

**AUSTRALIAN HERRING
RESOURCE HARVEST
STRATEGY
2016 – 2021**

DRAFT

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1 INTRODUCTION

Harvest strategies for aquatic resources managed by the Western Australian (WA) Department of Fisheries (the Department) are formal documents prepared to support the management decision-making process and ensure it is consistent with the principles of Ecologically Sustainable Development (DoF 2002) and Ecosystem Based Fisheries Management (DoF 2010; Fletcher et al., 2010). The objectives of ESD are reflected in the objects of the *Fish Resources Management Act 1994* (FRMA), Section 3, and the draft *Aquatic Resources Management Bill 2015*, Clause 9, which will replace the FRMA once enacted.

The publication of these strategies is intended to make the decision-making considerations and processes for the management of specified aquatic resources publicly transparent and provide a basis for informed dialogue on management actions with resource users and other stakeholders (DoF, 2015; Fletcher et al., 2016).

These strategies provide guidance for decision-makers, but do not derogate from or limit the exercise of discretion required for independent decision-making under the FRMA by either the Minister for Fisheries, the Director General of the Department or other delegated decision-makers in order to meet the objects of the FRMA.

Harvest strategies make explicit the objectives, performance indicators, reference levels, and harvest control rules for each defined ecological resource taken into consideration by the Department when preparing advice for the Minister for Fisheries (DoF 2015). 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 and the broader goals of ESD and EBFM. This requires a resource-based approach whereby all fishing activities (commercial, recreational and customary) affecting a resource are considered collectively.

In accordance with the Department's *Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia* (DoF 2015) this harvest strategy outlines the additional recovery-phase performance indicators, reference levels, and harvest control rules that have been implemented to rebuild the resource, and which form the basis of the recovery plan.

1.1 Review Process

It is recognised that fisheries change over time and that a review period should be built into each harvest strategy to ensure that it remains relevant. This harvest strategy will remain in place for a period of five (5) years, after which time it will be fully reviewed; however, the document may be subject to further review and amended as appropriate within the five year period.

2 SCOPE

This harvest strategy relates to the Australian herring (*Arripis georgianus*) resource and the fishing activities that impact this resource in the South Coast and West Coast Bioregions of WA (Figure 1). The species is targeted in estuarine and nearshore waters by both commercial and recreational fishers.

The strategy for the herring resource has been developed in line with the Government's *Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia* (Fisheries Management Paper No. 271) and relevant state (Fletcher, 2002) and national policies/strategies (ESD Steering Committee 1992), and guidelines (e.g. Fletcher et al., 2004; Sloan *et al.* 2014).

Given the current high sustainability risk to herring, this first version of the harvest strategy is focused on the impacts of fishing on the herring resource. Consistent with the Department's policy, however, as the impacts of herring fishing on other ecological components such as bycatch, habitats and endangered, threatened and protected (ETP) species are currently considered low risk (Smith et al., 2015) they did not require inclusion. Harvest strategies for these components will only be developed and included in future versions if this becomes relevant.

This document has been developed in consultation with the WA Fishing Industry Council (WAFIC), Recfishwest and the South Australian Research and Development Institute (SARDI) and has been approved by the Director General of the Department of Fisheries and the Minister for Fisheries.

2.1 Environmental Context

The South Coast and West Coast Bioregions of WA have a Mediterranean climate, with most rainfall occurring during the winter months. Coastal water temperatures are strongly influenced by the Leeuwin Current, which transports warm, low-nutrient water from the tropics southward along the shelf break and outer parts of the shelf. The Leeuwin Current suppresses predictable large-scale upwelling on the west coast and, as a result, plays a role in maintaining low levels of productivity. The ecology of the region is also influenced by the lack of river discharge along the coast, with the few significant rivers in south-western WA only flowing intermittently. A low run-off and limited terrigenous nutrient inputs results in low turbidity, making the coastal waters of south-western WA relatively clear (CoA 2008).

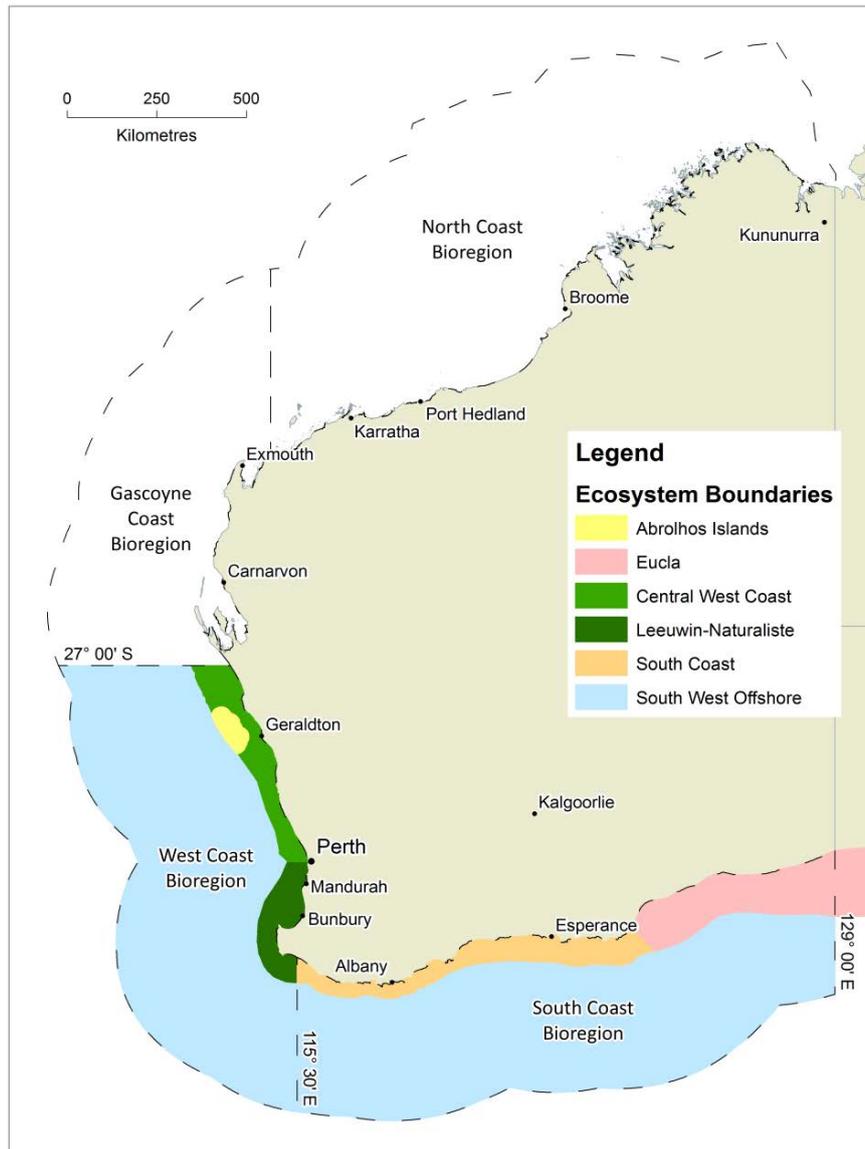


Figure 1. Map of the South-West Bioregions and associated ecosystems.

