

Ecosystem-Based Fisheries Management (EBFM) Risk Assessment of the Western Australian Abalone Managed Industry

Webster, F. J., Wise, B.S. and Hart, A.



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

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Terms, Acronyms & Abbreviations

AMM	Annual management meeting
AMP	Abalone Management Plan
Broodstock	Any abalone which is (intended to be) used for breeding
C	Consequence level
CALM Act	<i>Conservation and Land Management Act 1984</i>
Department	Department of Fisheries, Western Australia
EBFM	Ecosystem-based Fisheries Management
ERA	Ecological Risk Assessment
ESD	Ecologically-Sustainable Development
ETP	Endangered, threatened or protected
FRDC	Fisheries Research and Development Corporation
FRMR	<i>Fish Resource Management Regulations 1995</i>
L	Likelihood level
OHS	Occupational Health and Safety
MSC	Marine Stewardship Council
OCS	Offshore Constitutional Settlement
SSBA	Surface Supplied Breathing Apparatus
SD	Statement of Determination
TAC	Total allowable catch
VMS	Vessel Monitoring System
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council

Executive Summary

The Department of Fisheries utilises an ecosystem-based fisheries management (EBFM) approach which considers all relevant ecological, social, economic and governance issues to deliver community outcomes. In order to assess the level of fisheries' impacts and prioritise management activities across these four areas, periodic ecological risk assessments are undertaken for fisheries resources in Western Australia (WA).

This report provides a comprehensive overview of the Western Australian (WA) Abalone Managed Fishery (AMF) and the outcomes from the 2015 ecological risk assessment of this fishery. The AMF targets three species of abalone greenlip (*Haliotis laevis*), brownlip (*H. conicopora*) and Roe's abalone (*H. roei*). Greenlip and brownlip abalone are primarily targeted on the south coast of WA, while Roe's abalone is primarily targeted on the West Coast. Commercial fishing for abalone in WA has been undertaken since 1964.

The risk analysis methodology utilised for the 2015 risk assessment is based on the global standard for risk assessment and risk management (AS/NZS ISO 31000). This methodology utilises a consequence-likelihood analysis, which involves the examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls. Initial scoping work to identify components and sub-components within each of the four EBFM areas was undertaken by Departmental research and management staff and the Abalone Industry Association of WA prior to a formal stakeholder workshop held in Perth, Western Australia, in December 2015 in which these issues were scored.

One hundred and two issues were identified and scored. The majority of issues identified for the AMF were considered to be a low or negligible risk. Twenty four issues were evaluated as a medium risk, four issues as a high risk and one a severe. The treatment of issues classified as medium or higher is addressed by identifying the monitoring, reporting and management procedures in place to mitigate risk and ensure stocks are sustainably managed.

1 Introduction

In accordance with international treaties and initiatives, the Australian Government is committed to implementing the principles of Ecologically Sustainable Development (ESD). ESD is a dynamic concept that seeks to integrate short- and long-term economic, social and environmental effects into the decision-making processes of government and industry. As per the *National Strategy for Ecologically Sustainable Development* (CoA 1992), ESD is defined as “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”. ESD is accepted as the foundation for natural resource management in Australia and is a major component of all fisheries legislation, at both Commonwealth and State levels.

The WA Government is committed to the concepts of ESD, and these principles are implicitly contained in the objectives of fisheries legislation. In 2002, the then Minister for Fisheries released a *Policy for the Implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia* (Fletcher 2002) to articulate how the Department of Fisheries (the Department) can demonstrate to both the government and the broader community that these requirements are being achieved.

A major element of this policy was reporting on the progress of each commercial fishery against the major ESD objectives, and this document reports on the progress of the AMF against these objectives. The reporting framework operates by identifying the relevant issues for a fishery within three main categories of (1) ecological sustainability, (2) community well-being and (3) ability to achieve industry objectives. Once the issues are identified a process to prioritise each is undertaken, typically using a formal risk assessment process.

The risk assessment process can be summarised as a consideration of the potential consequences of an issue and how likely the consequences are to occur. The combination of the level of consequence and the likelihood is used to produce an estimated level of risk associated with a particular issue. The risk assessment process helps to identify and prioritise issues requiring specific management actions, and therefore ongoing assessment of performance, from those issues that require only justification for low risk rating (Fletcher et al. 2002). Typically only issues of sufficient risk (ranked moderate to extreme) require specific management actions. Nonetheless, the rationale for classifying issues as low risk or even negligible risk needs to be documented. The documentation of the risk assessment process allows all stakeholders and interested parties to see why issues were accorded certain risk ratings.

This report provides an overview of the information pertaining to the AMF and presents the results of a comprehensive risk assessment against the ESD principles. Several key documents were consulted for preparing the background information and should be referred to for additional knowledge these include The *MSC Report for the Western Australian Abalone Managed Fishery* (Hart et al. 2017) and relevant legislation (Section 2.2.1).

This report should also be read in conjunction with the *Western Australian Abalone Resource Harvest Strategy* (Department of Fisheries, in prep.), which outlines the operational objectives, performance indicators and reference levels used to assess the performance of commercial abalone collection. The performance of the fishery against these objectives is reported in the annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the State of the Fisheries*.

The scope of this Ecological Risk Assessment (ERA) is for the next five years of industry operations (through December 2020). It is envisioned that ERA's will be undertaken periodically (approximately every five [5] years) to reassess any current or new issues that may arise in the industry; however, a risk assessment can also be triggered if there are significant changes identified in industry operations or management activities or controls that may change current risk levels. This cycle coincides with the review of the harvest strategy.

2 Background on the AMF

The AMF is a commercial dive fishery that operates in the shallow coastal waters of southwest WA. The fishery targets greenlip (*Haliotis laevis*), brownlip (*H. conicopora*) and Roe's abalone (*H. roei*). Greenlip and brownlip abalone are primarily targeted on the south coast of WA, while Roe's abalone is primarily targeted on the WC. In 2014/15, the total commercial landings of greenlip and brownlip abalone were 159 t and 34 t respectively worth approximately 7.2 million. The landings for Roe's abalone in 2014/15 in the AMF was 49 t with an estimated value of 1.2 million.

These species are also targeted by recreational fishers, particularly the Roe's abalone in the Perth Metropolitan region. Recreational catches of greenlip and brownlip abalone comprise approximately 3 – 4 % of the total annual catches of these species, while recreational catches of Roe's abalone comprise approximately 40 % of the total annual catch (Hart et al. 2015 a & b).

2.1 Fishery Description

A commercial abalone fishery has been operating in WA since the 1960s, and it is one of the most valuable fisheries in the state (Fletcher and Santoro 2015). There are currently 52 licences in the AMF (29 licences endorsed to take Roe's abalone, 23 licences endorsed to take Greenlip and Brownlip abalone) in one or more of the eight management Areas (Figure 2.1). The Greenlip/Brownlip fishery operates in management areas, 1-4, and the Roe's fishery operates in areas 1,2,5,6,7 & 8. The fishery is managed primarily through output controls in the form of annual quotas for each of the management Areas in the fishery (see Table 2.1).

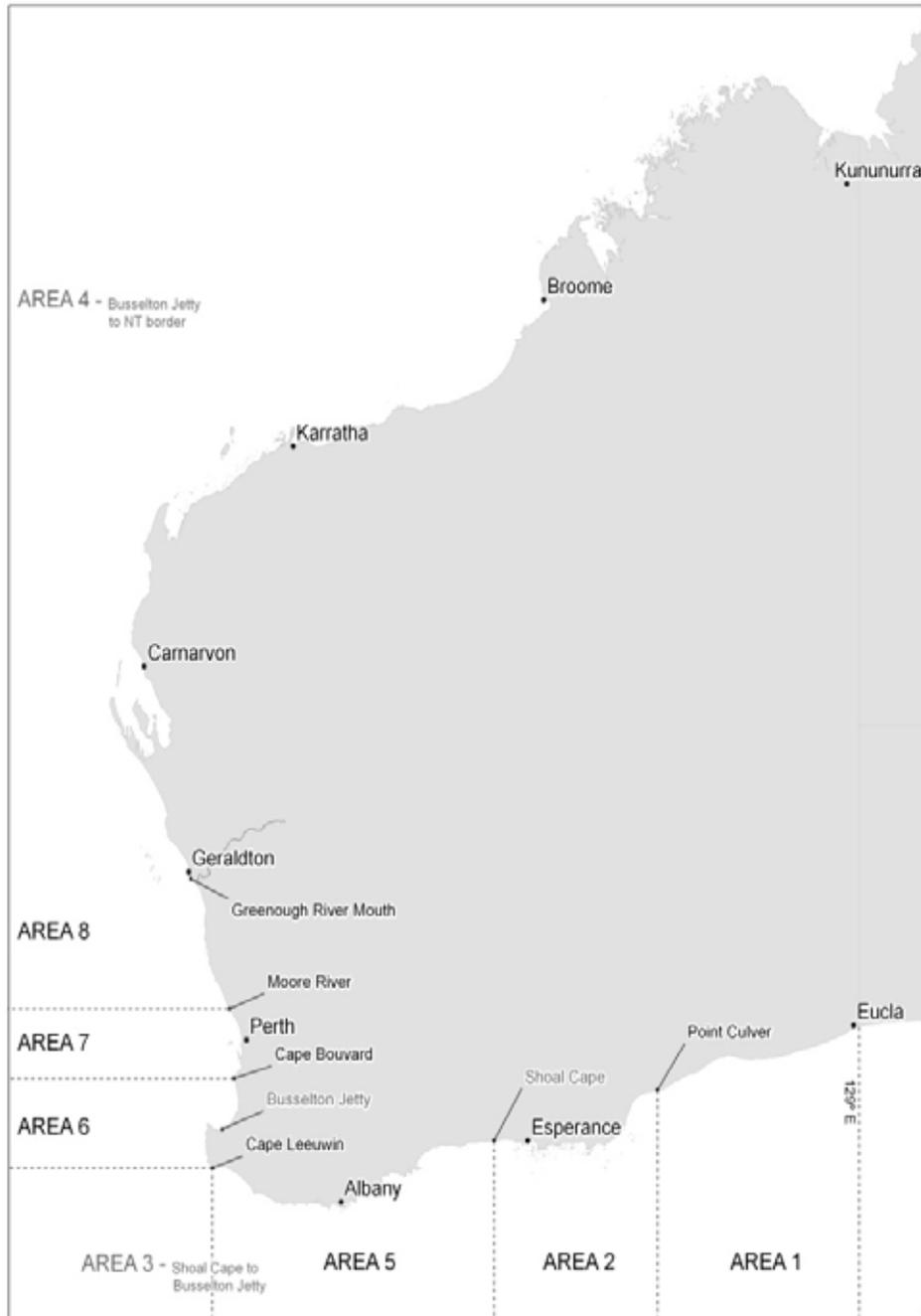


Figure 2.1 AMF fishery boundaries and management Areas.

2.1.1 Abalone fishing

The AMF is a hand collection fishery. Fishing is carried out by divers utilising surface supplied breathing apparatus (SSBA or ‘hookah’) attached to a medium sized vessel, generally less than 9 m length (Figure 2.2). The vessel tows the divers slowly over the abalone reefs, and the divers collect legal-sized abalone as they are encountered (b). Animals are prised from the rock surfaces with an implement known as an ‘abalone iron’, and divers often use an underwater scooter or other motorised device such as a shark cage to increase their efficiency and reduce fatigue from continuously swimming.

Abalone are stored in large catch bags. When it is full or the maximum bottom time for the diver has been reached (to avoid risk of decompression sickness), the diver fills a lift bag on his equipment with air, and the unit rises to the surface. A pulley system is used to hoist the catch and equipment onto the vessel, where the abalone are counted and measured.

Fishing is largely confined to daylight hours and is usually undertaken close to shore (or around offshore islands) as abalone tends to inhabit shallow water (< 40 m depth). The fishing method is species-specific with no other species harvested.

To maximise the quality of the catch, greenlip and brownlip abalone may be shucked (i.e. animals removed from the shell with the gut removed and discarded) at sea and packed into saltwater-filled containers. The Department requires that the shell from these animals is kept in bags and available for inspection until the meat arrives at an approved processor. Roe's abalone must be landed whole with the shell attached.

Upon arrival at shore, the weight of the catch is determined, and statutory catch and disposal records (CDRs) are completed for research and compliance purposes. The abalone are then transported to the processor for weighing, cleaning, and packaging.

Fishing can occur all year round; however, operations are weather dependent, with less activity over the winter due to less favourable conditions (e.g. a high number of storms). For the greenlip and brownlip abalone, commercial operators typically suspend fishing over summer months due to the abalone having less meat weight over this period.

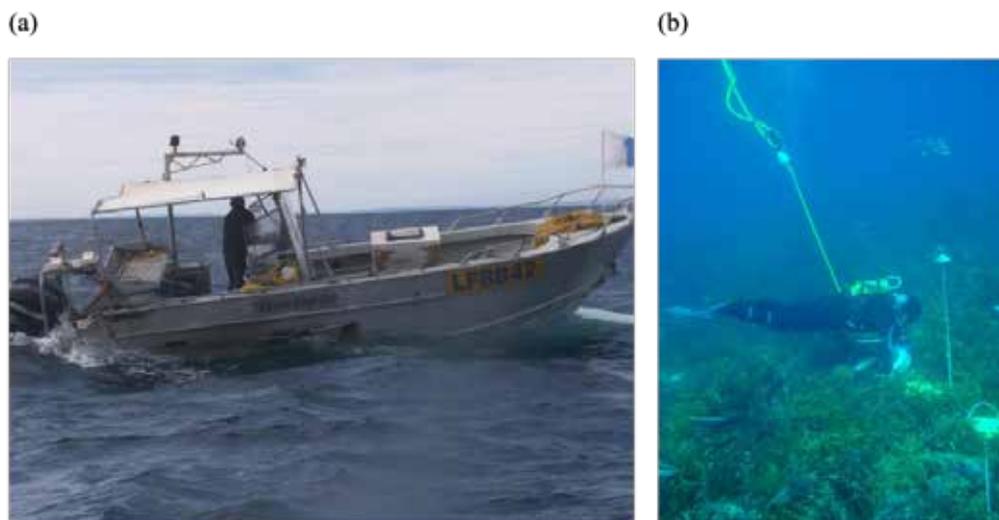


Figure 2.2 Abalone (a) fishing vessel and (b) abalone diver

2.1.2 Abalone catches

2.1.2.1 Greenlip abalone

Greenlip abalone are collected along the south coast of WA with the majority of catch coming from Areas 2 and 3. There is no quota allocated to Area 4 and catches in Area 1 are minimal. In Areas 2 and 3, catches are not evenly distributed but concentrated in certain areas such as Augusta, Windy Harbour and east of Esperance (Figure 2.3).

2.1.2.2 Brownlip abalone

Brownlip abalone are also collected along the south coast of WA but in much lower numbers than greenlip species. Brownlip catches are also predominately in Areas 2 and 3, with a focus of catches from Windy Harbour and east of Esperance (Figure 2.4).

2.1.2.3 Roe's abalone

Fishing for Roe's abalone occurs in Areas 1, 2, 5, 6, and 7. Area 8 was closed to fishing in 2011 due to marine heat wave causing abalone mass mortality. Roe's abalone are collected along the west and south coast of WA, with the majority of catches coming from the metropolitan area (Area 7), the capes region (Area 6) and Esperance (Area 2) (Figure 2.3).

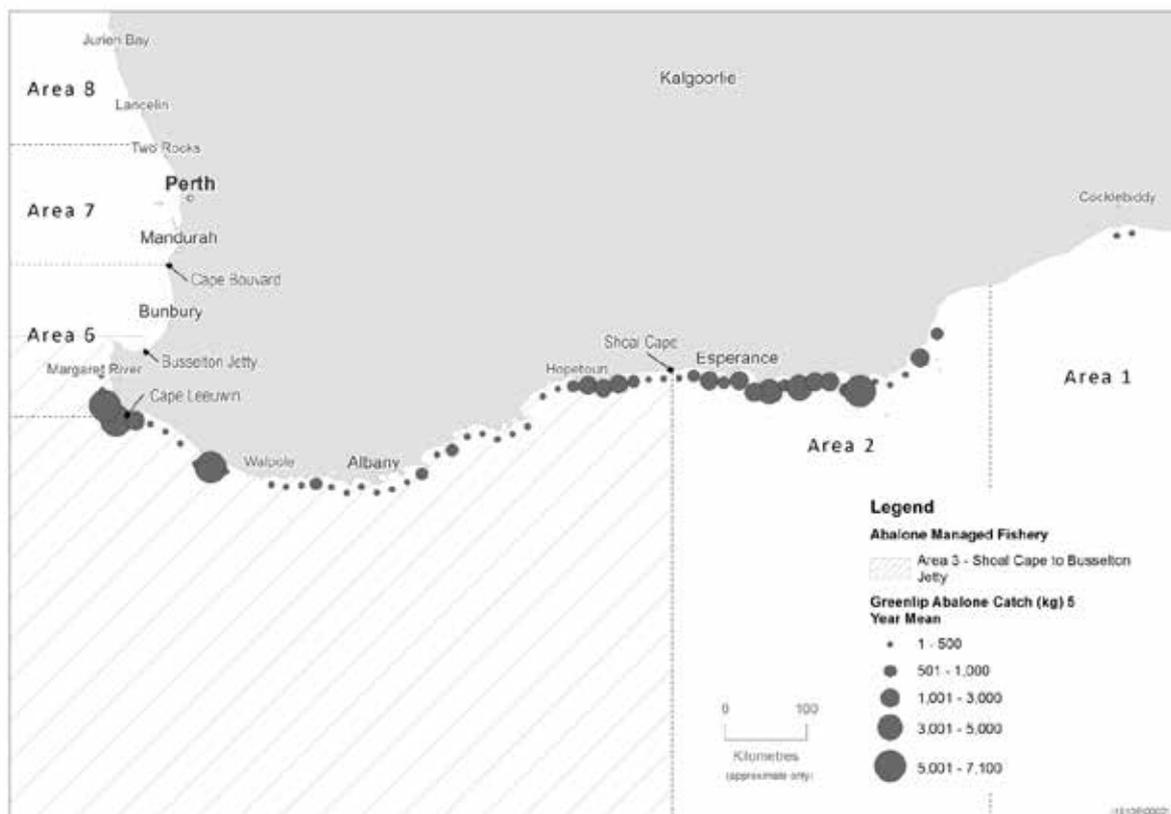


Figure 2.3 Average annual catch of greenlip abalone in the AMF between 2009-2014. Note different scale for different species.

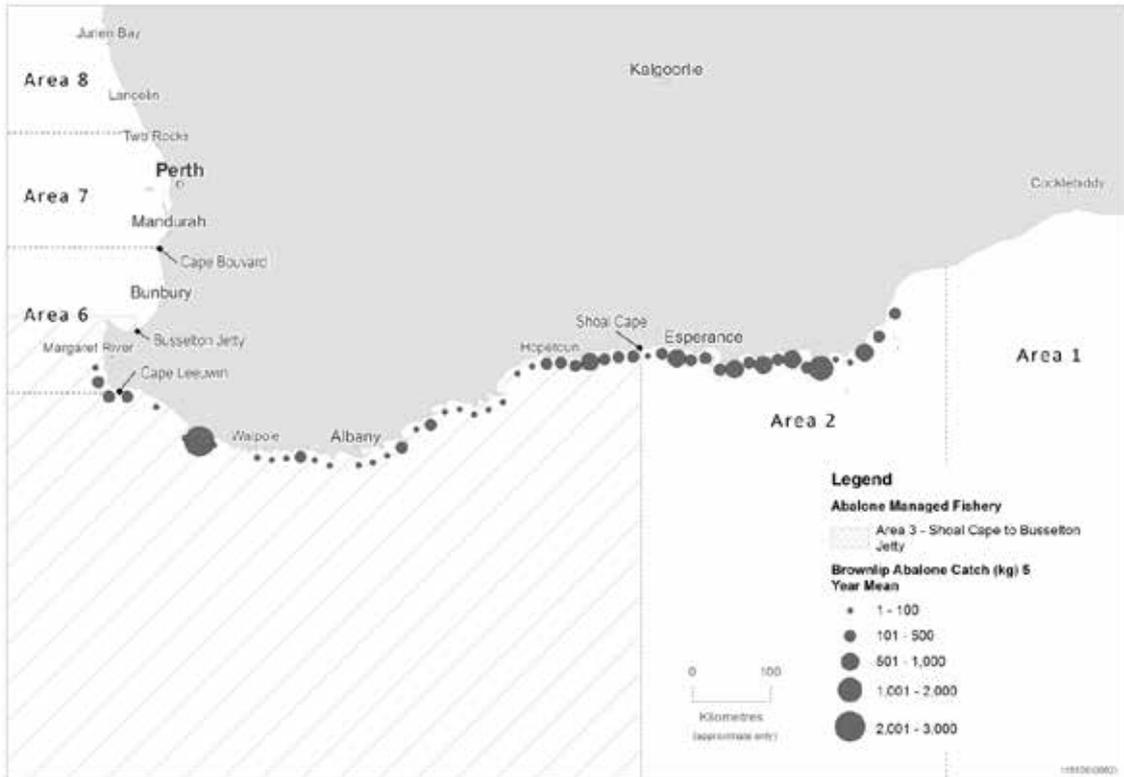


Figure 2.4 Average annual catch of brownlip abalone in the AMF between 2009-2014. Note different scale for different species.



Figure 2.5 Average annual catch of Roe's abalone in the AMF between 2009-2014. Note different scale for different species.

2.2 Management

2.2.1 Legislation and Arrangements

The *Fish Resources Management Act 1994* (FRMA) and the *Fish Resources Management Regulations 1995* (FRMR), together with subsidiary instruments including the *Abalone Management Plan 1992* (AMP), regulatory Notices, a Statement of Determination (SD), licences and licence conditions, provide power for the management of all aspects of the WA commercial abalone industry.

It is important to note that the current fisheries legislation will be replaced by the *Aquatic Resource Management Act* in the near future (currently before Parliament as the *Aquatic Resource Management Bill 2015*).

Fishers must also comply with the requirements of:

- The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Western Australian Marine Act 1982*; and
- *Western Australian Wildlife Conservation Act 1950*
- *Western Australian Conservation and Land Management Act (CALM) 1984*

The management measures for the AMF are summarised in Table 2.1.

2.2.2 Harvest Strategy

A harvest strategy has been developed for the AMF to ensure biological sustainability of captured stocks, and to ensure the broader ecological objectives as well as social and economic objectives are met (DoF 2017). Harvest strategies make explicit the objectives, performance indicators, reference levels, and harvest control rules for each defined ecological asset. They also indicate the scope of management actions required in relation to the status of each resource in order to meet the specific long- and short-term management objectives for the resource and the broader goals of the ESD strategy.

Table 2.1 Management measures and instrument of implementation for AMF

Measure	Description	Instrument
Species Restrictions	The AMF is limited to the collection of Roe's, greenlip and brownlip abalone.	FRMR AMP
Size Limits	Minimum size for Roe's abalone is a shell length of 75 mm in Area 1, 70 mm in Area 7 and 60 mm in all other Areas of the Fishery. Minimum size for greenlip abalone is a shell length of 140 mm. Minimum size for brownlip abalone is a shell width of 140 mm. Method of determining shell size is by measuring the shell from edge to edge across the longest diameter.	AMP FRMR
Quota System	The AMF is managed via output controls in the form of a total allowable commercial catch (TACC), which is divided into individually transferable quota units for Roe's, greenlip and brownlip abalone within each management Area. The maximum quantity of abalone that maybe taken from relevant Areas for Roe's abalone in the 2015 period was: Area 1 – 5000 kg Area 2 – 18000 kg Area 5 – 20000 kg Area 6 – 12000 kg Area 7 – 32000 kg Area 8 – 0 kg The maximum quantity of abalone that maybe taken from relevant areas for greenlip abalone is: Area 1 – 1200 kg Area 2 – 21000 kg Area 3 – 32000 kg Area 4 – 0 kg The maximum quantity of abalone that maybe taken from relevant areas for brownlip abalone is: Area 1 – 60 kg Area 2 – 5000 kg Area 3 – 5000 kg Area 4 – 0 kg	AMP
Licence Requirements	Operators must hold a Managed Fishery Licence to undertake commercial abalone fishing in WA. Licences are renewed annually.	AMP
Spatial Restrictions and Closures	The Fishery is divided into eight management areas. Abalone quota units are currently distributed across Areas 1 – 2 and 5 – 8 for Roe's abalone, and Areas 1 – 4 for greenlip and brownlip abalone. Note Area 8 is currently closed to fishing for Roe's abalone. Commercial fishing for Roe's abalone is not permitted between the North Mole at Fremantle and Trigg Island at any time. Commercial fishing for abalone is not permitted in certain protected areas within Marine Parks and Fish Habitat Protection Areas.	AMP <i>Prohibition on Taking Abalone (North of Moore River) Order 2011</i> FRMR
Temporal Restrictions	Roe's abalone fishing is prohibited in Area 7 on Saturdays, Sundays and Public Holidays.	AMP

2.2.3 Compliance

The Department encourages voluntary compliance through education, awareness and consultation activities. Compliance is also actively enforced through an Operational Compliance Plan which is underpinned by a risk assessment conducted for each fishery.

