	0	0	0	39.730122	0.8	62
fish	turtle:	0	0	0	114.1024	-21.5328	0	0	0	0	0	39.730122	0.8	90
fish	turtle:	0	0	0	119.0164	-19.0093	0	0	0	0	0	45.5937	0.8	75
fish	turtle:	0	0	0	119.6019	-19.8966	0	0	0	0	0	45.5937	0.8	61
fish	turtle:	0	0	0	118.9088	-18.9141	0	0	0	0	0	45.5937	0.8	105
fish	turtle:	0	0	0	119.7473	-18.0385	0	0	0	0	0	37.5937	0.8	76
fish	turtle:	0	0	0	119.8572	-18.1181	0	0	0	0	0	37.5937	0.8	118
fish	turtle:	0	0	0	119.5977	-19.7792	0	0	0	0	0	37.5937	0.8	91
fish	turtle:	0	0	0	119.5081	-19.8303	0	0	0	0	0	37.5937	0.8	74
fish	turtle:	0	0	0	119.0344	-19.7451	0	0	0	0	0	37.5937	0.8	96
fish	turtle:	0	0	0	117.8531	-19.156	0	0	0	0	0	37.5937	0.8	74
fish	turtle:	0	0	0	114.3927	-21.6766	0	0	0	0	0	37.5937	0.8	98
fish	turtle:	0	0	0	118.5497	-19.9828	0	0	0	0	0	37.5937	0.8	76
fish	turtle:	0	0	0	119.5486	-19.6775	0	0	0	0	0	37.5937	0.8	61
fish	turtle:	0	0	0	116.9409	-19.7338	0	0	0	0	0	37.5937	0.8	91
fish	turtle:	0	0	0	119.0948	-19.6405	0	0	0	0	0	37.5937	0.8	107

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	117.4921	-19.2794	0	0	0	0	0	37.5937	0.8	30
fish	turtle:	0	0	0	116.1286	-20.7377	0	0	0	0	0	37.5937	0.8	118
fish	turtle:	0	0	0	119.7942	-18.8134	0	0	0	0	0	37.5937	0.8	76
fish	turtle:	0	0	0	118.5602	-17.6763	0	0	0	0	0	37.5937	0.8	87
fish	turtle:	0	0	0	117.9428	-19.1876	0	0	0	0	0	37.5937	0.8	104
fish	turtle:	0	0	0	116.7603	-20.1915	0	0	0	0	0	43.381588	0.8	75
fish	turtle:	0	0	0	119.8147	-19.1911	0	0	0	0	0	43.381588	0.8	90
fish	turtle:	0	0	0	119.7382	-18.9542	0	0	0	0	0	43.381588	0.8	61
fish	turtle:	0	0	0	119.7106	-19.8039	0	0	0	0	0	35.381588	0.8	46
fish	turtle:	0	0	0	118.1936	-19.1277	0	0	0	0	0	35.381588	0.8	90
fish	turtle:	0	0	0	119.4805	-18.2268	0	0	0	0	0	35.381588	0.8	60
fish	turtle:	0	0	0	117.0275	-19.9797	0	0	0	0	0	35.381588	0.8	120
fish	turtle:	0	0	0	117.6966	-19.6231	0	0	0	0	0	35.381588	0.8	64
fish	turtle:	0	0	0	118.0867	-20.0208	0	0	0	0	0	35.381588	0.8	45
fish	turtle:	0	0	0	118.633	-18.1152	0	0	0	0	0	35.381588	0.8	92
fish	turtle:	0	0	0	119.9943	-18.6711	0	0	0	0	0	35.381588	0.8	45
fish	turtle:	0	0	0	119.6866	-18.4113	0	0	0	0	0	35.381588	0.8	60
fish	turtle:	0	0	0	119.3771	-17.841	0	0	0	0	0	35.381588	0.8	104
fish	turtle:	0	0	0	119.3274	-17.8983	0	0	0	0	0	35.381588	0.8	37
fish	turtle:	0	0	0	117.202	-20.3429	0	0	0	0	0	35.381588	0.8	90
fish	turtle:	0	0	0	116.8522	-19.5918	0	0	0	0	0	35.381588	0.8	98
fish	turtle:	0	0	0	115.6421	-21.16	0	0	0	0	0	35.381588	0.8	42
fish	turtle:	0	0	0	117.3465	-19.8893	0	0	0	0	0	41.091034	0.8	67