2.2 Target Species— Australian herring

Australian herring is a schooling fish that occurs in coastal waters and the lower reaches of estuaries. The species is endemic to southern Australia, occurring from Shark Bay (WA) southwards to Port Phillip Bay (Victoria). It represents a genetically homogeneous population across this range. The breeding stock occurs only in the West Coast Bioregion (WCB) of WA (Smith and Brown 2014). Other areas, including the south coast of WA, South Australia and Victoria, contain immature / pre-spawning fish, which migrate to the WCB prior to spawning. Adults remain in the WCB after spawning (i.e. there is no evidence of a return migration back to the south coast). Due to this life cycle, the age/size composition of fishery landings varies between regions. Although herring are caught in WA, South Australia and Victoria, the quantity of herring caught in Victoria is regarded as insignificant, while the recreational and commercial fisheries in WA and South Australia take significant quantities of herring.

Landings along the southern coast of Australia are dominated by juveniles and young adults, whereas fishery landings in the WCB are comprised of a wider range of ages and sizes that are representative of the entire breeding stock (Ayvazian *et al.* 2000, Smith *et al.* 2013).

Stock assessments in 2009/10-2010/11 (Smith *et al.* 2013) and 2011/12-2012/13 (DoF unpubl.) demonstrated that overfishing of the herring resource had been occurring. The management response to these findings was guided by the Minister for Fisheries stated preference that access to the herring resource should be for recreational amenity and human consumption purposes, rather than as low value bait.

To achieve the required catch reduction, of 50 to 100% of the total catch, and consistent with the Government's policy position, in March 2015 the Minister for Fisheries decided to close the south coast commercial 'G-trap' fishery (which was largely a bait fishery) and reduced the recreational bag limit for herring from 30 to 12. Following successful implementation of these adjustments, herring stocks are now considered to be in a recovery phase and are being monitored to assess recovery.

2.3 Fishing Activities

2.3.1 Governance

In Western Australia Australian herring is targeted by commercial, recreational and customary fishing sectors. These fishing sectors are managed by the Department under the following legislation and administrative tools:

- *Fish Resources Management Act 1994 (FRMA)*;
- *Fish Resources Management Regulations 1995 (FRMR)*;
- FRMA Part 6 – Management Plans (e.g. *Cockburn Sound (Fish Net) Managed Fishery Management Plan 1995* and *South Coast Estuarine Managed Fishery Management Plan 2005*);
- FRMA Section 43 Orders (e.g. *Closed Waters Professional Netting (Rivers, Estuaries, Inlets and Lakes South of 23 ° South Latitude) Notice 1992*, *Closed Waters Recreational Netting Restrictions (Rivers, Estuaries, Inlets and Lakes South of 23 ° South Latitude) Notice 1992* and *Prohibition on Commercial Fishing (South-West Coast Beach Net) Order 2010*);
- Fishing Boat Licence Conditions; and
- Commercial Fishing Licence Conditions.

Fishers must also comply with the requirements of:

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

- Western Australian *Conservation and Land Management Act 1984*.

2.3.2 Commercial Fishing

Australian herring have been caught using set and haul nets in estuaries and off the beaches of south-western WA since the early years of colonisation (Walker and Clarke 1987). It was not until the mid-1940s, however, that commercial catches of this species started to increase as a consequence of the establishment of a beach seine fishery for Western Australian salmon (*Arripis truttaceus*) between Perth and Bremer Bay (Ayvazian *et al.* 2000).

During the 1950s and 1960s, the majority of Australian herring caught in south-western WA was canned and the remainder sold on the fresh fish market (Ayvazian *et al.* 2000). It was also around that time that rock lobster fishers started to target this species for bait. The annual commercial catch of Australian herring in the WCB reached a historical peak of 211 t in 1988, with catches in the South Coast Bioregion (SCB) peaking at 1427 t in 1991 (Smith *et al.* 2013). Since then, commercial catches of this species in WA have steadily declined as a result of a combination of factors, including declines in fishing effort due to reduced availability of fish and low market demand.

Australian herring is currently commercially landed in very small amounts by a number of commercial fisheries in south-western WA using different types of set and haul nets. The majority of commercial Australian herring catches over the past decade have been landed in the SCB by the South Coast Trap Net Fishery (also known as the 'G-trap' fishery) and the South Coast Estuarine Managed Fishery, with smaller catches taken in the WCB by the Cockburn Sound (Fish Net) Managed Fishery and a beach seine fishery operating in coastal waters around Bunbury. In 2014 the state-wide commercial catch of herring across all fisheries was approximately 150 t (Fletcher and Santoro 2015).

2.3.3 Recreational Fishing

The recreational catch of Australian herring is mostly taken by shore or boat-based line fishing (angling). Approximately 60-70% of the total recreational catch of Australian herring is believed to be taken by shore-based fishers (Smith *et al.* 2013). There are no current estimates of the total recreational catch of this species due to the lack of recent surveys of shore-based fishing. During the 2009/10-2010/11 assessment, the total recreational catch was estimated to be approximately equal to the commercial catch (Smith *et al.* 2013). In 2013/14 the estimated state-wide catch of herring by boat-based anglers was 173,408 fish (s.e.15,113), of which 24% were released (Ryan *et al.* 2015).

2.3.4 Customary Fishing

There are no data on the current level of customary fishing for finfish in estuarine and nearshore waters of south-western WA; however, catches are likely to be low.

2.4 Catch-Share Allocations

The Australian herring resource is fished by commercial, recreational and customary sectors without any explicit catch share allocation between sectors. A formal sectoral allocation process (designated as Integrated Fisheries Management, IFM, in Western Australia) to define and assign long-term sectoral shares of the permitted catch of this resource has not yet been undertaken.

3 HARVEST STRATEGY

3.1 Long-Term Management Objectives

In addition to the ecological sustainability of the resource itself, this harvest strategy also includes social and economic objectives. It is important to note that the social and economic objectives are applied within the context of ESD.

3.1.1 Ecological Sustainability Objective

- 1) To maintain spawning stock biomass of Australian herring at a level where the main factor affecting recruitment is the environment;

3.1.2 Social and Economic Objectives

- 1) That, consistent with the Minister for Fisheries' stated position, access to the herring resource is for recreational amenity and human consumption purposes, rather than as low value bait;
- 2) To provide commercial fisheries with reasonable opportunities to maximise their livelihood in supplying seafood to the community, within the constraints of ecological sustainability; and
- 3) To provide non-commercial fishing participants with reasonable opportunities to maximise cultural, recreational and lifestyle benefits of fishing, within the constraints of ecological sustainability.