2.2.3.1 AMF Operational Compliance Plan

The AMF Operational Compliance Plan has the following objectives:

- To provide clear and un-ambiguous direction and guidance to Fisheries and Marine Officers for the yearly delivery of compliance in the fishery;
- To protect the fisheries' environmental values, while providing fair and sustainable access to the fishery's commercial and social values;
- To encourage voluntary compliance through education, awareness and consultation activities; and
- To provide processes which ensure that the fisheries are commercially viable in the international market yet environmentally sustainable in the local context.

2.2.3.2 Compliance Strategies for the AMF

Compliance strategies and activities that are used in the fishery include:

- Land and sea patrols;
- Inspections of abalone wholesale and retail outlets;
- Undertaking covert operations and observations;
- Inspections at abalone processing facilities;
- Inspection in port;
- At-sea inspection of fishing boats;
- Quota management;
- Aerial surveillance; and
- Intelligence gathering and investigations.

2.2.4 Industry Initiatives

The Abalone Industry Association of WA (AIAWA) has developed a Code of Practice for the greenlip and brownlip abalone fishery which outlines the environmental responsibilities of licence holders. The Code stipulates harvest procedures to minimise impacts to abalone and the environment, diver and boat safety, pollution management, procedures for cleaning and handling abalone and methods to minimise the potential spread of disease. The Code also emphasises the importance of supporting Departmental research and engagement in with Departmental management decisions (AIAWA 2015a).

The AIAWA has also developed a Diver Induction and Instruction Manual for Area 2 and 3 of the AMF. The manual specifies voluntary management measures including: summer closure for greenlip (dates reviewed at each general meeting but typically for the entire three months), minimum sizes for certain Areas (less than specified in the AMF), leaving some immature size and large abalone on each reef when fishing and moving on from recently fished areas (as evidenced by abalone scars on the reef). The manual recommends that shark shields and cages be used/worn at all times to prevent shark attack, and the importance of correctly completing the CDR to ensure the fishery is sustainably managed (AIAWA 2015b & c).

The AIAWA strategic plan has a mission plan “to create a healthy fishery resource managed for the benefit of industry and the Australian community”. The plan mainly outlines industry initiatives and market opportunities but with emphasis on sustainability.

2.3 Abalone Biology

Greenlip, brownlip abalone and Roe’s abalone live on exposed, high-energy coasts and have evolved life-history characteristics to enable survival in this environment. General traits include: a muscular foot capable of providing solid attachment during periods of prolonged exposure; a feeding behaviour primarily focused on drifting algae dislodged by wave action, rather than actively grazing as do many other gastropods herbivores (Shepherd and Steinberg 1992). All three species exhibit separate sexes with a 1:1 sex ratio, which is typical for most abalone species and populations. Reproduction is by broadcast spawning, synchronised by seasonal cues such as change in water temperature and lunar periods. The larval life span is relatively short 5 and 10 days to allow for quick settlement back into localised populations, with larvae preferring crustose coralline algae as a settlement substrate (McShane 1992).

2.3.1 Greenlip abalone

Greenlip abalone are temperate endemic Australian species, which grow to approximately 200 m shell length and a distribution that extends from the south-west of WA to Tasmania. Genetic research on this species indicates that stocks are composed of local populations linked by occasional larval dispersal into metapopulations. Genetic differentiation increases with distance, and overall it was estimated that populations encompass areas of around 30 km² which are largely maintained through self-recruitment (Shepherd and Brown, 1993).

Greenlip abalone typically are found on exposed granite or limestone rocky reefs, between one and 40 m depth; however, the commercial fishery primarily targets the 5 to 25 m depth range (Figure 2.6).

The breeding season of greenlip abalone varies between locations but is generally confined to the spring/summer months (Shepherd et al. 1992). Size at-maturity for greenlip abalone varies with growth and averages between 78 and 97 mm in WA (Hart et al., 2013a). Based on growth rate, age-at-maturity is around 3 years, although there is some evidence that maturation is not entirely age dependent and can be accelerated under optimal conditions (McAvaney et al., 2004).

(a)



(b)



Figure 2.6 Greenlip abalone (a) in its natural habitat and (b) harvested for sale

2.3.2 Brownlip abalone

Brownlip abalone co-occur with green lip abalone with a slightly more restricted distribution that extends from the south-west of WA to South Australia. The genetic stocks of brownlip abalone are local populations with occasional larval dispersal. Populations encompass areas of around 30 km² and are mostly maintained through self recruitment (Shepherd and Brown 1993).

Brownlip abalone are a large species which grow to around 200 mm shell length. Brownlip typically inhabit exposed granite or limestone rock reefs in water depths of < 40m (Figure 2.7). There is no published information on the breeding season of brownlip abalone. Size at maturity for brownlip abalone is less well known. Wells and Mulvay (1992) showed that maturation occurs rapidly between 110 and 130 mm, but all animals below 110 mm were immature. Age at maturity is about 3 years, similar to greenlip abalone.

(a)



(b)



Figure 2.7 Brownlip abalone in its (a) natural habitat, and (b) harvested for sale.

2.3.3 Roe's abalone

Roe's abalone are a smaller species which grow to 89 cm (Figure 2.8). This species are found in commercial quantities from the South Australian border to Shark Bay, although they are not uniformly distributed throughout this range. Genetic studies indicate high levels across south western WA (Hancock 2004).

Roe's abalone populations occur on semi-continuous reef complexes, which are generally less than 10 km of coastal length. This species typically found in water < 10 m in depth on the intertidal reef platforms and shallow adjoining sub-tidal reef for up to 30 to 40 m beyond the reef platforms.

(a)



(b)



Figure 2.8 *Haliotis roei* in its (a) natural habitat, and (b) harvested for sale.

The major spawning period for Roe's abalone in Perth metropolitan stocks is during winter (Wells and Keesing 1989), whereas in South Australia the species appears capable of spawning all year round (Shepherd and Laws 1974). Size at maturity for females is around 40 mm, which is about three years (Hart et al. 2013a).

2.3.4 Disease in abalone populations

An Australia-wide survey of diseases and parasites in abalone found a number of organisms with disease potential, including *Perkinsus* and *Vibrio* species (Handler et al. 2006). The principal parasite affecting several abalone species (which may all three species) is a protozoan parasite known as *Perkinsus* (Goggin and Lester 1995). This causes flesh deformities which greatly reduces market value, and is pathogenic in native populations such as in areas of the NSW blacklip abalone fishery (Handler et al., 2006). *Perkinsus* parasites have been found in over 30 species of molluscs and is naturally occurring in greenlip abalone from South Australia (Goggin and Lester, 1995) and New South Wales (Liggins and Upston, 2010). It was found to be seasonally variable, being more abundant in late summer and autumn than in late winter, and abalone are more susceptible to infection at high temperatures. *Perkinsus* was heavily implicated in the demise of the New South Wales

blacklip abalone fishery and evidence of substantial tissue necrosis, organ damage and haemocyte activity associated with *Perkinsus* sp. cells in surveys between 2002 and 2005 showed that this parasite is pathogenic to abalone in that state (Liggins and Upston, 2010).

A national study by Handler et al. (2006) did not detect any viruses in Australian abalone stocks. However subsequently an extremely pathogenic herpes-like-virus (Abalone Viral Ganglioneuritis - AVG) was discovered in wild stocks in Victoria and Tasmania and is causing significant concern to the industry and community in all abalone-producing areas (Corbeill et. al., 2010; Savin et. al, 2010; Hooper et. al., 2007). The Western Zone blacklip abalone fishery in Victoria was decimated by this virus and TACC is current only around 10% of the levels experienced during pre-virus times.

To date there has been no occurrence of major disease outbreaks in WA abalone stocks. Biosecurity protocols are in place and these include mandatory disease testing and quarantine protocols for animals being moved.

Research has recently been initiated in WA examining abalone and other molluscs for the presence of disease in WA populations. A native species, *Perkinsus. olseni* has found to be naturally occurring in greenlip and Roe's abalone, and has also been identified as naturally occurring in other molluscs such as cockles. The Department has recently submitted a funding application to FRDC for extend this research to assess what other species also have this protozoan and the geographical extent over which it can be found.

2.4 Major Environments

The AMF extends across two bioregions of WA the West Coast Bioregion and the South Coast Bioregion. Harvesting for greenlip and brownlip species primarily occurs in the Southern Bioregion, while Roe's are commercially harvested from Shark Bay to the South Australian Border, with the majority of the catch coming from the Perth metropolitan Area.

The West Coast Bioregion (WCB) extends from south of Shark Bay to Augusta. The marine environment of the WCB is predominantly a temperate oceanic zone, but it is heavily influence by the Leeuwin Current. Coastal water temperatures range from 18° C to about 24° C, which are generally higher than would be expected at these latitudes due to the current's influence.

The WCB is characterised by exposed sandy beaches and a limestone reef system that creates surface reef lines, often about five kilometres off the coast. Major significant marine embayments of the WCB include Cockburn Sound and Geographe Bay.

The WCB has medium to high species diversity and is one of the global hotspots for endemism. Benthic habitats are characterised by sand and limestone shoreline platforms and subsurface reefs. The benthic communities in the intertidal and subtidal reefs areas are dominated by temperate macroalgae. Seagrasses tend to grow predominantly in sand with the diversity of seagrasses in temperate south WA the highest for any temperate region in the world

The South Coast Bioregion (SCB) extends east from Augusta to the South Australian border. The shelf waters of the SCB are generally temperate but low in nutrients, due to the seasonal winter presence of the tail of the tropical Leeuwin Current and limited terrestrial run-off. Sea surface temperatures typically range from approximately 15° C to 21° C. The SCB is a high energy environment, heavily influenced by large swells generated in the Southern Ocean. The coastline from Cape Leeuwin to Israelite Bay is characterised by white sand beaches separated by high granite headlands. East of Israelite Bay, there are long sandy beaches backed by large sand dunes that are replaced by high limestone cliffs at the South Australian border. There are few large areas of protected water along the south coast, the exceptions being around Albany and in the Recherche Archipelago off Esperance.

The marine habitats of the SCB are similar to the coastline with fine clear sand floors, interspersed with occasional granite outcrops and limestone reefs. A mixture of seagrass and kelp habitats occur in the SCB, with seagrass more abundant in protected waters (CoA 2008, Fletcher and Santoro 2015).

2.4.1 Habitats within the Fishery

Abalone live on hard surfaces, usually limestone reefs or granite boulders in waters < 30 m deep. The hard surface provides a substrate for their large foot to secure and which with the external shell provides protection from predators. Abalone are typically sedentary and do not move large distances or across areas of sediment (Geiger and Owen 2012).

Studies on greenlip abalone in WA have found that they are not evenly distributed across hard limestone and granite rock areas, but instead form aggregations characterised by “bare habitat” which have a low abundance of macroalgae and/or macro-invertebrates (Hart et al. 2013b). Intensive habitat surveys were undertaken as a part of an abalone restocking program to determine suitable locations and habitats for releasing juvenile abalone. A survey of 32 ha of reef identified that only around 2 % of the benthic habitat was considered “bare habitat” suitable for greenlip abalone with the remaining 98 % a combination of sand, seagrass and unsuitable reef (Hart 2015c).

Roe’s abalone are also not evenly distributed across hard reef surfaces. Research in the Perth metropolitan area at on reef platforms at Trigg, Watermen’s and Cottesloe found abalone to be concentrated on areas of bare reef (Wells et al. 2007).

2.5 Catch and Effort

The total annual catch and effort are presented for greenlip (Figure 2.9), brownlip (Figure 2.11) and Roe’s abalone (Figure 2.12). There is no data for catches in Zone 4, as is the northern management Area of the AMF where these species are not commercially fished.

The current standardised catch per unit effort (SCPUE) model used takes into account technology and environmental effects on catching efficiency. The SCPUE for greenlip and Roe’s abalone are presented in Figure 2.10 and Figure 2.13. Detailed information on the TAC, total catch, total effort, and CPUE for each species are provided in Appendix 1.

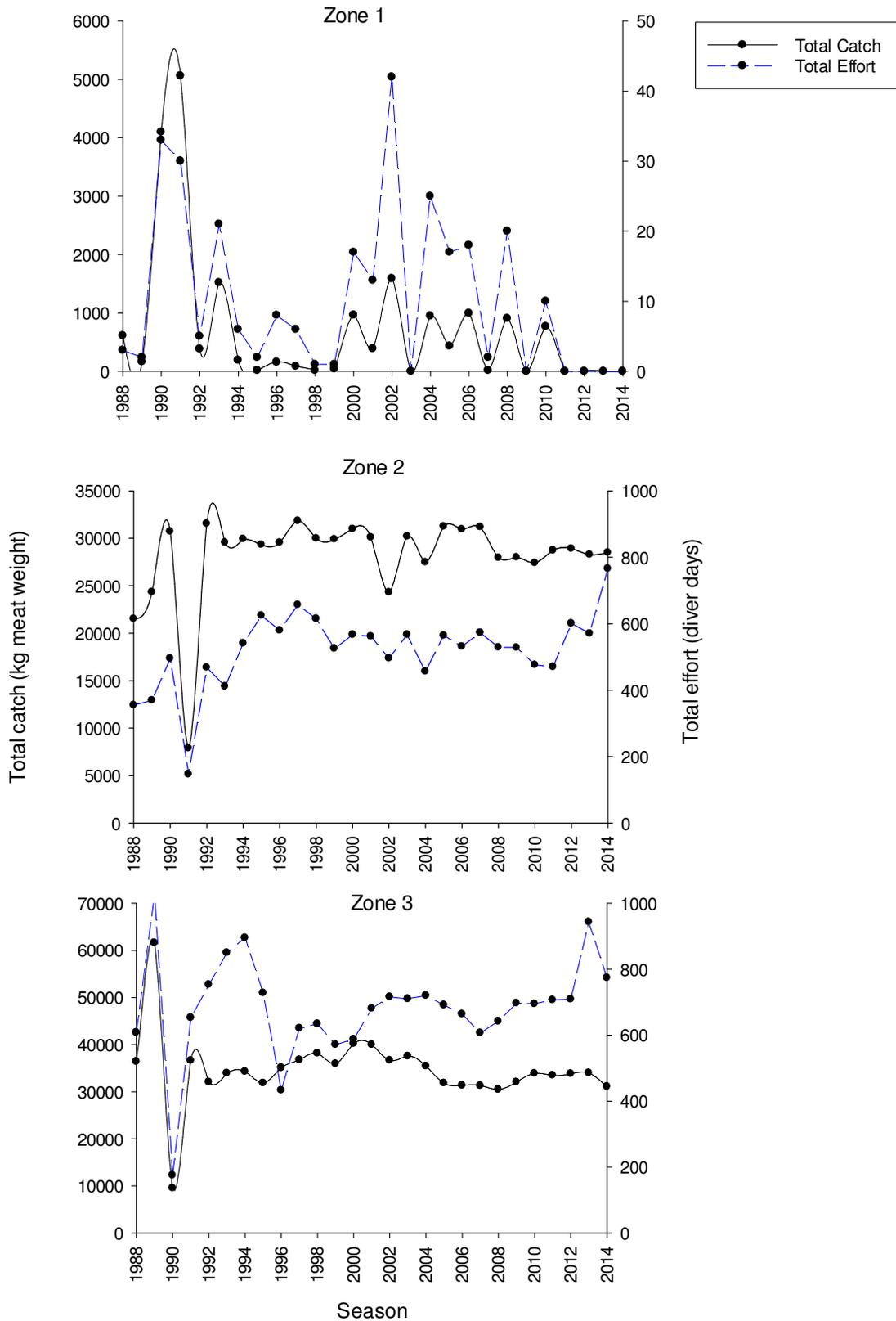


Figure 2.9 Total annual catch (kg meat weight) and effort (diver days) for Areas 1, 2 and 3 for greenlip abalone. Note no catch in Zone 4.

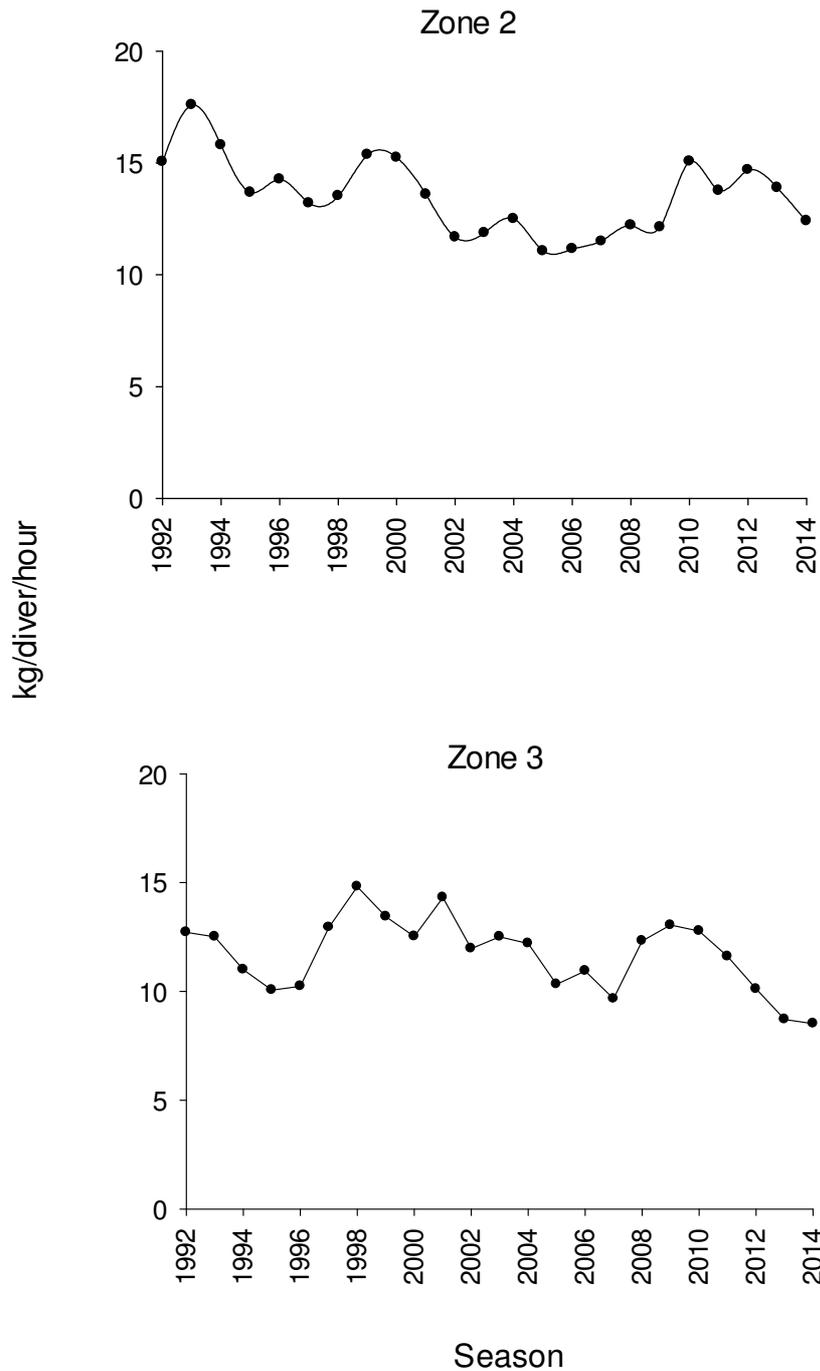


Figure 2.10 Standardized CPUE (kg/diver/hour) for Areas 2 and 3 for greenlip abalone. Note there is currently no SCPUE data for Zone 1.

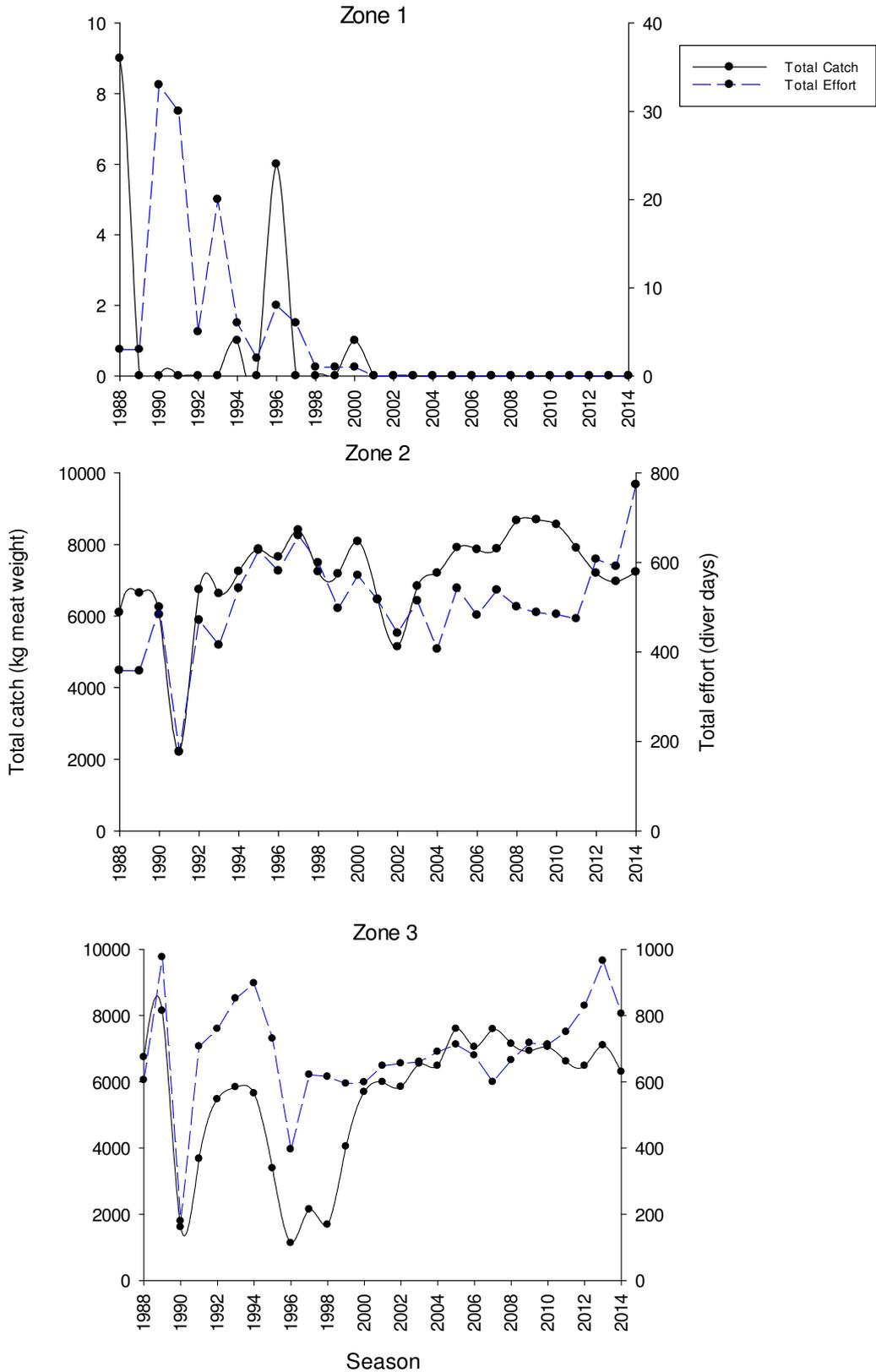


Figure 2.11 Total annual catch (kg meat weight) and effort (diver days) for Areas 1, 2 and 3 for brownlip abalone. Note no catch in Zone 4.

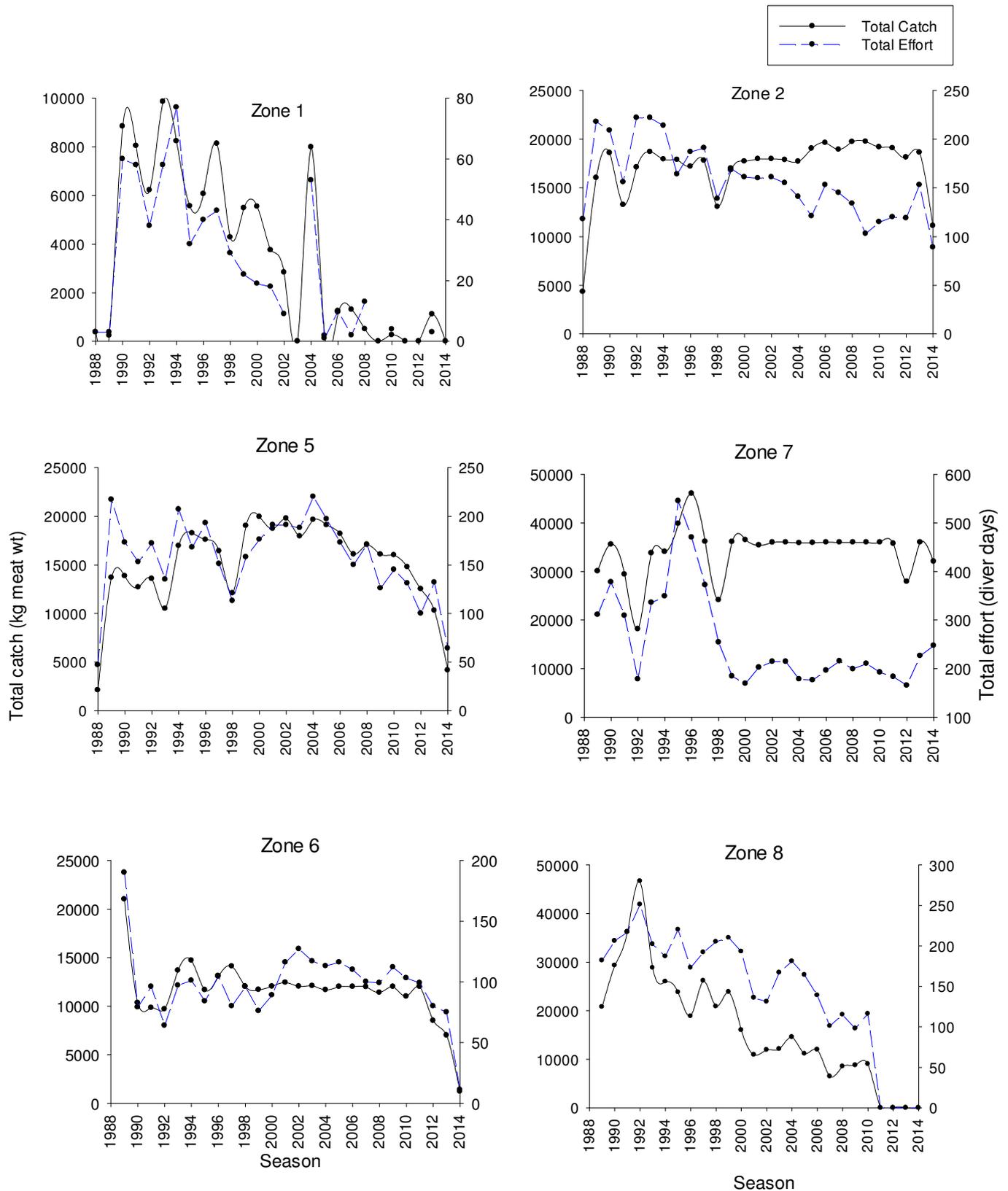


Figure 2.12 Total annual catch (kg meat weight) and effort (diver days) for Areas 1, 2, 5, 6, 7 & 8 for Roe's abalone.

