



Department of
Primary Industries and
Regional Development

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Western Australia.*

Fisheries Management Paper No. 276

**Western Australian Silverlip
Pearl Oyster (*Pinctada maxima*)**

Resource

Harvest Strategy

2022–2026

Version 2.0

June 2022

Version control

Version	Change description	Date
1.0	First published Fisheries Management Paper No. 276 Harvest Strategy for this resource.	June 2016
2.0	Updated after first periodic review. Key changes include: <ul style="list-style-type: none">• Inclusion of new harvest control rule for +175 mm shell length pearl oysters.• General structural changes and revised wording to maintain consistency with other harvest strategies.	June 2022

Important disclaimer

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Department of Primary Industries and Regional Development
Gordon Stephenson House
140 William Street
PERTH WA 6000
Telephone: (08) 6551 4444
Website: dpird.wa.gov.au
ABN: 18 951 343 745

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Contents

1.0 INTRODUCTION	1
1.1 Review process	1
2.0 SCOPE	2
2.1 Environmental Context	3
2.2 Target Species	3
2.3 Fishing Activities	4
2.3.1 Governance	4
2.3.2 Commercial Fishing	5
2.3.2.1 Bycatch, ETP, habitats and ecosystems	6
2.3.3 Recreational Fishing	6
2.3.4 Customary Fishing	7
3.0 HARVEST STRATEGY	8
3.1 Harvesting and Management Approach	8
3.2 Long-term Objectives	8
3.2.1 Ecological Sustainability	8
3.2.2 Social Objective (POF)	9
3.2.3 Economic Objective (POF)	9
3.3 Operational Objectives	9
3.4 Ecological Sustainability	9
3.4.1 Performance Indicators, Reference Levels and Tolerance Levels	10
3.4.1.1 Reference Periods	10
3.4.1.2 120 to 175 mm shell length pearl oysters.....	11
3.4.1.3 +175 mm shell length pearl oysters	11
3.4.1.4 Tolerance Levels.....	12
3.4.1.5 Other Ecological Assets	12
3.4.1.6 Social and Economic Objectives.....	13
3.5 Monitoring and Assessment Procedures	19
3.5.1 Information and Monitoring	19
3.5.1.1 Fishery-Dependent Information.....	19
3.5.1.2 Fishery-Independent Information	19
3.5.2 Assessing Fishery Impacts	20
3.5.2.2 Ecological Risk Assessments	20

4.0 MANAGEMENT MEASURES AND IMPLEMENTATION.....	21
4.1 Management Measures	21
4.1.1 Implementing Changes to the Management Measures.....	22
4.1.2 Consultation.....	22
4.1.2.1 Commercial Sector Consultation.....	22
4.1.2.2 Consultation with Other Groups	25
5.0 COMPLIANCE AND ENFORCEMENT	26
5.1 Operational Compliance Plans.....	26
5.2 Compliance Strategies.....	26
5.3 Vessel Monitoring System.....	27
6.0 REFERENCES	28
7.0 APPENDIX 1	31

List of acronyms

ALC -	Automatic Location Communicator.
AMM -	Annual Management Meetings
ARMA -	<i>Aquatic Resources Management Act 2016</i>
BMSY - yield	Biomass that enables a fish stock to deliver the maximum sustainable yield
CPUE -	Catch Per Unit Effort
DoF –	Department of Fisheries (now known as DPIRD)
DPIRD -	Department of Primary Industries and Regional Development
EBFM -	Ecosystem Based Fisheries Management
EPBC -	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
ERA -	Ecological Risk Assessment
ESD -	Ecologically Sustainable Development
ETP -	Endangered, Threatened and Protected
FRMA -	<i>Fish Resources Management Act 1994</i>
GFC -	Global Financial Crisis
GVP -	Gross Value of Production
HCR -	Harvest Control Rules
HL -	Harvest Level
ITQ -	Individual Transferable Quotas
MOP -	Mother-of-Pearl
MSC -	Marine Stewardship Council
OCP -	Operational Compliance Plan
PA –	<i>Pearling Act 1990</i>
POF -	Pearl Oyster Fishery
PR -	<i>Pearling (General) Regulations 1991</i>
PRI –	Point of recruitment impairment
SAWG -	Stock Assessment Working Group
SCPUE -	Standardised Commercial Catch Per Unit Effort
SD –	Standard Deviation
SHL -	Sustainable Harvest Level
SL -	Shell Length
SLA -	Service Level Agreement

TAC - Total Allowable Catch
TACC - Total Allowable Commercial Catch
VMS - Vessel Monitoring System
WA – Western Australia
WAFIC - Western Australian Fishing Industry Council

1.0 Introduction

Harvest strategies for aquatic resources in Western Australia (WA) are formal documents that support decision making processes which are consistent with the principles of Ecologically Sustainable Development (ESD; Fletcher 2002) and Ecosystem Based Fisheries Management (EBFM; Fletcher et al. 2012). The objectives of ESD are reflected in the *Fish Resources Management Act 1994* (FRMA), Section 3, and the *Aquatic Resources Management Act 2016* (ARMA), Section 9, which will replace the FRMA once enacted.

This Harvest Strategy aligns with DPIRD's *Harvest Strategy Policy for Aquatic Resources* (Department of Fisheries 2015) and is consistent with national Harvest Strategy policies and guidelines (Sloan et al. 2014; Department of Agriculture and Water Resources 2018a, b). It describes the performance indicators, reference levels, and Harvest Control Rules (HCRs) that achieve the long and short-term management objectives for the resource, and the broader goals of ESD and EBFM.

Publication of this Harvest Strategy makes transparent the decision-making processes for the management of specified aquatic resources. It also provides a basis for informed dialogue on management actions with stakeholders (Department of Fisheries 2015). The strategy provides guidance for decision makers but does not derogate from or limit the exercise of discretion required for independent decision making by the Minister for Fisheries, the Director General of DPIRD, or other delegated decision makers to meet the objectives of the FRMA and ARMA, once enacted.

Consistent with DPIRD's *Stakeholder Engagement Guideline* (Department of Fisheries 2016), formal stakeholder consultation with industry members and peak commercial and recreational fishing sector bodies, as well as public consultation processes was carried out in the development of this document. It has been approved by the Minister for Fisheries.

1.1 Review process

The WA Harvest Strategy Policy (Department of Fisheries 2015) recognises that fisheries change over time and that a review period should be built into each Harvest Strategy to ensure that it remains relevant. This is the second version of the Harvest Strategy for the Silverlip pearl oyster (*Pinctada maxima*: *P. maxima*) resource (wildstock only¹) which was independently assessed, and third party certified as sustainable by the globally recognised Marine Stewardship Council (MSC) in 2017. This Harvest Strategy will remain in place until it is incorporated into and replaced by the Pearl Oyster Aquatic Resource Management Strategy (ARMS), which will be developed in accordance with ARMA.

¹ 1 Note, activity related to pearl culture and the hatchery-production of *P. maxima* that occur in conjunction with the collection of wild pearl oysters is beyond the scope of this Harvest Strategy. The management strategies for these aspects are encompassed in the Pearling legislation, the Pearl Oyster Translocation Protocol and pearling industry Codes of Conduct.

2.0 Scope

This Harvest Strategy has been developed for the wildstock *Pinctada maxima* resource. The Pearl Oyster Fishery (POF) is the only fishery that commercially targets *P. maxima* in WA waters. The POF boundaries encompass the northern coastal waters from the Northwest Cape (114° 10' E longitude), including Exmouth Gulf, northeast to the Northern Territory border (Figure 1). *P. maxima* are principally used for the culture of South Sea pearls and to a lesser extent, for mother-of-pearl (MOP) nacre and pearl oyster meat.

In addition to considering fishing impacts on the target species (*P. maxima*), it also considers impacts on bycatch², endangered, threatened and protected (ETP) species, benthic habitats, and broader ecosystem processes to ensure the risks to these elements are managed effectively. This strategy also sets out and summarises matters relevant to the independent, third-party assessment of the fishery against the MSC sustainability standard and should be read in conjunction with the MSC Assessment Report for this resource (Hart et al. 2016). This document has been developed via a consultative process with industry members and has been approved by the Director General of DPIRD and the Minister for Fisheries.

² Bycatch is described as the part of the catch which is returned to the sea (usually referred to as non-retained or discarded) either because it has no commercial value or because legislative requirements preclude it being retained.