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.1889	-18.0552	0	0	0	0	0	41.091034	0.8	47
fish	turtle:	0	0	0	119.3496	-19.2459	0	0	0	0	0	41.091034	0.8	94
fish	turtle:	0	0	0	119.4407	-17.6911	0	0	0	0	0	33.091034	0.8	90
fish	turtle:	0	0	0	116.6232	-19.7321	0	0	0	0	0	33.091034	0.8	77
fish	turtle:	0	0	0	119.1693	-18.6676	0	0	0	0	0	33.091034	0.8	120
fish	turtle:	0	0	0	119.5396	-18.4785	0	0	0	0	0	33.091034	0.8	28
fish	turtle:	0	0	0	118.6974	-19.2398	0	0	0	0	0	33.091034	0.8	76
fish	turtle:	0	0	0	117.9379	-20.1353	0	0	0	0	0	33.091034	0.8	31
fish	turtle:	0	0	0	119.7369	-17.2698	0	0	0	0	0	33.091034	0.8	92
fish	turtle:	0	0	0	119.7682	-18.2476	0	0	0	0	0	33.091034	0.8	37
fish	turtle:	0	0	0	116.5881	-20.0066	0	0	0	0	0	33.091034	0.8	82
fish	turtle:	0	0	0	115.6055	-19.9109	0	0	0	0	0	33.091034	0.8	47
fish	turtle:	0	0	0	116.7853	-20.3865	0	0	0	0	0	33.091034	0.8	42
fish	turtle:	0	0	0	117.1503	-20.5552	0	0	0	0	0	39.719305	0.8	104
fish	turtle:	0	0	0	119.7454	-19.6801	0	0	0	0	0	39.719305	0.8	108
fish	turtle:	0	0	0	115.3208	-21.139	0	0	0	0	0	37.719305	0.8	90
fish	turtle:	0	0	0	119.5091	-19.427	0	0	0	0	0	37.719305	0.8	99
fish	turtle:	0	0	0	118.7896	-19.2235	0	0	0	0	0	30.719305	0.8	46
fish	turtle:	0	0	0	119.3756	-18.981	0	0	0	0	0	30.719305	0.8	120
fish	turtle:	0	0	0	115.8626	-20.204	0	0	0	0	0	30.719305	0.8	108
fish	turtle:	0	0	0	116.3874	-20.2267	0	0	0	0	0	30.719305	0.8	105
fish	turtle:	0	0	0	117.9956	-19.5447	0	0	0	0	0	30.719305	0.8	104
fish	turtle:	0	0	0	119.8574	-17.9975	0	0	0	0	0	30.719305	0.8	105

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.645	-19.7066	0	0	0	0	0	30.719305	0.8	103
fish	turtle:	0	0	0	119.4659	-19.475	0	0	0	0	0	30.719305	0.8	102
fish	turtle:	0	0	0	118.6909	-17.7415	0	0	0	0	0	30.719305	0.8	40
fish	turtle:	0	0	0	119.7927	-18.8021	0	0	0	0	0	30.719305	0.8	102
fish	turtle:	0	0	0	114.5936	-21.5366	0	0	0	0	0	30.719305	0.8	46
fish	turtle:	0	0	0	115.5087	-21.2839	0	0	0	0	0	35.2635	0.8	79
fish	turtle:	0	0	0	119.7827	-19.2139	0	0	0	0	0	35.2635	0.8	109
fish	turtle:	0	0	0	116.2878	-19.8021	0	0	0	0	0	33.2635	0.8	61
fish	turtle:	0	0	0	115.8827	-20.8845	0	0	0	0	0	33.2635	0.8	108
fish	turtle:	0	0	0	118.9303	-19.3337	0	0	0	0	0	28.2635	0.8	60
fish	turtle:	0	0	0	118.7624	-19.4249	0	0	0	0	0	28.2635	0.8	106
fish	turtle:	0	0	0	119.4233	-19.008	0	0	0	0	0	28.2635	0.8	60
fish	turtle:	0	0	0	114.8635	-20.7258	0	0	0	0	0	28.2635	0.8	92
fish	turtle:	0	0	0	119.6285	-19.8341	0	0	0	0	0	28.2635	0.8	42
fish	turtle:	0	0	0	119.768	-18.8045	0	0	0	0	0	28.2635	0.8	102
fish	turtle:	0	0	0	118.4293	-19.6369	0	0	0	0	0	28.2635	0.8	78
fish	turtle:	0	0	0	119.779	-17.3447	0	0	0	0	0	28.2635	0.8	94
fish	turtle:	0	0	0	119.9144	-18.5419	0	0	0	0	0	28.2635	0.8	62
fish	turtle:	0	0	0	118.5272	-17.7558	0	0	0	0	0	30.720646	0.8	94
fish	turtle:	0	0	0	116.1058	-19.789	0	0	0	0	0	30.720646	0.8	37
fish	turtle:	0	0	0	114.5234	-21.5391	0	0	0	0	0	28.720646	0.8	106
fish	turtle:	0	0	0	116.7083	-19.8894	0	0	0	0	0	28.720646	0.8	44
fish	turtle:	0	0	0	119.5569	-18.1045	0	0	0	0	0	25.720646	0.8	121