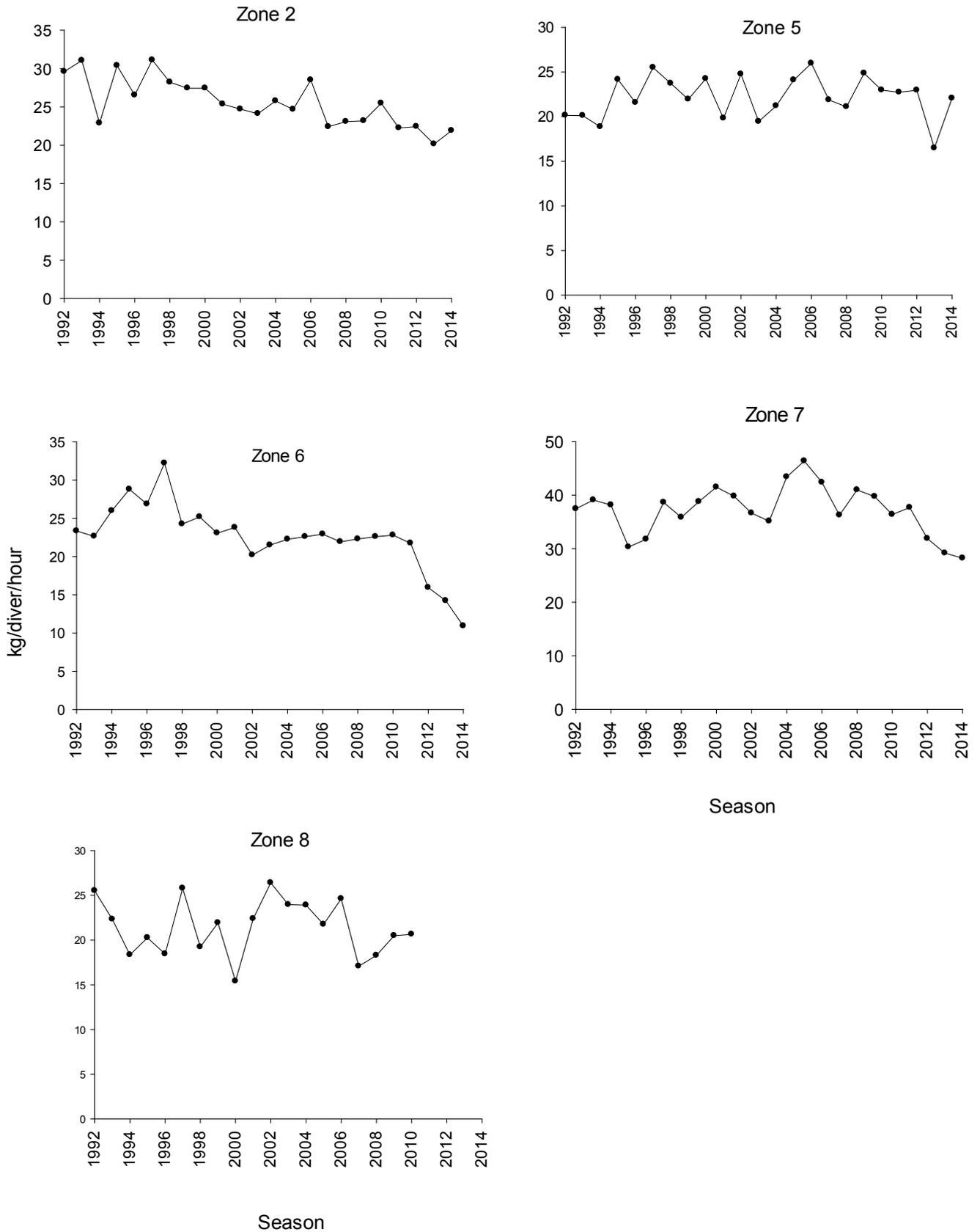


Figure 2.13 Standardized CPUE (kg/diver/hour) for Areas , 2, 5, 6, 7 & 8 for Roe's abalone. Note there is currently no SCPUE data for Zone 1.

2.6 Research and Monitoring

2.6.1 Statutory Reporting

There is a statutory obligation for abalone fishers to provide monthly and daily catch and effort data. This information is used for research, management and the setting of quota.

2.6.1.1 Monthly catch and effort logbooks

The initial catch and effort information was collected on a monthly basis by divers submitting compulsory Catch and Effort Statistics (CAES) to the Research Division. The system, which is utilised by all fisheries WA, which is mostly based a large grid systems (60 x 60 mile). Catch data on abalone has been entered into this system since the late 1970's and provides a useful source of historical information. In 2015 the monthly CAES for abalone was replaced with daily catch and effort records.

2.6.1.2 Daily catch and disposal records

For each day's fishing, commercial divers record estimates of catch (kg), effort (hours) spent diving for abalone, and location fished using a 10 x 10 nautical mile grid system. The data is recorded daily on a CDR that accompanies each daily catch. The reported catch is officially weighted a licensed processor, and entered into the Abalone Catch and Effort database (ACE) at the Busselton Fisheries Office. Catch quotas are managed through statutory CDR returns.

2.6.2 Additional Monitoring

Additional monitoring is undertaken in the fishery in order to better estimate stock abundance and fishing impacts.

Fishery-independent population surveys are undertaken regularly in the different Areas of the fishery to collect data on the size and density of abalone. These data provide information on recruitment, estimates of mortality and independent measures of abundance to compare to fishery-dependent catch rates for the different species.

2.6.2.1 Greenlip and brownlip abalone

Surveys of greenlip and brownlip abalone along the southern coast are undertaken periodically at fixed sites throughout the fishery (86 sites in Area 2 and 131 sites in Area 3). Survey sites were selected on the basis of known stock distributions and range broadly in the level of productivity. Two main sub-Areas (Arid in Area 2 and Augusta in Area 3) are surveyed annually (71 sites), while other Areas are visited once every 2 – 3 years.

2.6.2.2 Roe's abalone

Population surveys of Roe's abalone are undertaken annually at 13 indicator sites in the Perth metropolitan Area between Yanchep and Penguin Island (11 fished sites and 2 sites within the Waterman's Reserve Marine Protected Area and the Cottesloe Fish Habitat Protection Area). Surveys are carried out on two habitats, the reef platform and the sub-tidal habitat,

which generally correspond to the recreational and commercial fisheries, respectively (Hart et al. 2013a).

2.6.3 Other Research

2.6.3.1 Stock enhancement research

Stock enhancement of greenlip abalone have been carried out in collaboration with industry divers since 2004. Relevant publications from this work can be found in Hart et al. 2013a to d).

2.6.3.2 Recovering collapsed abalone stock through translocation

In the summer of 2010/11 an anomalous environmental event termed a marine heat wave resulted in increased water temperatures (Pearce et al. 2011). Temperature stress combined with deoxygenation of water over an extended calm period effectively wiped out the entire stock in Area 8, resulting in complete closure of the fishery. In 2011 a project was funded by the Australian Seafood Cooperative Research Centre to investigate the potential for recovery stocks through translocation. This research project is still in operation with results not yet available.

2.6.3.3 Brownlip abalone: exploration of wild and cultured harvest potential.

Brownlip abalone is the largest and possibly fastest growing abalone species in Australia. Due to its large size and high meat yield (approx. 35% greater meat weight per length than greenlip abalone) it is extremely suitable for wild, cultured or ocean grown, whole meat export markets. A project is currently underway to determine growth and natural mortality of wild and cultured brownlip abalone, habitat identification and optimizing market potential.

2.6.3.4 Marine Park abalone surveys: Cape Leeuwin – Cape Naturaliste

In 2007 a series of abalone surveys were undertaken in areas proposed as sanctuary zones in the proposed Ngari Capes Marine Park as well as control areas. These areas were designed to estimate total abalone biomass in the sanctuary zones and provide information on the quantity of catch which may be foregone as a result of the closure of abalone fishing in these zones. The survey sites will be visited on a periodic basis following the implementation of the Marine Park. Further details are available in Hesp et al. (2008).

2.6.3.5 Abalone health and disease

In addition to the research conducted as a part of the above monitoring programs, the Departments Fish Health Unit also provide a comprehensive disease-test program to industry.

Research has recently been initiated in WA examining abalone and other molluscs for the presence of disease in WA populations. A native species *Perkensus. olsenii* has been found to be naturally occurring in greenlip and Roe's abalone, and has also been identified as naturally occurring in other molluscs such as cockles. The Department has recently submitted a funding application to FRDC for extend this research to assess what other species also have this protozoan and the geographical extent over which it can be found.

2.7 Reports and Publications

The Department provides a comprehensive range of formal reports to stakeholders on annual fishery performance, including information on fishery outcomes, management, relevant findings and recommendations from research, monitoring, evaluation and review activities. This information is published and publically available on the Department's website and includes:

- The *Annual Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher and Santoro 2015).
- The Department's *Annual Report* to Parliament.
- The *Research, Monitoring, Assessment and Development Plan 2015 – 2020* Fisheries Occasional Publication No. 122,
- Fisheries Management Papers (FMP), Fisheries Research Reports (FRR), Fisheries Occasional Papers (FOP) and peer-reviewed scientific journal articles. For example, recent publications relevant to the AMF includes:
 - The *Abalone Resource Harvest Strategy 2016 – 2021* (DoF. *in prep*)
 - Fisheries Management Paper No. 204. Integrated Fisheries Management Report – Abalone Resource. (DoF, 2005a).
 - Fisheries Management Paper No. 226. Integrated Fisheries Management Allocation Report – Roe's Abalone Resource, Perth Metropolitan Region. (DoF, 2009b).
 - Fisheries Management Paper No. 243. Future management of the metropolitan recreational Roe's abalone fishery. (DoF 2010a).
 - Fisheries Research Report No 227. Assessment of the risks associated with the release of abalone sourced from abalone hatcheries for enhancement or marine grow-out in the open ocean areas of WA. (Jones and Fletcher, 2012).
 - Fisheries Occasional Publication No 32. Allocation of the Western Australian Abalone Resource between user groups. (DoF, 2005b).
 - Fisheries Research Report No 185. Performance indicators, biological reference points and decisions rules for Western Australian abalone fisheries (*Haliotis sp*): (1) Standardised catch per unit effort. (Hart et al. 2009).
 - Fisheries Research Report No. 170. Biomass and commercial catch estimates for abalone stocks in areas proposed as sanctuary zones for the Capes Marine Park. (Hesp, et al 2008).
 - Fisheries Research Report No. 241. Biology History and assessment of Western Australian abalone fisheries. (Hart et al. 2013).
 - Hart, A.M., Strain, L., Fabris, F., Brown, J., Davidson, M. (2013). Stock enhancement of greenlip abalone: (1): Long-term growth and mortality. *Reviews in Fisheries Science* 21: 299-309.
 - Hart, A.M., Fabris, F., Murphy, D., Brown, J., Strain, M., Davidson, M., (2013). Stock enhancement of greenlip abalone: (2): Population and ecological effects. *Reviews in Fisheries Science* 21: 310-320.
 - Hart, A.M., Strain, L.W.S., Hesp, A. (2013). Stock enhancement of greenlip abalone: (3): Bioeconomic evaluation. *Reviews in Fisheries Science* 21: 354-374.
 - Mayfield, S., Mundy, C., Gorfine, H., Hart, A.M., Worthington, D. (2012). Fifty years of sustained production from the Australian abalone fisheries. *Reviews in Fisheries Science* 24: 220-250.

3 Risk Assessment Methodology

The Department of Fisheries has implemented an ecosystem based fisheries management (EBFM) approach as the primary strategy to achieve the goal of ESD for fisheries in WA. EBFM deals with the aggregate management of all fisheries-related activities within an ecosystem or bioregion and takes into account the impacts of fishing on retained species, discarded bycatch species, protected species, habitats and the broader ecosystem — regarded as ‘ecological assets / components’ — and the social, economic and governance outcomes. In utilising a broad EBFM approach, managers are required to consider a wide and diverse set of issues.

Risk assessments offer a means to filter and prioritise the various identified issues for management and have been used in fisheries management in Australia for over a decade (Fletcher et al. 2002). The risk analysis methodology utilised for the AMF industry risk assessment was based on the global standard for risk assessment and risk management (AS/NZS ISO 31000), which has been adopted for use in a fisheries context (see Fletcher et al. 2002, Fletcher 2005; Fletcher 2015).

The risk assessment process which is an essential part of implementation of risk management is summarised in Figure 1. The first stage involved establishing the context or scope of the risk assessment – which included identifying the activities, stakeholders and geographical extent to be covered, the objectives to be delivered, timeframe for the assessment and what was considered acceptable performance (Section 3.1).

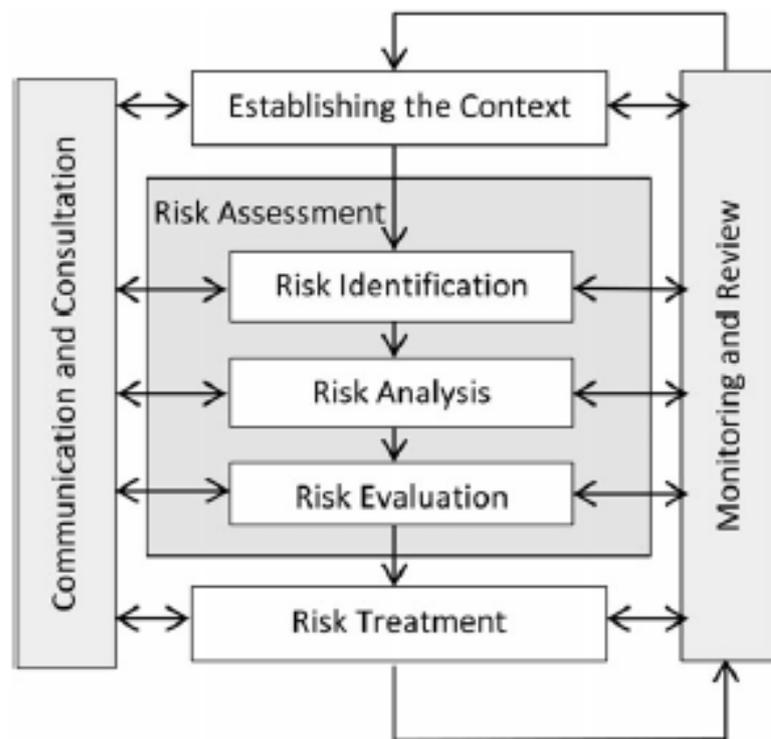


Figure 3.1 Position of risk assessment within the risk management process (modified from SA 2012)

Risk identification involves the process of recognising and describing risks, which involves the identification of risk sources and their causes (Section 3.2). Once the risks are identified they are scored by the risk analysis process. This process involves the examination of the sources of risk (issue identification), the potential consequences (impacts) associated with each issue and the likelihood (probability) of a particular level of consequence actually occurring. The combination produces a risk score. Section 3.3 provides a description of the risk assessment methodology and Section 4 documents the results from risk analysis, with detailed justifications for each score.

Risk evaluation (Section 5) is completed by comparing the risk score with those associated with different levels of risk which is compared to established levels of risk. The risk evaluation step uses the risk levels to help make decisions about which risks need treatment.

Risk treatment (Section 6) involves addressing the issues with levels of risk which are considered undesirable. This involves identifying the likely monitoring and reporting requirements and associated management actions, which can either address and/or assist in reducing the risk to acceptable levels.

An important part of the risk assessment and risk management process is communication and consultation with stakeholders. The abalone ERA involved a high level of consultation through:

- Provision of a background document prior to the workshop explaining the purpose, background, risk assessment process and preliminary identification of issues
- Workshop – inviting a wide range of invited stakeholders (See Appendix 4)
- Risk assessment report (this report) summarising the results, justification, evaluation and treatment. This report was sent for review to all invited stakeholders prior to publication on the Departments website.

3.1 Scope

This risk assessment covers the commercial collection of abalone as a part of the AMF. The geographical extent is from Shark Bay to the South Australian border, which covers the main commercial fishing grounds.

For the purpose of this assessment, risk was defined as *the uncertainty associated with achieving a specific management objective or outcome* (adapted from Fletcher 2015). The risk is different depending on the context. For a fisheries agency, ‘risk’ is the chance of something affecting the agency’s performance against the objectives laid out in their relevant legislation. In contrast for the commercial fishing industry, the term ‘risk’ generally relates to the potential impacts on their long term profitability. For the general community, ‘risk’ could relate to possible impact on their enjoyment¹ of the marine environment.

¹ Broader community values include non-extractive and non-direct uses

Stakeholders included the commercial abalone industry, recreational fishing sector, State and Commonwealth departments, museums and universities, and non-Government Organisations, Indigenous organisations and the Department of Fisheries (full list of invited, attendance and participant list provided in Appendix 4).

The aim for each of these groups is to ensure the ‘risk’ of an unacceptable impact is kept to an acceptable level.

The calculation of a risk in the context of a fishery is usually determined within a specified time frame, which, for the AMF ERA is the next five years i.e. until December 2020.

3.2 Risk identification (Component trees)

The first step in the ERA process is to identify the issues relevant to the fishery being assessed. This step is equivalent to the ‘hazard identification’ process used in most risk assessment procedures. Issues were identified using the assistance of the component tree approach (Fletcher et al. 2002). Generic component trees have been established for of the main principles of ESD which include:

- Ecological sustainability – the impact of the AMF on ecological resources/assets;
- Community wellbeing – the contribution of the AMF to the abalone fishing industry, local community and broader WA community in terms economic and social wellbeing;
- External factors – external environmental, social and economic drivers that impact the AMF performance; and
- Governance – management processes and arrangements that impact the AMF performance.

An example of a generic component tree for ecological sustainability is provided in Figure 3.2. For the component trees, each of the major components is at a level too high to develop sensible operational objectives, and consequently each of the components is deconstructed into more specific sub-components. For example, in the AMF, under the retained species component there are three sub components; greenlip, brownlip and Roe’s abalone, with each species having a different operational objective for each management Area.

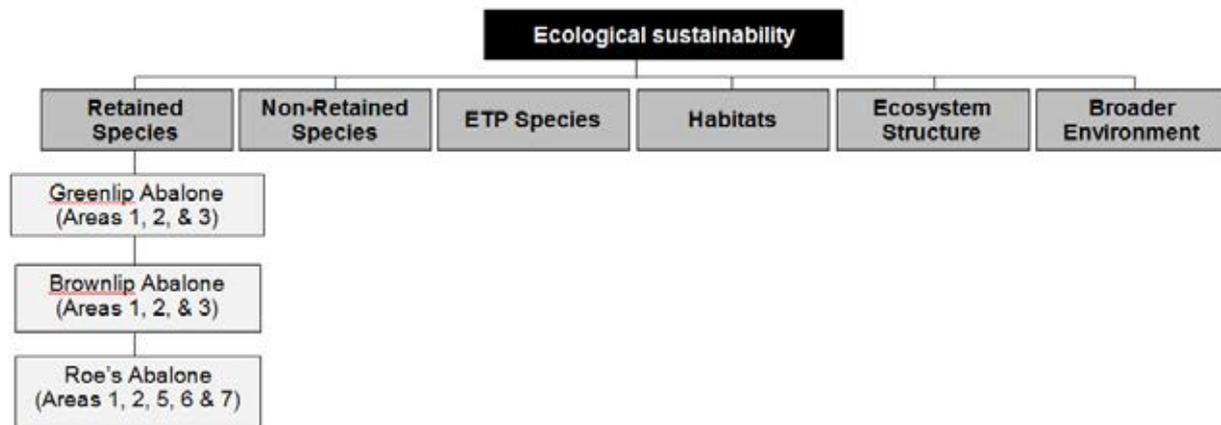


Figure 3.2 An example of a generic component tree for ecological sustainability, identifying the main components (solid boxes) and sub components for retained species in the AMF.

The identification of issues involves tailoring each of the trees to suite the individual circumstances of the fishery being examined, by adding/expanding some components and collapsing or removing others. For the AMF the development of the component trees with industry specific issues were based on:

- Previous risk assessments undertaken in the fishery under the *EPBC Act 1999* to achieve approval for Wildlife Trade Operations². A summary of the issues identified in previous risk assessments and risk ratings is provided in Appendix 2.
- A gap analysis undertaken in an internal Departmental workshop involving research and management staff in November 2015
- Identified gaps in the Marine Stewardship Council (MSC) performance indicators (as identified during a pre-assessment of the industry against the MSC Fisheries Standards in 2014) and
- Consultation with industry and external stakeholders during the ERA workshop on December 9th 2015.

3.3 Risk Assessment Process

The risk assessment process assists in separating minor acceptable risks from major, unacceptable risks and prioritising management actions. Once the components and issues were identified for the AMF, the process to prioritise each was undertaken using the ISO 31000-based qualitative risk assessment methodology. This methodology utilises a consequence-likelihood analysis, which involved the examination of the magnitude of potential consequences from fishing activities and the likelihood that those consequences will occur given current management controls (Fletcher 2015).

² All previous risk assessments are available on the Commonwealth Department of the Environment's website <http://www.environment.gov.au/marine/fisheries/wa/abalone>

Consequence and likelihood analyses range in complexity; here, we applied a 5 x 5 level system, with the consequence levels ranging from 1 (e.g. minor impact/consequence to fish stocks) to 5 (e.g. catastrophic consequences for fish stocks) and likelihood levels ranging from 1 ('remote', i.e. < 5 % probability) to 5 ('certain', i.e. > 90 % probability). Scoring involved assessing the likelihood that each level of consequence is actually occurring or is likely to occur within the next five years. Note that if an issue was not considered to have any measurable impact, it was considered to be a 0 consequence; however, this was only permitted where the likelihood of each other consequence level occurring was 0 (i.e. so remote that it is considered essentially impossible in the next five years). The scores for each of the consequence and likelihood levels were then multiplied to determine the risk score, .e. Risk = the highest Consequence × Likelihood (Table 3.1).

The ERA used a set of pre-defined consequence and likelihood levels (see Appendix 3). Different consequence tables were used in the risk analysis to accommodate for the variety of issues and potential outcomes. For example the potential consequences of commercial fishing on ecological sustainability of retained species was assessed using a Fish stocks consequence table where effects of the fishery on community well-being were assessed using the Social consequence table.

The level of consequence was determined at the appropriate scale for the issue, e.g. for the retained species, the consequence of the AMF was based at the stock / population level where as the ecosystem / environment was considered at a whole-of-system scale. In total 10 consequence tables were utilised in the assessment:

1. Fish stocks (retained/non-retained species) – measured at a stock level
2. ETP species measured at a population or regional level
3. Habitats – measured at a regional level
4. Ecosystem/Environment – measured at a regional level
5. Public reputation and image
6. Economic (measured at a regional or entire fishery level)
7. Safety and Health
8. Social
9. Community (Social Structures/Culture) – measured at a regional level
10. Operational Effectiveness

For the abalone ERA where applicable, risks were assessed separately for the species, management Area and/or bioregion. For example, issues associated with commercial collection of abalone, risk was assessed separately for species and management Area i.e. greenlip, abalone was assessed separately for Area's 1, 2 and 3 due to different commercial catches in each Area. Some issues were separated into west coast (WC) and south coast (SC) due to the different ecosystems and/or pressures occurring in each region.

The formal risk analysis was conducted at a stakeholder workshop held on 9th December 2015 at the WA Fisheries and Marine Research Laboratories in Hillarys, Perth. Stakeholders present during the workshop included representatives from the commercial abalone industry, the Western Australian Fishing Industry Council (WAFIC), Department of Parks and Wildlife, Aquaculture Council of WA and, the WA Department of Fisheries (full attendance and participant list provided in Appendix 4). The group at the workshop made a realistic estimate of the risk level for each issue, based on the combined judgement of the participants at the workshop, who collectively were considered to have appropriate expertise on the areas examined.

Based on the calculated score, each issue was assigned a Risk Rating within one of five categories: Negligible, Low, Medium, High or Severe (Table 3.2). The rationale for classifying issues at each risk level was documented at the workshop and forms the majority of this report. This allows all stakeholders and interested parties to see the rationale and justification for the final risk ratings.

