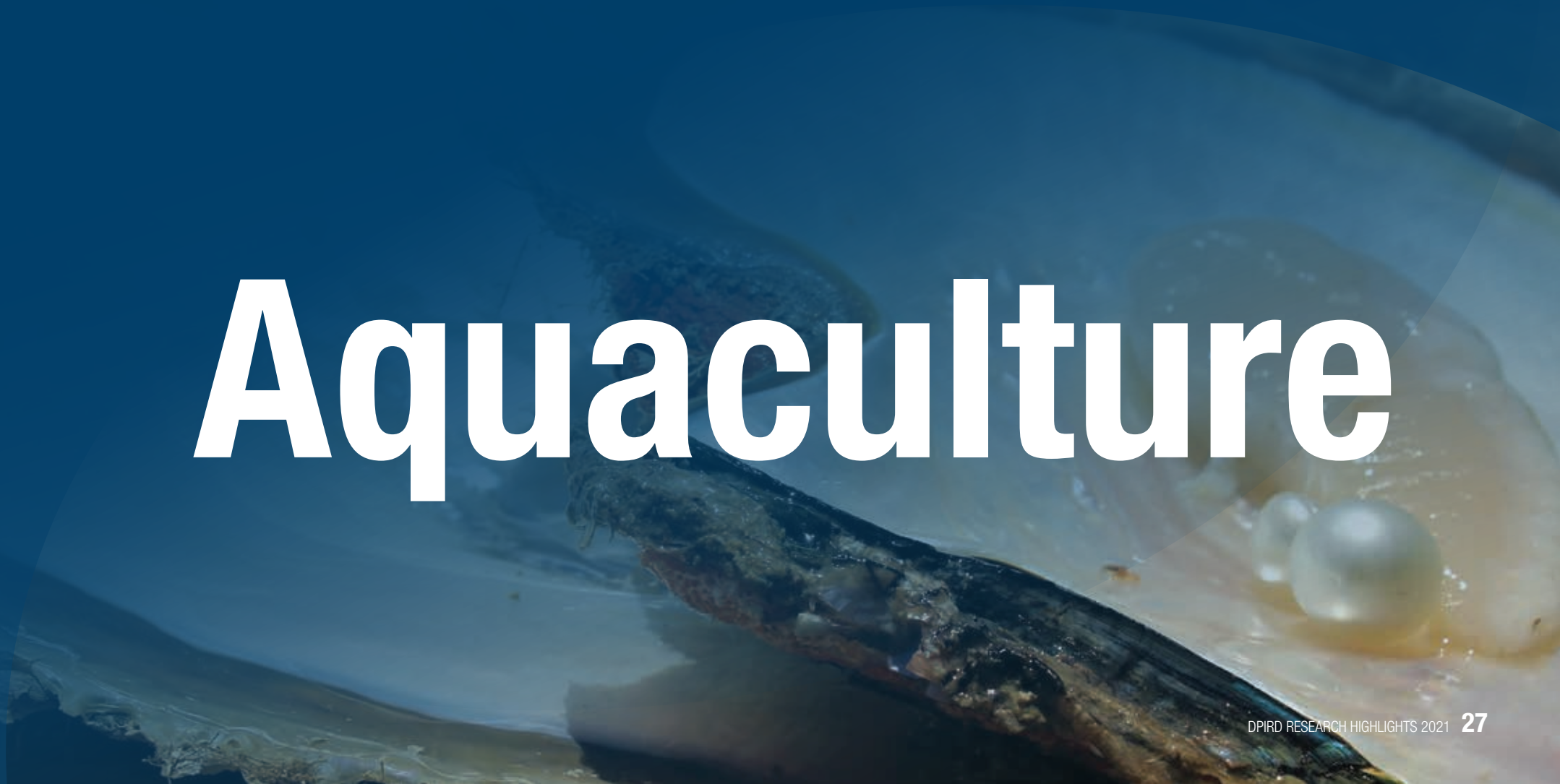
Aquaculture



Overview

Aquaculture is the world's fastest growing food production sector. The proportion of farmed species in the global fishery industry was projected to exceed that of wild-caught species for the first time in 2020.

Greg Jenkins
DIRECTOR, AQUACULTURE DIRECTORATE

IN WESTERN AUSTRALIA, aquaculture is relatively small by global standards. The total value of commercial fisheries and aquaculture production in 2017–18 in WA was $633 million, of which pearling contributed $52 million and aquaculture $27 million.

To support the expansion of the aquaculture industry and grow market share, in 2017 the WA Government established the Aquaculture Directorate within the primary industries development pillar of DPIRD.

With significant state government investment, the DPIRD aquaculture team has embarked on a range of infrastructure, research and industry development projects to lift the productivity, sustainability and market competitiveness of the state's aquaculture industry.

Our core team of 30 scientists, managers and technicians is working closely with industry to supply juvenile fish and shellfish for commercial production and carry out research and development into fish and shellfish genetics, breeding, nutrition and diseases.

Current and proposed investment in WA aquaculture by industry and government is projected to increase direct and indirect employment from an estimated 280 jobs to almost 6000 jobs when operating at full capacity.

AQUACULTURE DIRECTORATE

Purpose: to grow the commercial aquaculture industry in WA.

COMMERCIAL AQUACULTURE

TEST

Supply juvenile fish and shellfish to emerging aquaculture businesses for grow-out trials.

GROW

Supply juvenile fish and shellfish to commercial grow-out operations.

RECREATIONAL FISHERIES

STOCK

Breed and stock freshwater and marine fish to create or enhance recreational fisheries.

RESEARCH AND DEVELOPMENT

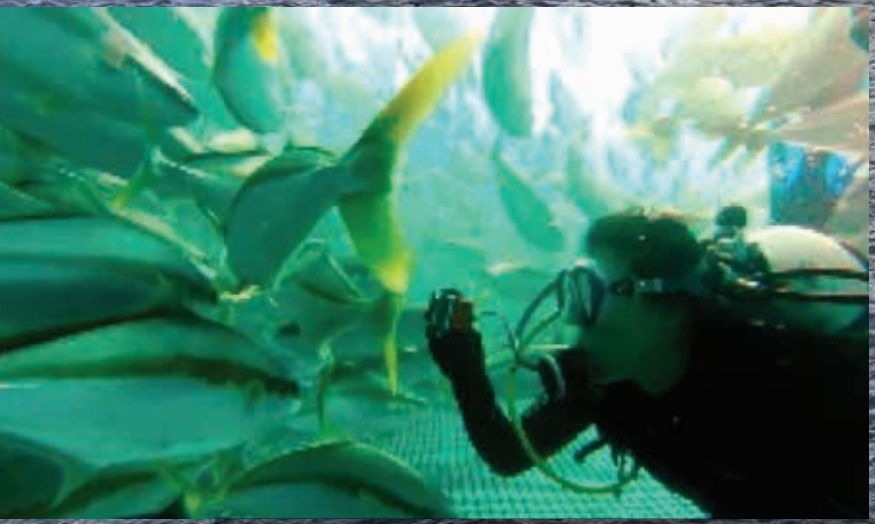
DEVELOP

Identify and support development opportunities for existing and new aquaculture species.