3.2 Operational Objectives

Longer-term management objectives are often operationalised by using shorter-term (e.g. annual or periodic) fishery-specific objectives for which one or more performance indicators that can be measured are identified which enables performance to be assessed against pre-defined reference levels. In order to meet the long-term management objectives outlined above, operational objectives have been developed to maintain the resource close to the target level, or rebuild the resource if it has fallen below the threshold or the limit levels (see below).

The Australian herring stock is currently in a recovery phase following management intervention in Western Australia responding to stock assessments in 2009/10-2010/11

(Smith *et al.* 2013) and 2011/12-2012/13 (DoF unpubl.) which demonstrated that overfishing had been occurring. The recovery phase commenced in 2015 when management changes designed to reduce the total Western Australian catch of Australian herring by at least 50% were implemented. The operational objectives for Australian herring are currently focused on stock recovery.

3.3 Harvesting and Management Approaches

The Australian herring resource is harvested in WA using a *constant exploitation approach*, where the annual catch taken varies in proportion to variations in the stock abundance.

In line with this harvesting approach, the commercial net fisheries in the WCB and SCB are managed using a range of management measures (Section 4.1). Effort is primarily constrained by a cap on the number of licences / vessels (limited entry) in each fishery and restrictions on fishing gear (net length and mesh sizes). Spatial and temporal closures further limit fishing effort.

The recreational (finfish) fishing sector is also managed through a range of management measures (Section 4.1). These include spatial and seasonal closures, temporal restrictions, gear controls (e.g. net specifications and mesh sizes), and daily bag limits. Recreational fishers taking herring with the use of a boat are required to hold a current Recreational Fishing from Boat Licence (RFBL). Unlicensed fishers on boats can fish if at least one other person on board has an RFBL, provided the total catch of everyone on board stays within the bag limits of the licenced fisher(s). Additionally, a Recreational Net Fishing Licence (RNFL) is required for all recreational net fishing using set (gill) nets, haul nets or throw nets.

3.4 Performance Indicators, Reference Levels, Harvest Control Rules and Tolerance Levels

Suitable indicators have been selected to describe performance of fisheries for Australian herring in relation to each management objective, with a set of reference levels established to separate acceptable from unacceptable performance. Where relevant, these levels include:

- A target level (i.e. where you want the indicator to be);
- A threshold level (i.e. where you review your position); and
- A limit level (i.e. where you do not want the indicator to be).

Control rules define what management actions should occur based on the value of each performance indicator relative to the limit, threshold or target levels. A summary of the management objectives, performance indicators, reference levels and control rules for the resource is provided in Table 1.

Where a stock (such as herring) is in a recovery phase, instead of using these standard performance levels, the recovery plan should establish how an appropriate rate of recovery

will be measured, consistent with the vulnerability and productivity of the species involved plus the dynamics of the fishery (DoF, 2015; Fletcher, *et al.*, 2016).

3.4.1 Identifying Performance Indicators & Reference Levels

3.4.1.1 Evaluating stock status

The indicator used to evaluate the status of the Australian herring stock is spawning biomass, or an appropriate proxy (Table 2). Historically fishing mortality (F) (year^{-1}) was used as a proxy for spawning biomass. However, with the availability of recent biological information future assessments will be based on spawning potential ratio (SPR). The performance indicator will be estimated periodically and compared to associated reference levels (Table 1) that are consistent with those used by the Department in other similar assessments and are based on internationally accepted benchmarks (Mace 1994; Caddy and Mahon 1995; Gabriel and Mace 1999; Wise *et al.* 2007).

Table 1. Harvest strategy for Australian herring, including reference levels, and harvest control rules.

Management objectives	Performance Indicators	Reference Levels	Control Rules
Ecological			
To maintain spawning stock biomass at a level where the main factor affecting recruitment is the environment.	Periodic estimates of spawning stock biomass (B , or appropriate proxy)	<p>Target: B_{Target}</p> <p>Threshold: $B_{\text{Threshold}}$</p> <p>Limit: B_{Limit}</p>	<p>No management action required.</p> <p>If the Threshold is breached, a review is triggered to investigate the reasons for the variation. If sustainability is considered to be at risk, appropriate management action will be taken to reduce the total catch by up to 50%.</p> <p>If the Limit is breached, management strategies to further protect the breeding stock will be implemented (50 – 100% reduction of total catch).</p>
To recover spawning stock biomass to a level where the main factor affecting recruitment is the environment.	Periodic estimates of spawning stock biomass (B , or appropriate proxy)	<p>Target: $B_{t+1} > B_t$</p> <p>Threshold: $B_{t+1} \leq B_t$</p>	<p>No management action required.</p> <p>If the Threshold is breached, a review is triggered to investigate the reasons for the variation. If sustainability is considered to be at risk, appropriate management action will be taken to reduce the total catch by up to 50%.</p>

3.4.1.2 Recovery Phase Reference Levels

Australian herring is relatively short-lived (maximum age ~12 years). Sexual maturity and recruitment to the fishery occur at age 2-3 years. The age structure of samples collected in 2013/14 and-2014/15 suggests very limited numbers of fish older than 4 years exist in the population and the indicators (SPR and F) were both below their limit reference levels (see

Appendix 1). Based on the biological attributes of herring, simulation modelling predicts that the 50% catch reduction in 2015 will have sufficiently reduced fishing mortality to enable stock recovery to between the threshold and limit level in 3 to 6 years (Table 2).

Given the precision of the performance indicators available, the reference levels that will be used during the recovery phase will be based on the direction of their trajectory. Evidence of an acceptable level of stock recovery occurring will be measured by comparing estimates of SPR among assessments. If the SPR is increasing (i.e. $SPR_{t+1} > SPR_t$) and estimates of F are decreasing (i.e. $F_{t+1} < F_t$) over time (t) this will be considered adequate recovery performance. Changes in the trajectories among assessments may not be linear due to factors influencing stock abundance and structure, e.g. variable recruitment strength.

3.4.1.3 Economic and Social Benefits

In line with the principles of ESD, this harvest strategy also includes objectives for the economic and social amenity benefits of fishing. These objectives relate to the provision of opportunities to ensure (1) commercial fishers can maintain / enhance their livelihood and (2) that all recreational fishers can maximise cultural, recreational and / or lifestyle benefits of fishing. It is important to note that management actions relating to these objectives are applied within the constraints of ecological sustainability.

The economic and social objectives do not currently have explicit performance measures within this harvest strategy. Rather, it is through formal consultation processes that regulatory impediments to maintaining or enhancing economic return, and maximising social benefits of fishing, are discussed. Where possible, and in due consideration of ecological sustainability, fisheries management arrangements can be adjusted or reformed to help meet these objectives.