Table 3.1 Standard Consequence — Likelihood Risk Matrix (based on AS 4360 / ISO 31000; adapted from Department of Fisheries 2015)

		Likelihood				
		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)	Certain (5)
Consequence	Minimal (1)	1	2	3	4	5
	Moderate (2)	2	4	6	8	10
	High (3)	3	6	9	12	15
	Major (4)	4	8	12	16	20
	Catastrophic (5)	5	10	15	20	25

Table 3.2 Risk levels applied to all assets by the Department of Fisheries WA (modified from Fletcher 2005)

Risk Category / Level	Description	Likely Reporting & Monitoring Requirements	Likely Management Action
1 Negligible	Acceptable; Not an issue	Brief justification – no monitoring	Nil
2 Low	Acceptable; No specific control measures needed	Full justification needed – periodic monitoring	None specific
3 Medium	Acceptable; With current risk control measures in place (no new management required)	Full Performance Report – regular monitoring	Specific management and/or monitoring required
4 High	Not desirable; Continue strong management actions OR new / further risk control measures to be introduced in the near future	Full Performance Report – regular monitoring	Increased management activities needed
5 Severe	Unacceptable; Major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

3.4 Previous risk assessments for the AMF

Multiple risk assessments have been undertaken previously for the AMF, with the first comprehensive risk assessment involving external undertaken in 2002 under the *EPBC Act 1999* to achieve approval for Wildlife Trade Operations. This ERA was subsequently been internally reviewed by the Department and the CEO of the AIAWA in 2009 and 2014 as a part of the WTO renewal process. In 2015 environmental approvals for the AMF under the EPBC Act 1999 was extended for 10 years until 2025. A summary of previous identified components, issues and risk ratings is provided in Appendix 2. A full list of previous assessments and outcomes can be found on the DoE website at: <http://www.environment.gov.au/marine/fisheries/wa/abalone>.

4 Risk Analysis

The risk analysis involved scoring each of the 102 identified issues across the four principles of ESD using the consequence x likelihood analysis. Note the risk justifications include comments from individual stakeholders at the workshop; these comments are a summary of individual views and may not be representative of every stakeholder at the workshop; however, the risk scores are reflective of the group consensus at the workshop, as well as follow-up discussions between the Department, industry and workshop participants. Where discrepancies in risk levels occurred, all risk ratings are provided, along with the justification for any differences.

4.1 Ecological sustainability

Twenty ecological sub components were identified as potentially impacted by the AMF (Figure 4.1), with 39 associated issues. The majority of the issues were scored as negligible (27), and low (2) risk. Eleven issues were scored as medium risk, with none scored as high or severe.

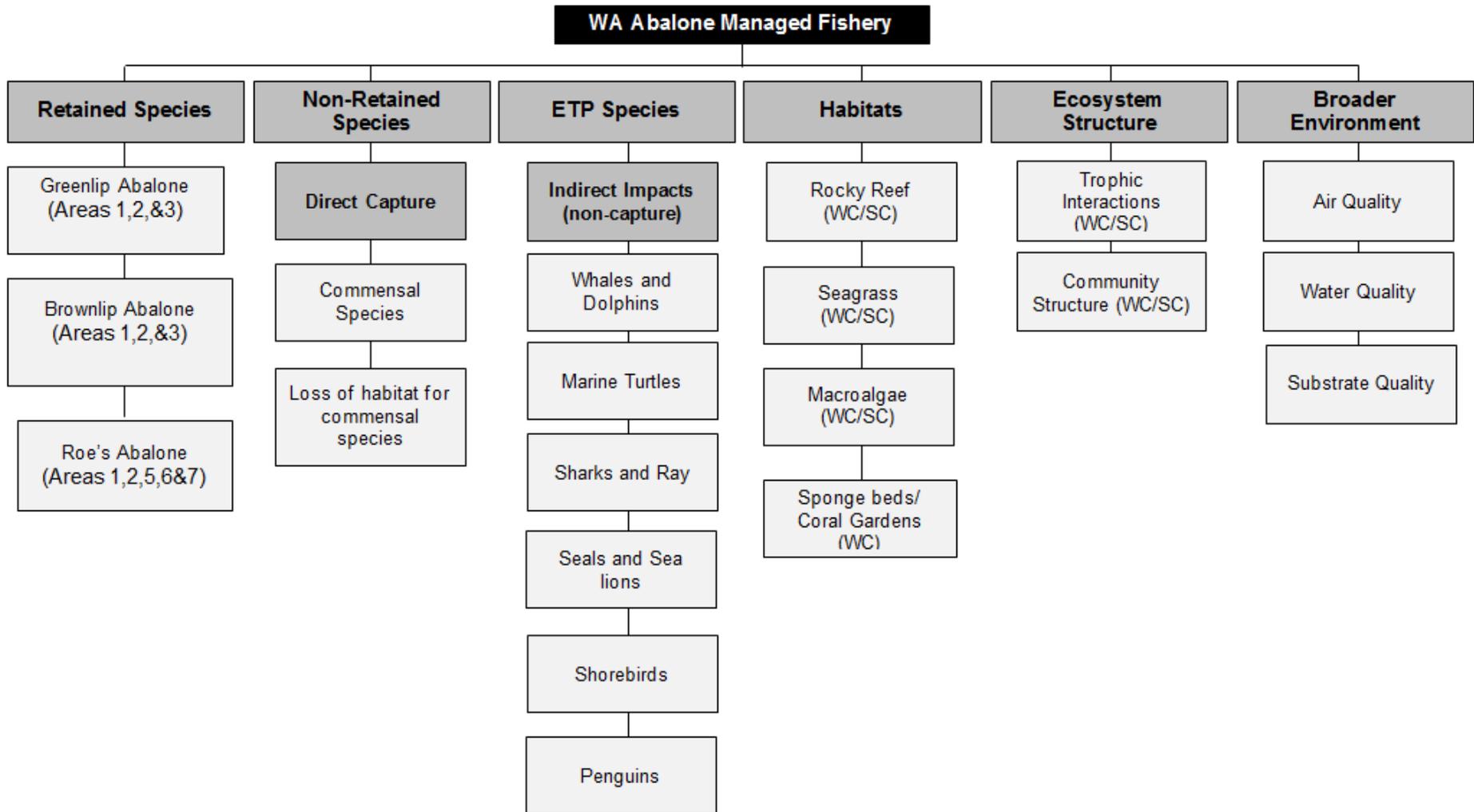


Figure 4.1 Component tree for the ecological sustainability aspects of the AMF

Table 4.1 Overview table of Identified Components, Objectives, Sub-Components, Issues, Risk Score and Assessed Risk ratings related to the Ecological Sustainability of the AMF

Component	Fishery Objective	Sub-component	Issues	Management Area	Risk Score	Risk Rating
Retained Species	To maintain spawning stock biomass of <i>H. laevigata</i> at a level where the main factor affecting recruitment is the environment	Greenlip Abalone	Commercial fishing	1	C1, L4 = 4	LOW
				2	C 2, L5 = 10	MEDIUM
				3	C 2, L5 = 10	MEDIUM
			Introduction of high risk virus	1, 2 & 3	C4, L2 = 8	MEDIUM
	To maintain spawning stock biomass of <i>H. conicopora</i> at a level where the main factor affecting recruitment is the environment	Brownlip Abalone	Commercial fishing	1	C1, L1 = 1	NEGLIGIBLE
				2	C2, L5 = 10	MEDIUM
				3	C2, L5 = 10	MEDIUM
			Introduction of high risk virus	1, 2 & 3	C4, L2 = 8	MEDIUM
	To maintain spawning stock biomass of <i>H. roei</i> at a level where the main factor affecting recruitment is the environment	Roe's Abalone	Commercial fishing	1	C2, L2 = 4	LOW
				2	C2, L5 = 10	MEDIUM
5				C2, L5 = 10	MEDIUM	
6				C2, L5 = 10	MEDIUM	
7				C2, L5 = 10	MEDIUM	
Introduction of high risk virus			1, 2, 5, 6 & 7	C4, L2 = 8	MEDIUM	

Component	Fishery Objective	Sub-component	Issues	Bioregion	Risk Score	Risk Rating
Non-retained Species	To ensure fishing impacts do not result in serious or irreversible harm to bycatch (non-retained) species populations	Commensal Species	Commensal ('Piggy back') species populations	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Loss of commensal ('Piggy back') species habitat	WC/SC	C1, L1 = 1	NEGLIGIBLE
ETP Species	To ensure fishing impacts do not result in serious or irreversible harm to ETP species' populations	Whales and Dolphin	Boat strike	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Marine Turtles	Boat strike	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Sharks and Rays	Boat strike	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Diver interaction	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Sea lion / Seals	Boat strike	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Shorebirds	Driving on beaches	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Penguins	Boat strike	WC	C1, L1 = 1	NEGLIGIBLE
Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function	Rocky Reef	Prising abalone from habitat	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Diver and diver equipment	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Anchoring	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Walking on intertidal areas	SC	C1, L1 = 1	NEGLIGIBLE
		Seagrass	Anchoring	WC/SC	C1, L1 = 1	NEGLIGIBLE

Component	Fishery Objective	Sub-component	Issues	Bioregion or Species	Risk Score	Risk Rating
Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function	Macroalgae	Diver and diver equipment	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Anchoring	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Sponge/Coral gardens	Anchoring	Roe's (WC - Garden Island)	C1, L1 = 1	NEGLIGIBLE
Ecosystem Structure	To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes	Trophic Interactions	Predator – prey interactions	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Discarding abalone gut	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Community Structure	Changes in community structure	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Introduction of diseases, pests, pathogens or non native species	WC/SC	C1, L1 = 1	NEGLIGIBLE
Broader Environment	To ensure the effects of fishing do not result in serious or irreversible harm to the broader environment	Air Quality	Exhaust	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Greenhouse gas emissions	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Water Quality	Debris/litter	WC/SC	C1, L1 = 1	NEGLIGIBLE
			Oil discharge	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Substrate Quality	Driving on beaches	WC/SC	C1, L1 = 1	NEGLIGIBLE

4.1.1 Retained Species

4.1.1.1 Greenlip Abalone

4.1.1.1.1 Commercial Fishing for Greenlip Abalone

Rationale for Inclusion: Greenlip abalone is one of three main target species in the AMF. It is primarily targeted by commercial fishers on the south coast of WA.

Risk Rating: Impact of commercial fishing on spawning stocks of greenlip abalone in:

Area 1 – C1, L4 = 4; LOW

Area 2 – C2, L5 = 10; MEDIUM

Area 3 – C2, L5 = 10; MEDIUM

Justification:

- Catch and effort are reported at a high level of accuracy by fishers in daily logbooks, which include catch by weight and numbers, effort in dive hours or minutes, statistical reporting block, and location of fishing.
- Catch has been controlled successfully by the TACC for 30 years and catch levels have been accurately recorded by a daily quota monitoring programme.
- Effort has been tightly controlled for over 40 years. Factors affecting fishing efficiency have been incorporated in the assessment.
- Fishery-independent surveys show no long-term decline in spawning biomass or harvest density of greenlip abalone.
- The stock assessment and establishment of the TAC takes into consideration the fact that abalone are sedentary with a tendency to form aggregations and can be easily targeted by fishers.
- Area 1 – fishing occurs across a large geographic area with only two hotspots. Weather conditions are often unfavourable for fishing. Fishing is typically low in with no commercial catches in Area 1 since 2010.
- Areas 2 and 3 fished more regularly than Area 1, with the TAC taken every year. The capacity to take the TAC annually indicates that the stock is currently fished sustainably. The TAC is set as a proxy as B_{MSY} .
- Industry have voluntarily reduced quota in Area 3 due to lower stock abundance mitigating potential impacts on stocks.
- Fishers currently operate by rotating different fishing grounds to ensure that localised depletion does not occur.

- The Harvest Strategy (DoF. in prep) and control rules currently ensure that there are clearly defined management outcomes should stock levels become depleted to unacceptable levels.

4.1.1.1.2 Impact of introduction of AVG (or other devastating/high impact diseases)

Rationale for inclusion: The movement of commercial fishers between states and within WA could result in the introduction of and spread of highly virulent viruses and diseases.

Risk Rating: Impact of introduction of AVG (or other devastating/high impact diseases) from commercial activities on populations of greenlip abalone in:

All Areas – C4, L2 = 8; MEDIUM

Justification:

- Abalone stocks in Tasmania and Victoria have been strongly affected by the AVG virus, resulting in severe reductions of the TAC in these states. The Victorian abalone stocks are showing strong signs of recovery from the AVG virus.
- To date there has been no occurrence of major disease outbreaks in WA abalone stocks. Biosecurity protocols are in place and these include disease testing and quarantine protocols for animals being moved.
- The Abalone Industry has established a Code of Practice to minimise the risk of spreading disease which includes recommendations for daily wash down procedures for boats and dive gear, minimising movement between locations whilst fishing within the same day and avoiding disease affected locations.
- The movement of vessels from disease infected areas interstate into WA is extremely rare.
- There is a highly level of paranoia and vigilance by abalone fishers in relation to introducing and/or spreading viruses and disease.

4.1.1.2 Brownlip Abalone

4.1.1.2.1.1 Commercial Fishing for Brownlip Abalone

Rationale for Inclusion: Brownlip abalone is one of three main target species in the AMF. It is primarily targeted by commercial fishers on the south coast of WA.

Risk Rating: Impact of commercial fishing on spawning stocks of brownlip abalone in:

Area 1 – C1, L1 = 1, NEGLIGIBLE

Area 2 – C2, L5 = 10, MEDIUM

Area 3 – C2, L5 = 10, MEDIUM

Justification:

- Catch and effort are reported at a high level of accuracy by fishers in daily logbooks, which include catch by weight and numbers, effort in dive hours or minutes, statistical reporting block, and location of fishing.
- Catch has been controlled successfully by the TACC for 30 years and catch levels have been accurately recorded by a daily quota monitoring programme.
- Effort has been tightly controlled for over 40 years. Factors affecting fishing efficiency have been incorporated in the assessment.
- Brownlip abalone is extremely cryptic and difficult to which reduces fishing pressure on these species.
- Area 1 – fishing occurs across a large geographic area. Weather conditions are in are often unfavourable for fishing. Area 1 is typically never fished for brownlip abalone, last reported commercial catches of 1kg was in 2000.
- Areas 2 and 3 fished more regularly than Area 1, with the TAC taken every year. The capacity to take the TAC annually indicates that the stock is currently fished sustainably. The TAC is set as a proxy as B_{MSY} .
- Fishers currently operate by rotating different fishing grounds to ensure that localised depletion does not occur.
- The Harvest Strategy (DoF 2017) and control rules currently ensure that there are clearly defined management outcomes should stock levels become depleted to unacceptable levels.

4.1.1.2.1.2 Impact of introduction of AVG (or other devastating/high impact diseases)

Rationale for inclusion: The movement of commercial fishers between states and within WA could result in the introduction of and spread of highly virulent viruses and diseases.

Risk Rating: Impact of introduction of AVG (or other devastating/high impact diseases) from commercial activities on populations of brownlip abalone:

All Areas – C4, L2 = 8; MEDIUM

Justification:

- Abalone stocks in Tasmania and Victoria have been strongly affected by the AVG virus, resulting in severe reductions of the TAC in these states. The Victorian abalone stocks are showing strong signs of recovery from the AVG virus.
- To date there has been no occurrence of major disease outbreaks in WA abalone stocks. Biosecurity protocols are in place and these include disease testing and quarantine protocols for animals being moved.

- The Abalone Industry has established a Code of Practice to minimise the risk of spreading disease which includes recommendations for daily wash down procedures for boats and dive gear, minimising fishing and movement between Areas within the same day and avoiding disease affected Areas.
- The movement of vessels from disease infected areas interstate into WA is rare.
- There is a highly level of paranoia and vigilance by abalone fishers in relation to introducing and/or spreading viruses and disease.

4.1.1.3 Roe's Abalone

4.1.1.3.1.1 Commercial Fishing for Roe's Abalone

Rationale for Inclusion: Roe's abalone is one of three main target species in the AMF. It is primarily targeted by commercial fishers on the south-west coast of WA, particularly in the Perth Metropolitan area and around Cape Naturaliste in the south.

Risk Rating: Impact of commercial fishing on spawning stocks of Roe's abalone in:

Area 1 – C2, L2 = 4; LOW

Area 2 – C2, L5 = 10; MEDIUM

Area 5 – C2, L5 = 10; MEDIUM

Area 6 – C2, L5 = 10; MEDIUM

Area 7 – C2, L5 = 10; MEDIUM

Justification:

- Catch and effort are reported at a high level of accuracy by fishers in daily logbooks, which include catch by weight and numbers, effort in dive hours or minutes, statistical reporting block, and location of fishing.
- Catch has been controlled successfully by the TACC for 30 years and catch levels have been accurately recorded by a daily quota monitoring programme.
- Effort has been tightly controlled for over 40 years. Factors affecting fishing efficiency have been incorporated in the assessment.
- Area 1 is not geographically remote and not fished often. Weather conditions are often unfavourable for fishing. Quota for Area 1 has never been caught for Roe's abalone since the inception of fishing.
- Areas 2 and 7 fished more regularly with the TAC typically taken every year. The capacity to take the TAC annually indicates that the stock is currently fished sustainably. The TAC is set as a proxy as B_{MSY} .

- Area 6 quota has not been caught in recent years due to access difficulties and poor market performance. Marine park zoning will reducing fishing in this area in next few years. mar
- Area 8 is currently closed due to stock depletion associated with the marine heat wave. There will be no quota allocated to this fishery for the next five years.
- Fishers currently operate by rotating different fishing grounds to ensure that localised depletion does not occur.
- The stock assessment and establishment of the TAC takes into consideration the fact that abalone are sedentary with a tendency to form aggregations which can be easily targeted by fishers.
- The Harvest Strategy (DoF 2017) and control rules currently ensure that there are clearly defined management outcomes should stock levels become depleted to unacceptable levels.

4.1.1.3.1.2 Impact of introduction of AVG (or other devastating/high impact diseases)

Rationale for inclusion: The movement of commercial fishers between states and within WA could result in the introduction of and spread of highly virulent viruses and diseases.

Risk Rating: Impact of introduction of AVG (or other devastating/high impact diseases) from commercial activities on populations of Roe's abalone:

All Areas – C4, L2 = 8; MEDIUM

Justification:

- Abalone stocks in Tasmania and Victoria have been strongly affected by the AVG virus, resulting in severe reductions of the TAC in these states. The Victorian abalone stocks are showing strong signs of recovery from the AVG virus.
- To date there has been no occurrence of major disease outbreaks in WA abalone stocks. Biosecurity protocols are in place and these include disease testing and quarantine protocols for animals being moved.
- The Abalone Industry has established a Code of Practice to minimise the risk of spreading disease which includes recommendations for daily wash down procedures for boats and dive gear, minimising fishing and movement between Areas within the same day and avoiding disease affected Areas.
- There is a highly level of paranoia and vigilance by abalone fishers in relation to introducing and/or spreading viruses and disease.
- The movement of vessels from disease infected areas interstate into WA is extremely rare and unlikely to introduce and/or spread viruses and disease.

4.1.2 Non-Retained Species

4.1.2.1 Commensal ('Piggyback') Species

4.1.2.1.1.1 Removal of commensal (piggyback species)

Rationale for Inclusion: The Roe's, greenlip and brownlip abalone are all encrusted with commensal organisms that use the shell of as substrate. Within WA, primary abalone fouling organisms include coralline algae, sponges and small invertebrates. These organisms are harvested together with the abalone.

Risk Rating: Impact of collecting abalone on commensal (piggyback) species populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Commensal species live on a wide variety of organisms and none are known to live exclusively on greenlip, brownlip or Roe's abalone.

4.1.2.1.2 Removal of commensal (piggyback species) habitat

Rationale for Inclusion: The Roe's, greenlip and brownlip abalone are all encrusted with commensal organisms that use the shell of as substrate. Within WA, primary abalone fouling organisms include coralline algae, sponges and small invertebrates. These organisms are harvested together with the abalone.

Risk Rating: Impact of removing abalone on commensal (piggyback) species as a source of habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The limited harvest of abalone ensures an adequate level of shells remain within the fishing grounds to provide substrate for any organisms that may show a preference for shells as habitat.
- Commensal species live on a wide variety of organisms and none are known to live exclusively on greenlip, brownlip or Roe's abalone.

4.1.3 Endangered, Threatened and Protected (ETP) Species

4.1.3.1 Whales and Dolphins

Rationale for Inclusion: There are 46 species of cetations listed in WA, 43 of which may be present in South and West Coast Bioregions. Whilst most of the species are not common in shallow water, the overlap of whale and dolphin distributions with the AMF means that they could potentially interact with the fishery.

4.1.3.1.1 Boat Strike

Risk Rating: Impact of fishery boat strikes on whale and dolphin populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Most whale species are typically associated with deep water (e.g. baleen whales) or are very rarely encountered (e.g. *Mesoplodon* beaked whales).
- Of the dolphin species, only one the Bottlenose dolphin (*Turisops truncatus*) is commonly encountered in southern inshore waters.
- The AMF is a hand collection fishery which utilises small vessels typically less than 9 m in length. Currently there are 52 managed fishery licences in the AMF. The low number of small, highly manoeuvrable vessels operating in the fishery reduces the likelihood of any interactions with protected species.
- Aggregations of whales are avoided by abalone divers due to the increased presence of white sharks associated with the whales.
- There have been no recorded interactions between these species and the AMF since the statutory reporting requirements for interactions with ETP species was introduced.

4.1.3.2 Marine Turtles

4.1.3.2.1 Boat Strike

Rationale for Inclusion: Six species of marine turtles are known from WA waters; Loggerhead (*Caretta caretta*), Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Olive Ridley (*Lepidochelys olivacea*), Flat back (*Natator depressus*) and Leatherback turtles (*Dermochelys coriacea*). All species are typically found in tropical waters but may appear as vagrants in the cooler west coast, or even south coast in the case of Leatherbacks. The overlap of turtle distributions with the AMF means that they could potentially interact with the fishery.

Risk Rating: Impact of boat strikes on marine turtle populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Nesting is restricted to tropical and subtropical regions with Loggerheads having the most southern rookeries of any species at Shark Bay
- The AMF is a hand collection fishery which utilises small vessels typically less than 9 m in length. Currently there are 52 managed fishery licences in the AMF. The low number of small, highly manoeuvrable vessels operating in the fishery reduces the likelihood of any interactions with protected species.

- There have been no recorded interactions between these species and the AMF since statutory reporting requirements for interactions with ETP species was introduced.

4.1.3.3 Sharks and Rays

Rationale for Inclusion: There are 38 species of shark are protected in WA with 25 of those being reported in West and South Coast bioregions. A few WA fisheries operate under exemption, allowing them to take certain species of sharks

All rays are considered commercially protected species in Western Australia although some fisheries work under a specific exemption from this protection.

4.1.3.3.1 Boat Strike

Risk Rating: Impact of boat strikes on shark and ray populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMF is a hand collection fishery which utilises small vessels typically less than 9 m in length. Currently there are 52 managed fishery licences in the AMF. The low number of small, highly manoeuvrable vessels operating in the fishery reduces the likelihood of any interactions with protected species.
- There have been no recorded interactions between these species and the AMF vessels since statutory reporting requirements for interactions with ETP species was introduced.

4.1.3.3.2 Diver Interaction

Risk Rating: Impact of interactions with divers and equipment on shark and ray populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMF has reported four interactions with sharks between 2008 and 2015. One was reported as a blacktip shark, while the others were reported as White Sharks. In the cases of the White Shark interactions, animals are reported as “alive” at the conclusion of the interaction, while the blacktip is noted as “unknown”.
- Divers in the AMF utilise shark cages and shark shields to minimise the risk of attack

4.1.3.4 Seals and Sealions

Rationale for Inclusion: Two species of pinnipeds are resident in the south and west coast bioregions. The Australian Sea lion (*Neophoca cinerea*) and the New Zealand Fur Seal (*Arctocephalus forsteri*). While other pinnipeds are occasionally encountered, they are

vagrants from circumpolar regions (e.g. elephant seals) rather than residents. The overlap of seals and sea lions with the AMF means that they could potentially interact with the fishery.

4.1.3.4.1.1 Boat Strike

Risk Rating: Impact of boat strikes on seal and sealion populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMF is a hand collection fishery which utilises small vessels typically less than 9 m in length. Currently there are 52 managed fishery licences in the AMF. The low number of small, highly manoeuvrable vessels operating in the fishery reduces the likelihood of any interactions with protected species.
- There have been no recorded Interactions between these species and the AMF since the statutory reporting requirements for interactions with ETP species was introduced.

4.1.3.5 Shorebirds

4.1.3.5.1.1 Driving on Beaches

Rationale for inclusion: There are at least 180 protected species of seabirds and shorebirds in WA, approximately 140 of which occur in southern and western bioregions. Several shorebirds inhabit and nest on south-WA beaches, including the Hooded plovers (*Thinornis rubricollis*), Red-capped plovers (*Charadrius ruficapillus*), Pied oyster catchers (*Haematopus longirostris*) and Sooty Oyster catchers (*H. fuliginosus*). Fishers which drive on beaches to remote fishery areas may disturb shorebirds and shorebird nests.