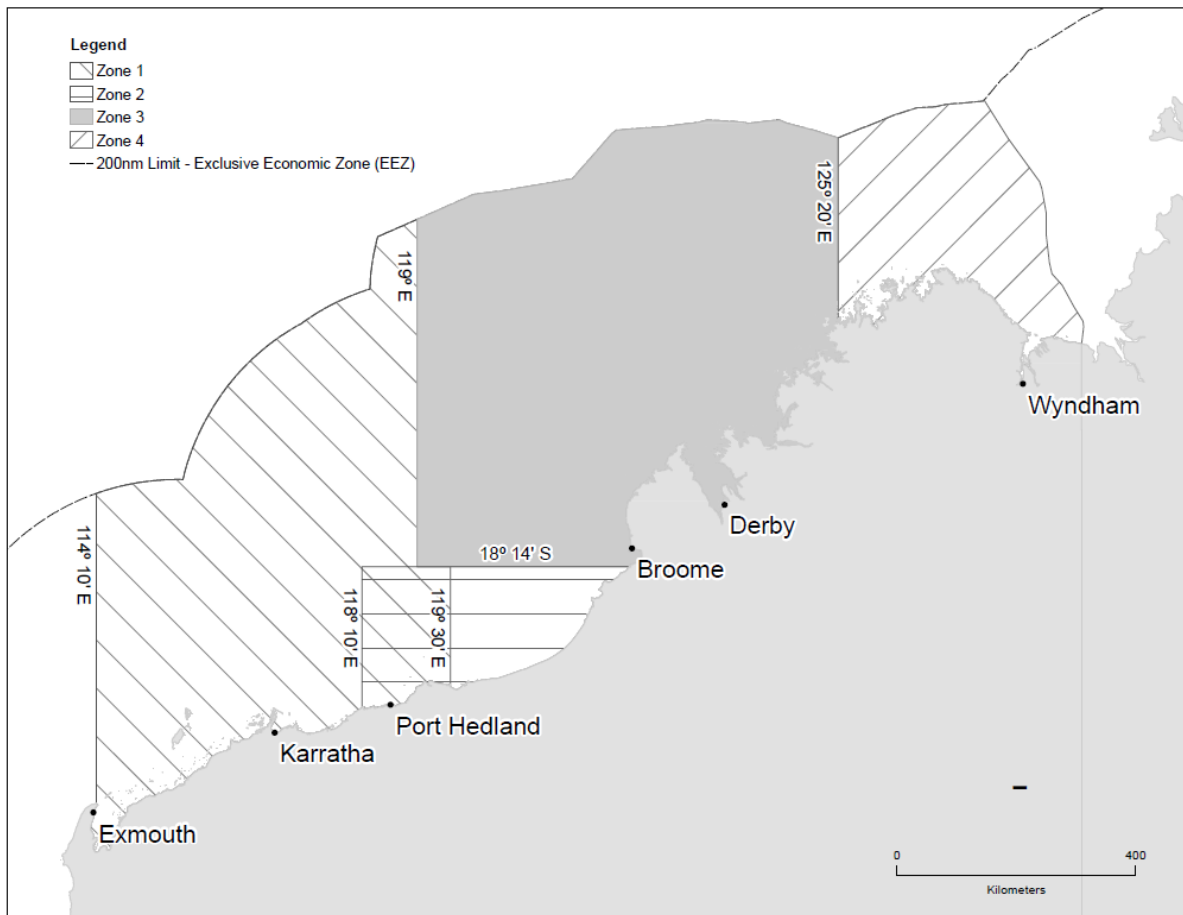


Figure 1: Location and boundaries of the Western Australian Pearl Oyster Fishery

2.1 Environmental Context

The POF is located on the Northwest Shelf of Australia. Harvesting of *P. maxima* primarily occurs in water depths of 10 – 35 metres off the southern Kimberley Coast, at Eighty Mile Beach and the Lacepede Islands, although a small amount of fishing has historically occurred in Exmouth Gulf. This region has a semi-arid, tropical climate with rainfall mainly occurring during the November to March monsoonal season. The occurrence of cyclones during this time can have major localised effects including high seas, large waves and storm surges. The wide continental shelf in the region results in large tidal amplitudes of up to 11 metres, and strong tidal currents produce a range of ecologically diverse filter-feeding communities. The region also has several ETP species, including cetaceans, dugong, marine turtles, sea snakes, crocodiles, syngnathids (seahorses and pipefish), sharks, rays and sea and shore birds.

2.2 Target Species

P. maxima is a filter-feeding bivalve mollusc and is the largest of four *Pinctada* species found in WA. The species has an Indo-Pacific distribution and is found in coastal waters north of Exmouth across northern Australia to Cooktown, Queensland. It occurs in shallow, subtidal habitats characterised by strong tidal currents in five to >50 metres depth. *P. maxima* is a broadcast spawner, and its life cycle includes a planktonic egg and larval stage of 28 to 35 days. Initial genetic analyses (using allozymes) indicated

high levels of connectivity between populations (Johnson and Joll 1993); however, more recent analyses (using microsatellite markers) have found differentiation between stocks in WA, the Northern Territory (NT) and Indonesia. Within WA, low levels of differentiation were also identified between geographically distant populations in Exmouth Gulf and the northern Kimberley region (Benzie and Smith-Keune 2006). For management purposes *P. maxima* in WA are considered a single stock.

P. maxima is a protandrous hermaphrodite; animals mature first as males around three to four years of age (110 to 120 mm shell length³), after which they undergo a sex change and become females. By 170 mm shell length (SL), half of the animals are females, and by 190 mm SL, most of the population is female (Hart and Joll 2006). Since animals can spawn every year, each individual can function as both a male and then a female for several spawning seasons. Very few animals are both male and female simultaneously. Spawning occurs between September and May each year, with a peak from October to December and a smaller, secondary spawning event in February and March (Rose et al. 1990; Rose and Baker 1994).

Egg production by *P. maxima* is high, and mature female gonads contain from 20 to 50 million eggs. Recruitment of juveniles appears to be driven primarily by environmental conditions including sea surface temperature, rainfall and wind conditions (Hart et al. 2011), and *P. maxima* are commonly found in areas where the seabed has crevices that allow the young animals to settle into a protected environment. Large *P. maxima* individuals (>200 mm SL) are estimated to be 15 to 20 years old. The instantaneous rate of natural mortality is relatively low and varies from 0.1 to 0.18 yr⁻¹, depending on habitat; this corresponds to a mortality of 10 to 16.5% annually (Hart and Friedman 2004).

2.3 Fishing Activities

2.3.1 Governance

The POF is primarily managed via the *Pearling Act 1990 (PA)*, subsidiary instruments and policy guidelines, including:

- *Pearling (General) Regulations 1991 (PR)*;
- *Pearling (Declaration of Pearl Oysters) Notice 1995*;
- *Pearling (Pearl Oyster Shell Size) Notice 1997*;
- *Pearling (Declaration of Zones) Notice 1995* and *Pearling (Declaration of Zones) Amendment Notice 1997*;
- Ministerial Policy Guideline (No. 17);
- *Administration Guideline No. 1 Assessment of Applications for Authorisations for Aquaculture and Pearling in Coastal Waters of WA*; and
- pearling leases and licences (and associated conditions).

Licence holders and fishers operating within the POF must also comply with the requirements of the:

³ All measurements referring to shell size are dorso-ventral measurements

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC);
- WA *Fish Resources Management Act 1994* (Part 3 and Division 1 of Part 11);
- WA *Fish Resources Management Regulations 1995* (Part 13A);
- WA *Marine Act 1982*;
- WA *Biodiversity Conservation Act 2016*;
- WA *Conservation and Land Management Act 1984*;
- WA *Environmental Protection Act 1986*; and
- Any other legislation governing the use of the marine environment in which activities occur.

Note that when ARMA comes into force, it will repeal the PA and the PR. From that point the POF will be managed under the provisions of ARMA.

2.3.2 Commercial Fishing

Commercial fishing for pearl oysters in Western Australia began in Shark Bay in 1850, where the smaller *Pinctada albina* pearl oyster formed the basis of the fishery (Southgate and Lucas 2008). The fleet gradually moved northwards along the coast through Cossack to Eighty Mile Beach, where plentiful stocks of *P. maxima* were discovered near Nickol Bay in the 1860s. Over the next few decades, a series of regulations were introduced, including the *Pearl Fishing Act 1886* and the *Pearling Act 1912*. This legislation created the management framework for the commercial POF.

Initially, the pearling industry harvested *P. maxima* pearl oysters (pearl oysters) of all sizes but favoured the larger oysters (+175 mm SL) which were used to produce MOP for buttons and inlays in furniture and watches. By 1910 there were nearly 400 luggers and 3500 people in the pearling industry. At its peak, around 2000 tonnes (approx. 2 million pearl oysters) was harvested annually, supplying up to 75% of global MOP production. The mass production of synthetic buttons and economic factors relating to the Great Depression led to the decline in fishing and MOP production, and pearling activities almost entirely ceased during World War II.

In 1949 the *Pearling Act Amendment Act 1922*, which prohibited the culture of pearls, was repealed, and the pearl culture phase of the pearling industry began to develop and replace the MOP fishery. *P. maxima* pearl culture activities began in Kuri Bay in the Kimberley region during the 1950s, and by the end of the 1970s, most of the pearling industry had moved into cultured pearl production. The annual catch of *P. maxima* used for MOP declined to 200 to 300 tonnes, however the catch of *P. maxima* used to culture pearls (oysters with 120 to 175 mm SL) increased to around 400 000 in the same period (Wells & Jernakoff 2006, Malone et al. 1988). This shift towards pearl culture saw a change in the location of fishing and decrease in the number of pearling vessels to 12, as well as the voluntary protection of larger oysters (+175 mm SL) to ensure continuity of high levels of recruitment considered necessary for adequate culture pearl oyster abundance.

During the 1990s hatchery techniques for *P. maxima* were pioneered by Rose & Baker (1994). In 1992, the WA Government granted hatchery options to licensees enabling production of pearls from hatchery-reared pearl oysters and reducing the reliance on

wildstock pearl oysters. Hatchery bred pearl oysters now supplement an important component of pearl production in WA (DoF 2001).

The POF is a dive-based hand collection fishery; highly trained divers collect individual pearl oysters while being towed behind vessels (usually under 35 metres), typically in depths of 10 to 35 metres. Collection of wild *P. maxima* generally occurs for three to four months of the year, March to July, during the neap phase of the tidal cycle when currents are reduced. Divers operate on hookah, with air supplied from a surface compressor. The present-day fishery is primarily a 'gauntlet fishery' focused primarily on the collection of 100 to 175 mm SL pearl oysters that are optimal for pearl culture. There is also a smaller harvest of +175 mm SL pearl oysters primarily used for MOP.