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.5439	-18.7498	0	0	0	0	0	25.720646	0.8	62
fish	turtle:	0	0	0	116.2122	-18.9665	0	0	0	0	0	25.720646	0.8	91
fish	turtle:	0	0	0	115.1873	-20.1216	0	0	0	0	0	25.720646	0.8	58
fish	turtle:	0	0	0	114.3518	-21.0013	0	0	0	0	0	25.720646	0.8	129
fish	turtle:	0	0	0	118.5606	-17.8128	0	0	0	0	0	25.720646	0.8	46
fish	turtle:	0	0	0	116.7187	-19.9501	0	0	0	0	0	25.720646	0.8	121
fish	turtle:	0	0	0	118.0037	-20.18	0	0	0	0	0	25.720646	0.8	49
fish	turtle:	0	0	0	116.2214	-20.044	0	0	0	0	0	25.720646	0.8	121
fish	turtle:	0	0	0	115.6708	-19.7002	0	0	0	0	0	25.720646	0.8	42
fish	turtle:	0	0	0	119.9786	-19.3843	0	0	0	0	0	23.087664	0.8	120
fish	turtle:	0	0	0	118.8663	-19.7419	0	0	0	0	0	23.087664	0.8	36
fish	turtle:	0	0	0	115.7849	-20.2663	0	0	0	0	0	23.087664	0.8	121
fish	turtle:	0	0	0	114.2207	-22.0011	0	0	0	0	0	23.087664	0.8	41
fish	turtle:	0	0	0	118.5749	-19.8512	0	0	0	0	0	23.087664	0.8	148
fish	turtle:	0	0	0	119.6759	-19.5119	0	0	0	0	0	23.087664	0.8	42
fish	turtle:	0	0	0	118.4753	-19.9604	0	0	0	0	0	23.087664	0.8	120
fish	turtle:	0	0	0	119.0959	-19.4371	0	0	0	0	0	23.087664	0.8	37
fish	turtle:	0	0	0	118.1838	-19.841	0	0	0	0	0	23.087664	0.8	39
fish	turtle:	0	0	0	118.8421	-19.1051	0	0	0	0	0	23.087664	0.8	124
fish	turtle:	0	0	0	117.5872	-19.8043	0	0	0	0	0	23.087664	0.8	37
fish	turtle:	0	0	0	119.2269	-19.7005	0	0	0	0	0	23.087664	0.8	107
fish	turtle:	0	0	0	119.597	-18.9571	0	0	0	0	0	23.087664	0.8	46
fish	turtle:	0	0	0	116.7197	-19.7764	0	0	0	0	0	20.361341	0.8	129