If suitable and measurable indicators for monitoring performance against the economic and social objectives are identified, these may be included in future revisions of this harvest strategy.

3.4.2 Control Rules

A review of management arrangements is triggered if evaluation against the operational objectives indicates the potential need for a management response (i.e. when a threshold level is breached) (Figure 2). This facilitates a precautionary approach to management, with potential issues recognised and addressed in a timely manner prior to the following fishing season.

When a threshold reference level is breached, management responses are likely to vary depending on the extent and circumstances related to the variation. Examples of management responses include restricting effort via spatial, temporal or additional gear restrictions. The ability to, and timeframe for, implementing these changes depends on the legal instrument under which the management measure occurs. Further information on the management measures in place for this fishery is provided in Section 4.

Table 2. Performance indicator and associated reference levels used to evaluate the status of the Australian herring stock. (where B_x = Biomass at x% of unfished level)

Performance Indicator	Reference Levels		
	Target	Threshold	Limit
Spawning biomass (B)	B_{40}	B_{30}	B_{20}
Spawning potential ratio (SPR)	SPR_{40}	SPR_{30}	SPR_{20}

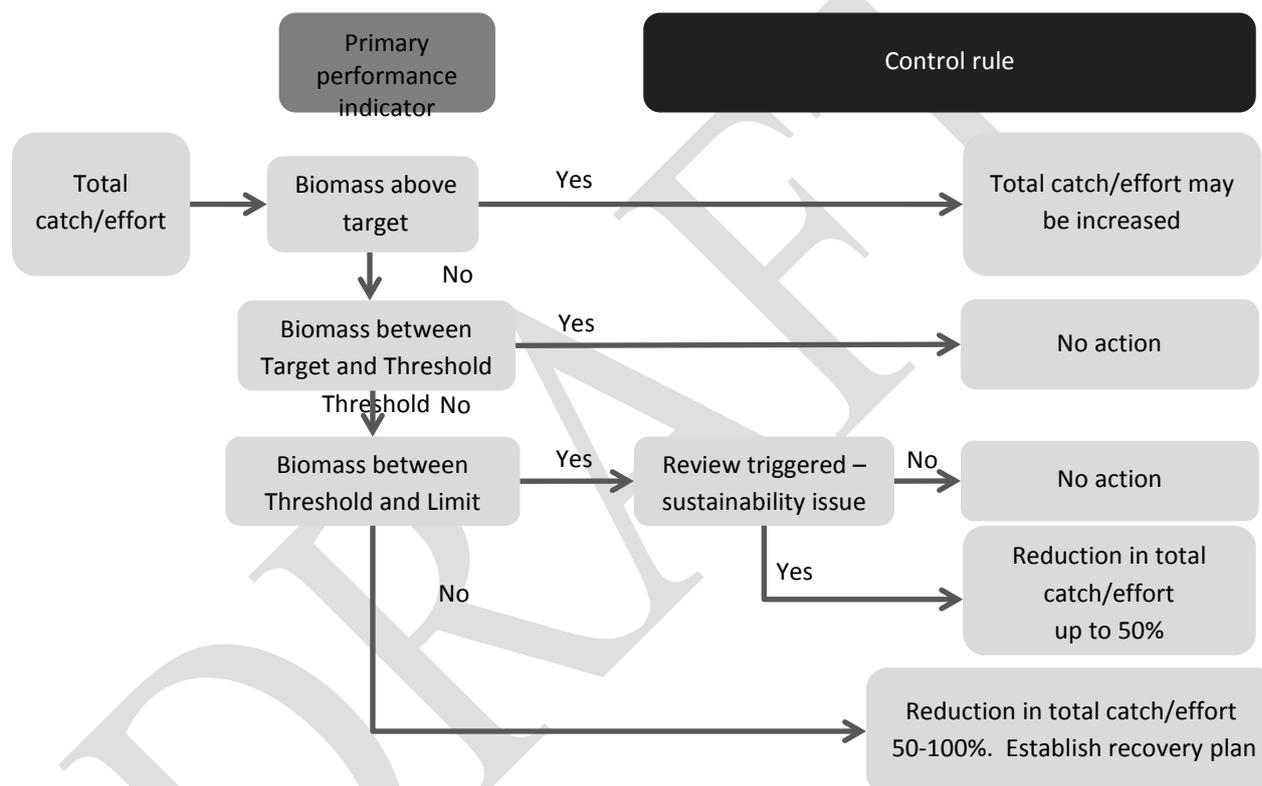


Figure 2. Harvest control rule decision tree.

3.4.3 Annual Tolerance Levels

Defining annual tolerance levels provides a formal but efficient basis to annually evaluate the effectiveness of current management arrangements in delivering the levels of catch (or effort, for quota-managed fisheries) specified by harvest control rules and, where relevant, any sectoral allocation decisions (Fletcher *et al.* 2016). If the annual catch and effort remains within the ‘tolerance range’ appropriate to the current stock status and control rule (based on historical variations in recruitment and/or fishing operations) the fishery is considered to be operating ‘acceptably’ with no need to adjust the management settings. Where the annual catch or effort falls outside of this range and this cannot be adequately explained (e.g. clear environmental or market induced impacts), this may result in adjustments to management

settings, further review of the cause and potentially a revision of the tolerance levels. If the status of the resource changes such that the control rules trigger additional management adjustments, the tolerance range for each fishery must also be adjusted accordingly.

For Australian herring, the current catch tolerance range used to assess annual commercial fishery performance is 50-179 tonnes. This range represents the minimum and maximum total annual catches by ‘minor’ herring fisheries (i.e. excluding G-trap net fishery) over the period 2000-2014. In these years, the G-trap net fishery contributed 55-82% of the total annual commercial catch. Thus the closure of the G-trap net fishery in 2015 effectively met the Control Rule that stipulated a >50% reduction in the total commercial catch. On this basis, the remaining commercial fisheries are expected to maintain their total catch within the 2000-2014 range during the recovery phase.

The current catch tolerance range used to assess annual recreational fishery performance is based on boat-based catches remaining below the estimated 2013/14 state-wide catch of herring (Ryan *et al.* 2015) (Table 3).

Table 3. Australian herring annual catch tolerance ranges (in tonnes) for commercial and recreational fisheries.

Fishery	Catch tolerance level (t)
Commercial	50-179
Recreational (boat-based)	<16

3.5 Monitoring and Assessment Procedures

3.5.1 Information and Monitoring

3.5.1.1 Age Structure

Fishery-dependent sampling of age structure of the stock has been conducted annually since 2009/10 in the commercial and recreational sectors. Occasional fishery-dependent sampling of age structure was conducted in previous years (since the 1980s), which allows some comparisons with current data (Smith *et al.* 2013). The age compositions of commercial and recreational fishery landings are sampled in the southern part of the WCB (Perth to Cape Naturaliste). The age structure in this area is considered to be the representative of the age structure of the breeding stock (Appendix 1).