The POF is managed primarily through output controls in the form of a Total Allowable Commercial Catch (TACC) that is divided into Individual Transferable Quotas (ITQs) (refer to Section 4.1.2.1.1). There are 572 total quota units, across management Zones 1 – 3 (Figure 1). One quota unit equates to a particular number of pearl oysters and varies from year to year. The value of a quota unit depends on the status of pearl oyster stocks and the annual TACC as set by the CEO of DPIRD, based on advice from a Stock Assessment Working Group (SAWG).

The total annual catch of *P. maxima* since 1979 has oscillated from 330 000 to 830 000 pearl oysters, with an overall average of 530 000 (\pm 120 000 SD). The POF is primarily based on *P. maxima* from Zone 2, which has supplied 70% of the total harvest in the past 30 years, and close to 100% in recent years. Total annual effort in Zone 2/3 since 1979 has oscillated from 3000 to 23 000 dive hours, with a stable trend and overall average of 14 400 (\pm 4000 SD).

A large proportion of pearls are sold to overseas markets. Fluctuations in the value of the Australian dollar and other macroeconomic factors can have a large influence on the POF.

2.3.2.1 *Bycatch, ETP, habitats and ecosystems*

Divers can specifically target pearl oysters of choice (size and quality), and no other species are retained. Although not directly targeted, commensal biofouling organisms that encrust the pearl oyster shells are collected; however, the harvested pearl oysters are young and generally have relatively little epiphytic growth (Daume et al. 2009).

The selective nature of the fishing method (hand collection by divers) minimises the risk of interactions with ETP species. There have been no interactions with any ETP species reported in the POF.

Habitat interactions in the POF are minimal. Divers swim about 1.5 metres off the seabed and are not in contact with the substrate. Since water clarity is paramount to divers being able to identify the appropriately sized pearl oysters, significant effort is put in place to ensure they do not strike the sea floor while collecting pearl oysters.

2.3.3 **Recreational Fishing**

No authorised recreational fishing has taken place under the PA.

2.3.4 Customary Fishing

Pearl oyster shell is an important resource of cultural significance to the Aboriginal people of Australia and has been harvested for at least 20 000 years (Yu and Brisbout 2011). Aboriginal Australians of the West Kimberley harvested pearl oyster shells from shallow waters and had well established traditional trading networks that extended throughout Australia (Akerman and Stanton 1994). Aboriginal communities ate the pearl meat, used the shell for decoration and other cultural purposes and the pearl shell has important cultural significance. The shells were collected, cleaned, shaped and often decorated with designs that were worn for ceremonial occasions. The *P. maxima* pearling industry was initiated in 1861 through trade between early explorers and Aboriginal Australians (Southgate and Lucas 2008).

Pearl oyster shell continues to be of important cultural significance and customary fishing rights in respect of *P. maxima* have been recognised in Native Title determinations and negotiated agreements. The size of the customary catch is unknown, as DPIRD does not record Customary catch.

3.0 Harvest Strategy

3.1 Harvesting and Management Approach

The Harvest Strategy for *P. maxima* is a constant exploitation approach whereby the same proportion of the stock is harvested each year. Since 1985 this approach has been operationalised through an annual TACC, divided into ITQs, which is set in proportion to overall stock abundance.

The harvesting approach accounts for this species being long-lived, with effort being focused primarily on the young, fast-growing males that are the optimal size for pearl culture. The bases of this approach are spat settlement surveys, which are used to calculate an index of abundance of 0+ and 1+ pearl oysters, and the standardised commercial catch per unit effort (SCPUE) of 120 to 175 mm SL pearl oysters, which is used as an index of abundance. These indices have been used to develop two predictive relationships between:

1. spat abundance and 120 to 175 mm SL pearl oyster SCPUE four years into the future; and
2. the current season's sustainable harvest level (SHL) and 120 to 175 mm SL pearl oyster SCPUE. As the catch of 120 to 175 mm SL pearl oysters is comprised mainly of two age classes (4+ and 5+ pearl oysters), these relationships allow recommendations on a SHL to be made up to three years in advance based on the spat settlement surveys (see Appendix 1).

In 2022, this predictive approach to harvesting was extended to pearl oysters +175 mm in SL. For +175 mm SL pearl oysters, the predictive approach combines the spat settlement surveys with a fishery-independent index of abundance, and utilises fishery efficiency and ecological parameters, such as area of pearl oyster stocks, to estimate SHL.

The control rules in place ensure that the catch is reduced when predicted recruitment is low, to provide increased protection to the stock, but also allows the catch to be raised in years when predicted abundance is high.

3.2 Long-term Objectives

The short title of the PA is “An Act to regulate pearling and pearl oyster hatchery activities, to provide for the conservation and management of pearl oyster fisheries, to repeal the *Pearling Act 1912* and for connected purposes”. The species declared under the PA is *P. maxima*. Fishery-specific objectives are provided below. In addition to ensuring the biological sustainability of all captured aquatic resources, this Harvest Strategy also includes broader ecological objectives for each ecosystem component, as well as social and economic objectives for the POF as a whole, which are applied within the context of ESD.

3.2.1 Ecological Sustainability

- 1) To maintain spawning stock biomass of the target species (i.e., *P. maxima*) at a level where the main factor affecting recruitment is the environment;

- 2) To ensure fishing impacts do not result in serious or irreversible harm⁴ to bycatch species populations;
- 3) To ensure fishing impacts do not result in serious or irreversible harm to ETP species populations;
- 4) To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function; and
- 5) To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes.

3.2.2 Social Objective (POF)

To provide flexible opportunities to ensure licence holders and fishers within the POF can maintain or enhance their livelihood, within the constraints of ecological sustainability.

3.2.3 Economic Objective (POF)

To optimise economic returns to the State through the production of pearls from the pearl oyster (*P. maxima*) resource.

3.3 Operational Objectives

Long-term management objectives are typically operationalised as short-term (e.g., annual), fishery-specific objectives through one or more performance indicators that can be measured and assessed against pre-defined reference levels to ascertain actual performance. Within the context of the long-term objectives provided above, operational objectives aim to maintain each resource above the threshold level (and, where relevant, close to the target level), or rebuild the resource if it has fallen below the threshold or limit levels.

3.4 Ecological Sustainability

A formal, resource-level review process is undertaken by DPIRD to assess the status of relevant target stocks and performance in relation to each ecological management objective. Suitable indicators have been selected to describe performance of the POF in relation to each management objective, with a set of reference levels established to separate acceptable from unacceptable performance. Where relevant, these levels include the following, defined and illustrated within Figure 2:

- Target level (where you want the indicator to be);
- Threshold level (where you review your position); and
- Limit level (where you do not want the indicator to be).

⁴ Serious or irreversible harm relates to a change caused by the fishery that fundamentally alters the capacity of the component (e.g., bycatch population, ETP species population) to maintain its function or to recover from the impact.

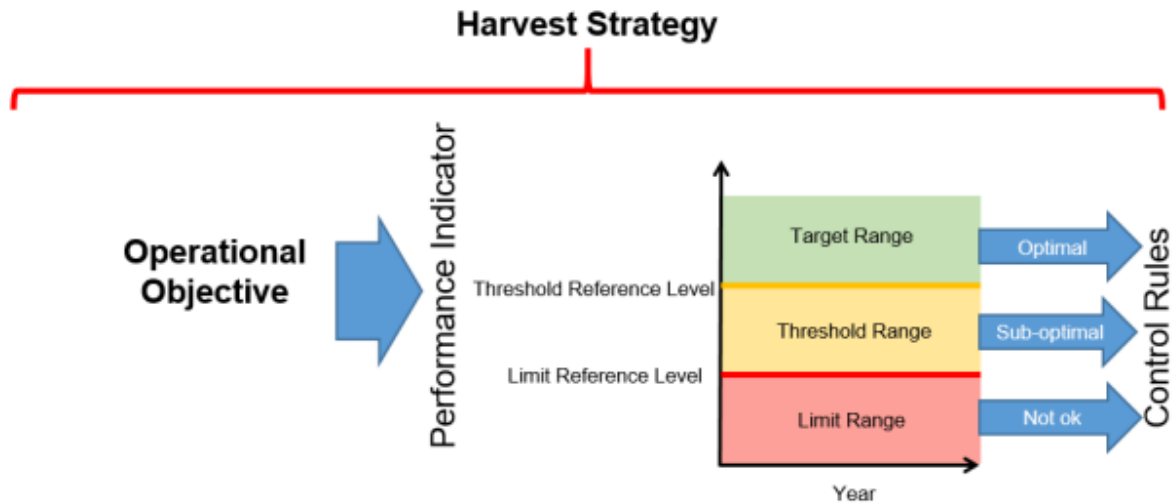


Figure 2: Performance indicators, limits, thresholds and targets.

The associated control rules define what management actions should occur in relation to each indicator approaching or crossing the limit, threshold or target levels. Summaries of the management objectives, performance indicators, reference levels and control rules for each component of the POF are provided in Table 2.

Note the ability and timeframe to implement the required management changes depends on the legal instrument under which the management measure occurs. Further information on the management measures in place for the POF is provided in Section 4.

3.4.1 Performance Indicators, Reference Levels and Tolerance Levels

3.4.1.1 Reference Periods

Reference levels for the assessment of the *P. maxima* resource have been established based on a range of information and monitoring data that has been collected since 1979 (see Section 3.5.1). Different reference periods have been used for setting the reference levels depending on the information available (Table 1).