Risk Rating: Impact of driving beaches and disturbing shorebirds and shorebird nests on bird populations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Fishers typically drive on existing roads, tracks and farmers firebreaks to access fishing areas.
- Beach areas accessed by fishers in the AMF are typically well used beaches which are also accessed by the public.
- The number of abalone fishers which drive on beaches to access remote fishing areas is low.

4.1.3.6 Penguins

Rationale for Inclusion: Only one penguin species, the Little Penguin (*Eudyptula minor*), is consistently present in WA waters. Its Australian distribution is south of Fremantle on the

west coast and it extends across the south coast to New South Wales. The overlap of penguins with the AMF means that they could potentially interact with the fishery.

Risk Rating: Impact of boat strikes on penguin populations in:

WC – C1, L1 = 1; NEGLIGIBLE

- Colonies in WA are patchily distributed as they tend to be associated with suitable offshore islands.
- There have been no recorded interactions with penguins from any WA fisheries, including the abalone fishery.

4.1.4 Habitats

4.1.4.1 Rocky Reef

4.1.4.1.1 Prising Abalone From Reef

Rationale for Inclusion: Abalone are prised from rock surfaces with a metal bar known as an ‘abalone iron’. During removal the abalone iron comes into contact with the rocky reef habitat.

Habitat

Risk Rating: Impact of prising abalone from reef on rocky reef habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The removal of abalone is done in a swift levering motion, mainly to break the suction of the foot from the rock with no visible impact on the substrate below

4.1.4.1.1.2 Anchoring

Rationale for Inclusion: Abalone divers can operate from vessels on anchor or alternatively drift dive to collect their catch. Anchors may physically alter or damage the benthic habitats where they are set.

Risk Rating: Impact of anchoring on rocky reef habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Fishing for greenlip and brownlip abalone on the south coast is typically by drift diving which does not involve anchoring.

- Anchoring does occur when fishing for Roe's with fishers using two anchors, one stern sand anchor and a front wire anchor. Anchors are typically set by divers to ensure that the boat is secure and impact to habitat is minimised.
- There are a low number boats in the AMF and large area over which the fishery operates. Fishers tend to visit each area infrequently throughout the season.

4.1.4.1.1.3 Diver and Diver Equipment

Rationale for Inclusion: Abalone divers carry several pieces of equipment with them for safety and abalone collection purposes, including an underwater breathing apparatus, a large mesh bag to store the catch and an underwater scooter or other motorised device such as a shark cage. Both the divers and their equipment may come into contact with benthic habitats while collecting abalone.

Risk Rating: Impact of divers and diving equipment on rocky reef habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Abalone fishers place their catch in a bag which rests on the bottom. As the bag becomes heavy the fishers inflate the attached lift bag so that it is easy to manoeuvre and divers do not have to drag the bag across the bottom.
- Divers can use shark cages and underwater scooters which are typically only slightly negatively buoyant and do not sit heavily on the bottom. Shark cages are not used in when fishing for Roe's abalone.

4.1.4.1.1.4 Walking on Intertidal Areas

Rationale for Inclusion: In some locations commercial divers may walk on intertidal reef to access fishing areas. The divers may crush reef habitat underfoot.

Risk Rating: Impact of walking on intertidal reef areas on rocky reef habitat in:

SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- On rare occasions divers walk on intertidal reef in the south coast to access fishing areas
- The habitats in intertidal zones are typically high energy zones and contain species capable of withstanding physical impacts. These areas are frequently exposed to natural disturbances such as storms.

4.1.4.2 Seagrass

4.1.4.2.1.1 Anchoring

Rationale for Inclusion: Abalone divers can operate from vessels on anchor or alternatively drift dive to collect their catch. Anchors may physically alter or damage the benthic habitats where they are set.

Risk Rating: Impact of anchoring on seagrass habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Fishing for greenlip and brownlip abalone on the south coast is typically by drift diving which does not involve anchoring.
- Abalone vessels typically operate in abalone habitat, which are rocky reef areas covered in macroalgae. Anchoring may however occur in adjacent seagrass beds or sponge gardens.
- Anchoring does occur when fishing for Roe's on the west coast with fishers using two anchors, one stern sand anchor and a front wire anchor. Anchors are typically set by divers to ensure that the boat is secure and impact to habitat is minimised.
- There are a low number boats in the AMF and large area over which the fishery operates. Fishers tend to visit each area infrequently throughout the season.

4.1.4.3 Macroalgae

4.1.4.3.1.1 Anchoring

Rationale for Inclusion: Abalone divers can operate from vessels on anchor or alternatively drift dive to collect their catch. Anchors may physically alter or damage the benthic habitats where they are set.

Risk Rating: Impact of anchoring on macroalgae habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Fishing for greenlip and brownlip abalone on the south coast typically by drift diving which does not involve anchoring.
- Abalone vessels typically operate in abalone habitat, which are rocky reef areas covered in macroalgae.
- Anchoring does occur when fishing for Roe's with fishers using two anchors, one stern sand anchor and a front wire anchor. Anchors are typically set by divers to ensure that the boat is secure and impact to habitat is minimised.

- There are a low number boats in the AMF and large area over which the fishery operates. Fishers tend to visit each area infrequently throughout the season.

4.1.4.3.1.2 Diver and Diver Equipment

Rationale for Inclusion: Abalone divers carry several pieces of equipment with them for safety and abalone collection purposes, including an underwater breathing apparatus, a large mesh bag to store their catch and an underwater scooter or other motorised device such as a shark cage. Both the divers and their equipment may come into contact with benthic habitats while collecting abalone.

Risk Rating: Impact of divers and diving equipment on macroalgae habitat in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Abalone fishers place their catch in a bag which rests on the bottom. As the bag becomes heavy the fishers inflate the attached lift bag so that it is easy to manoeuvre and divers do not have to drag the bag across the bottom.
- Divers can use shark cages and underwater scooters which are typically only slightly negatively buoyant and do not sit heavily on the bottom.

4.1.4.4 Sponge beds/Coral gardens

4.1.4.4.1.1 Anchoring

Rationale for Inclusion: Sponge beds and coral gardens occur around Garden Island, where some fishing for Roe's abalone occurs. Anchors may physically alter or damage the benthic habitats where they are set.

Risk Rating: Impact of anchoring on sponge bed habitat in:

Roe's (WC – Garden Island) – C1, L1 = 1; NEGLIGIBLE

Justification:

- Anchoring does occur when fishing for Roe's with fishers using two anchors, one stern sand anchor and a front wire anchor. Anchors are typically set by divers to ensure that the boat is secure and impact to habitat is minimised.
- There are a low number boats in the AMF and large area over which the fishery operates. Fishers tend to visit each area infrequently throughout the season.

4.1.5 Ecosystem Structure

4.1.5.1 Trophic Interactions

4.1.5.1.1.1 Trophic Interactions

Rationale for Inclusion: The removal of a species from the environment may alter the key elements of the local ecosystem including predator – prey interactions.

Risk Rating: Impact of removing abalone on trophic interactions in the ecosystem:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- In the wild, abalone are not distributed uniformly but rather form aggregations in suitable habitat. A survey of suitable habitats on the south coast identified around 2% suitable for greenlip and brownlip species (Hart et al. 2015).
- Abalone typically rely on drift algae for food rather than actively grazing on attached macroalgae (Shepherd and Steinberg 1992). Ecosystem studies on Blacklip abalone in Victoria demonstrated that this species had a very limited role in restricting the growth of macroalgae (Hamer et al. 2010).
- There are no species known to be dependent on Roe's, greenlip and brownlip abalone as a primary food source. Studies in Victoria in relation to black lip abalone as a source of prey found that common carnivorous fish species and sharks had a varied diet and none were dependent on abalone as a source of food (Hamer et al. 2010).
- The collection of abalone is restricted by an annual TAC and size limits, resulting in around 70% of the population remaining as a functional component of the ecosystem.
- Abalone divers are limited to shallower areas and calmer-weather seasons for safety reasons, providing areas and times of refuge from fishing activities for abalone populations.

4.1.5.1.1.2 Discarding Abalone Gut

Rationale for Inclusion: In the greenlip/brownlip fishery the gut is usually discarded at sea after the abalone is shucked. Fishers for Roe's abalone are currently not permitted to shuck abalone at sea but have recently applied to the Department to allow this activity. The discarding of the biological material to the environment provides a food source to other animals that would not normally have this food source and may affect the trophic structure of the community.

Risk Rating: Impact on trophic interactions from discarding of abalone guts (provisioning) in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Approximately one third (32.5%) of abalone by whole weight is the gut of greenlip/brownlip abalone. Given this an estimated 65 tonnes of abalone gut is discarded in WA each year. This 65 t of gut are spread across wide geographical area, approximately 1400km over approximately 1000+ fishing days.
- Fishing grounds are rotated and fishers tend not to visit the same area frequently each year.
- Greenlip and brownlip abalone are shucked at sea, with one person shucking whilst the other is drift diving resulting in the gut being dispersed over a large area.
- Seabirds have demonstrated an aversion to abalone guts
- Roe's abalone are shucked on land

4.1.5.2 Community Structure

4.1.5.2.1.1 Changes in Community Structure

Rationale for Inclusion: Removal studies where all abalone are removed for extended periods (both size and undersize) show the shifts can occur in the benthic community towards more structurally complex algal and invertebrate communities (Hamer et al. 2010).

Abalone have been attributed to controlling urchin populations in in other parts of the world through space exclusion (Lowry and Pearse 1970, North and Pearse 1970).

Risk Rating: Impact of abalone removal on community structure in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- In the wild, abalone are not distributed uniformly but rather form aggregations in suitable habitat. A survey of suitable habitats on the south coast identified around 2% suitable for greenlip and brownlip species (Hart et al. 2015b).
- A study by Hamer et al. 2010 concluded that before any major shifts in epi-benthic community structure due to abalone fishing to become noticeable at the reef scale, commercial abalone divers are likely to have already experienced low economic return and moved on to more profitable locations.
- In California overfishing of abalone in the 1940's and 1950's causing the commercial fishery to collapse resulted in an explosion of sea urchin populations a short time afterwards (Lowry and Pearse 1970, North and Pearse 1970)
- The fishery is well managed and a large proportion of the stock which is undersize is unfished. This ensures that ecosystem processes, including competition with other species remain functional.

- The collection of abalone is restricted by an annual TAC and size limits, resulting in a proportion of the population remaining as a functional component of the ecosystem.
- Abalone divers are limited to shallower areas and calmer-weather seasons for safety reasons, providing areas and times of refuge from fishing activities for abalone populations.
- In locations where there have been mass die offs of abalone whether due to heat waves (i.e. Kalbarri) or the AVG virus (i.e. Victoria) there has been no measureable changes to the community structure.

4.1.5.2.1.2 Introduction of Diseases, Pests, Pathogens or Non-Native Species

Rationale for Inclusion: Marine pests and diseases can form a significant threat to WA ecosystem structure. Abalone vessels and divers move between different areas for fishing which have the potential to translocate marine pests and/or disease.

Risk Rating: Impact of introducing diseases, pests, pathogens or non-native species from AMF vessels/equipment on the ecosystem in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Vessels fishing for abalone often are not stationary but instead drift or tow divers. Vessels are removed from the water and kept on land overnight, which is likely to kill an organisms attached to the hull.
- Very little interstate movement of boats and if boats do move from interstate boats are trailered with the bungs removed to ensure the boat drains dry. Generally there is at least 48 hours between boats moving between states which further reduces the opportunity to transfer pests and diseases.
- To date there have been no major disease or virus outbreaks in WA abalone stocks.
- Abalone fishers are highly vigilant and concerned about the introduction of pests and diseases to the marine environment. The Abalone Industry has established a Code of Practice to minimise the risk of spreading disease which includes recommendations for daily wash down procedures for boats and dive gear, minimising fishing and movement between areas within the same day and avoiding disease affected areas. There is a list of recommended products for sterilizing boats.
- The Department maintains an active surveillance program in the Fremantle Port for marine pests and diseases. There is also a passive surveillance program throughout WA, actively investigating any reports of abnormal mortalities, which are backed up by emergency response capability in the areas of both aquatic pests and diseases.
- A Departmental incident response manual has been developed, which details protocol associated with emergency biosecurity response. The Department is equipped with state-of-the-art diagnostic laboratories and capability. It participates in nationally-

coordinated proficiency testing programs and is accredited to ISO17025 for both pest identification and pathogen identification.

4.1.6 Broader Environment

4.1.6.1 Air quality

Rationale for Inclusion: Boats and cars which operate in the AMF utilise fuel and emit exhaust fumes

4.1.6.1.1 Exhaust Fumes

Risk Rating: Impact of fuel use and/or exhaust from fishing vessels on regional air quality in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- There are currently only 52 licences in the fishery, these vessels tend to be < 9 m in length.
- Low number boats, small size of vessels result in the generation of minimal exhaust.

4.1.6.1.1.2 Greenhouse Gas Emissions

Risk Rating: Impact of greenhouse gas emissions from fishing activities on regional air quality in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- There are currently only 52 licences in the fishery, these vessels tend to be < 9 m in length. The contribution to greenhouse gas emissions is minimal.

4.1.6.2 Water quality

Rationale for Inclusion: The AMF may reduce water quality through oil discharge and/or discard of litter.

4.1.6.2.1.1 Debris / Litter

Risk Rating: Impact of litter from fishing activities on regional water quality in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMF is hand collected fishery, which utilises small boats and minimal equipment.

- The fishery does not generate litter e.g. bait boxes and fishers are careful to store any personal litter.

4.1.6.2.1.2 Oil Discharge

Risk Rating: Impact of oil discharge from fishing vessels on regional water quality in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- There are currently only 52 licences in the fishery, these vessels tend to be < 9 m in length.
- Most boats have inboard engines which are four stroke and oil discharge is minimal

4.1.6.3 Substrate quality

Rationale for Inclusion: In some areas in the AMF fishers drive on the beach to access fishing areas.

4.1.6.3.1.1 Driving On Beaches

Risk Rating: Impact of driving on beaches to access fishing locations in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Fishers typically drive on existing roads, tracks and farmers firebreaks to access fishing areas.
- Beach areas accessed by fishers in the AMF are typically well used beaches which are also accessed by the public.
- The number of boats and cars which drive on the beaches to access remote fishing areas is low.
- The area of beach which the fishers drive on is restricted.

4.2 External factors

Sixteen external factor sub-components and 33 associated issues were identified as potentially impacting the AMF industry performance (Figure 4.2, Table 4.2). Most of the issues were scored as medium (15) or low risk (6). There were nine scored a medium risk, two as high and one as severe.

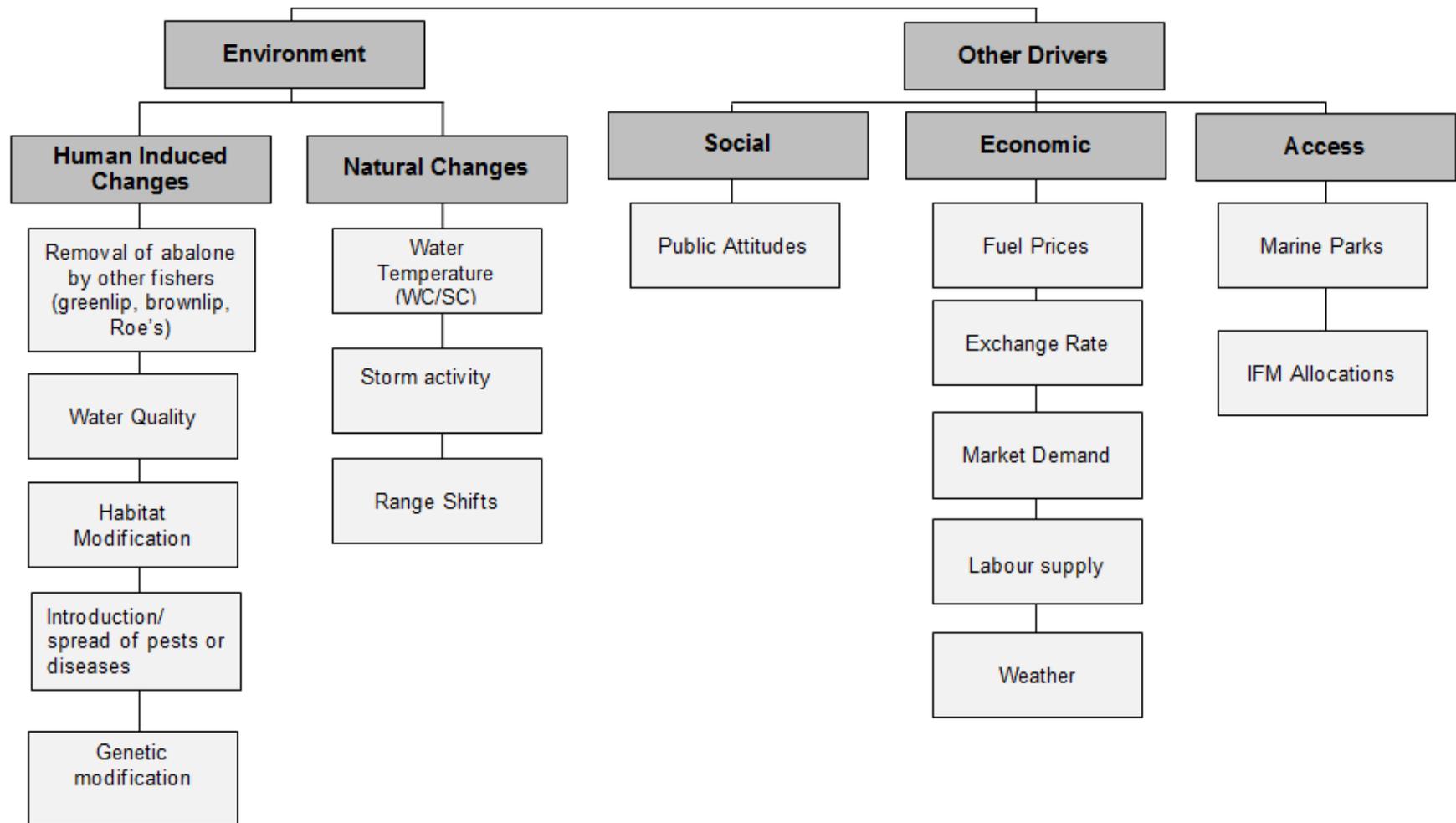


Figure 4.2 Component tree for external drivers that may impact on the AMF industry performance

Table 4.2 Overview table of Identified Components, Objectives, Sub-Components, Issues, Risk Score and Assessed Risk ratings related to the External Factors that may impact on the activities of the AMF

Component	Issue	Sub-component	Management Area/Species /Bioregion	Risk Score	Risk Rating	
Environment: Human-Induced Changes	Removal of abalone by others outside of the AMF	Recreational fishing	Greenlip	C1, L1 = 1	NEGLIGIBLE	
			Brownlip	C1, L1 = 1	NEGLIGIBLE	
			Roe's (Area 7)	C2, L5 = 10	MEDIUM	
			Roe's (other areas)	C1, L1 = 1	NEGLIGIBLE	
		Illegal Fishing	Greenlip	C1, L5 = 5	LOW	
			Brownlip	C1, L1 = 1	NEGLIGIBLE	
			Roe's	C1, L5 = 5	LOW	
		Brood stock collection	Greenlip	C1, L1 = 1	NEGLIGIBLE	
		Water Quality	Water quality	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Habitat modification	Port development and modification	WC (Area 7)	C4, L5 = 20	SEVERE
	Other areas			C1, L1 = 1	NEGLIGIBLE	
	Abalone aquaculture		WC/SC	C1, L1 = 1	NEGLIGIBLE	
	Abalone ranching		SC	C1, L1 = 1	NEGLIGIBLE	
	Recreational fishers walking on reef platforms		WC/SC	C1, L1 = 1	NEGLIGIBLE	
Introduction / spread of diseases and pests	Commercial shipping and recreational boating and fishing activities introducing and/or spreading highly virulent pests and diseases	WC/SC	C4, L1 = 4	LOW		
		WC/SC	C3, L2 = 6	LOW		
	Abalone aquaculture activities introducing and/or spreading pests or diseases	WC/SC	C3, L3 = 9	MEDIUM		

Aspect	Component	Issues	Management Area/Species /Bioregion	Risk Score	Risk Rating
Environment: Human-Induced Changes	Introduction / spread of diseases and pests	Abalone ranching activities introducing and/or spreading pests or diseases	SC	C3, L3 = 9	MEDIUM
	Genetic modification	Abalone aquaculture	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Abalone ranching	WC	C1, L1 = 1	NEGLIGIBLE
Environment: Natural/Climate	Water temperature (WC/SC)	Increases in water temperature	WC	C4, L3 = 12	HIGH
			SC	C4, L2 = 8	MEDIUM
	Storm activity	Storm activity	WC/SC	C1, L1 = 1	NEGLIGIBLE
	Range shifts	Species range shifts	WC/SC	C1, L1 = 1	NEGLIGIBLE
Social Drivers	Public Attitudes	Public attitude	All species	C2, L3 = 6	LOW
Economic Drivers	Fuel Prices	Fuel prices	All species	C2, L5 = 10	MEDIUM
	Exchange Rates	Exchange rates	All species	C3, L4 = 12	HIGH
	Market Demand	Global demand and competition from aquaculture	All species	C2, L5 = 10	MEDIUM
	Labour	Skilled divers	All species	C2, L5 = 10	MEDIUM
	Weather	Weather		SC	C2, L3 = 6
WC				C2, L5 = 10	MEDIUM
Access	Marine Protected Areas	Marine Protected Areas	WC	C2, L3 = 6	MEDIUM
	Integrated Fishery Management (IFM) Allocations	Catch allocations between commercial, recreational and indigenous sectors	All species	C1, L1 = 1	NEGLIGIBLE

4.2.1 Environment

4.2.1.1 Human-Induced Changes

4.2.1.1.1 Removal of Abalone by others outside of the AMF

4.2.1.1.1.1 Recreational Fishing

4.2.1.1.1.2 Recreational fishing for greenlip abalone

Rationale for Inclusion: The recreational collection of greenlip abalone may significantly affect the breeding stocks of this species.

Risk Rating: Impact of recreational fishing on greenlip abalone stocks:

All Areas - C1, L1 = 1; NEGLIGIBLE

- The recreational catch comprises 3-4% of the total catch of greenlip/brownlip abalone, which is estimated to be around 7 t per annum (Hart et al. 2015).
- Recreational fishers much purchase an Abalone Recreational Fishing Licence. The number of recreational licenses issued in for the 2014/15 season was 16,429.
- Daily bag limits apply of five per fisher, and a household possession limit of 20.
- The number of people fishing for greenlip abalone is low.
- The Department has published an estimate of recreational catch by boat based users (note it does not include shore based fishing). The 2013/2014 estimates for all abalone species combined was 3500 individuals on the west coast and 500 individuals on the south coast (Ryan et al. 2015).

4.2.1.1.1.3 Recreational fishing for brownlip abalone

Rationale for Inclusion: The recreational collection of brownlip abalone may significantly affect the breeding stocks of this species.

Risk Rating: Impact of recreational fishing on brownlip abalone stocks:

All Areas - C1, L1 = 1; NEGLIGIBLE

- The recreational catch comprises 3-4% of the total catch of greenlip/brownlip abalone, which is estimated to be around 7 t per annum (Hart et al. 2015).
- Recreational fishers much purchase an Abalone Recreational Fishing Licence. The number of recreational licenses issued 2014/15 season was 16,429.
- Daily bag limits apply of five per fisher, and a household possession limit of 20.
- The number of people fishing for brownlip abalone is low, and these species are difficult to find.

- The Department has published an estimate of recreational catch by boat based users (note it does not include shore based fishing). The 2013/2014 estimates for all abalone species combined was 3500 individuals on the west coast and 500 individuals on the south coast (Ryan et al. 2015).

4.2.1.1.1.4 Recreational fishing for Roe's abalone

Rationale for Inclusion: The recreational collection of Roe's abalone may significantly affect the breeding stocks of this species

Risk Rating: Impact of recreational fishing on Roe's abalone stocks in:

Area 7 – C2, L5 = 10; MEDIUM

Other Areas – C1, L1 = 1; NEGLIGIBLE

Justification:

- The recreational catch comprises 40% of the total catch of Roe's abalone, in 2014/2015 the total landing by the recreational sector was 34 tonnes (Hart et al. 2015b).
- A TAC of 40 t has been established for Area 7 (metropolitan area) of the recreational fishing sector, which can be adjusted depending on the status of the abalone stocks.
- Recreational fishers much purchase an Abalone Recreational Fishing Licence. The number of recreational licenses issued in issued 2014/15 season was 16,429.
- The Department has published an estimate of recreational catch by boat based users (note it does not include shore based fishing). The 2013/2014 estimates for all abalone species combined was 3500 individuals on the west coast and 500 individuals on the south coast (Ryan et al. 2015).
- In Area 7 the recreational fishing season is currently only open for five hours per season, between 07:00 and 08:00 on the first Sunday of the month between November and March.
- Fishing is not permitted in no take zones in the Marmion Marine Park, Cottesloe Fish Habitat Protection Area
- During the season the Department undertakes dedicated surveys of recreational abalone catches and independent assessments of stocks at dedicated monitoring sites which include both reef platforms and deeper reef areas.
- The Department has the capacity to reduce the fishing season if recreational fishing is thought to be having an unacceptable impact on stocks

4.2.1.1.1.1.5 Illegal Fishing

4.2.1.1.1.1.6 Illegal fishing for greenlip abalone

Rationale for Inclusion: Illegal fishing for greenlip abalone may affect the breeding stocks of this species

Risk Rating: Impact of illegal fishing on greenlip abalone stocks:

All Areas: C1, L5 = 5; LOW

- Intelligence operations have revealed that greenlip abalone is the most desirable black market abalone and is easily sold and on sold (Hart et al. 2013a).
- Illegal fishers do not adhere to size limits, taking any size abalone and stripping areas of reef clean. These intense localised impacts can affect local populations for several years.
- Illegal fishing tends to be sporadic, and is affected by the Australian market. If the dollar is low more illegal fishing occurs.
- The quantity of illegal catch is not known or measureable, but Departmental staff identified that if catches were thought to be large the commercial TAC would be adjusted accordingly and compliance operations intensified.
- The Department undertakes covert surveillance to detect and apprehend illegal operators.
- Luggage checks by airport security staff assist in restricting illegal movement of abalone catch
- The number of investigations and convictions is a reflection of the magnitude of illegal catch, illegal fishing has not been a major concern in recent years
- There is a compliance program in place to target illegal fishing on the south coast.
- The compliance risk assessment identified illegal fishing of greenlip to be relatively high risk due to remoteness of fishing areas and night time activities. The risk assessment also identified that there are insufficient staff and numbers of inspections for the greenlip fishery.