3.5.1.2 Other information

In addition to using age samples as the main basis for assessing status of the stock, other sources of information can help improve understanding of stock status. Therefore, a range of additional fishery-dependent and fishery-independent information is collected for Australian herring. Catch and effort for the commercial sector is reported in statutory monthly catch and

effort (CAES) returns. Estimates of catch and effort for parts of the recreational sector are collected through periodic fishing surveys undertaken by the Department. Fishery-independent recruitment surveys have also been undertaken by the Department since 1993 and studies of the biological characteristics of herring have periodically been undertaken. These sources of information are considered during stock assessments (Smith *et al.* 2013). Finally, anecdotal information from fishers (commercial and recreational) also provides additional insights into stock status.

3.5.2 Assessment Procedure

The age structure data is used in a catch curve analysis to estimate the instantaneous rate of total mortality (Z), and the instantaneous rate of fishing mortality (F) is then determined from the relationship $Z = F + M$, where M is instantaneous rate of natural mortality. M is estimated from a regression equation that is based on the maximum age in the stock (12 years for Australian herring).

The catch curve analysis is based on a model fitted to age and length data which accounts for annual variability in recruitment and length based-selectivity. This is compared to a traditional age-based catch curve approach based on the mean age of fully recruited fish in a sample (Chapman and Robson 1960) to assess differing modelling assumptions. Sensitivity of results to the M estimate are considered in the assessment. The estimates from these catch curve analyses are subsequently used in combination with other information (e.g. growth, size at maturity) in a per recruit analysis to estimate spawning potential ratio (SPR). The catch curve analysis, per recruit analysis along with other information including catch, catch rates, biological age and length data are used in a Risk-Based Weight of Evidence assessment approach to determine stock status.

Assessments are scheduled every two years, based on a data collection period of two years for each assessment. Completion of each assessment (after allowing time for data analysis, reporting and review) is expected to occur 12 months after data collection. The next assessments are scheduled for completion in mid-2018 and mid-2020 (Appendix 1).

4 MANAGEMENT MEASURES AND IMPLEMENTATION

4.1 Management Measures

There are a number of management measures in place for the commercial and recreational fishing sector (Table 3 and Table 4), which can be amended as needed to ensure this sector is achieving the resource objectives. These do not preclude the consideration of other options.

Table 1 Management measures and instrument of implementation for the Australian herring resource (commercial sector)

Measure	Description	Instrument
Limited Entry	<p>Fishers operating in a number of commercial “limited entry” fisheries take herring, including:</p> <ul style="list-style-type: none"> • Herring G-net Fishery (currently closed) • South Coast Estuarine Fishery • West Coast Estuarine Fishery • Cockburn Sound Fish Net Fishery <p>Herring are also taken in the South Coast open access line and net fishery. Access to and the future management of these open access fisheries is currently under review with a view to transitioning to managed fisheries (with limited entry)</p>	Relevant Management Plan
Effort Restrictions	With the exception of the South Coast open access line and net fishery, all of the other commercial fisheries that take herring are subject to effort controls	Relevant Management Plan Licence Conditions
Gear Controls	Restrictions on net length, mesh size and set depth for set and / or haul nets.	Relevant Management Plan Notices and Orders Licence Conditions
Spatial Closures	Parts of the Peel-Harvey Estuary, South Coast estuaries and some oceanic waters are permanently closed to commercial fishing.	Relevant Management Plan
Size Limits	Species-specific size limits are in place for some finfish species, however there is no minimum legal size for Australian herring	FRMR
Reporting	Fishers are required to report all retained species catches, effort, ETP species interactions and fishing location in statutory monthly logbooks.	FRMR

Table 2. Management measures and instrument of implementation for the Australian herring resource (recreational sector)

Measure	Description	Instrument
Effort Restrictions	Each recreational net fisher is only permitted to use a limited amount of gear when fishing for herring. Fishers operating from a boat are required to hold a current Recreational Fishing from Boat Licence.	FRMR

Gear Controls	Fishers may only take herring using permitted recreational fishing methods.	FRMR
Size Limits	There is no species-specific size limit for herring.	FRMR
Bag Limits	Mixed species and individual species daily bag limits are in place for herring	FRMR

4.2 Implementing Changes to the Management Arrangements

Decision-making processes can be triggered following the identification of new issues arising from research, management or compliance investigations.

There are two main processes for making decisions about the implementation of management measures and strategies for the Australian herring resource:

- Annual decision-making processes that may result in measures to meet the short-term, operational fishery objectives (driven by the harvest control rules); and
- Longer-term decision-making processes that result in new measures and / or strategies to achieve the long-term fishery objectives (i.e. changes to the management system).

However, if there is an urgent issue, stakeholder meetings may be called to discuss the issue and determine appropriate management action, as needed.

4.2.1 Consultation

Management changes are generally given effect through amendments to legislation, such as the commercial fishery management plan, regulations and orders. These changes generally require the approval of the Minister for Fisheries. In making decisions relevant to fisheries, the Minister for Fisheries may choose to receive advice from any source, but has indicated that:

- 1) The Department is the primary source of management advice;
- 2) Peak Bodies (Western Australian Fishing Industry Council [WAFIC] and Recfishwest) are the primary source of commercial and recreational sector advice and representation, respectively; and
- 3) Consultation with the public, other Government agencies, marine users, Native Title parties and NGOs is undertaken by the Department as needed.

The peak bodies are funded by Government under Service Level Agreements (SLAs) to undertake their representation/advisory and consultation roles.

4.2.1.1 Commercial Sector Consultation

Under its SLA with the Department WAFIC has been funded to undertake statutory consultation functions related to fisheries management plans and the facilitation of annual management meetings for licensed fisheries.

The FRMA requires the Minister to consult with affected parties when changes to a Part 6 management plan are being considered. In the case this includes all licence holders. Annual Management Meetings (AMM) between the Department, WAFIC and licence holders are generally held annually and are used as the main forum to consult with stakeholders and licence holders on the management of the fisheries. During these meetings, Departmental (research, management and compliance) staff, licence holders and WAFIC discuss current and future management issues that may have arisen during the previous fishing season and any proposed changes to the management plan. Follow-up meetings may be held as required.

The Department also consults directly with industry, where relevant, on specific management and operational issues.

4.2.1.2 Recreational Sector Consultation

Under the SLA with Recfishwest, the Department is required to consult with Recfishwest as the recognised peak body for recreational fishing in Western Australia. Recfishwest is required to engage and consult with recreational fishers as necessary in order to meet its obligations.