Table 1: Reference periods used for setting reference levels

Assessment	Performance indicator	Reference period(s)
120 to 175 mm SL pearl oyster abundance.	Fishery-dependent SCPUE	2003-2021
	Fishery-dependent CPUE	1979-2021
0+ and 1+ spat abundance	Spat settlement index	1990-2021
+175 mm SL pearl oyster abundance.	Fishery-independent SCPUE	2007-2021
	Population surveys	2001, 2012-2013

3.4.1.2 120 to 175 mm shell length pearl oysters

The primary performance indicator for the *P. maxima* resource is the SCPUE of 120 to 175 mm SL pearl oysters. The SCPUE is the mean annual number of 120 to 175 mm SL pearl oysters caught per hour within Zone 2/3 of the POF. The SCPUE index is available from 2003 onwards, during which time it has been highly correlated with the unstandardised catch per unit effort (CPUE) (Figure A-2.). The high correlation between SCPUE and the 1+ spat index from two to four years previous ($r^2 = 0.95$) confirms that the spat catch rates are indicative of future 120 to 175 mm SL pearl oyster abundance.

The limit reference level for *P. maxima* is a predicted SCPUE of 15 120 to 175 mm SL pearl oysters per hour (Table 2). This level coincides with a recruitment failure as estimated by the current predictive model for SCPUE (16.7 ± 3.3 SD) when settlement is 0 (Figure A-2.). This level is also close to the lowest value recorded in 1981 of 16 pearl oysters per hour. The ongoing sustainability of the stock over the last 40 years indicates that this limit reference level is set above the level where there is a substantial risk of recruitment impairment.

The threshold reference level is a predicted SCPUE of 20 120 to 175 mm SL pearl oysters per hour (Table 2). This level is 33% above the limit reference level and is used to provide an early warning that stock abundance is declining, enabling management action to be taken to reduce exploitation before the limit reference level is reached.

The target reference level is a predicted SCPUE of 25 120 to 175 mm SL pearl oysters per hour (Table 2). This level has been set well-above the limit and threshold reference levels, with the intention of maintaining the stock at levels of production consistent with BMSY.

In line with a constant exploitation harvesting approach, control rules calculate a SHL in Zone 2/3 of the POF each year based on the SCPUE (Table 2, Figure A-3.). When the SCPUE is predicted to be at or above target levels, the harvest control rule is used to calculate the Zone 2/3 SHL as a function of stock abundance (based on SCPUE) using a linear regression model that is updated annually. There has been relatively little or no catch and effort in Zone 1 of the POF in recent years. Consequently, a fixed SHL of 54 970 pearl oysters is currently recommended for Zone 1.

When the stock is predicted to be below target levels, harvest control rules adjust the total SHL against a 'baseline' of 457 000 pearl oysters for Zone 2/3 and 54 970 for Zone 1 (Table 2, Figure A-3.). These are the lowest values of the SHL since 2003 when the SCPUE index began. A range of fixed and variable reductions to the baseline SHL are made to ensure that exploitation is reduced as the stock abundance decreases and the limit reference level is approached.

3.4.1.3 +175 mm shell length pearl oysters

To bring the management of +175 mm SL pearl oysters in line with the smaller size-classes, a predictive model has been developed in 2021/22. Harvest control rules calculate a SHL in Zone 2/3 of the POF each year based on the predicted SCPUE for +175 mm SL pearl oysters (Table 2, Figure A-4, Figure A-5.). When the SCPUE is

predicted to be at or above target levels, the harvest control rule calculates the Zone 2/3 SHL as a function of stock abundance, using a linear regression model that is updated annually. The linear regression model is based on a high correlation between SCPUE of +175 mm SL pearl oysters (estimated from fishery-independent surveys), and the 1+ spat index from 7 to 8 years previous ($r^2 = 0.72$). This relationship shows that the harvest of +175 mm SL pearl oysters is made up primarily of 8- and 9-year-old cohorts.

The performance indicator for implementing this control rule is the annual fishery independent SCPUE of +175 mm SL pearl oysters in Zone 2/3 (Table 2). Reference levels have been set based on the reference period from 2007 to 2021 (Table 1). This is when routine monitoring of +175 mm SL pearl oysters commenced and is a period when the stock is known to have been above the point of recruitment impairment (PRI).

The limit reference level for *P. maxima* of a size +175 mm SL is a predicted SCPUE of five pearl oysters per hour (Table 2). The limit reference point is slightly below the lowest SCPUE of 6.6 pearl oysters per hour observed during the reference period (Hart et al. 2014b; Figure A-4). Densities of +175 mm SL pearl oysters rapidly increased from this low SCPUE of 6.6, and hence PRI was proved to be below 6. These rapid increases would not have occurred if PRI had been reached. Selecting a value of 5 to represent the PRI was therefore deemed appropriate.

The threshold reference level is a predicted SCPUE of 10 x 175 mm+ SL oysters per hour (Table 2; Figure A-4). This level is 100% above the limit reference level and is used to provide an early warning that stock abundance is declining, enabling management action to be taken to reduce exploitation before the limit reference level is reached.

The target reference level is a predicted SCPUE of 15 x 175 mm+ SL oysters per hour (Table 2; Figure A-4). This level has been set well-above the limit and threshold reference levels, with the intention of maintaining the stock at levels of production consistent with BMSY.

3.4.1.4 *Tolerance Levels*

Given the highly dynamic nature of fisheries it is often not possible to predict precisely what the catch will be each year. To minimise unnecessary management intervention, it may be important to define the level of tolerance in the control rules before management adjustments are made (DoF 2015). Specific tolerance levels are not required for the POF since the performance indicator for 120 to 175 mm SL pearl oysters allows accurate predictions of abundance and SHL four years in advance. This provides a medium-term outlook on the status of the stock that allows research and management staff to discriminate between minor or 'technical breaches' of control rules and genuine trends in abundance requiring management intervention.

3.4.1.5 *Other Ecological Assets*

Other ecological assets incorporated in this Harvest Strategy include bycatch, ETP species, habitats and ecosystem processes. Reference levels for these performance indicators have been set to differentiate acceptable fishery impacts (target levels) from

unacceptable fishery impacts (limit levels) according to the risk levels defined in Fletcher (2005).

3.4.1.6 *Social and Economic Objectives*

In line with DPIRD's Harvest Strategy Policy and the principles of ESD, this Harvest Strategy also includes social and economic objectives. It is important to note that management actions relating to these objectives are applied within the constraints of ecological sustainability.

Performance against the social objective is assessed by determining whether livelihood opportunities are provided to licence holders and fishers within the POF and whether they can access these opportunities (e.g., maintaining access to a resource, use of transferrable use rights), identifying any constraints on livelihood opportunities imposed by the management system and evaluating their satisfaction with the management system (based on Triantafillos et al. 2014).

Performance against the economic objective can be assessed but is not limited to monitoring changes in the annual Gross Value of Production (GVP) of the industry.

Explicit reference levels and control rules are not currently defined for these objectives. Rather, it is through the formal consultation process that occurs as part of annual management activities whereby regulatory impediments to maintaining social and economic returns, or opportunities for enhancing these, are discussed with the pearling industry (see Section 4.2.1 for more information on consultation processes within the POF).

It is important to note that fisheries managers cannot always address the causes of constraints on access to fishing activities, as these may be due to environmental or other factors or may compromise ecological sustainability. Where possible, and in due consideration of ecological sustainability, fisheries management arrangements may be adjusted or reformed to help meet these objectives.

Table 2: Harvest Strategy performance indicators, reference levels, control rules for the Silverlip pearl oyster (*P. maxima*) resource and associated ecological assets that may be impacted by fishing activities.

Component	Management objectives	Resource /asset	Assessment	Performance Indicators	Reference Levels	Control Rules
Target species	To maintain spawning stock biomass of the target species at a level where the main factor affecting recruitment is the environment.	Silverlip pearl oyster (<i>Pinctada maxima</i>).	Level 4 stock assessment incorporating standardised fishery-dependent relative abundance and fishery-independent recruitment surveys	Annual standardised commercial catch rate (SCPUE) of 120 to 175 mm SL pearl oysters in Zone 1 and Zone 2/3.	Target: SCPUE: 25 pearl oysters per hour.	Zone 1: baseline SHL of 54,970 oysters. SHL for Zone 2/3 calculated as a function of stock abundance using predictive model. (a) If predicted SCPUE between target and threshold, reduce SHL by 30% below baseline levels: <ul style="list-style-type: none"> Zone 1 SHL = 38,479 oysters; Zone 2/3 SHL = 319,900 oysters. (b) If predicted SCPUE between threshold and limit level, reduce SHL by 40 to 50% below baseline levels: <ul style="list-style-type: none"> Zone 1 SHL = 32,982 to 27,485 oysters; Zone 2/3 SHL = 274,200 to 228,500 oysters.
					Threshold: SCPUE: 20 pearl oysters per hour.	
					Limit:	If predicted SCPUE is below limit, reduce SHL by

Component	Management objectives	Resource /asset	Assessment	Performance Indicators	Reference Levels	Control Rules
					SCPUE is 15 pearl oysters per hour.	50 to 100% below baseline levels: <ul style="list-style-type: none"> Zone 1 SHL = <27,485 oysters; Zone 2/3 SHL = <228,500 oysters.
			Level 4 stock assessment incorporating standardised fishery-dependent relative abundance and fishery-independent recruitment surveys	Annual standardised fishery-independent catch rate (SCPUE) of +175 mm SL pearl oysters in Zone 1 and Zone 2/3.	<p>Target: SCPUE is 15 pearl oysters per hour.</p> <p>Threshold: SCPUE is 10 pearl oysters per hour.</p>	<p>Zone 1: baseline SHL of 15,000 pearl oysters.</p> <p>SHL for Zone 2/3 calculated as a function of stock abundance using predictive model.</p> <p>(a) If predicted SCPUE between target and threshold, reduce SHL by 30% below baseline levels:</p> <ul style="list-style-type: none"> Zone 1 SHL = 10,000 oysters; Zone 2/3 SHL = 37,100 oysters. <p>(b) if predicted SCPUE between threshold and limit, reduce SHL by 40 to 50% below baseline:</p> <ul style="list-style-type: none"> Zone 1 SHL = 6,000 to 7,500 oysters;