RESEARCH

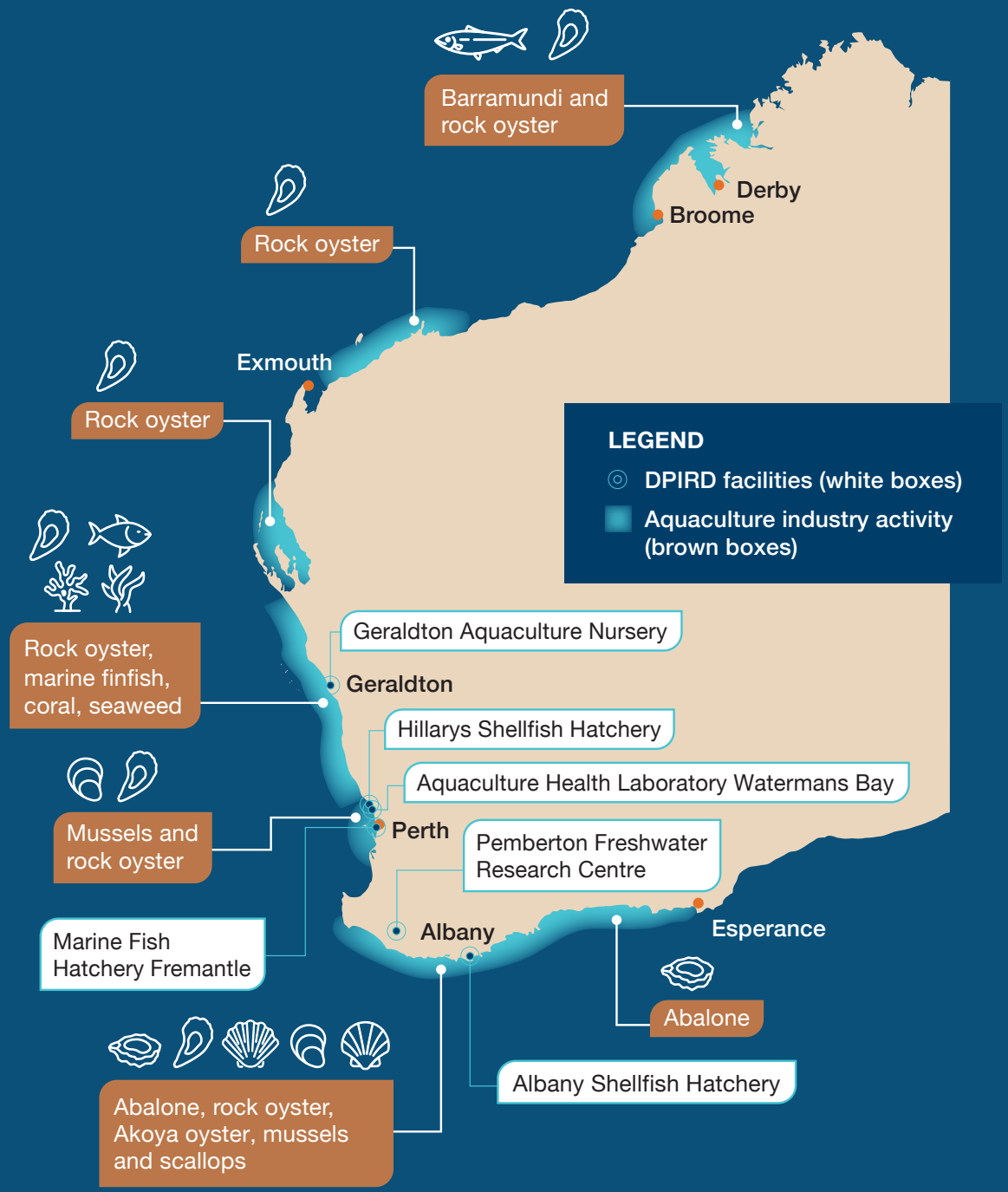
Research aquaculture health and production issues to support industry growth and address industry concerns.

Aquaculture



ABOVE: Yellowtail kingfish being grown-out to market size in a net-pen near Geraldton by Indian Ocean Fresh Australia (IOFA). Diver is Justine Arnold (IOFA).

MAIN IMAGE: IOFA fish farm manager Justine Arnold checks on the developing kingfish, which will be marketed once they reach about 3 kg. *Images courtesy of IOFA.*



Supply of juvenile fish and shellfish

The aquaculture team operates from six sites between Albany and Geraldton (see map) and provides juvenile fish and shellfish to aquaculture companies throughout the state.

For example, each year one million juvenile barramundi are supplied from our DPIRD hatchery in Fremantle to Australia's largest barramundi net-pen farm off Derby in the state's north. Each barramundi weighs just one gram and travels nearly 3000 kilometres by road before being transported by ship to be grown-out in the tropical waters of King Sound at Marine Produce Australia's facilities. Once they reach marketable size, the barramundi are destined for dinner plates across Australia and the world.

In addition to barramundi, the aquaculture team also supplies:

- juvenile yellowtail kingfish for Indian Ocean Fresh Australia's operation in Geraldton
- marron, rainbow and brown trout for commercial and recreational fishing opportunities in the south-west of WA
- juvenile tropical oysters (spat) to Maxima Opportunity in the Pilbara.

Juvenile yellowtail kingfish research trials at the Marine Fish Hatchery in Fremantle.

Aquaculture research and development

The aquaculture team is facilitating industry expansion through marine fish and shellfish development across the state.

Along with the continued culture of freshwater species, the most significant growth is anticipated in sectors culturing marine finfish and shellfish such as yellowtail kingfish, barramundi, abalone and edible oysters.

Aquaculture research and development takes place at six fish and shellfish facilities across WA.

Marine Fish Hatchery Fremantle

The Marine Fish Hatchery on the waterfront in Fremantle was established in 1993. The facility and its staff were transferred to DPIRD in July 2018.

The hatchery supplies commercial quantities of juvenile barramundi and yellowtail kingfish to aquaculture companies in Derby and Geraldton and carries out research and development into kingfish nutrition, health and disease resistance with funding support from the Fisheries Research and Development Corporation. Research has included health and productivity issues confronting the warm water culture of yellowtail kingfish, including treatment for fluke parasites and monitoring of stress levels, and developing ways to maintain purity of marine fish hatchery water.

Aquaculture

Restocking of black bream, yellowtail kingfish, snapper, mulloway and prawns has been undertaken through the hatchery in conjunction with WA's peak recreational fishing body, Recfishwest.

Aquaculture Health Laboratory Watermans Bay

As the seafood industry develops in WA, aquatic diseases and other problems that require immediate attention will inevitably appear. To address this the WA Government committed $1.2 million to build the state-of-the-art Aquatic Animal Health Research Laboratory at the collaborative Indian Ocean Marine Research Centre (IOMRC) at Watermans Bay.

Through the health laboratory, the aquaculture team develops applied research projects in line with the needs of the seafood industry. The team leads research projects on abalone and pearl oyster health, with the objective of lifting the productivity of these industries. Research has included the effect of seismic surveys on pearl oysters, management of summer mortality of abalone, and the biosecurity risk potential of recycling mollusc shell for shellfish reef restoration.

The co-location of the laboratory with strategic IOMRC partners – the University of Western Australia (UWA), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the Australian Institute of Marine Science (AIMS – fosters collaboration on applied research projects focused on supporting the expansion of the WA seafood industry.

The health laboratory has boosted aquatic animal health capability to support the aquaculture industry.

Indian Ocean Marine Research Centre.

Albany Shellfish Hatchery

The Albany Shellfish Hatchery is supporting the emerging oyster industry in WA by providing juvenile oysters and mussels for industry trials and expansion. The hatchery is state-owned but leased to a private operator and aims to become self-funding.