4.2.1.3 Consultation with Other Groups

Consultation with non-fisher stakeholders including Government agencies, conservation sector Non-Government Organisations, customary fishers, statutory advisory committees and other affected / interested parties is undertaken by the Department in accordance with the recently finalised departmental *Stakeholder Engagement Guideline* (Department of Fisheries in prep.). The Department's approach to stakeholder engagement is based on a framework designed to assist with selecting the appropriate level of engagement for different stakeholder groups and includes collaborating with and involving key stakeholders, seeking input from interested parties through a public consultation process and keeping all parties fully informed through the provision of balanced, objective and accurate information. Key fishery-specific documents such as harvest strategies, recovery plans and bycatch action plans are subjected to both formal key stakeholder consultation and public consultation processes.

4.3 Compliance and Enforcement

The key objective of the Department in relation to compliance is to encourage voluntary compliance through education, awareness and consultation activities.

4.3.1 Operational Compliance Plans

Management arrangements are enforced under Operational Compliance Plans (OCPs), with separate OCP's developed for each of the major fisheries in the region. Each OCP is

informed and underpinned by a compliance risk assessment conducted for each fishery. The overarching objectives of each OCP are:

- 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.

The OCP is reviewed every 1-2 years.

4.3.1.1 Compliance Strategies for the commercial fisheries

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

- land and sea patrols;
- inspections of scalefish at wholesale and retail outlets;
- inspection in port;
- at-sea inspection of fishing boats;
- aerial surveillance;
- undertaking covert operations and observations; and
- intelligence gathering and investigations.

Inspections may involve:

- inspection all compartments on board the vessels;
- inspection of all authorizations;
- inspection of associated paperwork;
- inspections of fishing gear; and
- inspection of catch on board the boat.

4.3.1.2 Compliance Strategies for the Recreational Sector

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

- Land patrols;
- On-water patrols;
- Catch, licence and gear inspections;

- Covert surveillance of persons of interest under approved operations;
- Road-side checkpoints; and
- Wholesale / retail inspections.

DRAFT

5 REFERENCES

- Ayvazian, S.G., Jones, G.K., Fairclough, D., Potter, I.C., Wise, B.S. and Dimmlich, W.F. (2000). Stock assessment of Australian herring. Fisheries Research and Development Corporation, Project No. 96/105. 229 pp.
- Caddy, J. and Mahon, R. (1995). Reference points for fisheries management. FAO Fisheries Technical Paper 347. FAO, Rome, 84 pp.
- Chapman, D.G. and Robson, D.S. (1960). The analysis of a catch curve. *Biometrics* 16: 354-368.
- Commonwealth of Australia (CoA). (2008). The South-West Marine Bioregional Plan: Bioregional Profile. Canberra: Department of Environment, Water, Heritage and the Arts.
- Department of Fisheries DoF (2010). A sea change for aquatic sustainability. Fisheries Occasional Publication 79. Department of Fisheries, Western Australia.
- Department of Fisheries DoF (2015). Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia. Fisheries Management Paper 271. Department of Fisheries, Western Australia.
- ESD Steering Committee (1992). National Strategy for Ecologically Sustainable Development. Endorsed by the Council of Australian Governments, December 1992. ISBN 0 644 27253 8.
- Fletcher, W.J. (2002). Policy for the implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia. Fisheries Management Paper 157. Department of Fisheries, Western Australia.
- Fletcher, W.J., Shaw, J., Metcalf S.J. & D.J. Gaughan (2010). An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. *Marine Policy* 34: 1226–1238.
- Fletcher, W. J. and Santoro, K. (eds). (2015). Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: The State of the Fisheries. Department of Fisheries, Western Australia
- Fletcher, W.J., Wise, B.S., Joll, L.M., Hall, N.G., Fisher, E.A., Harry, A.V., Fairclough, D.V., Gaughan, D.J., Travaille, K., Molony, B.W. and Kangas, M. (2016). Refinements to harvest strategies to enable effective implementation of Ecosystem Based Fisheries Management for the multi-sector, multi-species fisheries of Western Australia. *Fisheries Research*. 183: 594-608
- Gabriel, W.L. and Mace, P.M. (1999). A review of biological reference points in the context of the precautionary approach. NOAA Technical Memo NMFS-F/SPO-40, pp. 34-45.
- Lembo, G. (2006). Selected papers presented at the workshop on biological reference points Rome, 20–21 April 2004. Studies and Reviews No. 86. FAO, Rome, 95 pp.
- Mace, P.M. (1994). Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. *Canadian Journal of Fisheries and Aquatic Sciences* 51: 110-122.
- Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. *Rev. Fish Biol. Fish.* 2, 321–338.

- Ryan, K.L., Hall, N.G., Lai, E.K., Smallwood, C.B., Taylor, S.M., Wise, B.S. (2015). State-wide survey of boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. 268, Department of Fisheries, Western Australia. 208pp.
- Sloan, S.R., Smith, A.D.M., Gardner, C., Crosthwaite, K., Triantafillos, L., Jeffries, B. and Kimber, N. (2014). National Guidelines to Develop Fishery Harvest Strategies. FRDC Report – Project 2010/061. Primary Industries and Regions, South Australia, Adelaide.
- Smith K. and Brown J. (2014). Biological synopsis of Australian herring (*Arripis georgianus*). Fisheries Research Report No. 251. Department of Fisheries, Western Australia.
- Smith, K., Brown, J., Lewis, P., Dowling, C., Howard, A., Lenanton, R. and Molony, B. (2013). Status of nearshore finfish stocks in south-western Western Australia Part 1: Australian herring. Final Report on NRM Project 09003. Fisheries Research Report No. 246. Department of Fisheries, Western Australia.
- Smith, K., Quinn, A and M. Holtz (2015). West Coast nearshore and estuarine finfish resources status report. In: Fletcher, W.J. and Santoro, K. (eds.), Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: State of the Fisheries. Department of Fisheries, Western Australia. pp 65-83
- Walker, M.H. and Clarke, D.P. (1987). The Australian herring Fishery in Western Australia, 1973–1985. Fisheries Research Report No. 76, Department of Fisheries, Western Australia, 44 pp.
- Wise, B.S., St John, J. and Lenanton, R. (eds.) (2007). Spatial scales of exploitation among populations of demersal scalefish: Implications for management. Part 1: Stock status of the key indicator species for the demersal scalefish fishery in the West Coast Bioregion. FRDC Final Report on Project No. 2003/052. Fisheries Research Report No. 163. Department of Fisheries, Western Australia, 130 pp.
- Zhou, S, Yin, S., Thorson, J.T., Smith, A.D.M., and Fuller, M. (2012). Linking fishing mortality reference points to life history traits: an empirical study. *Canadian Journal of Fisheries and Aquatic Science* 69: 1292–1301

APPENDIX 1

Monitoring and assessment of the Australian herring stock

Previous assessments

The first age-based stock assessment of Australian herring was completed in 2013 (Smith *et al.* 2013). This comprehensive study included a synthesis of existing biological and fishery information (data from 1970 onwards) combined with additional fishery and fishery-independent sampling during 2009-2012. Stock status was assessed using a ‘weight of evidence’ approach. One of the major lines of evidence used in the assessment was fishing mortality (F), which was used as a proxy for spawning biomass. F estimated after a 2 year sampling period (2009/10 - 2010/11) was well above the limit reference level ($F_{limit} = 3/2M$, where M is natural mortality). Other lines of evidence including catch rate trends, recruitment trends and outcomes of ‘per recruit’ analyses also suggested unacceptable stock status. An independent review found the assessment to be robust and was in agreement with the conclusions (Jones 2013).