Component	Management objectives	Resource /asset	Assessment	Performance Indicators	Reference Levels	Control Rules
						<ul style="list-style-type: none"> Zone 2/3 SHL = 37,100 – 26,500 oysters.
					Limit: SCPUE is 5 pearl oysters per hour.	If predicted SCPUE below the limit, reduce SHL by 50 to 100% below baseline: <ul style="list-style-type: none"> Zone 1 SHL = <7,500 oysters; Zone 2/3 SHL = <26,500 oysters.
Bycatch (non-ETP) species	To ensure fishing impacts do not result in serious or irreversible harm to bycatch species populations.	All bycatch species	Periodic risk assessments incorporating: <ul style="list-style-type: none"> management arrangements, annual fishing effort and catch (including discards), review of alternative measures to minimise unwanted catch, species information, and other available research. 	Assessed level of risk for each bycatch species/group from fishery activities:	Target: Moderate or lower level of risk to asset from fishing.	Maintain current management arrangements aimed at achieving ecological, economic and social objectives.
					Threshold: High level of risk to asset from fishing.	Conduct a review to investigate the reasons for the variation within three months. If sustainability is at risk, implement appropriate management action to reduce the risk to an acceptable level as soon as practicable.
					Limit: Severe level of risk to asset from fishing.	Implement immediate management strategies to reduce the risk to an acceptable level.

Component	Management objectives	Resource /asset	Assessment	Performance Indicators	Reference Levels	Control Rules
ETP species	To ensure fishing impacts do not result in serious or irreversible harm to endangered, threatened and protected (ETP) species populations.	All ETP species	Periodic risk assessments incorporating: <ul style="list-style-type: none"> management arrangements, annual fishing effort and catch (including discards), species information and number of reported ETP species interactions, and other available research. 	Assessed level of risk for each bycatch species/group from fishery activities:	Target: Moderate or lower level of risk to asset from fishing.	Maintain current management arrangements aimed at achieving ecological, economic and social objectives.
					Threshold: High level of risk to asset from fishing.	Conduct a review to investigate the reasons for the variation within three months. If sustainability is at risk, implement appropriate management action to reduce the risk to an acceptable level as soon as practicable.
					Limit: Severe level of risk to asset from fishing.	Implement immediate management strategies to reduce the risk to an acceptable level.
Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function.	Benthic habitats	Periodic risk assessments incorporating: <ul style="list-style-type: none"> management arrangements, annual fishing effort, extent of fishing area annually, and other available research. 	Assessed level of risk for benthic habitats from fishery activities:	Target: Moderate or lower level of risk to asset from fishing.	Maintain current management arrangements aimed at achieving ecological, economic and social objectives.
					Threshold: High level of risk to asset from fishing.	Conduct a review to investigate the reasons for the variation within three months. If sustainability is at risk, implement appropriate management

Component	Management objectives	Resource /asset	Assessment	Performance Indicators	Reference Levels	Control Rules
						action to reduce the risk to an acceptable level as soon as practicable.
					Limit: Severe level of risk to asset from fishing.	Implement immediate management strategies to reduce the risk to an acceptable level.
Ecosystem	To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes.	Northwest Shelf Ecosystem, including ecological processes and assets.	Periodic risk assessments incorporating: <ul style="list-style-type: none"> • management arrangements, • catch levels, • number of reported ETP species interactions, • extent of fishing activities, • ecosystem information, and • other available research. 	Assessed level of risk for ecosystem processes and assets from fishery activities:	Target: Moderate or lower level of risk to asset from fishing.	Maintain current management arrangements aimed at achieving ecological, economic and social objectives.
					Threshold: High level of risk to asset from fishing.	Conduct a review to investigate the reasons for the variation within three months. If sustainability is at risk, implement appropriate management action to reduce the risk to an acceptable level as soon as practicable.
					Limit: Severe level of risk to asset from fishing.	Implement immediate management strategies to reduce the risk to an acceptable level.

3.5 Monitoring and Assessment Procedures

3.5.1 Information and Monitoring

3.5.1.1 Fishery-Dependent Information

Since 1979 there has been a statutory obligation to provide records of daily catch and effort in 10 x 10 nautical mile statistical reporting blocks. Information recorded includes catch by numbers, effort in dive hours, depth fished, statistical reporting block, visibility, quota record, and tag numbers for the panels where pearl oysters are stored. As a result of the constraints of diving to avoid decompression illness, the estimates of effort derived from the daily catch and effort logbook are highly accurate as they are dependent on pre-determined depth/time profiles that are consistent between pearl divers and from year to year. These commercial catch rates are used in the assessment of *P. maxima* stocks.

3.5.1.2 Fishery-Independent Information

3.5.1.2.1 Recruitment Monitoring

Recruitment is monitored using a unique settlement index (the “piggyback” spat index as described by Hart and Joll 2006). The piggyback spat index is derived by counting juvenile spat that settle onto adult oysters as part of the commercial monitoring program. The annual change in recruitment strength measured by this index is one of the primary tools used to forecast future stock abundance and consequently, the SHL. Spat samples are obtained from 30 000 to 155 000 adult pearl oysters each fishing year from individuals inspected on 200 to 800 dives. Spat are counted, measured and separated into two age classes based on their size frequency. The age classes are newly settled spat (age 0+) 5 to 35 mm SL (4 – 7 months old), and age 1+ 35 to 75 mm length (16 – 19 months old).

3.5.1.2.2 Population Surveys

Population surveys have been undertaken on a periodic basis over the history of the POF and have been incorporated into the annual monitoring for Zone 2/3 since 2007. Research personnel design the sampling regime at specified fixed sites each year and also several random sites within the POF. DPIRD hires highly experienced commercial divers to sample the target areas, capturing all observed pearl oysters. Research personnel record all measurements. 3000 to 5000 pearl oysters are measured from 30 to 150 sites per year. SCPUE of +175 mm SL pearl oysters during the surveys provide an index of spawning stock abundance and are used for stock assessment and in the harvest strategy (Table 2).

In addition to annual monitoring, two scientifically designed surveys to quantify the absolute abundance and SHL of +175 mm SL pearl oysters within Zone 2/3 were undertaken from 1999 to 2001 (Hart and Friedman 2004) and from 2012 to 2013 (Hart et al. 2014b).

3.5.2 Assessing Fishery Impacts

3.5.2.1.1 Standardisation of Catch Rate and Recruitment Indices

Commercial catch rate data are standardised using a generalised linear model to account for the effects of year, visibility, vessel, neap, grid, depth, and experience (of pearl divers). The resultant model is applied to the individual pearl drift (dive) catch rate data. Each pearl drift is undertaken by four to eight pearl divers of varying experience for a period of 30 to 60 minutes, depending on depth. The piggyback spat index of *P. maxima* recruitment is also standardised using a generalised linear model accounting for year, neap, patch and depth.

3.5.2.2 Ecological Risk Assessments

DPIRD uses a risk based EBFM framework to assess the impacts of fishing on all parts of the marine environment, including target species, bycatch, ETP species, habitats and the ecosystem. In line with this framework, periodic risk assessments are conducted for the POF. These assessments are used to prioritise research, data collection and monitoring needs, as well as management actions for the POF to ensure that fishing activities are managed both sustainably and efficiently.

In August 2015, an ecological risk assessment (ERA) workshop was held to assess the impacts of the WA *P. maxima* pearling industry, including the wild capture, hatchery and pearl culture operations (Travaille et al. 2016). The workshop participants included representatives from the pearling industry, the Western Australian Fishing Industry Council (WAFIC), environmental groups, DPIRD and the then NT Department of Industry, Tourism and Trade. The risk assessment framework applied during the workshop 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, 2015).

Four aspects were considered for the assessment: ecological sustainability, community wellbeing, external factors and governance (note only ecological sustainability is currently considered as part of this Harvest Strategy). Fourteen ecological components were identified as potentially impacted by the WA *P. maxima* Pearling Industry's operations, with 31 possible associated issues (Travaille et al. 2016).

Risk assessments will be undertaken periodically (every 3 – 5 years) to reassess any current or new issues that may arise in the POF; however, a risk assessment can also be triggered if there are significant changes identified in fishing operations or management activities or controls that may change current risk levels. A new ERA for the POF is scheduled to be conducted in 2022.

4.0 Management Measures and Implementation

4.1 Management Measures

The PA provides the overarching legislative framework to implement the management arrangements for the WA pearling industry. Table 3 presents the management measures in place for the POF that are used to help achieve the management objectives. These measures can be amended as needed to ensure the POF is achieving management objectives; however, these do not preclude the consideration of other options.

Table 3: Current management measures and instrument of implementation for the pearl oyster fishery.