The hatchery can grow multiple species of marine shellfish in mass quantities to supply grow-out farms throughout WA. This has reduced risk and costs to shellfish aquaculture operators and has resulted in companies investing significantly in the development of the industry. Demand from commercial operators for juvenile rock and Akoya oysters, mussels and scallops has increased steadily since the hatchery opened in December 2017. The increase in demand has led the state government to commit funds to building a shellfish nursery on the site to enable the Albany Shellfish Hatchery to meet the demand.

Geraldton Aquaculture Nursery

Design of the Geraldton Aquaculture Nursery began in 2020 to support the development of the marine fish aquaculture industry in the Mid West of WA. Once operational, the nursery is expected to produce 200 000 juvenile yellowtail kingfish every two months to supply new and existing commercial aquaculture operations in WA.

Aquaculture

DPIRD's Fremantle hatchery will supply the Geraldton nursery with yellowtail kingfish at a size of one gram. The nursery will nurture the tiny fish until they reach 50 grams when they will be transferred to commercial aquaculture operations.

Huon Aquaculture, the second largest salmon grower in Tasmania, has been allocated 2200 hectares in the Mid West Aquaculture Development Zone and plans to commence growing yellowtail kingfish in WA within two years.

Pemberton Freshwater Research Centre

DPIRD operates the Pemberton Freshwater Research Centre. The hatchery at the research centre is the foundation of the 'put and take' rainbow and brown trout fishery across the south-west of WA, which is enjoyed by around 9000 licensed anglers each year.

Without the annual inputs of fry (trout up to about 5 cm in length), juvenile trout (about 5 to 10 cm), yearlings (about 20 to 30 cm) and ex-broodstock fish, there would be no WA trout fishery, an industry estimated to contribute about $18 million annually to the South West regional economy.

Faster growing trout can be produced at the research centre and a unique genetic line of temperature-tolerant rainbow trout has attracted the attention of international research institutions.

Trout production and stocking continue to be the research centre's primary function, and recent research has investigated ways to improve survival of released fish.

In 2020 the research centre produced about 500 000 fry, grew-out at least 35 000 yearlings and released over 2300 ex-broodstock fish. WA aquaculture businesses grow-out over 75 000 fry each year, which are consumed in Perth restaurants and exported to premium Asian markets.

We are breeding genetically improved smooth marron, and staff will harvest juveniles in early 2022 to stock industry growth trials and marron farmers' ponds.

As well as commercial activities, we are working with the Perth Zoo on its hairy marron conservation program, which is overseen by the Department of Biodiversity, Conservation and Attractions. The endangered hairy marron, a freshwater crayfish, is only found in Margaret River.

Hillarys Shellfish Hatchery

DPIRD's Hillarys Shellfish Hatchery undertakes research into shellfish spat production and supplies small commercial quantities of new species to support farming trials and kick-start new initiatives. The research will develop guidelines for the shellfish industry and potential investors regarding the most suitable tropical rock oyster species for northern Australia, and the best techniques to farm them.

One such initiative already underway is the tropical black lip rock oyster project supported by the Cooperative Research Centre for Developing Northern Australia in collaboration with industry partner Maxima Rock Oyster Company.

Brood oyster stock collected from Cone Bay in the Kimberley has been successfully bred by the aquaculture team at Hillarys. Pilot-scale batches of oyster spat have been supplied to trial sites in the Pilbara and Kimberley to test the commercial viability of tropical rock oyster farming in these regions.

The oyster is a fast grower and expected to perform well in northern tropical conditions, making it a good economic option for farmers and it will potentially attract investment to expand the industry.

Aquaculture

Aquaculture is very much an emerging industry in WA and DPIRD's aquaculture team is well positioned to have a positive impact on the sector's continuing expansion.

GREG JENKINS

LEFT: Tropical rock oysters.

MAIN IMAGE: Barramundi being harvested from the crowd net using a crane-operated brail net at Marine Produce Australia, Cone Bay, WA.

MARINE FISH

Farm staff at Marine Produce Australia crowding barramundi in a net-pen in preparation for harvesting, Cone Bay, WA.

MARINE FISH

DPIRD's marine fish research and development team investigates all aspects of fish production from breeding and larval rearing through to genetic selection, nutrition and disease.

Dr Gavin Partridge
SENIOR RESEARCH SCIENTIST
(MARINE FISH)

OVER THE PAST TWO DECADES the team has successfully developed ways to culture a range of new aquaculture species and deliver juvenile fish to commercial aquaculture operations across Western Australia.

The current focus is on two species with significant potential for industry development in WA – yellowtail kingfish and barramundi.

Yellowtail kingfish are highly valued globally for white-fleshed sashimi.

Harvested barramundi from Marine Produce Australia, Cone Bay, WA.

There is strong domestic and export demand for barramundi. The company Marine Produce Australia plans to increase production to 30 000 tonnes per year by 2030 for domestic and export markets.

The significant growth that is anticipated for marine fish aquaculture in WA will contribute to economic development and boost regional employment.

Stress test provides timely fish health reports

Farmed marine fish and shellfish species are at increased risk of health issues compared to their wild counterparts. DPIRD research scientists are developing a method to assess fish health based on oxidation levels of blood proteins.

DPIRD staff (from left to right) Luke Pilmer (research technician and PhD student), Dr Lindsey Woolley (research scientist) and Dr Gavin Partridge (senior research scientist) sampling juvenile yellowtail kingfish under light sedation during a feed trial at the DPIRD Marine Fish Hatchery Fremantle.

Marine Fish

DPIRD'S AQUACULTURE RESEARCH team is developing an early warning system for monitoring the health of farmed fish and shellfish.

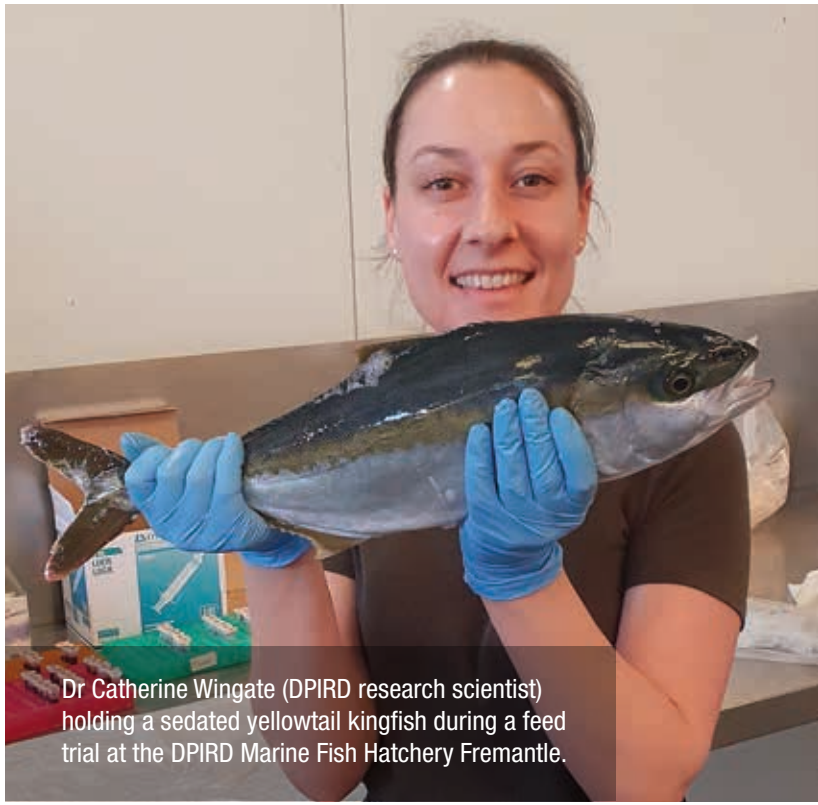
Research scientist Dr Catherine Wingate is leading the project in collaboration with the University of Western Australia (UWA) to adapt technology originally developed by UWA to monitor physiological stress in humans.