A second assessment was completed by the Department in 2014 based on new data collected in 2011/12 – 2012/13, using the same methods as Smith *et al.* (2013). This assessment indicated that stock status remained unacceptable, i.e. F was approximately equal to F_{limit} . An independent review of this assessment agreed with the conclusions, i.e. stock status was unacceptable (Haddon 2014).

A third assessment was completed in 2016 based on data collected in 2013/14 – 2014/15, as well as a re-analysis of data from the previous two assessments. Revised methods were used to estimate F , that took into account more of the available data and sources of uncertainty. This assessment indicated stock status was unacceptable in all years, i.e. a 100% probability that F was above F_{limit} (Appendix Figure 1). Spawning potential ratio (SPR), which is another proxy for spawning biomass, was used as a secondary performance measure in this assessment. There was a 100% probability of SPR being below the limit reference level in 2013/14 – 2014/15 (Appendix Figure 1).

Ongoing Assessment

After reviewing all available fishery-dependent and fishery-independent data, Smith *et al.* (2013) identified the following potential indicators of stock status of Australia herring: 1) **instantaneous rate of fishing mortality (F)** in the breeding stock, 2) **spawning potential ratio (SPR)**, i.e. per recruit analysis to determine ‘spawning potential’ relative to unfished level 3) **regional spawning stock abundance trends** (from fishery CPUE), and 4) **regional recruitment trends**. Stock assessment models to estimate **biomass** have not been developed due to lack of information about the total catch level (i.e. time series of catch from all sectors, particularly the shore-based recreational sector) and the uncertainty in trends in stock abundance and recruitment indices.

Currently, only F and SPR indicators can be used with ‘high confidence’ to assess stock status. Reference levels (Limit, Threshold, Target) for these indicators have been developed and are used to determine the management implications of the assessment. These are based on internationally acceptable levels of sustainability for exploited fish (see Section 3.4).

Estimates of F and SPR are considered along with other information including catch, catch rates, recruitment indices, catch composition (age/length/sex), and biological/ecological attributes, all of which are used in a Risk-Based Weight of Evidence assessment approach to determine stock status.

Indicator 1 - Fishing mortality (F)

The instantaneous rates of total mortality (Z) and fishing mortality (F) are estimated using the 'catch curve' method which requires a representative sample of the age structure of the stock.

The age composition of fishery landings in the southern WCB is believed to provide the best available representation of the age structure of the breeding stock, and is therefore used in the catch curve analysis. This sampling region was selected based on knowledge of fish migratory patterns and stock structure. All available evidence indicates that juveniles are distributed very widely (west and south coasts of WA, South Australia and Victoria), but breeding adults occur only in the WCB. Evidence from numerous tagging studies and surveys of spawning activity indicates that coastal waters from Perth to Cape Naturaliste is the main spawning area for Australian herring (Smith and Brown 2014). Young adults migrate from the south coast (including the south coast of WA, South Australia and Victoria) to the lower WCB to spawn for the first time, and then remain in this area after spawning. There is no evidence of a return migration to the south coast. Tagging has indicated that herring within the WCB continue to migrate northwards during the weeks immediately prior to spawning, with tagged fish moving from Geographe Bay to the Perth over this time, which suggests Perth is a key spawning area. After spawning, fish appear to disperse throughout the southern part of the WCB, but remaining north of Cape Naturaliste.

The age (and length) structure of commercial and recreational landings of herring in the southern part of the WCB (Perth to Cape Naturaliste) are monitored annually. Recreational samples are donated via the 'Send Us Your Skeletons' program, while commercial samples are purchased monthly from commercial fishers. Annual samples of otoliths from 300-500 fish per sector per year are collected, to generate an age structure that provides a robust F estimate.

Age structure samples from commercial and recreational sectors are analysed separately, resulting in two independent F estimates for each assessment period. The F estimate from the recreational sector is used as the performance indicator. The F estimate from the commercial sector is used if the recreational data is not available in a particular assessment period. There have been no statistically significant differences between F estimates from each sector obtained to date.

Recruitment fluctuations are a source of uncertainty when using the catch curve method to estimate mortality. Therefore, multiple* years of data are analysed to provide Z and F estimates, with a lower level of uncertainty than would occur if age structure data from single years were analysed. (*currently two consecutive years of age data are used for herring assessments).

The catch curve analysis is based on a model fitted to age and length data which accounts for annual variability in recruitment and length based-selectivity. This is compared to a traditional age-based catch curve approach based on the mean age of fully recruited fish in a sample (Chapman and Robson 1960) to assess differing modelling assumptions.

F is calculated from the equation $F = Z - M$, where M is the instantaneous rate of natural mortality. M is estimated from the widely used regression equation of Hoenig (1983) as well as a revised version of this equation by Then *et al.* (2014), which are based on the maximum age in the stock (12 years for herring). Sensitivity of results to the M estimate is considered in the assessment.

The estimated F is compared to the limit ($F_{\text{Limit}} = 1.5M$), threshold ($F_{\text{Threshold}} = 1M$) and target ($F_{\text{Target}} = 1.5M$) reference levels to determine stock status and monitor the recovery of the stock.

Indicator 2 - Spawning potential ratio (SPR)

The key biological and fishery characteristics of Australian herring are well studied, including growth, maturity, length-weight relationship and fishing selectivity (Smith and Brown 2014). These data are used in a ‘per recruit’ analysis, which is undertaken for Australian herring to determine the spawning potential ratio (SPR). SPR is the spawning biomass expressed as a proportion of the unfished biomass, at a specified level of fishing mortality (F). SPR is used as a proxy for spawning biomass. Estimation of current SPR is dependent on the estimates of F from the catch curve analyses.

The estimated SPR at current fishing mortality is compared to the limit reference point ($SPR_{0,2}$), threshold reference point ($SPR_{0,3}$) and target reference point ($SPR_{0,4}$) to determine stock status and monitor the recovery of the stock.

Risks to collecting data:

Inadequate WCB recreational fishery sample. As mentioned above, samples of recreationally-caught herring from the WCB are required for F-estimation. These are currently obtained via the Send Us Your Skeletons (SUYS) program. Should the recreational sample size be insufficient (i.e. <300 fish), the commercial fishery sample collected over the same period will be used instead to estimate F

Inadequate WCB commercial fishery sample. Samples of herring are obtained from WCB commercial landings by DOF researchers who take a random, monthly sample of the haul net catch by the *Cockburn Sound Fish Net Managed Fishery*. Samples are purchased at market rates. This relies on i) continued targeting of herring by the fishery, and ii) continued co-operation by the fisher who allows access to landings. To date, samples have been reliably obtained from this fishery and this is expected to continue.