Measure	Description	Instrument
Species restrictions	The pearling industry is limited to the collection, seeding and grow-out of <i>P. maxima</i> .	<i>Pearling (Declaration of Pearl Oysters) Notice 1995</i>
Size limits	The minimum size for wild stock collected <i>P. maxima</i> is 120 mm SL however, a minimum legal size of 100 mm SL (restricted to 15% of the total catch) has been trialled since 2011. The 100 mm trial was approved by the CEO at the request of the pearling industry to ascertain the suitability of smaller wild pearl oysters for seeding, noting that the 120 mm size had been in place for many years and that seeding techniques had progressed over time. The trial began in 2011 for three years and has now been approved to continue until 31 December 2022.	<i>Pearling (Pearl Oyster Shell Size) Notice 1997 Letter from CEO</i>
Method restrictions	Pearl oysters can only be taken by means of diving and by hand.	<i>Pearling (General) Regulations 1991</i>
Quota system	The POF is managed via output controls in the form of a TACC, which is divided into individually transferable quota units as conditions on Pearling (Wildstock) Licences. The total number of permanent wildstock quota units in the POF is 572, with the unit value determined annually based on stock assessment advice.	<i>MPG No. 17; Licence condition; Wildstock TACC determined annually by CEO</i>
Licence requirements	Operators must hold an appropriate licence to undertake wild collection, hatchery or seeding operations. Licences are renewed annually. PA (Section 23). Pearling (Wildstock) Licence holders are required to hold a minimum of 15 quota units.	<i>Pearling Act 1990 (Section 23)</i> <i>MGP No. 17</i>

	Pearling (Wildstock) Licences allow for the take of pearl oysters from the wild, transport or holding and the practice of pearl culture (seeding) techniques on wildstock pearl oysters.	
Spatial restrictions – zoning	The POF is divided into four Zones. Wildstock quota units are currently distributed across Zones 1 – 3.	<i>Pearling (Declaration of Zones) Notice 1995 and Pearling (Declaration of Zones) Amendment Notice 1997</i> <i>Pearling (Wildstock) Licence Conditions</i>

4.1.1 Implementing Changes to the Management Measures

Decision-making processes can be triggered following the identification of new or potential issues as part of an ERA (generally reviewed every 3 – 5 years), results of research, management or compliance projects or investigations, monitoring or assessment outcomes (including those assessed as part of the Harvest Strategy) and / or expert workshops and peer review of aspects of research and management.

There are two main processes for making decisions about the implementation of management measures and strategies in the POF:

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

If there is an urgent issue, stakeholder meetings may be called on an as-needed basis to determine appropriate management action.

4.1.2 Consultation

Management changes are generally given effect through amendments to legislation, such as the PA, PR, notices and Ministerial Policy Guidelines, as well as licence conditions. These changes generally require the approval of the Minister for Fisheries and/or the CEO of DPIRD (or appropriate delegates). In making decisions relevant to fisheries, the Minister for Fisheries may choose to receive advice from any source but has indicated that DPIRD is the primary source of management advice, with the commercial fishing industry also providing advice and representation.

4.1.2.1 Commercial Sector Consultation

Under a Service Level Agreement (SLA) with DPIRD, WAFIC has been funded to undertake statutory consultation functions related to fisheries management and the facilitation of annual management meetings for licensed fisheries. Annual Management Meetings (AMMs) between DPIRD, WAFIC and the pearling industry are used as the main forum to consult with stakeholders and licence holders on the

management of the POF. During the AMMs, current and future management issues that may have arisen during the previous fishing season, and any proposed changes to the management structure, are discussed. Follow-up meetings may be held as required.

4.1.2.1.1 TACC Setting Process

The annual TACC is determined by the CEO of DPIRD through a consultative process that occurs from October to December each year (refer to Figure 3). Results from the annual stock assessment, monitoring and research are presented by DPIRD to the SAWG, which is considered as the key source of advice in respect to setting the TACC. The SAWG comprises DPIRD and pearling industry members and meets to discuss the annual stock assessment and TACC recommendations in line with the harvest control rules.

The recommendations from SAWG are then provided to industry for comment. SAWG's recommendations, industry comments and the final recommendations for the TACC are then provided to the CEO of DPIRD for consideration and a final determination. Once the final determination is made, licence renewals and season arrangements commence for the following year.

In 2021, the SAWG recommended the Zone 2/3 TACC range of 731,200 to 776,900 pearl oysters with 100 to 175 mm SL, equating to an ITQ of 1600 to 1700 120 to 175 mm SL pearl oysters per unit within the existing rule.

Also in 2021, SAWG recommended that the Zone 2/3 TACC for pearl oysters with SL +175 mm, be set using the new predictive forecast model for the first time. The model has a large lead time, with abundance being predicted up to seven years in advance. Under this model, the TACC for +175 mm SL pearl oysters in Zone 2/3 was predicted to be 63,000 (95% CL: 36,000 to 90,000).

DPIRD advised that a quota of 63,000 +175 mm SL pearl oysters was appropriate.

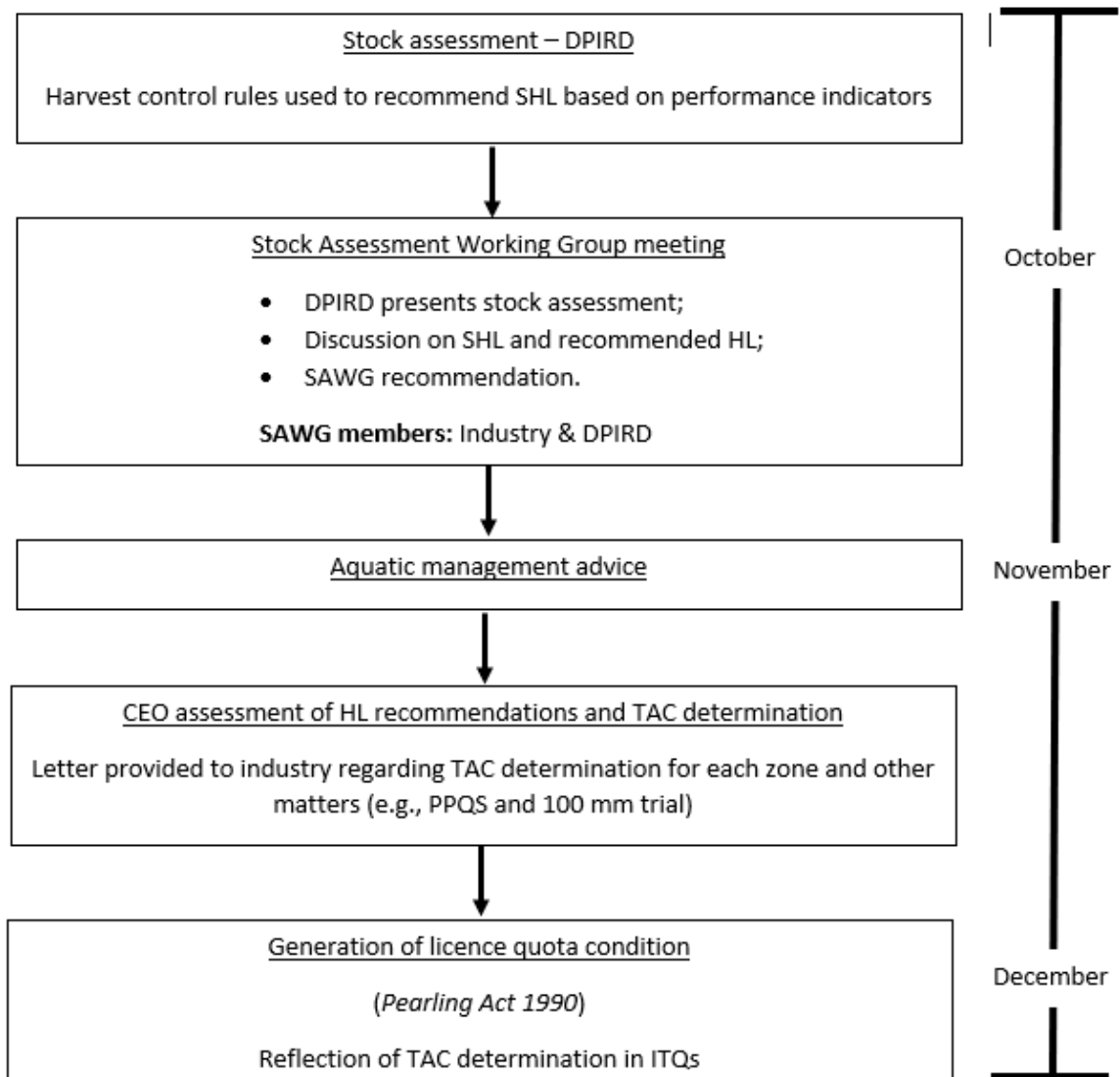


Figure 3: Annual Total Allowable Catch setting process for the Pearl Oyster Fishery.

4.1.2.2 *Consultation with Other Groups*

Consultation with the broader public, marine users, Native Title groups, customary fishers and non-fisher stakeholders, including Government agencies, conservation sector, Non-Government Organisations (NGOs) and other affected/interested parties is undertaken on an as needs basis in accordance with DPIRD's *Stakeholder Engagement Guideline* (Department of Fisheries 2016) and Administrative Guideline 1.

DPIRD'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 are subjected to both formal key stakeholder consultation and public consultation processes.

5.0 Compliance and Enforcement

As the key regulatory agency, DPIRD's compliance role is to achieve sustainability, economic and social objectives by addressing:

- Our ability and capacity to influence compliance with the rules; and
- The effectiveness, capacity and credibility of the compliance program.

DPIRD's compliance model is based on the *Australian Fisheries National Compliance Strategy 2016-2020* (the National Strategy). DPIRD's compliance program is aligned to support the three key compliance strategies recommended by the National Strategy:

- Maximising voluntary compliance;
- Effective deterrence; and
- Organisational capability and capacity

The Western Australian Fisheries Compliance Strategy (the Strategy; DPIRD 2018) provides the principles underlying DPIRD's compliance role and how its compliance services are delivered to the WA community. The Strategy aligns with, and complements DPIRD's *Compliance Framework and Risk Assessment Policy*, which informs the risk-based model, compliance planning and the governance structure applied to fisheries compliance services.