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	118.9699	-19.8992	0	0	0	0	0	20.361341	0.8	39
fish	turtle:	0	0	0	119.0529	-18.1786	0	0	0	0	0	20.361341	0.8	121
fish	turtle:	0	0	0	119.1243	-19.2004	0	0	0	0	0	20.361341	0.8	30
fish	turtle:	0	0	0	117.6761	-19.4055	0	0	0	0	0	20.361341	0.8	108
fish	turtle:	0	0	0	119.6226	-18.8107	0	0	0	0	0	20.361341	0.8	48
fish	turtle:	0	0	0	117.4514	-20.2391	0	0	0	0	0	20.361341	0.8	108
fish	turtle:	0	0	0	119.0328	-18.9812	0	0	0	0	0	20.361341	0.8	47
fish	turtle:	0	0	0	119.0716	-18.1833	0	0	0	0	0	20.361341	0.8	102
fish	turtle:	0	0	0	119.1336	-19.1788	0	0	0	0	0	20.361341	0.8	103
fish	turtle:	0	0	0	118.0503	-19.8613	0	0	0	0	0	20.361341	0.8	47
fish	turtle:	0	0	0	117.8061	-20.4235	0	0	0	0	0	20.361341	0.8	121
fish	turtle:	0	0	0	115.5809	-20.3684	0	0	0	0	0	20.361341	0.8	52
fish	turtle:	0	0	0	118.282	-19.0518	0	0	0	0	0	18.615352	0.8	124
fish	turtle:	0	0	0	119.416	-18.9778	0	0	0	0	0	18.615352	0.8	124
fish	turtle:	0	0	0	116.1257	-19.9278	0	0	0	0	0	18.615352	0.8	127
fish	turtle:	0	0	0	119.0776	-19.7728	0	0	0	0	0	18.615352	0.8	129
fish	turtle:	0	0	0	119.3889	-19.185	0	0	0	0	0	18.615352	0.8	126
fish	turtle:	0	0	0	119.9653	-18.6649	0	0	0	0	0	18.615352	0.8	122
fish	turtle:	0	0	0	119.7372	-19.3527	0	0	0	0	0	18.615352	0.8	56
fish	turtle:	0	0	0	119.3843	-19.73	0	0	0	0	0	18.588714	0.8	124
fish	turtle:	0	0	0	119.4901	-19.6115	0	0	0	0	0	18.588714	0.8	122
fish	turtle:	0	0	0	119.7123	-19.4612	0	0	0	0	0	18.588714	0.8	129
fish	turtle:	0	0	0	118.1509	-19.584	0	0	0	0	0	18.588714	0.8	124

Class	Taxon	Track?	Starts	Ends	Location			Velocity			Age	Mass	Stomach	Members
fish	turtle:	0	0	0	119.8927	-18.6256	0	0	0	0	0	18.588714	0.8	123
fish	turtle:	0	0	0	119.1339	-18.1589	0	0	0	0	0	18.588714	0.8	124
fish	turtle:	0	0	0	119.799	-17.4994	0	0	0	0	0	18.209777	0.8	123
fish	turtle:	0	0	0	118.0058	-20.3207	0	0	0	0	0	18.209777	0.8	120
fish	turtle:	0	0	0	118.159	-18.9688	0	0	0	0	0	18.209777	0.8	122
fish	turtle:	0	0	0	119.6661	-18.3359	0	0	0	0	0	18.209777	0.8	122
fish	turtle:	0	0	0	114.2359	-22.2251	0	0	0	0	0	18.209777	0.8	120
fish	turtle:	0	0	0	114.3046	-21.7791	0	0	0	0	0	18.209777	0.8	129
fish	turtle:	0	0	0	118.8784	-20.1205	0	0	0	0	0	18.209777	0.8	122
fish	turtle:	0	0	0	115.6	-20.6	0	0	0	0	0	18.49739	0.8	126
fish	turtle:	0	0	0	115.5	-20.4	0	0	0	0	0	18.49739	0.8	106
fish	turtle:	0	0	0	118	-20.3	0	0	0	0	0	18.49739	0.8	104
fish	turtle:	0	0	0	118.7419	-19.2147	0	0	0	0	0	18.49739	0.8	106
fish	turtle:	0	0	0	116.6	-20.45	0	0	0	0	0	18.49739	0.8	104
fish	turtle:	0	0	0	114.3	-21.75	0	0	0	0	0	18.49739	0.8	105
fish	turtle:	0	0	0	115.4	-21	0	0	0	0	0	18.49739	0.8	106