If recreational and commercial sampling both fail to yield an adequate sample, two options to obtain samples from the recreational sector will be explored. Firstly, fishery independent sampling by DoF staff could be undertaken, using recreational line-fishing methods. This type of sampling of herring has proved successful and cost-effective in the past. Secondly, Recfishwest could use its contacts to provide 300 recreational frames to DoF (Research Division) by 30 June each year to use in the assessment.

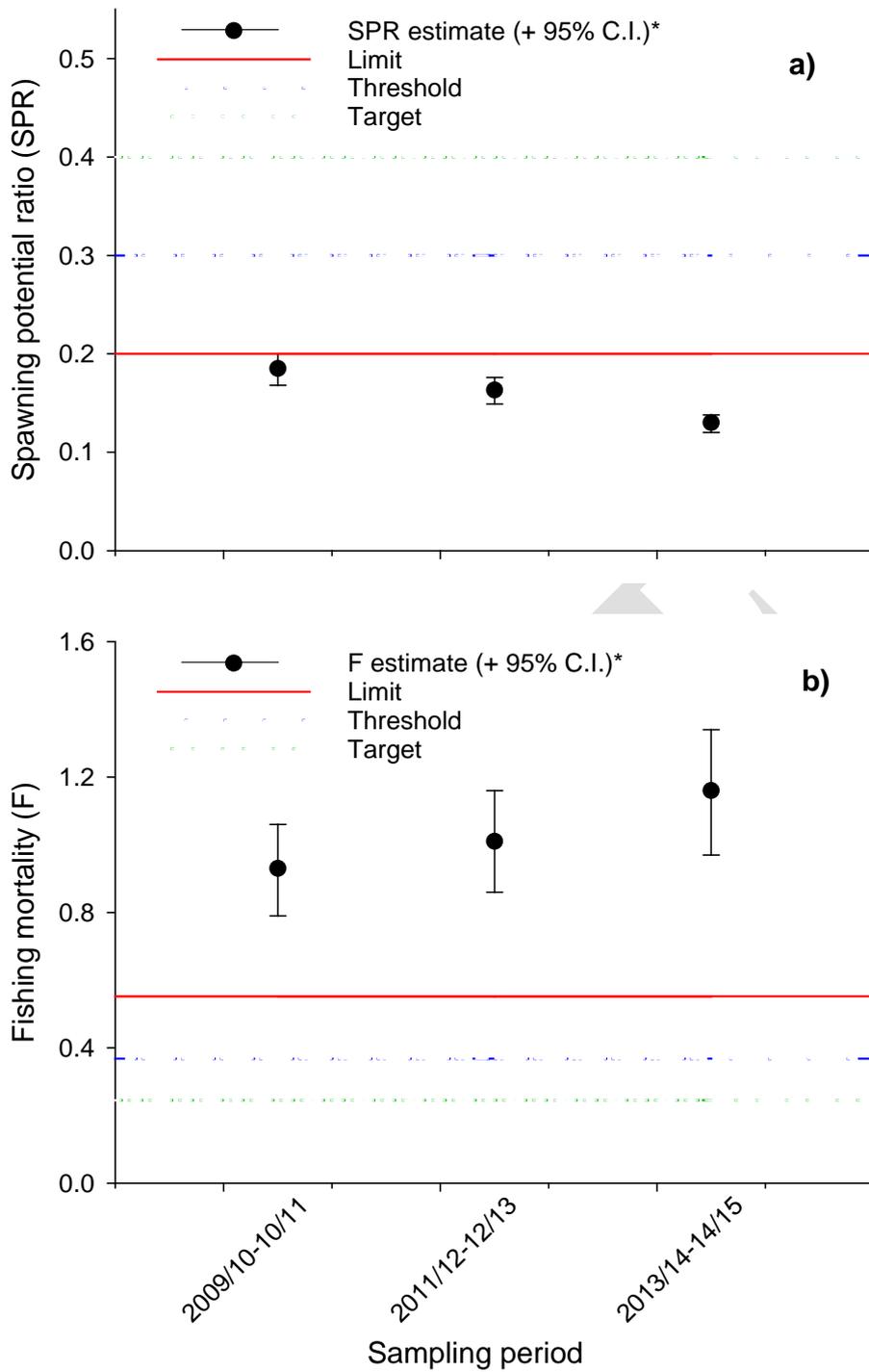
Assessment schedule

DOF currently has a 2 year assessment cycle for Australian herring. The next assessments are scheduled as follows:

<i>July 2015 – June 2017</i>	<i>Data collection</i>
<i>July – Dec 2017</i>	<i>Analysis</i>
<i>Jan – Jun 2017</i>	<i>Preparation of draft assessment</i>
<i>July 2018</i>	<i>Final 2015/16-2016/17 assessment issued</i>
<i>July 2017 – June 2019</i>	<i>Data collection</i>
<i>July – Dec 2019</i>	<i>Analysis</i>
<i>Jan – Jun 2020</i>	<i>Preparation of draft assessment</i>
<i>July 2020</i>	<i>Final 2015/16-2016/17 assessment issued</i>

References

- Haddon M. 2014. Review of the WA Herring Stock Assessment. Report to Department of Fisheries.
- Hoening J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 81:898-903.
- Jones K. 2013. Review of report on the ‘Status of nearshore finfish stocks in south-western Western Australia: Australian herring and tailor’ by Keith Jones, Sillago Research Pty Ltd for the Department of Fisheries, Western Australia. Fisheries Occasional Publication No. 116. Department of Fisheries, Western Australia.
- Smith K, Brown J, Lewis P, Dowling C, Howard A, Lenanton L & Molony B. 2013. Status of nearshore finfish stocks in south-western Western Australia. Part 1: Australian Herring. NRM Project 09003 Final Report. Fisheries Research Report No. 246. Department of Fisheries, Western Australia.
- Smith K. & Brown J. 2014. Biological synopsis of Australian herring (*Arripis georgianus*). Fisheries Research Report No. 251. Department of Fisheries, Western Australia.
- Then A. Y., Hoening J. M., Hall N. G. and Hewitt D. A. 2014. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science. doi: 10.1093/icesjms/fsu136.



Appendix Figure 1. Estimates of **a)** spawning potential ratio (SPR) and **b)** fishing mortality (F) (+ 95% confidence interval) for Australian herring during the past three assessment periods. Limit, threshold and target reference levels for SPR and F are shown. (*Each point estimate is calculated from age structure data collected over 2 consecutive years.)