4.2.1.1.1.1.7 Illegal fishing for brownlip abalone

Rationale for Inclusion: Illegal fishing for greenlip abalone may affect the breeding stocks of this species

Risk Rating: Impact of illegal fishing on brownlip abalone stocks in:

All Areas - C1, L1 = 1; NEGLIGIBLE

- Brownlip abalone are difficult to find and numbers are in low densities.
- Illegal fishing for brownlip abalone is likely to be very low.

4.2.1.1.1.8 Illegal fishing for Roe's abalone

Rationale for Inclusion: Illegal fishing for Roe's abalone may affect the breeding stocks of this species

Risk Rating: Impact of illegal fishing on Roe's abalone stocks in:

All Areas - C1, L5 = 5; LOW

- Illegal fishing for Roe's abalone does occur but it is less desirable than the greenlip species (Hart et al. 2013d).
- Roe's abalone are relatively easy to target for illegal fishing due to ease of access to stocks from land and at low tide.
- On the west coast small quantities of excess possession limit Roe's abalone are taken overseas as hand luggage or baggage to Hong Kong, and Singapore (Hart et al. 2013a).
- Recreational fishers much purchase an Abalone Recreational Fishing Licence.
- There is a compliance program in place specifically for Roe's abalone. During the Roe's recreational fishing season, there is strong enforcement by fisheries officers checking licences and catch.
- Volunteer Liaison Officers and the general public also assist in monitoring and ensuring reefs are not illegally fished
- The Department undertakes covert surveillance to detect and apprehend illegal operators.
- The Department has a FISHWATCH program to report illegal fishing
- Luggage checks by airport security staff assist in restricting illegal movement of abalone catch

4.2.1.1.1.9 Broodstock collection of greenlip abalone

Rationale for Inclusion: Greenlip abalone are collected as broodstock for aquaculture

Risk Rating: Impact of aquaculture broodstock collection on greenlip abalone stocks:

Greenlip: - C1, L1 = 1; NEGLIGIBLE

Justification

- There is a set limit of 300 broodstock per year, and currently there is only one license to collect broodstock
- Licensee is required to report how many abalone are collected, typically less than 100 are collected at once

4.2.1.1.1.2 Water Quality

Rationale for Inclusion: Poor water quality can affect the benthic habitat and ecosystem in which abalone live.

Risk Rating: Impact of water quality on fishery performance in:

WC/SC - C1, L1 = 1; NEGLIGIBLE

Justification:

- There is land based hatchery for abalone located in Bremer Bay, which is required to maintain a high level of hygiene and water quality as specified in the Abalone Aquaculture Policy (DoF 2010b).
- Abalone fishing tends to occur away from river and estuarine areas which areas which often have compromised water quality.
- Abalone tend to live in areas of high water movement which increases the potential for water circulation and dilution of areas of potentially poor water quality
- Historically there have been events related to poor water quality which have affected abalone populations (e.g. flooding, sludge from copper sulphate) but these events are rare and the effects were localised.

4.2.1.1.1.2.1 Habitat Modification

4.2.1.1.1.2.2 Port Development and modification

4.2.1.1.1.2.3 West Coast Area 7

Rationale for Inclusion: The development and modification of ports can affect the benthic habitats in which abalone live. There is a proposal for a marina to be developed at Ocean Reef which could be developed within the next five years.

Risk Rating: Impact of habitat modification from port/marina development on fishery performance in:

WC (Area 7) – C4, L5 = 20, SEVERE

Justification:

- The risk rating for west coast Area 7 was assessed with the view that the Ocean Reef marina will go ahead in the next five years.
- The Ocean reef marina has the potential to impact on a large area of reef which is important habitat for Roe's abalone. It is estimated that the marina could result in 40% loss of habitat and associated stock causing serious localised depletion.

4.2.1.1.1.2.4 Other areas

Rationale for Inclusion: The development and modification of ports can affect the benthic habitats in which abalone live

Impact of habitat modification from port/marina development on fishery performance:

WC/SC (All other Areas) – C1, L1 = 1, NEGLIGIBLE

- The marina has recently been extended in Augusta, with some very localised impacts to greenlip abalone.
- There are no other major port or marina developments in the state which are likely to affect the abalone fishery in the next five years.

4.2.1.1.1.2.5 Aquaculture (Abalone and other species)

Rationale for Inclusion: Aquaculture activities have the potential to impact the habitats in which abalone live.

Risk Rating: Impact of habitat modification from aquaculture on fishery performance in:

WC/SC – C1, L1 = 1, NEGLIGIBLE

Justification:

- Abalone aquacultural activities are land based with the only infrastructure in the water being pipelines. There are pipelines at Hillarys, Fremantle and Bremer Bay, the pipes are not large and impacts are extremely localised.
- Other aquacultural operations which overlap with abalone habitat in WA include fish pens in Jurien Bay which are currently not being used.
- There are no other major aquacultural operations planned for South West WA in the next five years.

4.2.1.1.1.2.6 Abalone Ranching

Rationale for Inclusion: Abalone ranching activities may cause damage to the habitat and affect sand and water movement in the area.

Risk Rating: Impact of habitat modification from abalone ranching on fishery performance IN:

SC – C1, L1 = 1, NEGLIGIBLE

Justification:

- There is one sea ranching operation for abalone in Augusta, which utilises artificial concrete structures placed in sand which is an area of low biological productivity, which abalone typically do not occupy.

- The abalone ranching operation required Departmental approval prior to placing the structures in the ocean
- There are no other major aquacultural operations in South West WA

4.2.1.1.1.2.7 Recreational Fishing (fishers walking on reef platforms)

Rationale for Inclusion: In the metropolitan area the majority of Roe's abalone are taken from intertidal reef platforms. During the recreational fishing season thousands of recreational fishers walk on the reef to collect abalone.

Risk Rating: Impact of habitat modification from recreational abalone fishing on fishery performance in:

WC/SC – C1, L1 = 1, NEGLIGIBLE

Justification:

- The habitats in intertidal zones are typically high energy zones and contain species capable of withstanding physical impacts. These areas are frequently exposed to natural disturbances such as storms.
- The recreational fishing season in Area 7 (metropolitan area) is currently only open for five hours per season, between 07:00 and 08:00 on the first Sunday of the month between November and March.
- Recreational fishing on intertidal reefs typically occurs between Trigg Beach and Hillarys, with most other reef areas in the metropolitan area being subtidal.
- Fishing is not permitted in no take zones in Marine Protected Areas
- The number of people walking on reefs to recreationally fish for abalone on the south coast is low.

4.2.1.1.1.3 Introduction of pests and diseases by activities of people outside of the AMF.

4.2.1.1.1.3.1 Highly virulent pests and diseases associated commercial ships, recreational boats and fishers

Rationale for inclusion: The movement of commercial ships, recreational boats and fishers within WA and also from interstate could result in the introduction of and spread of highly virulent viruses and diseases.

Risk Rating: Impact of introduction of AVG (or other devastating/high impact diseases) from recreational and commercial fishing and boating activities on populations of greenlip abalone in:

WC/SC – C4, L1 = 4, LOW

Justification:

- There are relatively few boats and fishers which move from interstate to WA, and those which do move between states typically do so via land.
- Movement of diseases such as AVG could occur through moist equipment such as ropes, gloves, anchors and knives. Recreational divers and cray fishers are likely to have the greatest potential to accidentally introduce a disease to an area.
- Recreational fishers are likely to be less aware of the AVG and other virulent diseases viruses and the risk of transferring such diseases etc. between locations. It is highly unlikely that recreational fishers wash down gear or equipment.

4.2.1.1.1.3.2 Other (lower risk) pests and diseases associated commercial ships, recreational boats and fishers

Rationale for inclusion: The movement of commercial ships, recreational boats and fishers within WA and also from interstate could result in the introduction of and spread of “other” pests and diseases.

Risk Rating: The movement of commercial and recreational boats and recreational fishers, especially from interstate could result in the translocation of “other” bests and diseases.

WC/SC – C3, L2 = 6, LOW

Justification:

- The Department maintains an active surveillance program in the Fremantle Port for marine pests and diseases. There is also a passive surveillance program throughout WA, actively investigating any reports of abnormal mortalities, which are backed up by emergency response capability in the areas of both aquatic pests and diseases.
- A Departmental incident response manual has been developed, which details protocol associated with emergency biosecurity response. The Department is equipped with state-of-the-art diagnostic laboratories and capability. It participates in nationally-coordinated proficiency testing programs and is accredited to ISO17025 for both pest identification and pathogen identification.

4.2.1.1.1.3.3 Abalone aquaculture

Rationale for Inclusion: Abalone aquaculture has the potential to introduce pests and or disease to the natural environment.

Risk Rating: Impact of abalone aquaculture on the spread of pests and diseases on commercial fishery performance in:

WC/SC - C3, L3 = 9; MEDIUM

Justification:

- Abalone aquaculture refers to the production of juveniles in aquacultural facilities.

- Under the Regulation 176 of the FRMR applications to translocate abalone from interstate are not considered
- The Department has produced an Abalone Aquaculture Policy (DoF 2010b) which addresses issues relating to abalone aquaculture including environmental impacts, broodstock sources, translocation of abalone and biosecurity.
- Under the policy all abalones farms are required to have a Management and Environmental Monitoring Plan and a Biosecurity Plan for approval by the CEO of the Department.
- Broodstock for breeding purposes can only be sourced from WA waters.
- Movement of abalone between genetic zones is considered on a case by case basis, subject to Departmental approval
- Prior to the sale or movement of any abalone spat from a hatchery 150 animals per batch must be submitted to the Department for health certification.
- Abalone leaving a licensed site must be accompanied by a copy of a consignment note, stating the number, species and size of abalone consigned. A duplicate copy must be forwarded to the local Departmental office within 24 hours of the consignment.
- Compliance programs for abalone aquaculture and ranching are currently being developed which are aimed to be proactive and preventative, with inspections undertaken on a six monthly basis by the Department's regional services.
- Abalone aquaculture occurs on land and there is a large spatial separation from the fishing grounds. If disease is detected there is the option to shut down aquacultural operations.
- Disease has been introduced to the wild from abalone aquaculture operations in other parts of the world and Australia. In these circumstances the problem is often related to extremely high stocking densities.

4.2.1.1.1.3.4 Abalone ranching

Rationale for Inclusion: Abalone ranching has the potential to introduce pests and or disease to the natural environment.

Risk Rating: Impact of abalone ranching on the spread of pests and diseases on commercial fishery performance in:

SC - C3, L3 = 9; MEDIUM

Justification:

- Abalone ranching refers to the transfer of juveniles from aqua-cultural facilities to ranching sites where they are grown up for harvest.

- The risk of disease transfer from ranching maybe higher due to the fact that unlike aquacultural operations, ranches can't be shut down.
- The risk of disease from ranching activities is mitigated through spatial controls with large separations between abalone ranches and abalone habitat.
- During relocation from the aquacultural facilities to ranches, abalone may undergo stress, increasing susceptibility to disease but once placed in the wild conditions are much calmer and more favourable.
- The Department has produced an Abalone Aquaculture Policy (DoF 2010b) which addresses issues relating to abalone aquaculture including environmental impact, broodstock, translocation and biosecurity.
- Under the policy all abalones farms are required to have a Management and Environmental Monitoring Plan and a Biosecurity Plan for approval by the CEO of the Department.
- Health certificates maybe required for abalone stock being moved from land based aquacultural facilities to ocean based ranches.

4.2.1.1.1.4 Genetic Modification of Wild Abalone Stocks

4.2.1.1.1.4.1 Abalone Aquaculture (greenlip, brownlip and Roe's)

Rationale for Inclusion: Farmed abalone and/or abalone larvae maybe released to the natural environment

Risk Rating: Impact of abalone aquaculture on the genetic structure of wild populations:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Abalone produced in hatcheries are used in ranching operations and stock enhancement programs.
- The Department has produced an Abalone Aquaculture Policy (DoF 2010b) which addresses issues relating to abalone aquaculture including environmental impact, broodstock, translocation and biosecurity.
- Broodstock for breeding purposes can only be sourced from WA waters.
- Movement of abalone between genetic zones is considered on a case by case basis, subject to Departmental approval.
- In aquacultural facilities abalone breeding is undertaken within a self-circulating system.
- Aquacultural operations are focused around rearing of juveniles, which are non-reproductive, therefore water released to the environment is highly unlikely to contain

eggs or sperm. Abalone eggs and sperm are only viable for a short period of time (Halm 1989).

- Abalone aquaculture is currently from wild broodstock only, no second generation abalone (F2) are produced, nor are hybrids.
- Genetic studies indicate that abalone stock are one metapopulation with local differentiation (Shepherd and Brown, 1993).

4.2.1.1.1.4.2 Abalone Ranching (greenlip)

Rationale for Inclusion: Ranched abalone are sourced from abalone hatcheries and released to the natural environment

Risk Rating: Impact of abalone ranching on the genetic structure of wild populations:

SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Abalone produced in hatcheries are used in ranching operations and stock enhancement programs.
- The Department has produced an Abalone Aquaculture Policy (DoF 2010b) which addresses issues relating to abalone aquaculture including environmental impact, broodstock, translocation and biosecurity.
- Broodstock for breeding purposes can only be sourced from WA waters.
- Movement of abalone between genetic zones is considered on a case by case basis, subject to Departmental approval.
- Abalone aquaculture is currently from wild broodstock only, no second generation abalone (F2) are produced, nor are hybrids.
- Genetic studies indicate that abalone stock are one metapopulation with local differentiation (Shepherd and Brown, 1993).

4.2.1.2 Natural Changes

4.2.1.2.1.1 Water Temperature

Rationale for Inclusion: Water temperature significantly affects biology and survival of marine organisms including abalone.

Risk Rating: Impact of increased water temperature on fishery performance in:

WC - C4, L3 = 12; HIGH

SC - C4, L2 = 8; MEDIUM

Justification:

- In 2011, marine heat wave conditions resulted in a mass mortality of Roe's abalone in Area 8 (Moore River to the Northern Territory/ WA border). Mortalities of Roe's abalone were estimated at 99.9 % (Caputi et al. 2010). Commercial and recreational fishing for Roe's abalone was closed in Area 8 in 2011.
- Abalone stocks on the south coast were affected by the 2011 marine heat wave with the main effects being reduced growth and reproduction, mass mortalities were not observed.
- Greenlip and brownlip abalone, unlike Roe's abalone are not on the edge of their geographic distribution, and therefore are not as vulnerable to temperature changes. Furthermore, both green and brownlip species inhabit deeper waters which are less influenced by thermal heating.
- Fishery independent surveys have provided some evidence that the increased water temperatures may affect future recruitment of all three species and the consequence was therefore was rated relatively high (C4).

4.2.1.2.1.2 Storms

Rationale for Inclusion: Storms disrupt abalone fishing due to increased danger of operations due increased swell and wind. Typically there is less fishing the winter months due to unfavourable weather.

Risk Rating: Impact of increased frequency/intensity of storms on fishery performance in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Future predictions for climate change induced changes include increased storm events

4.2.1.2.1.3 Range Shifts

Rationale for Inclusion: Marine species are known to undergo range shifts due to changes environmental conditions.

Risk Rating: Impact of species range shifts on fishery performance in:

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Range extensions have been noted for a number of WA marine species including in relation to increasing water temperatures (Caputi et al. 2014).
- The marine heat wave in 2011 resulted in a die off of kelp and a shift in the distribution of kelp to south of Kalbarri.

- On the east coast of Australia the long spined sea urchin (*Centrostephanus rodgersii*) has undergone a southerly range expansion from NSW to Tasmania. This urchin is well known for its capacity to overgraze macroalgal beds resulting in a shift to ‘barrens’ habitat. The spread of the urchin in Tasmania is affecting the viability of the blacklip abalone fishery (Strain 2009)
- There have been no reports of increased urchin abundances by commercial abalone divers or researchers throughout the history of the fishery

4.2.2 Social drivers

4.2.2.1 Public attitudes

Rationale for Inclusion: Community attitudes and perceptions can have a significant influence a fishery.

Risk Rating: Impact of community attitude on fishery performance in:

All Areas - C2, L3 = 6, LOW

Justification:

- Fishing for Roe’s abalone in Area 7 is prohibited on the weekends, which helps to maintain a good public image.
- There has never been a problem between the AMF, the public or conservation groups requiring the Department implement management changes.
- There is the potential for conflict with introduction of the Ngari Marine Park. The public have a heightened awareness about sharing space in marine parks.

4.2.3 Economic drivers

4.2.3.1 Fuel prices

Rationale for Inclusion: Changes in fuel prices can significantly affect the operating costs and profits of the fishery.

Risk Rating: Impact of fuel prices on fishery performance in:

All Species - C2, L5 = 10; MEDIUM

Justification:

- The risk rating was based on the assumption that the fuel rebate will be abolished within the next five years. The removal of the rebate will have a significant impact on the operating costs for the fishery.
- Abalone fishers operate small vessels which do not use large amounts of fuel.

- Impacts of changes in fuel prices are likely to be more significant to lease divers than the owners of licences.

4.2.3.2 Exchange rates

Rationale for Inclusion: Changes in the strength of the Australian dollar affect the price of abalone overseas and the export market.

Risk Rating: Impact of exchange rate on fishery performance in:

All Species - C3, L4 = 12; HIGH

Justification:

- Changes in the exchange rate are the highest economic driver for the fishery, a lower Australian dollar results in better economic sustainability.
- The impact of changes in exchange rate are higher for license owners than lease divers, and effects will depend on the level of debt for individual fishers.

4.2.3.3 Market demand

Rationale for Inclusion: Market demand for abalone can be affected by a range of factors such as the global financial crisis and competition from abalone produced from aquaculture

All Species: Impact of market demand on fishery performance in:

All Areas - C2, L5 = 10; MEDIUM

Justification:

- The Global Financial Crisis (GFC) had an impact on the AMF through changes to the price of abalone.
- Aquaculture of abalone in China, Korea and Chile has increased dramatically in recent times increasing by over 800% between 2002 and 2013 which has major effects on supply and demand (Cook 2014).

4.2.3.4 Labour force

Rationale for Inclusion: During the mining boom resulted in a lot of abalone divers left the AMF to work on the mines resulting in a shortage of skilled labour.

Risk Rating: Impact of reduction in skilled labour to work in the AMF:

All Areas - C2, L5 = 10. MEDIUM

Justification:

- Previously there was a shortage of skilled labour to work in the AMF due to many divers leaving to work in the mining industry. With the slowing down of the mining boom, divers are returning to the AMF.

4.2.3.5 Weather

Rationale for Inclusion: Abalone fishing is suspended during poor weather

Risk Rating: Impact of poor weather on economic performance of the AMF:

WC – C2, L5 = 10; MEDIUM

SC - C3, L2 = 6; LOW

- If the weather is poor, abalone fishing is suspended resulting in divers having to work extra days.
- Impacts of weather are more related to operational effectiveness than economic, with poor weather resulting in less efficiency.
- Although the weather may affect fishing activities, the quota for greenlip and brown lip species is generally still caught, just less efficiently.
- There have been seasons where the quota for Roe's abalone have not been caught due to interruption by poor weather.

4.2.4 Access

4.2.4.1 Marine Protected Areas

Rationale for Inclusion: Fishing for abalone can be prohibited in Marine Protected Areas

Risk Rating: Impacts of Marine Protected Areas on fishery performance:

WC - C2, L3 = 6; LOW

Justification:

- There are a number of marine protected areas in south WA which have been proclaimed under the CALM Act (1984), including Jurien Bay, Marmion, Swan Estuary, Shoalwater Islands and Ngari Capes (Fletcher and Santoro 2015). There are four Fish Habitat Protection Areas (FHPA) declared under the FRMA (1994), at the Abrolhos Islands, Lancelin Lagoon, Cottesloe Reef and Kalbarri Blue Holes. Several over area closures under Section 43 of the FRMA include Yallingup Reef, Cowaramup Bay, Busselton Underwater Observatory and Wrecks. Commercial and recreational fishing is prohibited in certain zones within some of the marine park areas.
- The Ngari Capes Marine Park, is scheduled to be gazetted in 2017 which will exclude commercial fishing for all three abalone species in certain zones.
- The exclusion of commercial fishing from certain zones will result in a loss of quota but it is likely to be relatively small relative to the entire fishery.

- Commercial abalone fishers will be compensated for loss of catch to NCMP under the *Fishing and Related Industries Compensation (Marine Reserves) Act 1997* however exactly how this works, and the value remains to be determined.
- Contract divers, deckhands and processors will lose work with the implementation of the NCMP.
- The introduction of marine parks may affect how fishers operate, for example for Roe's abalone, in Area 7, fishers were no longer permitted to access fishing grounds from the shore once the Marmion Marine Park was gazetted.

4.2.4.2 Integrated Fishery Management (IFM) Allocations – Roes.

Rationale for Inclusion: The allocation of catch between commercial, recreational and customary sectors may affect the sustainability of the AMF.

Risk Rating: Impacts of Integrated Fishery Management (IFM) Allocations on fishery performance:

All species - C1, L1 = LOW

Justification:

- The Department has an IFM Policy (DoF 2009a)
- The Roes abalone fishery was assessed by the Integrated Fisheries Allocation Advisory Committee (IFAAC) who made recommendations to The Minister (DoF 2009b)
- The Minister for Fisheries has determined that for Area 7 the commercial fishery has 36 t, the recreational 40 t and the customary 500 kg of Roe's abalone (http://www.fish.wa.gov.au/Documents/minister_determinations/determination-roe-abalone-resource.pdf)
- Under the new Act there will be provision for broodstock collection for the aquaculture industry

4.3 Community Wellbeing

The AMF could potentially affect the fishing, local and broader WA communities. Eight community wellbeing sub components were identified as potentially impacted by the AMF operations (Figure 4.3) with 13 associated issues scored (Table 4.3). All issues were scored as negligible (7) or low (3) risk.

4.3.1 Community Wellbeing Aspects

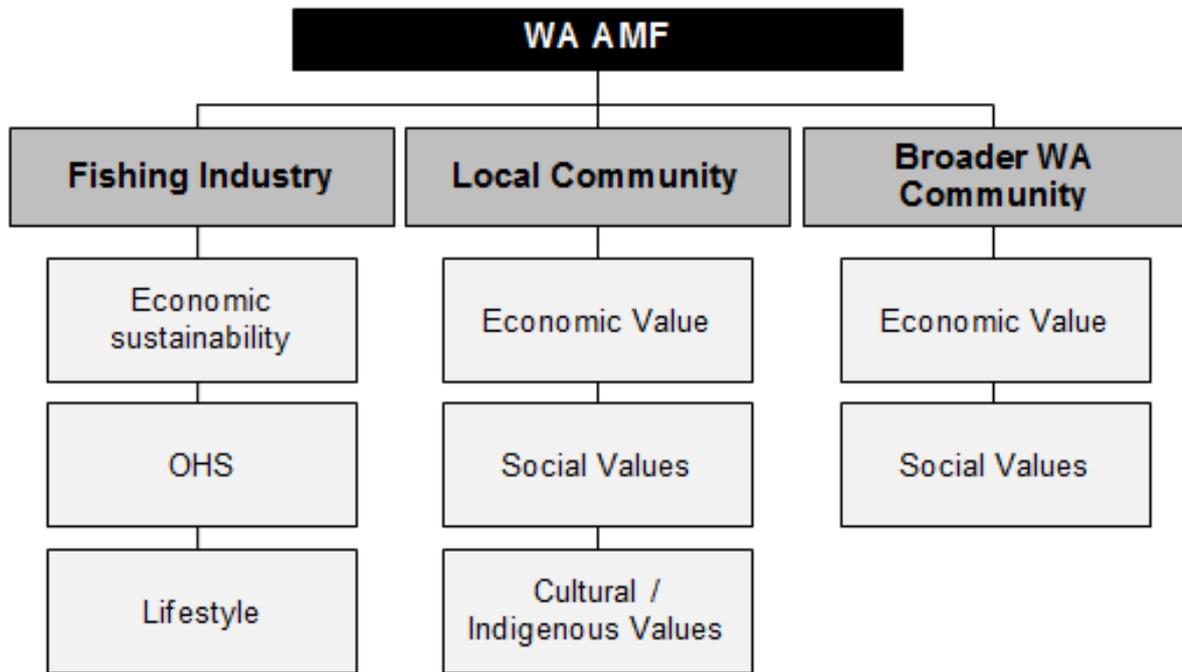


Figure 4.3 Component Tree for community wellbeing aspects of the AMF

Table 4.3 Overview table of Identified Components, Objectives, Sub-Components, Issues, Risk Score and Assessed Risk ratings related to the Community Wellbeing aspects of the AMF

Component	Objective	Sub-component	Issue	Management Area/Species /Bioregion	Risk Score	Risk Rating
Fishing Industry	To provide flexible opportunities to ensure fishers can maintain or enhance their livelihood, within the constraints of ecological sustainability	Economic Sustainability	Fisher Income	WC	C4, L3 = 12	HIGH
				SC	C1, L1 = 1	NEGLIGIBLE
		Occupational Health and Safety	Fisher Employment	WC	C4, L3 = 12	HIGH
				SC	C1, L1 = 1	NEGLIGIBLE
			Working Environment	WC/SC	C2, L2 = 4	LOW
Lifestyle Benefits	Lifestyle	WC/SC	C2, L2 = 4	LOW		
Local Community	To contribute to local community well-being, lifestyle and cultural needs	Economic Values	Economic value	WC/SC	C1, L1 = 1	NEGLIGIBLE
		Social Values	Social value	WC	C1, L1 = 1	NEGLIGIBLE
				SC	C2, L2 = 4	LOW
		Cultural/Indigenous values	Cultural/indigenous values	Community	C1, L1 = 1	NEGLIGIBLE
Broader WA Community	To contribute to regional community well-being, lifestyle and cultural needs	Economic Value	Economic value	Economic	C1, L1 = 1	NEGLIGIBLE
		Social Values	Social value	Social	C1, L1 = 1	NEGLIGIBLE

4.3.1.1 Fishing Industry

4.3.1.1.1 Economic stability

4.3.1.1.1.2 Income

Rationale for Inclusion: The AMF provides a source of income to license holders, divers, deck hands and people involved with the processing factories.