5.1 Operational Compliance Plans

Management arrangements for the POF are enforced under an Operational Compliance Plan (OCP) that is informed and underpinned by a compliance risk assessment and is reviewed every one to two years. The objectives of the POF OCP are to:

- Provide clear direction and guidance to officers regarding compliance activities that are required to support effective management of the fishery;
- Provide a mechanism that aids the identification of future and current priorities;
- Encourage voluntary compliance through education, awareness and consultation activities; and
- Review compliance strategies and their effective implementation.

5.2 Compliance Strategies

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

- Land and sea patrols;
- Catch validation against managed fishery licences;
- Inspections of wholesale and retail outlets;
- Inspections at processing facilities;
- Inspections of vessels in port
- Pre-season briefings;
- At sea inspections of fishing boats, equipment and leases.

Inspections may involve inspection of:

- All compartments on board the vessels;
- All authorizations;

- Logbooks and pearling tags;
- Equipment; and
- Catch on board the boat.

5.3 Vessel Monitoring System

Some boats operating within the POF are voluntarily fitted with a device known as an automatic location communicator (ALC). The ALC is used to track the location of a boat by transmitting information such as the geographical position, course and speed of the boat. VMS may become compulsory in the POF when it is transitioned to the ARMA.

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7.0 Appendix 1

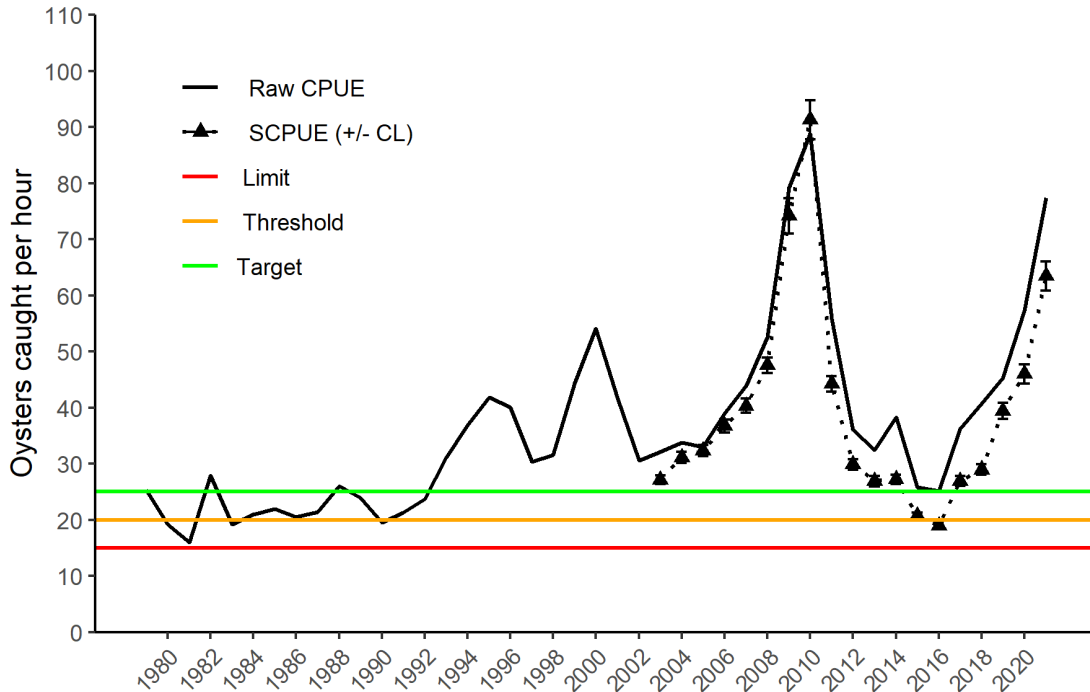


Figure A-1: Standardised catch rate (SCPUE) performance measure, and associated target, threshold and limit levels of 120 to 175 mm SL pearl oysters. Unstandardised CPUE is shown for comparison.

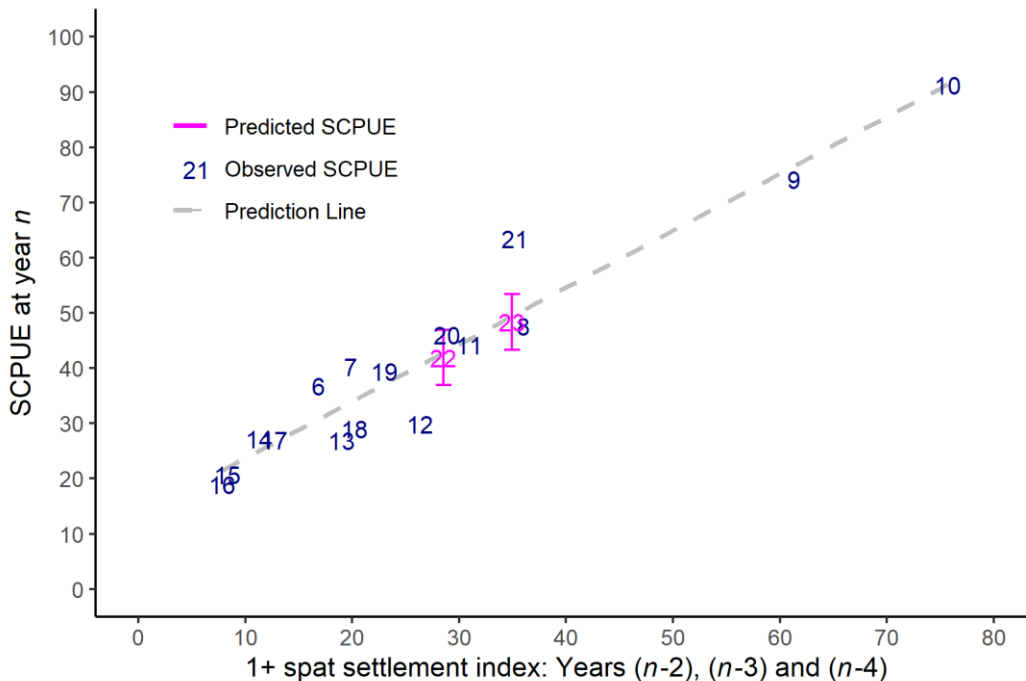


Figure A-2: Multiple regression model used to predict SCPUE of 120 to 175 mm SL pearl oysters in year n as a function of 1+ spat settlement index in years $n-2$, $n-3$, and $n-4$. Forecast values of SCPUE are used to calculate the sustainable harvest level (SHL), shown for 2022 and 2023

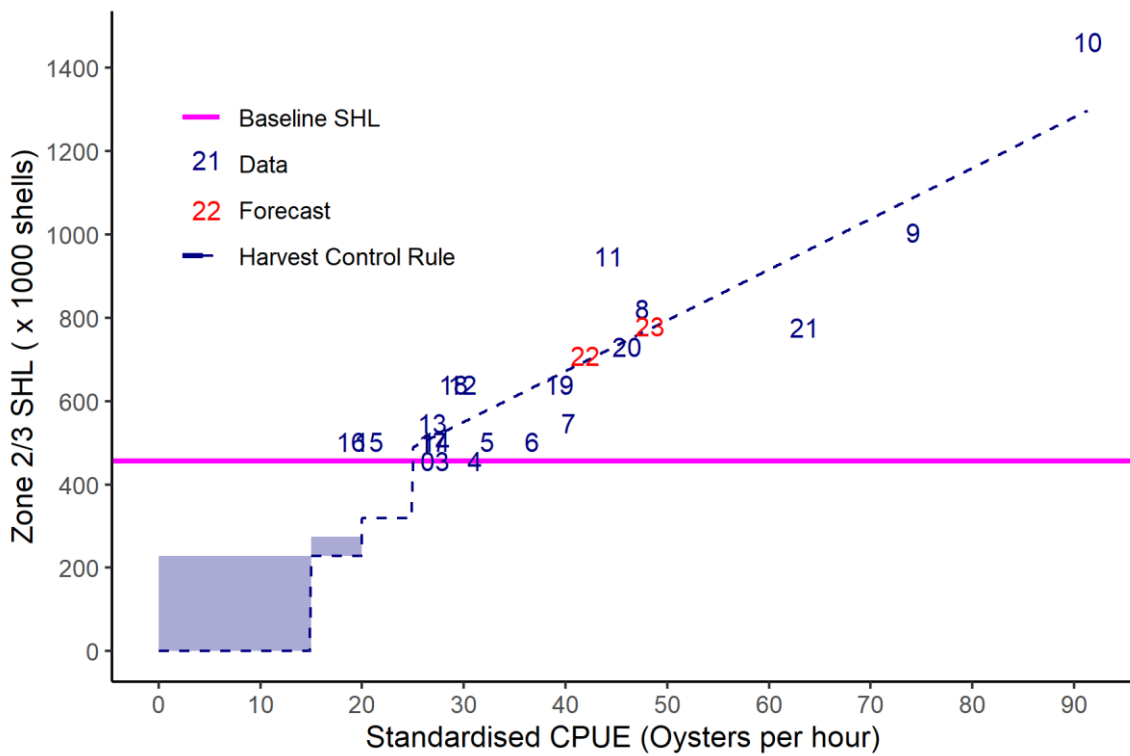


Figure A-3: The harvest control rule used for calculating the Zone 2/3 SHL (Sustainable Harvest Level) is based on forecast values of SCPUE from the spat settlement index. When forecast SCPUE is above target levels, the SHL is proportional to SCPUE. Blue numbers compare the SHL against the achieved SCPUE from 2003 to 2021. Red numbers are forecast values of the SHL. Below target levels the reductions are made relative to a baseline SHL. Blue shaded zones indicate range of values allowed under the harvest control rules when SCPUE is below threshold and limit levels.