These differences can result in stress levels that are currently difficult to pick up before fish growth rates decline or health issues arise.

Inflamark is a stress-detecting technology that measures the oxidative stress of blood protein biomarkers. In humans, a single drop of blood is collected by fingerprick and analysed in the laboratory for protein oxidation, which is a measure of physiological stress.

Farmed fish are handled more than their wild counterparts, while also growing in conditions and consuming diets not normally encountered in natural environments.

Juvenile kingfish.



Dr Catherine Wingate (DPIRD research scientist) holding a sedated yellowtail kingfish during a feed trial at the DPIRD Marine Fish Hatchery Fremantle.

But measuring physiological stress in fish blood is considerably more complex than in human blood. Humans have one main protein biomarker oxidised in blood, while the blood of yellowtail kingfish, for example, contains multiple proteins that are affected by stress.

While the discovery of the additional protein biomarkers in fish was initially seen as a setback, Catherine has since found that the extra biomarkers will actually greatly enhance the sensitivity of the final Inflamark test being developed.

DPIRD researcher Luke Pilmer taking a blood sample from a sedated kingfish.

Marine Fish

Early trials

Catherine has completed several trials to assess the potential of Inflamark to detect stress in yellowtail kingfish, barramundi, Atlantic salmon, rainbow trout and Sydney rock oysters (Figure 1). The preliminary assessments confirm that Inflamark is a sensitive measure of physiological stress across a range of commercially important species. Validation of the test is continuing and the project is seeking industry collaboration.

Realising the potential of Inflamark for aquaculture

Converting Inflamark from a specialised research technique to a practical tool for use by the aquaculture industry will require further validation of the technology as a stress test and a simplification of the blood collection process.

To validate Inflamark, existing testing methods used in commercial aquaculture will be used to compare Inflamark against measures such as growth, mortality and pathogen infection rates.

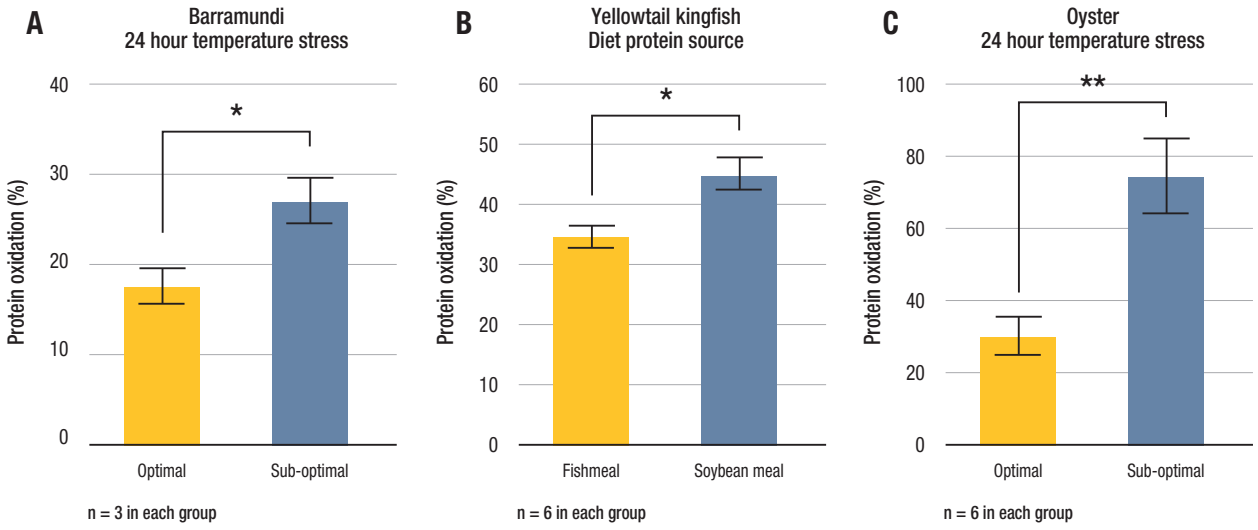


FIGURE 1. Inflamark measures changes in oxidation of fish blood (A, B) and oyster haemolymph (C) protein biomarkers under physiological stress

Twenty-four hours of exposure to non-optimal water temperature increased levels of oxidative stress in barramundi (A) and Sydney rock oysters (C). Soybean meal feed increased oxidative stress in yellowtail kingfish compared to fishmeal after 28 days on each diet (B). Data presented as mean ± S.E.M. with significance shown as *p <0.05, ** p<0.01

Currently, fish blood samples must be collected and processed on-site and then transported on dry ice to the laboratory for analysis. Not only does this require the skills of a trained scientist, it is impractical for use on a remote fish farm or offshore vessel.

Catherine is developing a more streamlined approach in which a drop of blood is dried in a specialised collection device containing fixative. The collection device will not require specialised skills to use and can be transported at room temperature without loss of sample integrity.

The ultimate goal is to develop Inflamark as a device that can be used on-farm to provide a timely warning about stress in fish.

MAIN IMAGE: Dr Lindsey Woolley feeding juvenile yellowtail kingfish in nursery tanks at DPIRD's Marine Fish Hatchery Fremantle.

INSET LEFT: Juvenile kingfish

Tasty treatment keeps kingfish clean

Farmed yellowtail kingfish are susceptible to fluke parasites. Collaborative research between DPIRD and the University of Western Australia is delivering a convenient, safe and reliable oral method to treat the parasites.

Commercial operations undertake regular bathing operations to treat kingfish for fluke parasites.
Image courtesy of IOFA

The mouth part of an adult gill fluke that grazes on the gill filaments of kingfish.

Dissected body of an adult gill fluke showing eggs.

YELLOWTAIL KINGFISH are susceptible to flukes, including one species of gill fluke and two species of skin flukes. Fluke infestations lead to anaemia, loss of appetite, poor growth and secondary infections that can lead to death. The flukes, therefore, pose a significant risk to the sustainability and profitability of the industry.

To control flukes in commercial operations, yellowtail kingfish are routinely bathed in their net-pens with a precise amount of hydrogen peroxide. However, the procedure is labour intensive, very costly and comes with a high mortality risk if not carried out correctly.

The current hydrogen peroxide method for controlling external flukes is very expensive and time-consuming and contributes up to 20 per cent of the operational costs of farming.

Fluke parasites have a rapid life cycle and hydrogen peroxide is ineffective at killing fluke eggs, which then hatch to re-infest the fish. Because of this, frequent treatments with hydrogen peroxide are needed.

To overcome the fluke treatment problem, the Marine Fish Hatchery team in Fremantle has developed an oral treatment that uses a broad spectrum anti-parasitic called praziquantel and a unique delivery method as an alternative to the difficult and expensive fluke treatments currently used by commercial kingfish farmers.

The new approach is a safer, cheaper and more reliable method to treat external fluke parasites on cultured yellowtail kingfish.

Breakthrough in taste-masking

Praziquantel is highly effective in the management and treatment of flukes but has a very bitter taste that is unpalatable to fish, and yellowtail kingfish are particularly sensitive to the taste – especially as they grow larger.

DPIRD's Marine Fish Hatchery team, led by senior research scientist Dr Gavin Partridge, has been investigating ways to disguise or mask praziquantel's bitter flavour in an attempt to convince fish to eat it.