Risk Rating: Contribution of the fishery to fisher income in:

WC – C4, L3 = 12; HIGH

SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- Income to SC abalone fishers is unlikely to change in the next five years.
- Abalone fishers in the WC could experience a change in income and employment in the next five years due to potential impacts from climate change, the proposed Ocean Beach marina and competition from aquaculture.

4.3.1.1.1.3 Employment

Rationale for Inclusion: The AMF provides a source of income to license holders, divers, deck hands and people involved with the processing factories.

- **Risk Rating: Contribution of the fishery to fisher employment in:**
- **WC – C4, L3 = 12; HIGH**
- **SC – C1, L1 = 1; NEGLIGIBLE**
- Income to SC abalone fishers is unlikely to change in the next five years.
- Abalone fishers in the WC could experience a change in income and employment in the next five years due to potential impacts from climate change, the proposed Ocean Beach marina and competition from aquaculture.

4.3.1.1.1.4 Occupational Health and Safety

Risk Rating: Contribution of the industry to a safe working environment in:

WC/SC – C2, L3, = 6; LOW

Justification:

- The use of dive tables and dive computers minimise the risk of decompression illness.
- The use of shark cages reduces the risk of shark attack.
- Currently the majority of injuries result in first aid treatment only.

4.3.1.1.1.5 Lifestyle benefits

Rationale for Inclusion: Working the AMF affords certain lifestyle benefits such as diving and working at sea, living in regional areas and independence.

Risk Rating: Contribution of the industry to lifestyle benefits in:

WC/SC – C3, L3 = 9, LOW

Justification:

- The AMF affords a certain quality of life to fishers, such as working on the ocean and seasonal work.

4.3.1.2 Local Community

4.3.1.2.1.1 Economic values

Rationale for Inclusion: The AMF contributes to the economic value of the local community.

Risk Rating: Contribution of the fishery to the economic value of the local community

WC/SC – C1, L1 = 1, NEGLIGIBLE

Justification:

- The SC abalone fishery is unlikely to change over the next five years, and there are no anticipated changes to the economic value of the fishery to the local community.
- The WC abalone fishery may experience some changes in economic revenue over the next five years due to potential effects of climate change, the Ocean Beach marina and competition from aquaculture. Whilst these economic changes could be significant to industry they are unlikely to have an impact on the west coast economy due to relatively low economic contribution to this area..

4.3.1.2.1.2 Social values

Rationale for Inclusion: The AMF fishermen and operations are a part of the local community.

Risk Rating: Contribution of the industry to social values of the local community in:

WC/SC – C2, L2 = 4; LOW

Justification:

- The number of people involved with the AMF is relatively low. There are no festivals or events held in either the south coast or west coast in relation to the AMF.
- The AMF fishermen and operations play a more influential role in the local community on the south coast than the west coast.

4.3.1.2.1.3 Cultural/Indigenous values

Risk Rating: Contribution of the industry to cultural and indigenous values of the local community

WC/SC – C1, L1 = 1; NEGLIGIBLE

Justification:

- There is little historical take of abalone by indigenous Australians.

4.3.1.3 Broader WA

4.3.1.3.1.1 Economic Value

Risk Rating: Contribution of the industry to economic value of the broader community:

C1, L1 = 1; NEGLIGIBLE

Justification:

- The abalone fishery only generates a small proportion of WA's gross domestic product.

4.3.1.3.1.2 Social Values

Risk Rating: Contribution of the industry to social values of the broader community:

C1, L1 = 1; NEGLIGIBLE

Justification:

- The number of people involved in the AMF is relatively low. There are no festivals or events specifically designed around the AMF.

4.4 Governance

Three main aspects of governance were identified as potentially impacting the AMF performance: government agencies, industry and other stakeholders (Figure 4.4). A number of sub-components were identified within each of the three areas, with 17 issues assessed (Table 4.4). Fourteen of the issues were considered to be negligible risk, two low risk and one medium risk.

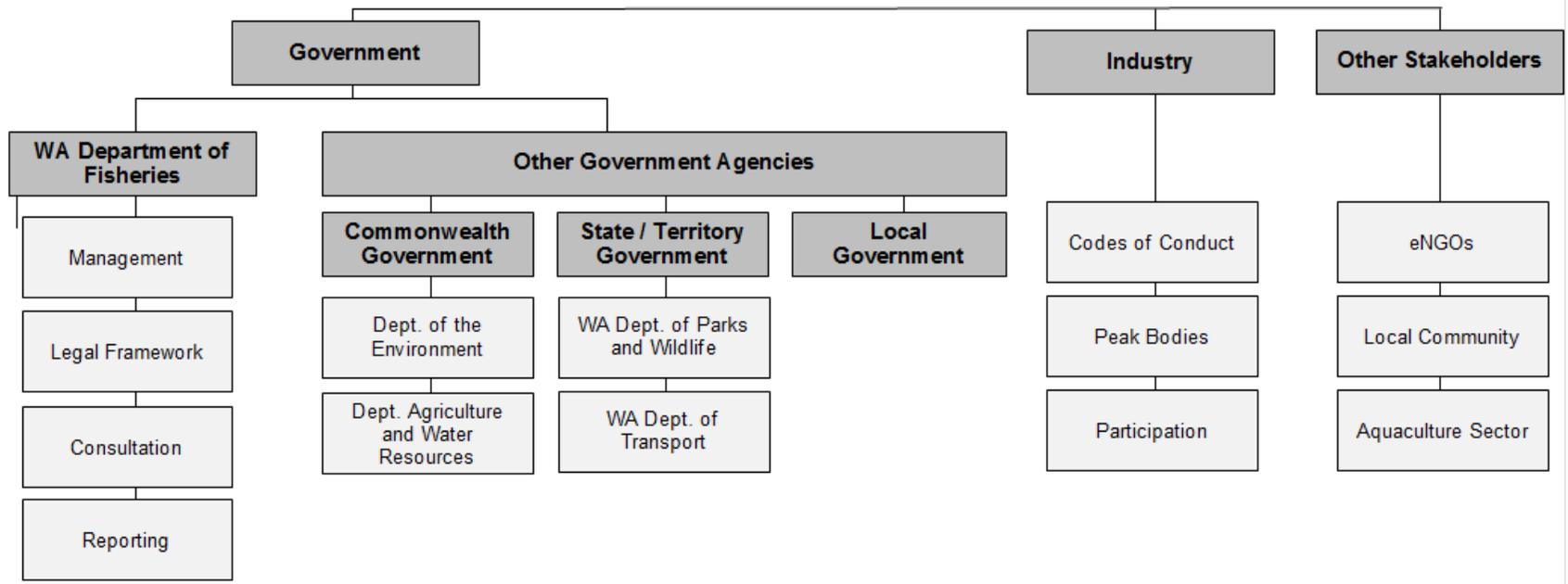


Figure 4.4 Component tree for governance aspects of the AMF

Table 4.4 Overview table of Identified Components, Objectives, Sub-Components, Issues, Risk Score and Assessed Risk ratings related to the Governance aspects of the AMF industry

Component	Fishery Objective	Sub-component	Issues	Risk Assessment	Risk Rating
Department of Fisheries	To ensure ESD principles are underpinned by legal, institutional, economic and policy frameworks capable of responding and taking appropriate peremptory and remedial actions.	Management	Effectiveness of management system	C2, L5 = 10	MEDIUM
		Legal Framework	Effectiveness of Fisheries Legal Framework	C2, L3 = 6	LOW
			Effectiveness of Access rights	C1, L1 = 1	NEGLIGIBLE
			Effectiveness of OCS arrangements	C1, L1 = 1	NEGLIGIBLE
		Consultation	Effectiveness of Participation	C1, L1 = 1	NEGLIGIBLE
			Effectiveness of Communication	C1, L1 = 1	NEGLIGIBLE
Reporting	Effectiveness of Reviews / Audits	C1, L1 = 1	NEGLIGIBLE		
Other Government Agencies:	To ensure ESD principles are underpinned by legal, institutional, economic and policy frameworks capable of responding and taking appropriate peremptory and remedial actions.	DotE (Commonwealth)	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
		DoAWR (Commonwealth)	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
		DPAW (State)	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
		DoT (State)	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
		Local Government	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
Industry	To ensure ESD principles are underpinned by legal, institutional, economic and policy frameworks capable of responding and taking appropriate peremptory and remedial actions.	Codes of Conduct	Effectiveness of Codes	C1, L1 = 1	NEGLIGIBLE
		Participation	Level of Participation		
		Peak Bodies	Effectiveness of Peak Bodies	C1, L1 = 1	NEGLIGIBLE
Other Stakeholders	To ensure ESD principles are underpinned by legal, institutional, economic and policy frameworks capable of responding and taking appropriate peremptory and remedial actions.	eNGOs	Effectiveness of Consultation Processes	C1, L3 = 3	LOW
		Local Community	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE
		Aquaculture Sector	Effectiveness of Consultation Processes	C1, L1 = 1	NEGLIGIBLE

4.4.1 Government: WA Department of Fisheries

4.4.1.1 Management

Rationale for Inclusion: The *Fisheries Management Act 1994* and the *Fisheries Management Regulations 1995* and the *Abalone Management Plan 1992* are the primary instruments for the management of the AMF in WA. The Fisheries Management Act also provides for the creation of subsidiary legislation in the form of Regulations, Management Plans, Notices, leases and licences (with conditions).

Risk Rating: Effectiveness of the management system:

C2, L5 = 10; MEDIUM

Justification:

- The effectiveness of the AMF management system was assessed in terms of:
 - Availability and comprehensiveness of management plans
 - Effectiveness of Compliance system
 - Comprehensiveness of information
 - Appropriate levels of resources
 - Effectiveness of inter-agency coordination
 - Effectiveness of allocation process and system
 - Pro-activeness of Management
- Industry members noted that decisions which need to be approved by the Minister can cause considerable delays in AMF strategic function and direction
- The transition of the AMF to Marine Stewardship Council certified will increase efficiency of management processes and priorities within the Department.

4.4.1.2 Legal Framework

Rationale for Inclusion: The legal framework includes Fisheries legislation, access rights and quota allocation among users, as well as Offshore Constitutional Settlement (OCS) arrangements with the Commonwealth government.

In 2010, the (then) Minister for Fisheries directed the Department to review the existing legislation and scope the requirements for a new WA Act of Parliament to ensure the sustainable development and conservation of the state's aquatic resources into the future. As a result the Aquatic Resource Management Act (currently before parliament as the *Aquatic Resource Management Bill 2015*³) was drafted and provides an innovative legislative and

³ The Bill can be viewed on the Parliamentary website
<http://www.parliament.wa.gov.au/parliament/bills.nsf/BillProgressPopup?openForm&ParentUNID=1D103914B411A4CF48257DF6001BBD6B>

administrative framework for the future management of the State's fish and aquatic resources, based on the principles of ESD and EBFM.

Risk Rating: Effectiveness of Fisheries Legal Framework:

C2, L3 = 6, LOW

Justification:

- The *FRMR 1994* and *FRMA 1995* will be replaced with the *Aquatic Resource Management Act* (currently before Parliament as the *Aquatic Resource Management Bill 2015*); however no significant changes to the management regime are occurring as a part of the process.
- The AMF fishermen would like to see Integrated Fisheries Management introduced for greenlip and brownlip species to provide certainty to their operations.

4.4.1.3 Consultation

Rationale for Inclusion: Consultation includes the participation of various stakeholder groups in management processes and the level of communication between the Department, industry and broader stakeholders. This is also dependent on the consultation requirements within the current legislative framework.

Risk Rating: Effectiveness of consultation in the AMF:

C1, L1 = 1, NEGLIBLE

Justification:

- There is collaboration and communication between the Department and the AIAWA throughout the year, with the annual management meeting (AMM) being the key forum for discussion of management matters. (although additional meetings and communications occur).
- There is an open and consultative process between industry and the Department involved with the setting of the TAC.
- The re-establishment of the Industry based research committee has allowed for increased industry participation

4.4.1.4 Reporting

Rationale for Inclusion: Reporting takes into account the level of information published by the Department in relation to research results, the status of abalone stocks and management strategies and outcomes. It also takes into account internal and external reviews of the management system or audits of the industry, such as against the MSC standards

Risk Rating: Effectiveness of reporting in the AMF:

C1, L1 = 1, NEGLIBLE

Justification:

- The management system has been the subject of periodic external review as part of the process undertaken to achieve accreditation by the Commonwealth Department of the Environment against the *Guidelines for the Ecologically Sustainable Management of Fisheries – V2* (CoA 2007c). The industry has also undergone an independent pre-assessment against the MSC fishery standard (MRAG 2014) and is currently pursuing MSC certification.
- There is effective reporting in place. The AMF performance outcomes for target and retained non-target species, bycatch, ETP species, habitats and ecosystems are also made publically-available in the annual *Status Report of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries*.
- The Department publishes the results of specific abalone research projects in Fisheries Research Reports (Hart et al. 2013d) and journal publications (Hart 2015, Hart et al. 2013a, b & c).

4.4.2 Government: Other agencies

Rationale for Inclusion: A number of other government agencies that influence industry activities were identified at the workshop including the Department of the Environment (DoE), Department of Agriculture, Water and Resources (DoAWR), WA Department of Parks and Wildlife (DPAW), WA Department of Transport (DOT) and Local Government..

Risk Rating: Effectiveness of Consultation Processes with:

DoE - C1, L1 = 1; NEGLIGIBLE

DoAWR - C1, L1 = 1; NEGLIGIBLE

DPAW - C1, L1 = 1; NEGLIGIBLE

DOT - C1, L1 = 1; NEGLIGIBLE

Local Government – C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMMs are attended by Departmental staff, WAFIC, the AIAWA and licence holders but can also be open to other stakeholder groups, e.g. Recfishwest, processors, universities, other Government departments and the conservation sector.
- The Department is currently working to improve consultation process with the non-fishing sector and has recently introduced changes to provide more opportunities for public and stakeholder involvement in fisheries management processes. Other opportunities may include public forums, targeted consultation with key interest groups or a regional approach depending on the fishery or issues under consideration.

- The AMF was recently given 10 year approval for Wildlife Trade Operations by the DoE.
- DoWAR work with the Department and the Department of Water in relation to fresh water fish kills.
- Consultations are undertaken with DPaW for marine park planning, particularly for the Ngari Capes Marine Park.
- The DOT is being merged with AMSA, which is not anticipated to result in significant changes to the consultation process.

4.4.3 Industry

4.4.3.1 Codes of Conduct

Rationale for Inclusion: Industry Codes of Conduct outline industry initiatives, viewpoints and activities that are undertaken voluntarily to improve industry outcomes.

Risk Rating: Effectiveness of Codes of Conduct:

C1, L1 = 1; NEGLIGIBLE

Justification:

- The AIAWA has developed a code of conduct for the greenlip and brownlip fishery and Induction and Instruction Manual for Area 2 and Area 3 of the fishery (AIAWA 2015 a - c). The Code which was developed with two NGO's; South Coast Natural Resource Management and Ocean Watch with funding from Caring for Country. The Code outlines environmental responsibilities of divers and sustainable fishing and operational practices, with particular emphasis on biosecurity.

4.4.3.2 Peak bodies

Rationale for Inclusion: The primary peak body for commercial fishing operations in WA is the WAFIC. The AIAWA is the primary association for the WA abalone fishing industry.

Risk Rating: Effectiveness of Peak Bodies:

C1, L1 = 1; NEGLIGIBLE

Justification:

- The AIAWA is the main forum for communication between the AMF and the Department. The AIAWA is a proactive organisation with 100% of licensees as voluntary members.
- The Department has a general practice of holding an annual management meeting with licensees to discuss research, management, compliance and other specific issues affecting the industry (e.g. marine park planning). These management meetings

underpin the decision-making process at the fishery-specific level. These meetings are generally coordinated by WAFIC.

- WAFIC also represent the AMF but on more broadscale issues such as potential removal of the fuel rebate.

4.4.3.3 Participation

Rationale for Inclusion: The primary peak body for commercial fishing operations in WA is the WAFIC. The AIAWA is the primary association for the WA abalone fishing industry.

Risk Rating: Effectiveness of Consultation Processes

C1, L1 = 1; NEGLIGIBLE

Justification:

- There is a high level of industry participation in management activities, including discussion of recommended harvest levels (which may influence the annual TAC), changes to management measures and industry initiatives, such as the pursuit of MSC certification.

4.4.4 Other stakeholders

4.4.4.1 Environmental organisations

Risk Rating: Effectiveness of Consultation Processes:

C1, L3 = 3; LOW

- There are some clear consultation processes in place, e.g. multiple environmental groups were invited to the risk assessment workshop in December 2015, and the Department is currently working to improve consultation processes with the non-fishing sector. This may include public forums, targeted consultation with key interest groups or a regional approach depending on the fishery or issues under consideration.
- The AMMs are attended by Departmental staff, WAFIC and licence holders, but can also be open to other stakeholder groups, e.g. Recfishwest, processors, universities, other Government departments and the conservation sector.
- The Department publishes a range of documents online which can be accessed by the public and environmental organisations including: Annual State of Fisheries Report; Research Reports; Management Reports and Harvest Strategies (<http://www.fish.wa.gov.au/About-Us/Publications/Pages/default.aspx>).

4.4.4.2 Local Community

Justification: The AMF is a part of and operates within the local community

Risk Rating: Effectiveness of Consultation Processes:

C1, L1 = 1; NEGLIGIBLE

Justification:

- The AMF is active at community events, with often stalls at local events which encourages engagement with the local community.

4.4.4.3 Aquaculture Sector

Rationale: There is an abalone aquaculture industry in Western Australia.

Risk Rating: Effectiveness of Consultation Processes:

C1, L1 = 1; NEGLIGIBLE

- The Aquaculture Industry Council of Western Australia is the State's peak aquaculture industry body, although most consultation is currently through WAFIC.
- Consultation between the abalone aquaculture industry and the AMF needs to be further developed.
- The Department facilitates consultation between the aquaculture sector and industry.

5 Risk Evaluation

A total of 102 issues associated with the AMF were scored for risk across the four principles: ecological, external factors, community wellbeing and governance. The majority of issues were evaluated as low or negligible risk (Table 5.1), which do not require specific control measures (as per Fletcher et al. 2002). Issues scored as medium risk or higher are further specified in Table 5.2.

Table 5.1. Summary of risk scores across each aspect considered in the 2015 risk assessment of the AMF

	Component	Risk Score					Total
		Negligible	Low	Medium	High	Severe	
Ecological Sustainability	Retained Species	1	2	11	0	0	14
	Non-retained Species	2	0	0	0	0	2
	ETP species	7	0	0	0	0	7
	Habitats	8	0	0	0	0	8
	Ecosystem Structure	4	0	0	0	0	4
	Broader Environment	5	0	0	0	0	5
External Factors	Environment: Human-induced changes	12	4	3	0	1	20
	Environment: Natural Changes	2	0	1	1	0	4
	Social Drivers	0	1	0	0	0	1
	Economic Drivers	0	1	4	1	0	6
	Access	1	0	1	0	0	2
Community Wellbeing	Fishing Industry	2	2	0	2	0	6
	Local Community	3	1	0	0	0	4
	Broader Community	2	0	0	0	0	2
Governance	Government: Department of Fisheries	5	1	1	0	0	7
	Government: Other Agencies	5	0	0	0	0	5
	Industry	2	0	0	0	0	2
	Other Stakeholders	2	1	0	0	0	3
Total		62	13	21	4	1	102

Table 5.2 Summary of issues identified as medium or higher risk in the 2015 risk assessment of AMF

Issue	Areas/Bioregion/Species	Risk Score
Ecological Factors		
Commercial fishing of greenlip abalone	2 & 3	MEDIUM
Introduction of high risk virus to greenlip abalone	1, 2 & 3	MEDIUM
Commercial fishing of brownlip abalone	2 & 3	MEDIUM
Introduction of high risk virus to brownlip abalone	1, 2 & 3	MEDIUM
Commercial fishing of Roe's abalone	2, 5, 6 & 7	MEDIUM
Introduction of high risk virus to Roe's abalone	1, 2, 5, 6 & 7	MEDIUM
External Factors		
Recreational fishing for Roe's abalone	Area 7	MEDIUM
Habitat modification	Area 7	SEVERE
Introduction of pests and diseases from aquaculture activities	WC/SC	MEDIUM
Introduction of pests and diseases from ranching activities	SC	MEDIUM
Increases in water temperature (WC)	WC	HIGH
Increases in water temperature (SC)	SC	MEDIUM
Increases in price of fuel	WC/SC	MEDIUM
Changes in exchange rate for the Australian dollar	All species	HIGH
Global demand and competition from aquaculture	All species	MEDIUM
Availability of skilled labour	All species	MEDIUM
Effect of poor weather	WC (Roe's)	MEDIUM
Establishment of new Marine Protected Areas	All species	MEDIUM
Community Wellbeing		
Fisher employment	WC	HIGH
Fisher Income	WC	HIGH
Governance		
Departmental Management of the AMF	All Areas	MEDIUM

6 Risk Treatment

This risk assessment has assisted in the identification and filtering of the different types of ecological risks associated with the AMF. Different levels of risk have different levels of acceptability, with different requirements for monitoring and reporting and management actions (See Table 3.2 for a summary). Risks identified as negligible or low are considered acceptable, requiring either no or periodic monitoring and no specific management actions. Risks identified as medium risk are considered acceptable providing there is specific monitoring, reporting and management measures are implemented. Risks identified as high are considered ‘not desirable’, requiring strong management actions or new control measures to be introduced in the near future. Severe risks are considered ‘unacceptable’ with major changes to management required in the immediate future (Fletcher et al. 2002).

A summary of issues identified as medium risk or higher with associated monitoring, reporting and management actions is provided in Table 6.1. Note that whilst risks identified as medium are considered acceptable and not requiring additional treatment, they are documented in Table 6.1 to provide clarity in relation to current reporting and management arrangements. All of the issues identified in the ERA as high or severe risk are outside of the Department's direct influence or jurisdiction. However, whilst the Department cannot directly influence these issues, the risks can be mitigated by ensuring that abalone stocks are sustainably managed through regular monitoring, targeted research and best management practices.

Table 6.1 Risk Treatment: Specification of likely reporting and monitoring requirements and management actions for issues scored medium risk or higher

Issue	Risk Score	Likely reporting and monitoring requirements	Likely management action
Ecological Factors			
Commercial fishing of greenlip, brownlip and Roe's abalone	MEDIUM	Continue current fisheries dependent and independent monitoring (See section 2.6). Continue with regular reporting (See Section 2.7)	Maintain current management practices as specified in the Abalone Management Plan. Continue implementation of annual TACC and Harvest Strategy, both which are responsive to stock status (Section 2.2).
Introduction of high risk virus to greenlip, brownlip and Roe's abalone	MEDIUM	Continue to maintain vigilance as specified in the Abalone Code of Practice (Section 2.2.4). The Department has a passive surveillance program throughout WA, actively investigating any reports of abnormal mortalities, which are backed up by emergency response capability in the areas of both aquatic pests and diseases.	Maintain current management practices to minimise the risk of disease introduction and spread as specified in the Abalone Code of Practice (Section 2.2.4).
External Factors			
Recreational fishing for Roe's abalone	MEDIUM	Continue current fisheries dependent and independent monitoring (See section 2.6). Continue with regular reporting (See Section 2.7)	Maintain current management practices as specified in the <i>FRMR 1995</i> . Continue implementation of annual TACC and Harvest Strategy, both which are responsive to stock status (Section 2.2).
Habitat modification	SEVERE	Provide scientific advice to the Environmental Protection Authority during the Environmental Impact Assessment process for the proposed Ocean Reef Marina	If the marina proceeds, the TACC and Harvest Strategy will be adjusted to mitigate risk to abalone stocks. The Department is likely to assist the AIAWA determining the value of the fishery and loss of potential income during compensation claims.
Introduction of pests and diseases from aquaculture activities	MEDIUM	Under the Abalone Aquaculture Policy, abalone farms are required to have an Environmental Monitoring Plan and a Biosecurity Plan which is approved by the CEO of the Department (Section 4.2.1.1.1.3.3). Continue with regular inspections of abalone aquaculture facilities	New aquaculture facilities require the approval by the Department and Environmental Protection Authority. Ensure that aquaculture practices and management comply with the Abalone Aquaculture Policy (Section 4.2.1.1.1.3.3).
Introduction of pests and diseases from ranching activities	MEDIUM	Under the Abalone Aquaculture Policy, abalone farms are required to an Environmental Monitoring and a Biosecurity Plan which is approved by the CEO of the Department (Section 4.2.1.1.1.3.4). Continue with regular inspections of abalone aquaculture facilities	Health Certificates may be required for abalone stock being moved from aquacultural facilities to ocean ranches. Maintain current management practices and policies in regard to abalone aquaculture (Section 4.2.1.1.1.3.3).