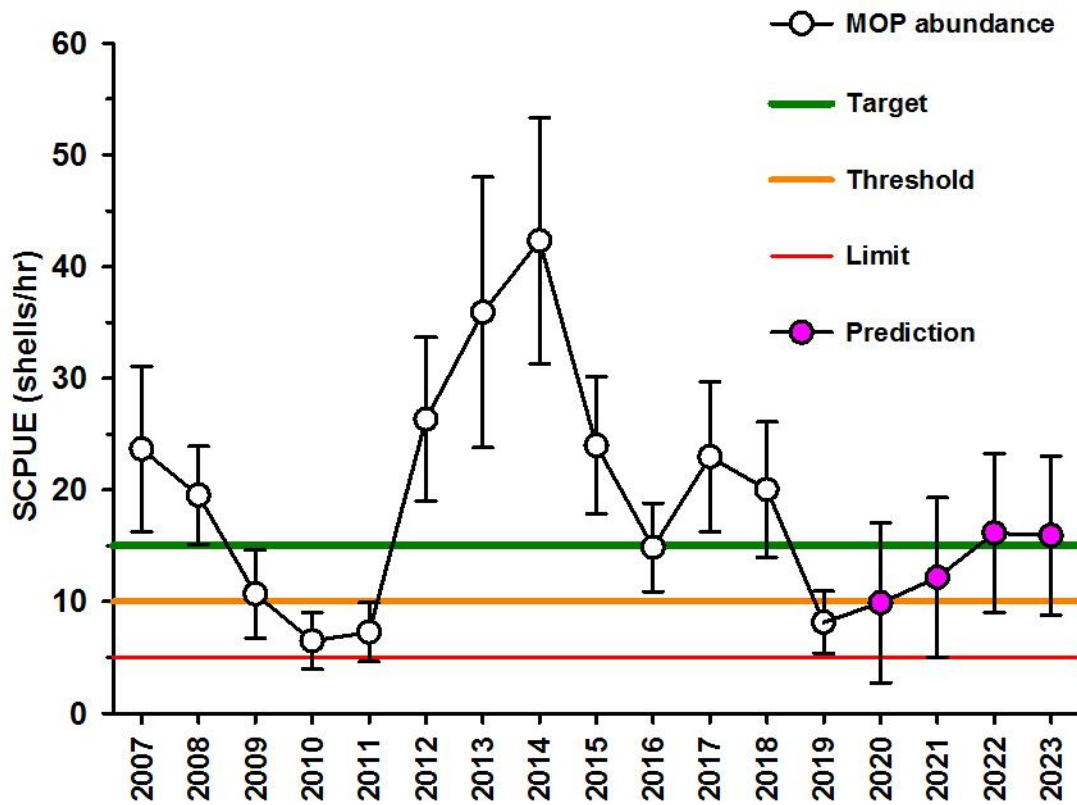


Figure A-4: Standardised catch rate (SCPUE) performance measure, associated target, threshold and limit levels, and abundance predictions for +175 mm SL pearl oysters.

$$\text{MOP}_{\text{SCPUE}} = 0.93 \text{ Age } 1+_{(n-7)} + 0.92 \text{ Age } 1+_{(n-8)} + 7.55 \quad (R^2 = 0.71)$$

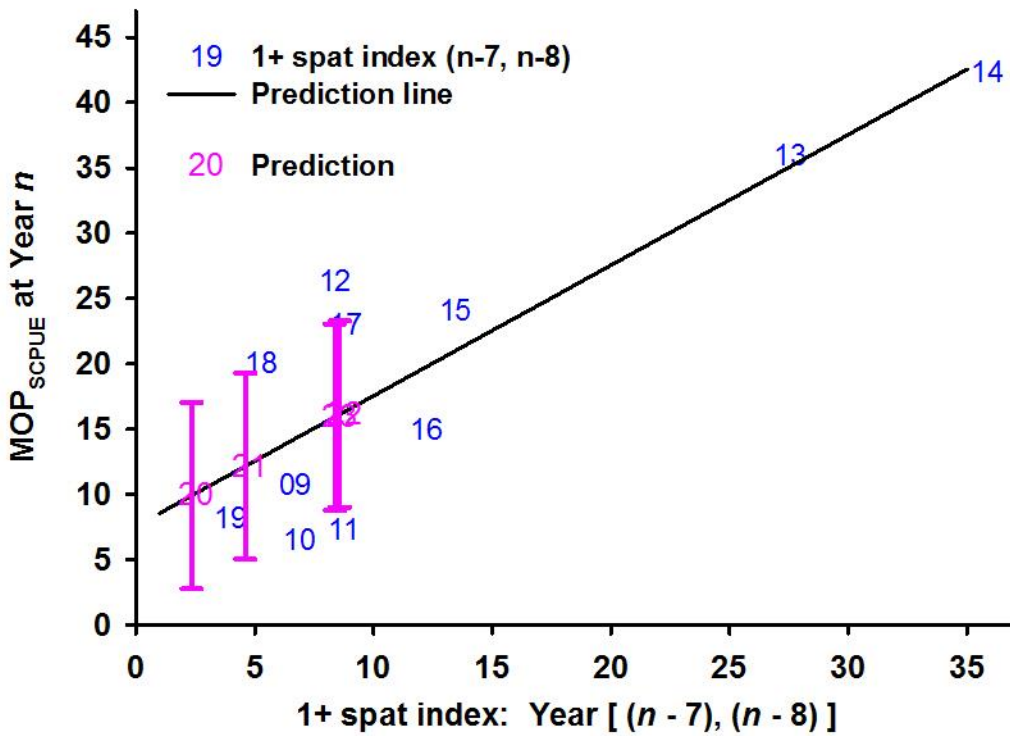


Figure A-5: Multiple regression model used to predict SCPUE of +175 mm SL pearl oysters in year n as a function of 1+ spat settlement index in years $n-7$, and $n-8$. Forecast values of SCPUE are used to calculate the sustainable harvest level (SHL), shown for 2022 and 2023

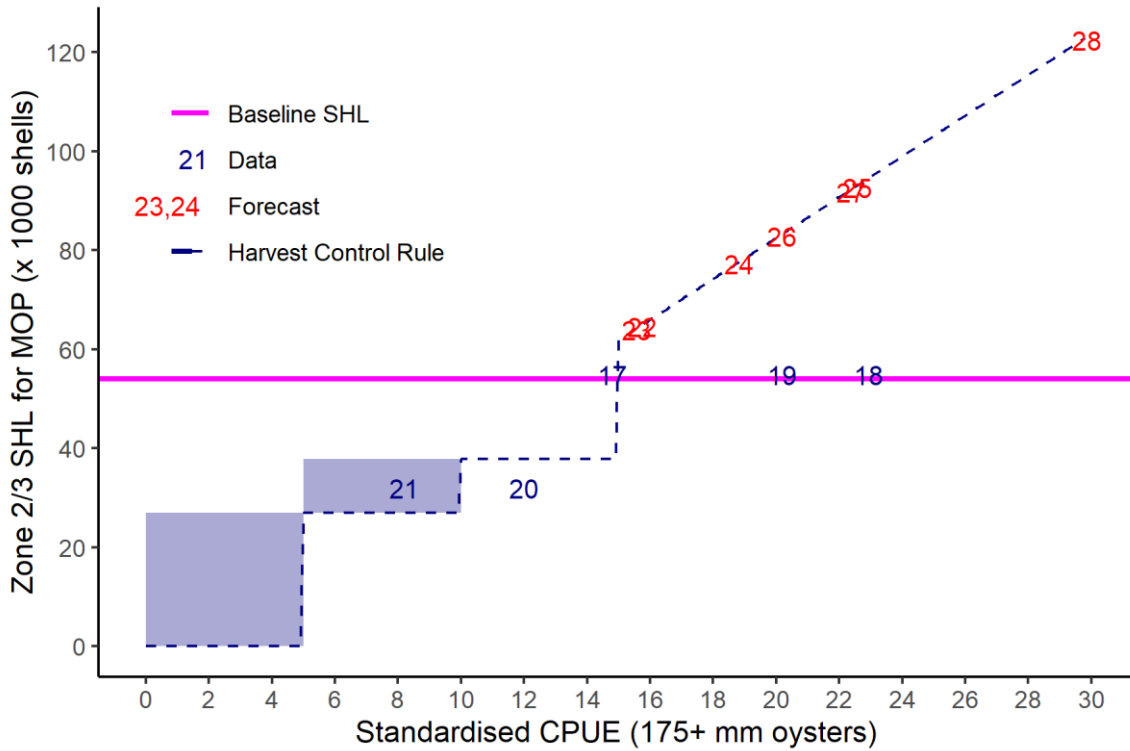


Figure A-6: The harvest control rule used for calculating the SHL for +175 mm SL pearl oysters in Zone 2/3. When forecast SCPUE is above target levels, the SHL is calculated using the SCPUE, and parameters for fishing efficiency and area of the stock. Blue numbers compare the SHL against the achieved SCPUE from 2017 to 2021, prior to a predictive capacity becoming available. Red numbers are forecast values of the SHL for +175 mm SL pearl oysters using the new predictive model. Below target levels the reductions are made relative to a baseline SHL. Blue shaded zones indicate range of values allowed under the harvest control rules when SCPUE is below threshold and limit levels.