A breakthrough in the research was delivered through collaboration with Professor Lee Yong Lim and Dr Edith Tang from the Faculty of Health and Medical Sciences at the University of Western Australia (UWA). UWA had previously developed and patented a preparation that masked the taste of medications for human use.

The DPIRD–UWA collaboration investigated various formulations of praziquantel with the taste-masking preparation, finally developing one that was both highly palatable and digestible for yellowtail kingfish.

Further efficacy trials of the palatable praziquantel formulation are planned in collaboration with UWA and industry, and the research team will investigate commercialisation and intellectual property protection options.

When successful, the technology will be of enormous benefit to yellowtail kingfish farmers in WA and other regions of Australia. It will also assist the many fish farmers struggling to control similar parasites, and those looking for a way to deliver oral treatments to fish via feed.

MARINE SHELLFISH

Oyster spat at the Albany Shellfish Hatchery.

MARINE SHELLFISH

A 2013 survey of the Western Australian aquaculture industry indicated that oysters could become a major industry in the state if a ready supply of juveniles (spat) became available.

Dr Michel Bermudes
SENIOR RESEARCH SCIENTIST
(MARINE SHELLFISH)

THE STATE GOVERNMENT subsequently invested $2.3 million to build the Albany Shellfish Hatchery, which was commissioned in 2018, and provided $1.35 million in operational funds to cover its first three years.

DPIRD's marine shellfish team was formed in 2018 to cater for the needs of the developing oyster industry.

The number of new entrants into the oyster industry and orders for spat have exceeded expectations and the new sector is growing rapidly.

Along with oysters, the marine shellfish team is developing hatchery technology for a range of other existing and new shellfish species suitable for aquaculture.

Interest and investment in the WA shellfish industry has increased significantly in recent times with proposed projects from Albany in the south all the way to Kalumburu in the north.

A total of 68 leases and exemptions to farm shellfish have been granted in WA, some in areas where edible shellfish have never been farmed before – in the Abrolhos Islands, Exmouth, Karratha and the Kimberley. The new shellfish farms will use native species with a low to neutral environmental footprint.

Assuming production at full capacity, WA's shellfish industry could potentially employ 2000 people based on current and proposed investment.

Tropical rock oyster spat produced by DPIRD.

Hatching new opportunities for WA's shellfish industry

DPIRD shellfish farming research is increasing the availability of juvenile shellfish for commercial investors, developing species-specific farming guidelines and supporting the farming of new shellfish species.

Deployment of the first batch of tropical rock oysters in the Pilbara, October 2020.

Image courtesy of Warren Ure, Maxima Rock Oyster Company

Marine Shellfish

Aquaculture

ONE OF THE GREATEST RISKS faced by commercial shellfish growers in WA is a shortage of juvenile shellfish (spat) for their grow-out farms. DPIRD is mitigating that risk with the production of commercial quantities of spat at the Albany Shellfish Hatchery, and the work of its shellfish research team.

A major focus of the shellfish research team is developing hatchery technology for new shellfish species for aquaculture, and refining technology for existing aquaculture species including rock oyster, Akoya oyster and mussel.

DPIRD technical officer Aisling Fontanini dissecting tropical rock oysters for pathogen screening.

To further its work on hatchery technology, DPIRD has recently established the Hillarys Shellfish Hatchery, a pilot-scale research and development hatchery located at Hillarys Marina north of Perth. The research taking place at Hillarys complements the work already being done at the Albany Shellfish Hatchery to supply rock oyster, Akoya and mussel spat to existing commercial operators.

The DPIRD shellfish research team, led by research scientist Dr Michel Bermudes, is developing hatchery technology for four new shellfish species that are native to WA.

In April 2020 the research team successfully produced spat for two species of black lip tropical rock oyster, an achievement that represents the first step in the establishment of a tropical rock oyster industry in northern WA.

As part of the project, small batches of tropical rock oyster spat (1000 to 100 000 seed) have been produced for testing under farm conditions in the Pilbara and Kimberley.

The team is also investigating two species of scallop for hatchery production. In 2021 the DPIRD shellfish research team will commence project work to produce scallop spat to supplement wild fishery stock. The scallop spat will boost the productivity of wild fisheries and provide a contingency for the fishing sector should stocks be depleted by climate change events such as marine heat waves.

In addition to producing spat, the team is developing farming guidelines for the shellfish industry and conducting commercial feasibility studies for new shellfish species.

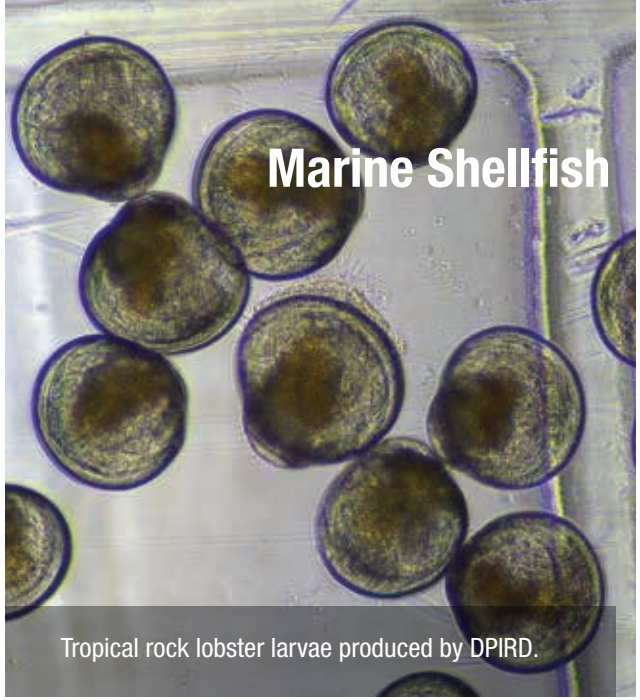
Marine Shellfish

DPIRD technical officer Scott Bennett (right) undertaking a site inspection of a shellfish farm in the Pilbara.

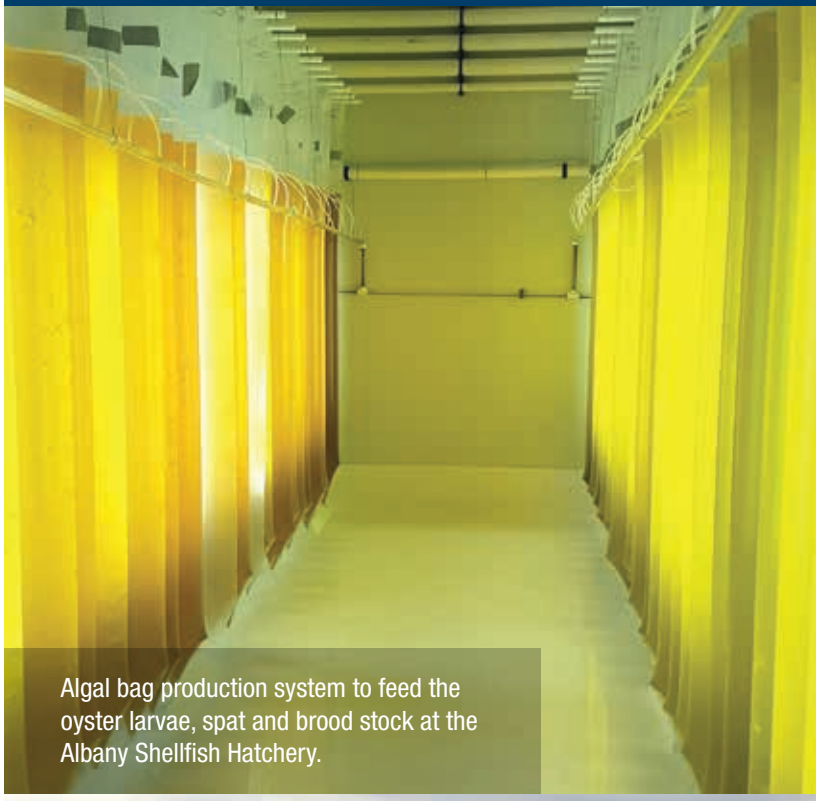
Homegrown shellfish

Common species for shellfish farming – such as the Pacific oyster, which is farmed throughout the world, and the Asian green mussel – are imported species that can also become serious pests.