Vessels.cfg

Class	Taxon	Starts	Ends	Sample interval	Report file	Targets
DOT	dot:	0	0	monthly	dot.tbl	T: vessel

vessel	stdvessel:	Albert	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Albion	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	Alert	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	AlexTBrown	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Alkimos	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	AlmaMay	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Arcadia	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	EdmundFitzgerald	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
Vessel	stdvessel:	Abemama	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Aboyne	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Activity	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Adela	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Advance	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	African	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agincourt	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agnes	Dampier	1	1/01/2001	0	5000	portLineOre4.rt

vessel	stdvessel:	Airlie	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Ajax	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Alacrity	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Albatross	Port-Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Alpha	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amur	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnMaria	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Anne	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung	Port-Hedland	1	1/01/2001	0	5000	portLineOre2.rt

Vessels_1p.cfg

DOT	dot:	0	0	monthly	dot.tbl	T:	vessel

vessel	stdvessel:	Albert	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Albion	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	Alert	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	AlexTBrown	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Alkimos	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt

vessel	stdvessel:	AlmaMay	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Arcadia	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	EdmundFitzgerald	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Abemama	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Aboyne	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Activity	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Adela	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Advance	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	African	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agincourt	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agnes	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Airlie	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Ajax	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Alacrity	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Albatross	Port-Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Alpha	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amur	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnMaria	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Anne	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle	Port-Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung	Port-Hedland	1	1/01/2001	0	5000	portLineOre2.rt

Vessel	stdvessel:	Arab	Port-Hedland	1	1/01/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_B	Port-Hedland	1	1/01/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_B	Port-Hedland	1	1/06/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_B	Dampier	1	1/01/2002	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_B	Dampier	1	1/01/2002	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_B	Dampier	1	1/01/2002	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_B	Dampier	1	1/01/2002	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope	Port-Hedland	1	1/01/2003	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_C	Port-Hedland	1	1/01/2003	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_C	Port-Hedland	1	1/06/2003	0	5000	portLineOre.rt
Vessel	stdvessel:	Arcadia_C	Dampier	1	1/01/2003	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_C	Dampier	1	1/01/2003	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_C	Dampier	1	1/01/2003	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_C	Dampier	1	1/01/2003	0	5000	portLineOre4.rt
Vessel	stdvessel:	Arab_B	Port-Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_D	Port-Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_D	Port-Hedland	1	1/06/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_D	Dampier	1	1/01/2004	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_D	Dampier	1	1/01/2004	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_D	Dampier	1	1/01/2004	0	5000	portLineOre3.rt

vessel	stdvessel:	Ajax_D	Dampier	1	1/01/2004	0	5000	portLineOre4.rt
Vessel	stdvessel:	Antelope_B	Port-Hedland	1	1/01/2005	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_E	Port-Hedland	1	1/01/2005	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_E	Port-Hedland	1	1/06/2005	0	5000	portLineOre.rt
Vessel	stdvessel:	Arcadia_E	Dampier	1	1/01/2005	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_E	Dampier	1	1/01/2005	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_E	Dampier	1	1/01/2005	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_E	Dampier	1	1/01/2005	0	5000	portLineOre4.rt

Vessels_2p.cfg

DOT	dot:	0	0	monthly	dot.tbl	T:	vessel

vessel	stdvessel:	Albert	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Albion	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	Alert	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	AlexTBrown	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Alkimos	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	AlmaMay	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt

vessel	stdvessel:	Arcadia	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	EdmundFitzgerald	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Abemama	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Aboyne	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Activity	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Adela	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Advance	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	African	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agincourt	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agnes	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Airlie	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Ajax	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Alacrity	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Albatross	Port_Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Alpha	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amur	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnMaria	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Anne	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung	Port_Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Arab	Port_Hedland	1	1/01/2002	0	5000	portLineOre.rt

vessel	stdvessel:	Amicitia_B	Port_Hedland	1	1/01/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_B	Port_Hedland	1	1/06/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_B	Dampier	1	1/01/2002	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_B	Dampier	1	1/01/2002	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_B	Dampier	1	1/01/2002	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_B	Dampier	1	1/01/2002	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope	Port_Hedland	1	1/01/2003	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_C	Port_Hedland	1	1/01/2003	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_C	Port_Hedland	1	1/06/2003	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_C	Dampier	1	1/01/2003	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_C	Dampier	1	1/01/2003	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_C	Dampier	1	1/01/2003	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_C	Dampier	1	1/01/2003	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_B	Port_Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_D	Port_Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_D	Port_Hedland	1	1/06/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_D	Dampier	1	1/01/2004	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_D	Dampier	1	1/01/2004	0	5000	portLineCossack.rt