Table 6.1 (cont.) Risk Treatment: Specification of likely reporting and monitoring requirements and management actions for issues scored medium risk or higher

Issue	Risk Score	Likely reporting and monitoring requirements	Likely management action
External Factors			
Increases in water temperature (WC)	HIGH (WC)	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Maintain current management practices as specified in the Abalone Management Plan. Continue implementation of annual TACC and Harvest Strategy, both which are responsive to stock status (Section 2.2). If required reduce the TACC or close Areas to abalone to mitigate risk from environmental influences (e.g. closure of Area 8 to commercial and recreational fishing for Roe's which was severely impacted by the 2011 heatwave)
	MEDIUM (SC)		
Increases in price of fuel	MEDIUM	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Ensure sustainable management of abalone stocks to assist in the mitigation of external impacts.
Changes in exchange rate for the Australian dollar	HIGH	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7)..	Ensure sustainable management of abalone stocks to assist in the mitigation of external impacts.
Global demand and competition from aquaculture	MEDIUM	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7)..	Ensure sustainable management of abalone stocks to assist in the mitigation of external impacts. .
Availability of skilled labour	MEDIUM	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Ensure sustainable management of abalone stocks to assist in the mitigation of external impacts.
Effect of poor weather	MEDIUM	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Ensure sustainable management of abalone stocks to assist in the mitigation of external impacts.
Establishment of new Marine Protected Areas	MEDIUM	Outside of the Departments jurisdiction. DPaW is responsible for marine park gazettal and management. Provide scientific advice to DPaW regarding the gazettal and impacts of the marine park. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7)..	Once the Marine Park is implemented adjustment of TACC and Harvest Strategy may be required. Fishers will be compensated for loss of income and economic value through the <i>Fishing and Related Industries Compensation (Marine Reserves) Act 1997</i>

Table 6.1 (cont.) Risk Treatment: Specification of likely reporting and monitoring requirements and management actions for issues scored medium risk or higher

Community Wellbeing			
Fisher employment	HIGH (WC)	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Maintain current practices to ensure abalone stocks are well managed to ensure fishers can maintain or enhance their livelihood, within the constraints of ecological sustainability
Fisher Income	HIGH (WC)	Influenced by factors outside of the Department. Continue with current monitoring and reporting on abalone stocks (Sections 2.6 and 2.7).	Maintain current practices to ensure abalone stocks are well managed to ensure fishers can maintain or enhance their livelihood, within the constraints of ecological sustainability
Governance			
Departmental Management of the AMF	MEDIUM	Continue with current management arrangements, consultation and reporting	Maintain current management practices as specified in the Abalone Management Plan and Harvest Strategy.

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8 Appendices

8.1 Appendix 1. Commercial catch and effort history for the AMF

Table 7.8.1 Total Allowable Catch (TAC), Total Catch (kg meat weight), Total Effort (diver days) and Catch Rate (kg/diver/day) for each quota year for greenlip abalone in each of the different management areas

Quota Year	Area 1				Area 2				Area 3			
	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)
1987	n/a				n/a				50,000	33,940	588	58
1988	n/a	614	3	205	n/a	21,521	355	61	48,000	36,405	608	60
1989	n/a	166	2	83	n/a	24,341	369	66		61,590	1,030	60
1990	n/a	4,097	33	124	*30,000	30,729	495	62	*16,000	9,567	175	55
1991	n/a	5,059	30	169	*10,000	7,888	147	54	*44,000	36,620	653	56
1992	n/a	383	5	77	*30,000	31,541	468	67	*40,000	32,074	753	43
1993	*1,800	1,517	21	72	*30,000	29,564	411	72	*40,000	33,936	850	40
1994	*3,000	188	6	31	*30,000	29,928	541	55	*40,000	34,278	895	38
1995	*3,000	17	2	9	*30,000	29,319	625	47	*35,096	31,864	728	44
1996	*3,000	157	8	20	*30,000	29,541	580	51	*36,000	35,088	433	81
1997	*3,000	86	6	14	*32,400	31,838	657	48	*40,000	36,747	621	59
1998	*3,000	15	1	15	*30,000	29,998	615	49	*40,000	38,158	634	60
1999	3,000	43	1	43	30,000	29,900	525	57	36,000	35,961	571	63
2000	3,000	965	17	57	30,000	30,974	567	55	40,000	40,201	588	68
2001	3,000	390	13	30	30,000	30,095	562	54	40,000	40,000	681	59
2002	3,000	1,587	42	38	30,000	24,321	496	49	40,000	36,646	716	51
2003	3,120	0	0		31,200	30,200	567	53	41,616	37,565	710	53
2004	1,200	949	25	38	28,620	27,477	456	60	41,616	35,460	720	49
2005	1,200	433	17	25	31,200	31,265	565	55	32,000	31,815	691	46
2006	1,200	995	18	55	31,200	30,955	531	58	32,000	31,324	664	47
2007	1,200	18	2	9	31,200	31,183	573	54	32,000	31,302	607	52
2008	1,200	906	20	45	28,000	27,959	529	53	32,000	30,488	642	47
2009	1,200	0	0		28,000	27,999	528	53	35,000	32,052	697	46
2010	1,200	766	10	77	28,000	27,409	476	58	35,000	33,902	695	49
2011	1,200	0	0		28,800	28,732	470	61	35,000	33,484	707	47
2012	1,200	0	0		28,800	28,922	601	48	35,000	33,831	709	48
2013	1,200	0	0		28,800	28,284	571	50	35,000	33,999	943	36
2014	1,200	0	0		28,800	28,497	766	37	**32,000	31,079	774	40

* Greenlip and Brownlip quota combined. ** Voluntary reduction to 32,000kg as of 15-06-15

Table 7.8.2 Total Allowable Catch (TAC), Total Catch (kg meat weight), Total Effort (diver days) and Catch Rate (kg/diver/day) for each quota year for brownlip abalone in each of the different management Areas

Year	Area 1			Area 2				Area 3				
Quota Year	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)	TAC kg	Total catch (kg meat wt)	Total Effort (diver days)	Total Catch Rate (kg/diver/day)
1987									*	2,953	591	5
1988	n/a	9	3	0	n/a	6,100	358	17	*	6,739	605	11
1989	n/a		3	3	n/a	6,643	357	19	*	8,139	976	8
1990	n/a		33	0	*6,000	6,044	500	12	*	1,604	179	9
1991	n/a		30	0	*2,000	2,191	177	12	*	3,673	706	5
1992	n/a		5	0	*6,000	6,740	471	14	*	5,467	759	7
1993	*		20	0	*6,000	6,626	415	16	*	5,836	851	7
1994	*	1	6	0	*7,200	7,245	542	13	*	5,643	897	6
1995	*		2	1	*7,200	7,872	627	13	*	3,383	730	5
1996	*	6	8	0	*7,200	7,651	581	13	*	1,126	396	3
1997	*		6	1	*7,900	8,403	660	13	*	2,143	621	3
1998	*		1	0	*7,200	7,240	599	12	*	1,684	615	3
1999	0		1	0	7,200	7,178	497	14	4,000	4,041	594	7
2000	30	1	1	0	7,920	8,087	571	14	6,000	5,685	598	10
2001	30				7,200	6,469	516	13	6,000	5,989	648	9
2002	30				7,200	5,139	442	12	6,000	5,844	655	9
2003	31				8,150	6,838	514	13	6,800	6,542	660	10
2004	0				7,200	7,198	406	18	6,800	6,480	690	9
2005	0				7,900	7,914	542	15	7,500	7,595	712	11
2006	0				7,900	7,862	482	16	8,000	7,044	679	10
2007	0				7,900	7,881	538	15	8,000	7,583	599	13
2008	60				8,700	8,665	501	17	8,000	7,141	665	11
2009	60				8,700	8,692	488	18	8,000	6,928	717	10
2010	60				8,700	8,560	484	18	8,000	7,043	712	10
2011	60				7,920	7,900	474	17	8,000	6,610	750	9
2012	60				7,200	7,199	607	12	7,200	6,475	829	8
2013	60				7,000	6,966	591	12	7,200	7,100	965	7
2014	60				7,200	7,229	774	9	7,200	6,294	805	8

* Greenlip and Brownlip quota combined.

Table 7.8.3 Total Allowable Catch (TAC) and Total Catch (kg whole weight) for each quota year for Roe's abalone in each of the different management Areas

Year	Area 1		Area 2		Area 5		Area 6		Area 7		Area 8	
	TAC kg	Total catch (kg whole wt)	TAC kg	Total catch (kg whole wt)	TAC kg	Total catch (kg whole wt)	TAC kg	Total catch (kg whole wt)	TAC kg	Total catch (kg whole wt)	TAC kg	Total catch (kg whole wt)
1988	n/a	381	n/a	4,320	n/a	2,102	n/a		n/a		n/a	
1989	n/a	239	n/a	16,031	n/a	13,689	*	20,986	*	30,061	*	20,781
1990	n/a	8,840	18,000	18,586	*12,000	13,844	*	10,327	*	35,563	*	29,286
1991	n/a	8,039	14,000	13,256	*12,000	12,693	*	9,826	*	29,420	*	36,211
1992	n/a	6,216	18,000	17,111	*12,000	13,564	*	9,676	*	18,139	*	46,635
1993	15,000	9,852	18,000	18,697	20,000	10,491	*	13,659	*	33,773	*	28,809
1994	12,960	8,231	18,000	17,940	20,000	16,947	*	14,698	*	34,052	*	25,968
1995	9,960	5,563	18,000	17,897	20,000	18,254	*	11,655	*	39,836	*	23,797
1996	9,960	6,067	18,000	17,202	20,000	17,576	*	13,047	*	46,052	*	18,856
1997	10,290	8,132	18,500	17,812	20,000	16,409	*	14,099	*	36,151	*	26,134
1998	7,560	4,279	13,200	13,075	13,200	12,077	*	12,013	*	24,123	*	20,858
1999	9,900	5,482	18,000	16,811	20,000	19,017	12,000	11,681	36,000	36,091	24,000	23,868
2000	9,900	5,541	18,000	17,728	20,000	19,939	12,000	12,027	36,000	36,509	20,000	15,991
2001	9,900	3,753	18,000	17,976	20,000	18,718	12,000	12,427	36,000	35,406	12,000	10,893
2002	9,900	2,835	18,000	17,971	20,000	19,775	12,000	12,020	36,000	35,965	12,000	11,906
2003	9,900	0	18,000	17,879	20,000	17,942	12,000	12,084	36,000	36,007	15,000	12,094
2004	9,900	7,985	18,000	17,708	20,000	19,636	12,000	11,663	36,000	35,889	15,000	14,567
2005	9,900	237	19,800	19,038	20,000	19,095	12,000	11,996	36,000	35,912	15,000	11,116
2006	9,900	1,196	19,800	19,635	20,000	18,185	12,000	11,989	36,000	36,005	15,000	11,963
2007	9,900	1,302	19,800	18,935	20,000	16,094	12,000	11,976	36,000	35,998	12,000	6,444
2008	9,900	508	19,800	19,729	20,000	17,050	12,000	11,386	36,000	35,995	9,000	8,531
2009	5,000	0	19,800	19,769	20,000	16,078	12,000	12,002	36,000	35,996	9,000	8,768
2010	5,000	263	19,800	19,191	20,000	15,999	12,000	10,994	36,000	36,001	9,000	8,970
2011	5,000	0	19,800	19,092	20,000	14,785	12,000	12,005	36,000	35,726	0	0
2012	5,000	0	19,800	18,128	20,000	12,509	12,000	8,497	36,000	27,895	0	0
2013	5,000	1,118	19,800	18,638	20,000	10,298	12,000	6,992	36,000	36,003	0	0
2014	5,000	0	19,800	11,105	20,000	4,150	12,000	1,203	32,000	32,058	0	0

* Formally part of west coast quota combined with Areas 6 & 8. TAC 1990 to 1994 of 75 tonne, TAC 1995 to 1998 of 78 tonne.

Table 7.8.4 Total Effort (diver days) and Catch Range (kg/diver/day) for each quota year for Roe's abalone in each of the different management Areas

Year	Area 1		Area 2		Area 5		Area 6		Area 7		Area 8	
	Total diver days	Kg/diver /day	Total diver days	Kg/diver / day	Total diver days	Kg/diver/ day	Total diver days	Kg/diver / day	Total diver days	Kg/diver / day	Total diver days	Kg/diver / day
1988	3	127	118	37	47	45						
1989	3	80	218	74	217	63	190	110	311	97	182	114
1990	60	147	209	89	173	80	79	131	378	94	206	142
1991	58	139	156	85	153	83	96	102	309	95	217	167
1992	38	164	222	77	172	79	64	151	178	102	251	186
1993	58	170	222	84	135	78	97	141	336	101	202	143
1994	77	107	214	84	207	82	101	146	349	98	187	139
1995	32	174	164	109	168	109	84	139	545	73	220	108
1996	40	152	187	92	193	91	105	124	470	98	173	109
1997	43	189	191	93	151	109	80	176	372	97	192	136
1998	29	148	139	94	113	107	96	125	254	95	205	102
1999	22	249	170	99	158	120	76	154	184	196	210	114
2000	19	292	161	110	176	113	89	135	169	216	193	83
2001	18	209	160	112	191	98	116	107	202	175	136	80
2002	9	315	161	112	191	104	127	95	214	168	131	91
2003			155	115	188	95	117	103	214	168	167	72
2004	53	151	141	126	220	89	113	103	178	202	181	80
2005	1	237	121	157	197	97	116	103	176	204	164	68
2006	10	120	153	128	173	105	110	109	196	184	139	86
2007	2	651	145	131	150	107	100	120	215	167	101	64
2008	13	39	134	147	171	100	99	115	199	181	115	74
2009			103	192	126	128	112	107	210	171	98	89
2010	4	66	115	167	145	110	103	107	192	188	116	77
2011			120	159	131	113	99	121	183	195	0	
2012			119	152	100	125	80	106	165	169	0	
2013	3	373	153	122	132	78	75	93	226	159	0	
2014			89	125	64	65	11	109	247	130	0	

8.2 Appendix 2. Risk ratings of identified risks in the 2002 ERA workshop*

Component and Sub/component	Issue	Risk Rating
Retained species		
Greenlip Abalone Area 1	Impact on Breeding stock	C1 L4 - LOW
Greenlip Abalone Area 2	Impact on Breeding stock	C1 L4 - LOW
Greenlip Abalone Area 3	Impact on Breeding stock	C3 L4 - MODERATE
Greenlip Abalone Area 4	Impact on Breeding stock	NEGLIBLE
Brownlip Abalone Area 1	Impact on Breeding stock	C0 L3 - NEGLIGIBLE
Brownlip Abalone Area 2	Impact on Breeding stock	C2 L5 - MODERATE
Brownlip Abalone Area 3	Impact on Breeding stock	C3 L4 - MODERATE
Brownlip Abalone Area 4	Impact on Breeding stock	NEGLIGIBLE
Roe's Abalone Area 1	Impact on Breeding stock	C2 L5 - MODERATE
Roe's Abalone Area 2	Impact on Breeding stock	C2 L3 - MODERATE
Roe's Abalone Area 3	Impact on Breeding stock	C3 L3 - MODERATE
Roe's Abalone Area 5	Impact on Breeding stock	C3 L3 - MODERATE
Roe's Abalone Area 6	Impact on Breeding stock	C3 L3 - MODERATE
Roe's Abalone Area 7	Impact on Breeding stock	C3 L4 - MODERATE
Roe's Abalone Area 8	Impact on Breeding stock	C3 L3 - MODERATE
Non retained species		
Piggy-Backers	Impact on Breeding stock	
General environment		
Removal of all organisms	Removal of abalone and piggy-back species on the ecosystem	C1 L4 - LOW
Discarding undersize abalone	Impact on environment from discards	C0 L1 - NEGLIBLE
Discarding abalone gut	Impact on trophic structure	C0 L2 - NEGLIGIBLE
Non-native and disease introduction	Impact of translocation of organisms on vessel hulls	C4 L0 - MODERATE
Stock enhancement	Impact of stock enhancement	C4 L0 - MODERATE
Scraping abalone from rocks	Impact of scraping abalone from rocks	C0 L1 - NEGLIGIBLE
Diver/diver gear	Impact of interaction between diver gear and habitat	C0 L1 - NEGLIBLE
Reef Walking	Impact of reef walking	C0 L1 - NEGLIGIBLE
Indirect Interactions	Impact on other wildlife	C0 L1 - NEGLIGIBLE
Heat Wave events	Impact of heatwave events	C5 L4 - MODERATE

*Note this ERA was updated in 2009 and 2014 with no changes to the risk ratings.

8.3 Appendix 3. Likelihood and Consequence tables

Standard Consequence — Likelihood Risk Matrix

		Likelihood				
		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)	Certain (5)
Consequence	Minimal (1)	1	2	3	4	5
	Moderate (2)	2	4	6	8	10
	High (3)	3	6	9	12	15
	Major (4)	4	8	12	16	20
	Catastrophic (5)	5	10	15	20	25

Risk Levels applied by the Department of Fisheries

Risk Category / Level	Description	Likely Reporting & Monitoring Requirements	Likely Management Action
1 Negligible	Acceptable; Not an issue	Brief justification – no monitoring	Nil
2 Low	Acceptable; No specific control measures needed	Full justification needed – periodic monitoring	None specific
3 Medium	Acceptable; With current risk control measures in place (no new management required)	Full Performance Report – regular monitoring	Specific management and/or monitoring required
4 High	Not desirable; Continue strong management actions OR new / further risk control measures to be introduced in the near future	Full Performance Report – regular monitoring	Increased management activities needed
5 Severe	Unacceptable; Major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

LIKELIHOOD LEVELS

(Note: If not measurable, Likelihood Level is essentially 0)

1. Remote – Never heard of but not impossible here (< 5 % probability)
2. Unlikely – May occur here but only in exceptional circumstances (> 5 %)
3. Possible – Clear evidence to suggest this is possible in this situation (> 30 %)
4. Likely – It is likely, but not certain, to occur here (> 50 %)
5. Certain – It is almost certain to occur here (> 90 %)

CONSEQUENCE LEVELS

Note: if not measurable Consequence Level is essentially 0

FISH STOCKS (retained / non-retained species) – measured at a stock level

1. Measurable but minor levels of depletion of fish stock
2. Maximum acceptable level of depletion of stock
3. Level of depletion of stock unacceptable but still not affecting recruitment level of the stock
4. Level of depletion of stock are already (or will definitely) affect future recruitment potential / level of the stock
5. Permanent or widespread and long-term depletion of key fish stock, close to extinction levels

ETP SPECIES – measured at a population or regional level

1. Level of capture is common but will not further impact on stock and is well below that which will generate public concern
2. Level of capture is the maximum that will not impact on recovery or cause unacceptable public concern
3. Recovery may be being affected and/or some clear, but short-term public concern will be generated
4. Recover times are clearly being impacted and/or public concern is widespread
5. Further declines in ETP species stocks are occurring or major public concern is ongoing

HABITATS – measured at a regional level

1. Measurable impacts to habitats but still not considered to impact on habitat dynamics or system
2. Maximum acceptable level of impact to habitat with no long-term impacts on region-wide habitat dynamics
3. Above acceptable level of loss / impact with region-wide dynamics or related systems may begin to be impacted
4. Level of habitat loss clearly generating region-wide effects on dynamics and related systems
5. Total region-wide loss of habitat and associated systems

ECOSYSTEM / ENVIRONMENT – measured at a regional level

1. Measurable but minor change in the environment or ecosystem structure but no measurable change to function
2. Maximum acceptable level of change in the environment / ecosystem structure with no material change in function
3. Ecosystem function altered to an unacceptable level with some function or major components now missing and/or new species are prevalent
4. Long-term, significant impact with an extreme change to both ecosystem structure and function; different dynamics now occur with different species / groups now the major targets of capture or surveys
5. Permanent or widespread long-term damage to the environment; total collapse or complete shift in ecosystem processes

PUBLIC REPUTATION and IMAGE

1. Negligible negative impact and news profile
2. Low negative impact, low news profile
3. Some public embarrassment, moderate impact and news profile, minor Ministerial involvement
4. High public embarrassment, high impact and news profile, third-party actions, public and significant Ministerial involvement
5. Extreme public embarrassment, very high multiple impacts, high widespread news profile, third-party actions, public and prolonged Ministerial involvement, Government censure, Upper House enquiry

ECONOMIC – measured at a regional or entire fishery level

1. A small, measurable but temporary impact on economic sustainability of some fishers in relevant fisheries
2. A minor, ongoing impact on economic sustainability of all / most fishers in relevant fisheries
3. Temporary significant impact on economic sustainability or ongoing moderate impact on economic performance of the fishery
4. Long-term, major reduction in economic sustainability for relevant fisheries and their related industries
5. Permanent and widespread complete cessation of economic sustainability for the relevant fisheries and their related industries

SAFETY AND HEALTH

1. First Aid Only
2. Some minor medical treatment required, eg visit to doctor's surgery. Less than a week off work.
3. Hospitalisation and/or intensive and extended treatment period required.
4. Serious or extensive injuries / disease. Hospitalisation and extended recuperation period > 1 month
5. Death or multiple severe permanent disabilities.

SOCIAL

1. Temporary and minor additional stakeholder restrictions or expectations (< 1 year)
2. Some minor ongoing restrictions or loss of expectations
3. Some important expectations suspended or severely restricted in the medium term (> 2 years)
4. Long-term suspension or restriction of expectation in some key activities
5. Permanent loss of all key expectations for activities on this asset

COMMUNITY (Social Structures / Culture) – measured at a regional level

1. Some minor impacts may be measurable but minimal concerns
2. Clear impacts but no local communities threatened or social dislocations
3. Major impacts at least at local level, disruptions now evident
4. Impacts occurring at broader level or severe local impacts
5. Complete alteration to social structures across a region

OPERATIONAL EFFECTIVENESS

1. Minor delay in achievement of a key deliverable
2. Minor element of one key deliverable unable to be achieved on time
3. Significant delay in achievement of key deliverable
4. Non-achievement of more than one key deliverable or major delay to entire strategic directive
5. Non-achievement of an entire strategic directive

8.4 Appendix 4: Stakeholder Workshop Participants and Reviewers

Attendees	Representative Body
Facilitators	
Dr Brent Wise	Department of Fisheries WA
Dr Fiona Webster	Department of Fisheries WA
Kendra Travaille	Department of Fisheries WA
Participants	
Dr Anthony Hart	Department of Fisheries WA
Dave Murphy	Department of Fisheries WA
Dr Emily Fisher	Department of Fisheries WA
Julia Pezzaniti	Department of Fisheries WA
Marion Massam	Department of Fisheries WA
Martin Holtz	Department of Fisheries WA
Richard Petty	Department of Fisheries WA
Sascha Brand Gardner	Department of Fisheries WA
Shane Walters	Department of Fisheries WA
Tim Nicholas	Department of Fisheries WA
Melissa Evans	Department of Parks and Wildlife
Mike Rule	Department of Parks and Wildlife
Tina Thorne	Aquaculture Council of Western Australia
Nathan Adams	Western Australian Abalone Industry Association (CEO)
Kerry Rowe	Western Australian Abalone Industry Association
John Lashmar	Western Australian Abalone Industry Association
Peter Rickerby	Western Australian Abalone Industry Association
Steve Beres	Western Australian Abalone Industry Association
Todd Strickland	Western Australian Abalone Industry Association
Guy Leyland	Western Australian Fishing Industry Council

Observers

Matt Watson	Marine Stewardship Council (MSC)
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Other invited attendees (who did not respond)

Ray Masini	Environmental Protection Authority of WA
Gordon Motherwell	Environmental Protection Authority of WA
Keven McAlpine	Environmental Protection Authority of WA
Andrew Rowland	Recfishwest
Piers Verstegen	Conservation Council of WA
Peter Robertson	WA Wilderness Society
Paul Gamblin	World Wildlife Fund
Justin Bellanger	South Coast Natural Resource Management
Wayne Nannup	South West Aboriginal Land and Sea Council

Apologies

Professor Peter Cook	Abalone and Aquaculture Scientist, Director of Aquaculture Stewardship Council
Dr Fred Wells	Consultant Marine Ecologist (ex-curator of Molluscs WA Museum)
Kerry Cameron	Department of the Environment
Lisa Kirkendale	WA Museum
Jane Fromont	WA Museum

Additional Reviewers of EBFM Risk Assessment Report

Dr Fred Wells	Consultant Marine Ecologist (ex-curator of Molluscs WA Museum)
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