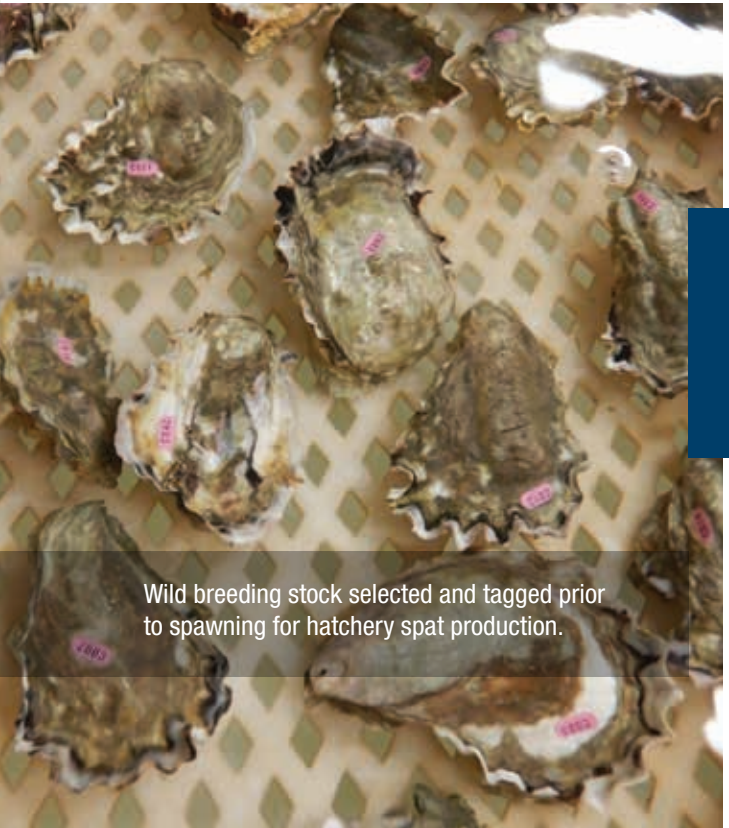
To address this biosecurity issue, Michel and his team are investigating shellfish species that are native to WA to identify those with potential for shellfish farming. The project will identify where each species can be farmed to minimise biosecurity issues related to genetic interaction, pests and pathogens.



Tropical rock lobster larvae produced by DPIRD.



Algal bag production system to feed the oyster larvae, spat and brood stock at the Albany Shellfish Hatchery.



Wild breeding stock selected and tagged prior to spawning for hatchery spat production.

The shellfish species will be assessed for their biological traits – how fast they grow, how well they survive, their meat-to-shell ratio and their colour and shape – to select the most promising native shellfish.

To improve performance and productivity, the native shellfish will be domesticated through selective breeding.

Shellfish lend themselves to advanced breeding processes that can produce sexually sterile animals with superior growth performance and palatability. A further quality of sterile stock is that it can be farmed in areas that extend its native range.

Tropical rock oyster R&D trial in Cossack, Pilbara.

Image courtesy of Warren Ure, Maxima Rock Oyster Company

FRESHWATER AQUACULTURE

Hatchery coordinator Terry Cabassi with brown trout broodstock.

DPIRD Pemberton Freshwater Research Centre trout pond.

Rainbow trout broodstock in a net cradle ready for collection of eggs or sperm.

FRESHWATER AQUACULTURE

DPIRD's freshwater aquaculture team has responsibility for Western Australia's trout stocking program via the Pemberton Freshwater Research Centre trout hatchery that has operated in the South West for more than 80 years.

Andrew Beer
SENIOR RESEARCH SCIENTIST
(FRESHWATER AQUACULTURE)

THE TROUT STOCKING PROGRAM releases hundreds of thousands of rainbow and brown trout in about 70 locations between Albany and Perth each year. About 9000 licensed freshwater recreational anglers travel throughout the south-west annually to catch the trout in rivers and dams, contributing about $18 million each year to the regional economy.

Larger trout to boost future fish numbers

Recreational fishing for trout in the south-west of Western Australia relies on the annual stocking of waterbodies with captive-bred trout. DPIRD is working to improve the trout stocking program to maintain a quality fishing experience for recreational anglers in a changing environment.

RECREATIONAL TROUT FISHING in WA has depended on the annual release of up to 800 000 juvenile trout that are purpose-bred at the DPIRD Pemberton Freshwater Research Centre (PFRC) before being released into streams, rivers and dams across the south-west.

The PFRC is the only trout hatchery in WA and has released rainbow and brown trout into local waterways for the past 80 years. Trout rarely breed naturally in WA waterways due to unsuitable spawning conditions, so the release of the PFRC's trout is essential for maintaining the fishery.

Climate change and private water storage dams for commercial irrigation are growing challenges for the trout release program. Reduced rainfall and streamflow in the south-west affect stream security and productivity, which in turn reduce trout growth and survival.

To ensure ongoing success of the trout release program DPIRD formed the WA Inland Fisheries Research Advisory Committee (WAIFRAC), which brings together Recfishwest, WA trout fishing experts, the CSIRO, the Regional Development Commissions and DPIRD trout research and production specialists.

The committee will research ways to improve trout survival and identify the best locations to stock trout and lift angler numbers in the south-west.