vessel	stdvessel:	Aboyne_D	Dampier	1	1/01/2004	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_D	Dampier	1	1/01/2004	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_B	Port_Hedland	1	1/01/2005	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_E	Port_Hedland	1	1/01/2005	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_E	Port_Hedland	1	1/06/2005	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_E	Dampier	1	1/01/2005	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_E	Dampier	1	1/01/2005	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_E	Dampier	1	1/01/2005	0	5000	5000portLineOre3.rt
vessel	stdvessel:	Ajax_E	Dampier	1	1/01/2005	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_C	Port_Hedland	1	1/01/2006	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_F	Port_Hedland	1	1/01/2006	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_F	Port_Hedland	1	1/06/2006	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_F	Dampier	1	1/01/2006	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_F	Dampier	1	1/01/2006	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_F	Dampier	1	1/01/2006	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_F	Dampier	1	1/01/2006	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_G	Port_Hedland	1	1/01/2007	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_G	Port_Hedland	1	1/01/2007	0	5000	portLineOre.rt

vessel	stdvessel:	Amur_G	Port_Hedland	1	1/06/2007	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_G	Dampier	1	1/01/2007	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_G	Dampier	1	1/01/2007	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_G	Dampier	1	1/01/2007	0	500	5000portLineOre3.rt
vessel	stdvessel:	Ajax_G	Dampier	1	1/01/2007	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_H	Port_Hedland	1	1/01/2008	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_H	Port_Hedland	1	1/01/2008	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_H	Port_Hedland	1	1/01/2008	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_H	Dampier	1	1/01/2008	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_H	Dampier	1	1/01/2008	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_H	Dampier	1	1/01/2008	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_H	Dampier	1	1/01/2008	0	5000	portLineOre4.rt
vessel	stdvessel:	Anne_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre2.rt
vessel	stdvessel:	Arcadia_I	Dampier	1	1/01/2009	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_I	Dampier	1	1/01/2009	0	5000	portLineCossack.rt

vessel	stdvessel:	Aboyne_I	Dampier	1	1/01/2008	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_I	Dampier	1	1/01/2009	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_J	Port_Hedland	1	1/01/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_J	Port_Hedland	1	1/01/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_J	Port_Hedland	1	1/06/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_J	Dampier	1	1/01/2010	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_J	Dampier	1	1/01/2010	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_J	Dampier	1	1/01/2010	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_J	Dampier	1	1/01/2010	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_K	Port_Hedland	1	1/01/2011	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_K	Port_Hedland	1	1/01/2011	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_K	Port_Hedland	1	1/06/2011	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_K	Dampier	1	1/01/2011	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_K	Dampier	1	1/01/2011	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_K	Dampier	1	1/01/2011	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_K	Dampier	1	1/01/2011	0	5000	portLineOre4.rt

Vessels2p.cfg

DOT	dot:	0	0	monthly	dot.tbl	T:	vessel	
vessel	stdvessel:	Albert	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Albion	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	Alert	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	AlexTBrown	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Alkimos	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	AlmaMay	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Arcadia	Dampier	1	1/01/2001	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel	Dampier	1	1/01/2001	0	5000	portLineCossack.rt
vessel	stdvessel:	EdmundFitzgerald	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Abemama	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Aboyne	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Activity	Dampier	1	1/01/2001	0	5000	portLineOre3.rt
vessel	stdvessel:	Adela	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Advance	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	African	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agincourt	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Agnes	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Airlie	Dampier	1	1/01/2001	0	5000	portLineOre4.rt
vessel	stdvessel:	Ajax	Dampier	1	1/01/2001	0	5000	portLineOre4.rt

vessel	stdvessel:	Alacrity	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Albatross	Port_Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Alpha	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Amur	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnMaria	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	Anne	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle	Port_Hedland	1	1/01/2001	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung	Port_Hedland	1	1/01/2001	0	5000	portLineOre2.rt
vessel	stdvessel:	Arab	Port_Hedland	1	1/01/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_B	Port_Hedland	1	1/01/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_B	Port_Hedland	1	1/06/2002	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_B	Dampier	1	1/01/2002	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_B	Dampier	1	1/01/2002	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_B	Dampier	1	1/01/2002	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_B	Dampier	1	1/01/2002	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope	Port_Hedland	1	1/01/2003	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_C	Port_Hedland	1	1/01/2003	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_C	Port_Hedland	1	1/06/2003	0	5000	portLineOre.rt

vessel	stdvessel:	Arcadia_C	Dampier	1	1/01/2003	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_C	Dampier	1	1/01/2003	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_C	Dampier	1	1/01/2003	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_C	Dampier	1	1/01/2003	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_B	Port_Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_D	Port_Hedland	1	1/01/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_D	Port_Hedland	1	1/06/2004	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_D	Dampier	1	1/01/2004	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_D	Dampier	1	1/01/2004	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_D	Dampier	1	1/01/2004	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_D	Dampier	1	1/01/2004	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_B	Port_Hedland	1	1/01/2005	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_E	Port_Hedland	1	1/01/2005	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_E	Port_Hedland	1	1/06/2005	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_E	Dampier	1	1/01/2005	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_E	Dampier	1	1/01/2005	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_E	Dampier	1	1/01/2005	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_E	Dampier	1	1/01/2005	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_C	Port_Hedland	1	1/01/2006	0	5000	portLineOre2.rt

vessel	stdvessel:	Amicitia_F	Port_Hedland	1	1/01/2006	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_F	Port_Hedland	1	1/06/2006	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_F	Dampier	1	1/01/2006	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_F	Dampier	1	1/01/2006	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_F	Dampier	1	1/01/2006	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_F	Dampier	1	1/01/2006	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_G	Port_Hedland	1	1/01/2007	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_G	Port_Hedland	1	1/01/2007	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_G	Port_Hedland	1	1/06/2007	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_G	Dampier	1	1/01/2007	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_G	Dampier	1	1/01/2007	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_G	Dampier	1	1/01/2007	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_G	Dampier	1	1/01/2007	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_H	Port_Hedland	1	1/01/2008	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_H	Port_Hedland	1	1/01/2008	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_H	Port_Hedland	1	1/06/2008	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_H	Dampier	1	1/01/2008	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_H	Dampier	1	1/01/2008	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_H	Dampier	1	1/01/2008	0	5000	portLineOre3.rt

vessel	stdvessel:	Ajax_H	Dampier	1	1/01/2008	0	5000	portLineOre4.rt
vessel	stdvessel:	Anne_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieLisle_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre.rt
vessel	stdvessel:	AnnieYoung_I	Port_Hedland	1	1/01/2009	0	5000	portLineOre2.rt
vessel	stdvessel:	Arcadia_I	Dampier	1	1/01/2009	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_I	Dampier	1	1/01/2009	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_I	Dampier	1	1/01/2009	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_I	Dampier	1	1/01/2009	0	5000	portLineOre4.rt
vessel	stdvessel:	Arab_J	Port_Hedland	1	1/01/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Amicitia_J	Port_Hedland	1	1/01/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_J	Port_Hedland	1	1/06/2010	0	5000	portLineOre.rt
vessel	stdvessel:	Arcadia_J	Dampier	1	1/01/2010	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_J	Dampier	1	1/01/2010	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_J	Dampier	1	1/01/2010	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_J	Dampier	1	1/01/2010	0	5000	portLineOre4.rt
vessel	stdvessel:	Antelope_K	Port_Hedland	1	1/01/2011	0	5000	portLineOre2.rt
vessel	stdvessel:	Amicitia_K	Port_Hedland	1	1/01/2011	0	5000	portLineOre.rt
vessel	stdvessel:	Amur_K	Port_Hedland	1	1/06/2011	0	5000	portLineOre.rt

vessel	stdvessel:	Arcadia_K	Dampier	1	1/01/2011	0	5000	portLineN_Rankin_A.rt
vessel	stdvessel:	Ariel_K	Dampier	1	1/01/2011	0	5000	portLineCossack.rt
vessel	stdvessel:	Aboyne_K	Dampier	1	1/01/2011	0	5000	portLineOre3.rt
vessel	stdvessel:	Ajax_K	Dampier	1	1/01/2011	0	5000	portLineOre4.rt