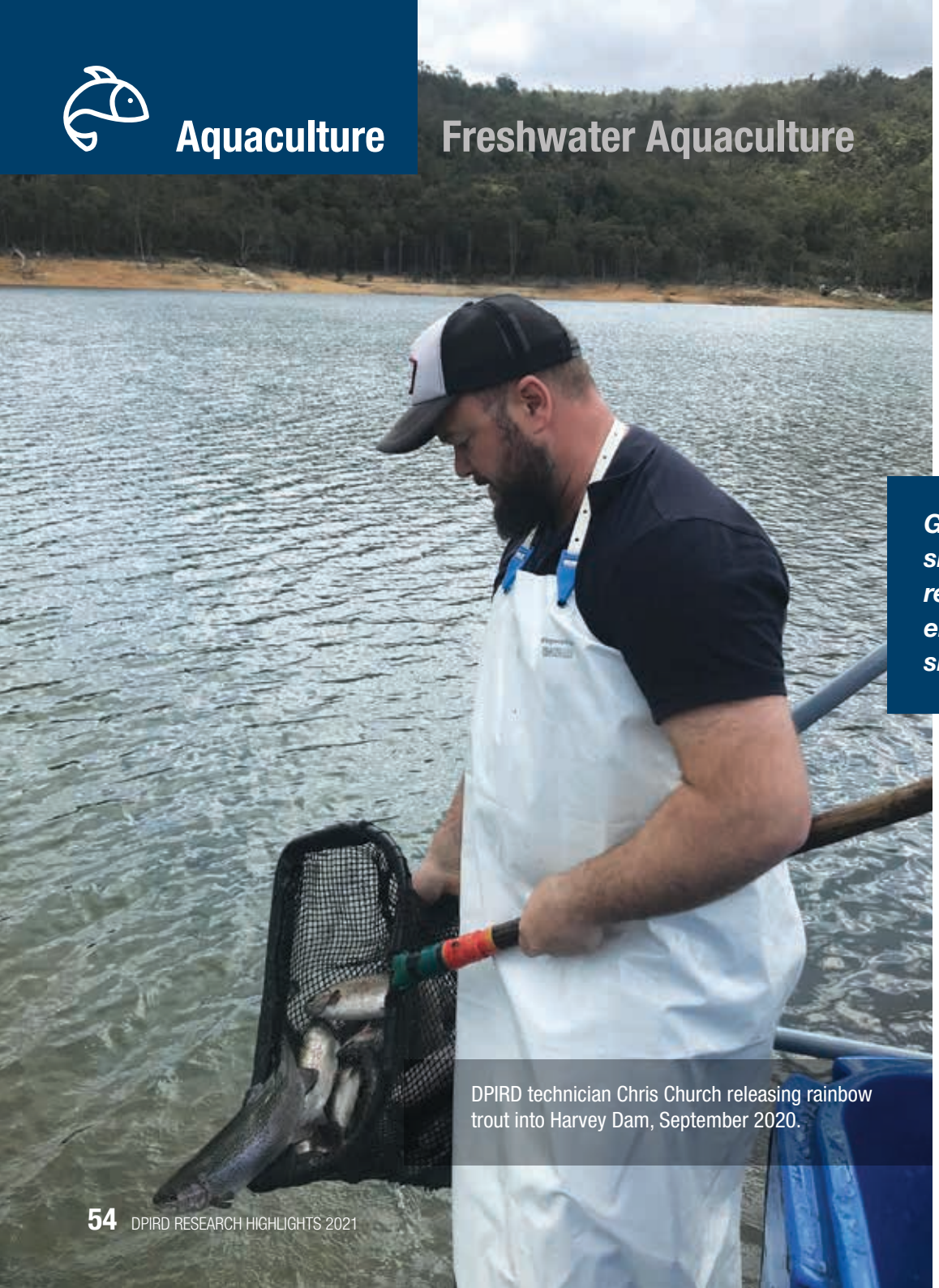
Freshwater Aquaculture

DPIRD technicians selecting trout for spawning at the Pemberton Freshwater Research Centre.

DPIRD technician Chris Church with a rainbow trout broodstock.

Rainbow trout yearlings being released into a stream on the Warren River catchment, September 2020.

Freshwater Aquaculture



DPIRD technician Chris Church releasing rainbow trout into Harvey Dam, September 2020.

Larger trout for increased survival

One of the strategies WAIFRAC has recommended so far is the release of fewer, but larger, trout.

Growing trout to a larger size before release should improve their survival rate and reduce how much food they need from their environment to grow to the legal capture size of 300 mm.

Historically, up to 800 000 juvenile trout, called fingerlings, of about 50 mm in length have been released in spring when streams fill and flow following winter rainfall. But with lower rainfall and increased water extraction by industry, these streams now dry up quickly and many no longer flow throughout summer.

From 2020 the PFRC plans to release up to 400 000 larger fingerlings (up to 100 mm) and up to 40 000 trout yearlings each year. Some of these yearlings will be ready to catch (larger than 300 mm). The benefit–cost ratio of the strategy will be assessed over coming years.

By retaining trout fingerlings in the PFRC nursery until they are larger, the fish will be more robust and can be released into larger bodies of water and will be able to compete more successfully, especially against the introduced and predatory redfin perch.

Timing of trout release is also important for fish survival and, where possible, is timed to coincide with a natural abundance of food and cool weather following winter rains. Using DPIRD's global information services, DPIRD research scientist Andrew Beer, in collaboration with the WAIFRAC, can identify suitable stream conditions for the restocking program by reviewing the environmental flows at each release location.

To accommodate the new strategy, the PFRC trout production system is being adjusted to an additional 10 000 to 20 000 yearlings each year. DPIRD may develop commercial partner arrangements within the aquaculture industry for extra yearlings to be grown.

Along with juvenile trout, the PFRC releases adult ex-broodstock into the Lefroy Brook on the Warren River and five south-west dams each year. These larger fish offer an instant fishery as they can be captured immediately by recreational anglers. In the spring of 2020, about 1800 rainbow trout and 500 brown trout weighing over 1.5 kg were released.

Terry Cabassi placing fertilised eggs into an incubator tray.

Chris Church with rainbow trout ready for release.

Eggs collected from females in preparation for fertilisation with sperm solution.

AQUACULTURE HEALTH RESEARCH

PhD candidate Eliot Hanrio is based at DPIRD and enrolled at UWA.

AQUACULTURE HEALTH RESEARCH

DPIRD's aquaculture health research team investigates ways to improve shellfish health and productivity to develop established and emerging aquaculture industries.

Dr Cecile Dang
SENIOR RESEARCH SCIENTIST
(AQUACULTURE HEALTH)

A MAJOR FOCUS OF current research is unravelling the reasons behind a dramatic decline in productivity of the pearling industry.

In the mid-2000s the industry employed 1000 workers and was worth more than $125 million per year but a decade later the industry has been reduced by half.

Detailed investigations are underway to determine if the decline is caused by disease.

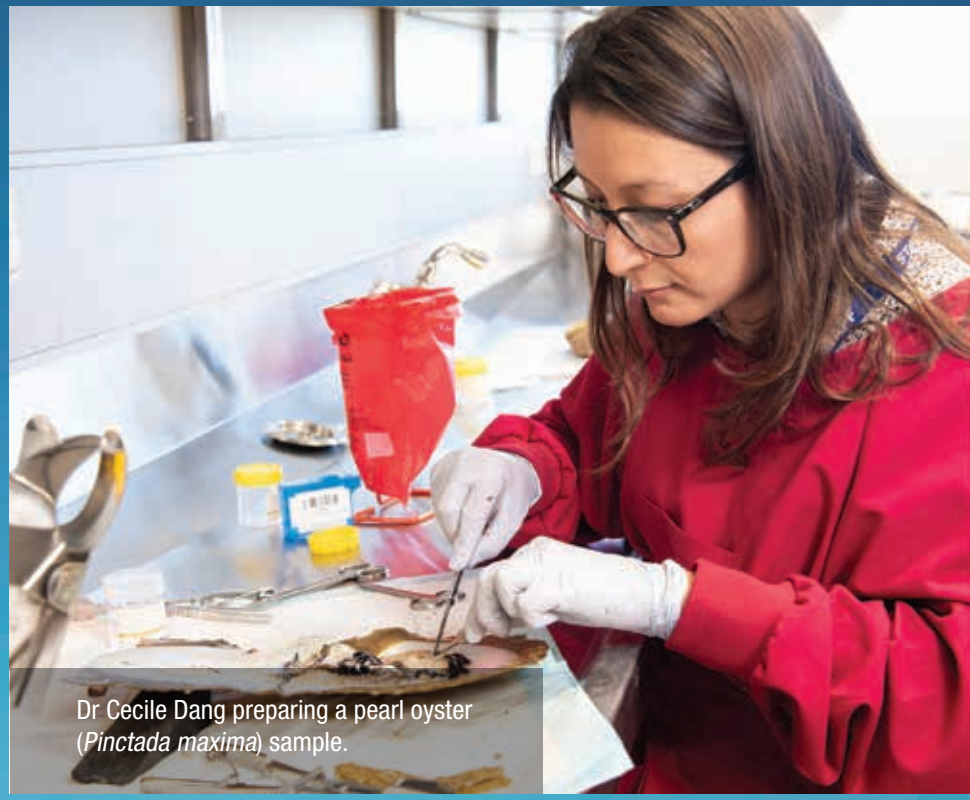
The team is also developing an improved diagnostic test for the parasite *Perkinsus olseni* that could affect the developing Western Australian abalone industry.