world.cfg

```
projection     projection:    map.rc    nws
csurface       bathymetry:              nws_dem_xy.pfm
#csurface      bathymetry:              merged_xy.pfm

#timeseries    tuv:      0       0       tuv_ml.data
timeseries     tuv:      0       0       tuv_mn.data
#timeseries    tuv:      0       0       tuv_mh.data

#dsurface      current:    0      0      bathymetry
scsurface      current:    0      0      map.rc     nws    100    @tuv    currents.data
#scsurface     wind:       0      0      map.rc     nws    100    @tuv    wind.data

variable       rainfall:    0     0      rainfall_60.ts
#variable      rainfall:    0     0      rainfall_90.ts
```

```
catastrophe     bangsplat:     0     0     Flattened.dat     Cyclones.data     benthic     vessel     animal
#catastrophe    dredgesplat:   0     0     Dredged.dat       Disasters.data    benthic     vessel     animal

cadastre     deepwater:     deep.xy.pt     map.rc     none     0     0
cadastre     sediment:      sed381.xy.pt   map.rc     none     0     0
```

Zones.cfg

```
cadastre     rig-zones:     rigs-cadastre.xy.pt     map.rc     none     0     0
cadastre     wells:         abbrev_wells.xy.pt      map.rc     none     0     0     \
cadastre     pipelines:     abbrev_pipelines_new.xy.pt     map.rc     none     0     0

cadastre     pilbara-closed:       pilbara-closed.xy.pt     map.rc     none     0     0
cadastre     pilbara-zones:        pilbara-zones.xy.pt      map.rc     none     0     0
cadastre     prawn-zones:     abbrev_pilbara-prawns.xy.pt     map.rc     none     0     0
cadastre     pilbara-trap-zones:   abbrev_pilb_traps.xy.pt  map.rc     none     0     0
```

ACKNOWLEDGMENTS

The authors would like to thank Linda Thomas, William Upcher and Brendon Ward for their assistance in compiling this report.

This study was funded by the Western Australia Department of Environmental Protection as part of the North West Shelf Marine Environmental Management Study. AIMS and CSIRO Marine Research provided in-kind support.

Clodagh Jones worked to improve the accuracy, consistency, and editorial style of the bibliography. We are grateful to all of those who supplied us with references, publications and suggestions for research needs.

The following people and agencies have contributed significantly to the Study through the provision of technical expertise and advice, and historical data and information. The Study partners gratefully acknowledge their contribution.

Western Australian State agencies
Department of Environment and Conservation (Department of Conservation and Land Management and Department of Environment)
Department of Fisheries
Department of Industry and Resources (Department of Mineral and Petroleum Resources)
Department of Land Information
Department for Planning and Infrastructure (Department of Transport)
Pilbara Tourism Association
Shire of Roebourne
Town of Port Hedland
Tourism Western Australia
Western Australian Land Information System
Western Australian Museum

Commonwealth agencies
Australian Institute of Marine Science
Geoscience Australia (formerly Australian Geological Survey Organisation)

Consultants
Cognito Consulting
David Gordon International Risk Consultants
METOCEAN Engineers (formerly Weather News International, Perth)
Oceanica (formerly DA Lord and Associates)

Industries
Australian Petroleum Production Exploration Association (APPEA)
Apache Energy
BHP Petroleum
Chevron Australia
Dampier Salt
Hamersley Iron
Mermaid Marine
Woodside Energy

Individuals
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Graham Cobby
Nick D'Adamo
Mike Forde
David Gordon
Andrew Heyward
Barry Hutchins
Bryan Jenkins
Di Jones
Ian LeProvost
Ray Masini
Mike Moran
Steve Newman
Eric Paling
Kelly Pendoley
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Chris Simpson
Shirley Slack-Smith
Di Walker

Editorial and publishing
Louise Bell – Graphics/cover design
Lea Crosswell – Webpage design
Rob McKenzie – Editor
Diana Reale – Webpage design
Linda Thomas – Editorial consultant/layout and design
Helen Webb – Editorial consultant/Project Manager

Front cover photos courtesy of:
Centre – Coral reef ecosystem, WA Museum, Clay Bryce
Aquaculture pearls, Department of Fisheries WA
Recreational fishing, Department of Fisheries WA, Jirri Lockman
Offshore petroleum platform, Woodside Energy Ltd
Commercial Fishing, Department of Fisheries WA
Tourism, CSIRO
Coastal development aerial photos, Hamersley Iron Pty Ltd