Opened pearl oyster with pearl and pearl meat.
Image courtesy of Pearl Producers Association

Sampling abalone blood to investigate health status.

Pearl oysters suffer mysterious decline

In 2006 large numbers of pearl oysters mysteriously died, resulting in a fall in productivity from which the Australian pearling industry has not recovered. DPIRD is working with industry groups to identify what is causing the productivity losses and develop solutions for this important industry of northern Australia.



Dr Cecile Dang preparing a pearl oyster (*Pinctada maxima*) sample.

Roebuck Bay Farm.
Image courtesy of Pearl Producers Association

Aquaculture Health Research

Image courtesy of Paspaley Pearling Company

Dr Cecile Dang demonstrating to staff from two pearling companies in the Kimberley how to sample pearl oysters.

The pearling industry is among Australia's oldest and most valuable fishing and aquaculture industries.

IN OCTOBER 2006, 2.8 million pearl oysters died in the Exmouth Gulf in Western Australia. Soon afterwards, deaths occurred in other parts of WA and in the Northern Territory.

The deaths, together with the global financial crisis in 2008, reduced the gross value of production of the industry by half, from $125 million before 2006 to $64 million in 2018.

The industry is based on the silver-lipped pearl oyster and stretches from North West Cape in WA to Torres Strait, providing employment and infrastructure in remote regional northern Australia.

The industry relies on wild-stock fisheries and hatchery production for pearl oyster supply.

It was suspected that an infection was the cause of the deaths, based on available environmental and industry data and the fact that other bivalve species in the region appeared unaffected.

However, despite several research investigations by different organisations, including DPIRD, the cause of the initial deaths and the subsequent productivity and health issues observed in pearl oysters remains a mystery.

Aquaculture Health Research

The aquaculture health research section of the DPIRD aquaculture research team, along with the Pearl Producers Association with support from the Fisheries Research and Development Corporation (FRDC), is investigating the ongoing productivity problems that are affecting the pearling industry.

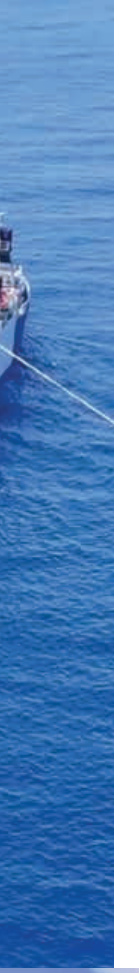
They have developed a long-term research and development strategy to guide research into pearl oyster health and productivity:

- What do affected oysters have in common in terms of micro-organisms and biological responses? What affect do these micro-organisms have on the host?
- Can epidemiology characterise the health and productivity issues?
- Can the development of a comprehensive health management plan mitigate biosecurity risks and reduce losses in future outbreaks or low productivity events?

To begin the research, DPIRD's senior research scientist Dr Cecile Dang and her team are attempting to identify the common micro-organisms and genetic and physiological responses present in affected oysters. Innovative state-of-the-art technologies will be used to identify and sequence the genes of the micro-organisms and oysters to better understand what is causing the loss in oyster productivity.

The team is also undertaking an epidemiology project to identify the risk factors associated with the pearling industry's productivity issues. Initially, the plan is to collect production data from all pearl oyster farms to determine if a retrospective analysis is feasible.

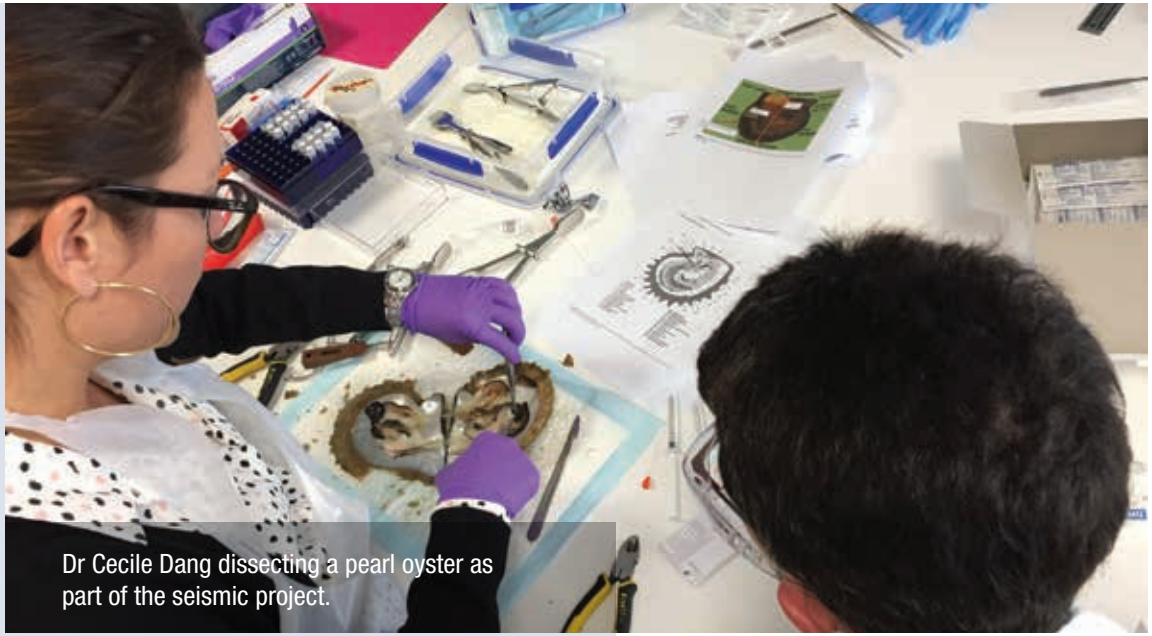
Seismic survey being carried out above pearl oyster beds.
Image courtesy of Australian Institute of Marine Science



Preserving wild pearl oyster stocks

Australia has the only pearling industry in the world that has access to wild-harvested pearl oysters for cultured pearls. The oysters are fished by hand, almost exclusively from Eighty Mile Beach, south of Broome, which is the only remaining significant wild-stock fishery for pearl oysters in the world.

There has been increasing concern in recent years that seismic surveys used for oil and gas exploration may be affecting the sustainability of the wild-stock fishery and the ability of exposed oysters to produce market-quality pearls.



Dr Cecile Dang dissecting a pearl oyster as part of the seismic project.

This is particularly relevant to the North West Shelf region of WA, where exploration for oil and gas occurs in an area that also supports the vast majority of Australia's pearling industry.

Cecile and technical officer Dr Hosna Gholipour-Kanani are investigating the impact of seismic surveys on the mortality, condition and health of pearl oysters. This work is part of the Australian Institute of Marine Science's $14 million North West Shoals to Shore project which is looking at the effects of seismic energy on pearl oysters.

Haemolymph sampling from a pearl oyster. *Image courtesy of Australian Institute of Marine Science*

Dr Hosna Gholipour-Kanani processing pearl oysters samples for biochemistry analysis.