The decline of black bream in the Blackwood River Estuary: is restocking an ongoing requirement?

A Workshop Report - April 2007

Western Australian Fish Foundation
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Introduction
The Western Australian Fish Foundation (WAFF) convened this workshop on February 26, 2007 at the Fremantle Maritime Museum to discuss the implications of the recently-completed project entitled "Restocking the Blackwood River Estuary with the Black Bream Acanthopagrus butcheri", which was funded by the Fisheries Research and Development (FRDC) Corporation. The Workshop was convened by the WA Fish Foundation and sponsored by WAFF, the FRDC, Challenger TAFE, Murdoch University, the WA Department of Fisheries and the Blackwood Basin Group.

The aim of the Workshop was 1). to discuss the results and implications of the above study on Black bream and of the current environmental condition of the Blackwood River Estuary, 2). to consider whether it would be appropriate to continue restocking this estuary with Black Bream and 3). to determine what associated issues should be addressed in the future.

This report comprises the Synoptic Overview by Dr Peter Rogers followed by the Workshop Summary. A number of relevant speakers (see Appendix 1 for the Workshop Schedule) presented during the morning with the Workshop being conducted during the afternoon. Attendance was by invitation (50) and the list of the 48 participants can be found at Appendix 2. Power point presentations and/or summaries from the speakers can be found at Appendix 3 and additional Workshop Notes at Appendix 4.
1: The Synoptic Overview by Dr Peter Rogers

On 26th February 2007, a workshop was held at the Fremantle WA Maritime Museum to consider the issue of Black Bream stocks in the Blackwood River and the need for restocking.

The evidence presented pointed to a general decline in the health of the environment of the riverine and estuarine waters of the Blackwood River Estuary over an extended period since the early 1970s. This was linked to declining average rainfall (approximately 30%), consequential reduced run off and river water flow, exacerbated by increased use of freshwater entrapment for viticulture and other agricultural purposes, rising soil salinity, increasing concentration of nutrients, particularly nitrogen and phosphate, and, within the Scott River catchment area, rising acid leaching from acid-sulphate soils.

This combination of factors has significantly reduced freshwater flows into the Blackwood and has led to increased periods of stratification of oxygen-depleted water, which are detrimental to those fish occupying the deeper reaches of the river. Evidence of eutrophication has also been apparent since 2000 through increasing nutrient levels and the appearance of harmful blue green algae and dinoflagellates that has culminated in an increasing incidence of "fish deaths" and occasional ulcerated fish around Molloy Island and upstream.

This picture of declining health of the riverine and estuarine system of the Blackwood, and the knowledge that further development of the catchment, long-term climate change and falling rainfall levels are likely to occur, suggests that this detrimental environmental trend will continue.

Black Bream stocks in the Blackwood River Estuary are believed to have declined markedly during the last two to three decades, on the basis of anecdotal community advice that catches of this species have continued to fall and little evidence of significant recent recruitment of juvenile Black Bream. Survey work undertaken by Murdoch University (Beckley et al. in press) points to a significant reduction in Black Bream catch by recreational fishers from the river and estuary to about one sixth of that taken in 1973/74 in 2005/2006.
This fall in catch is despite similar orders of magnitude of fishing effort being applied over both surveys.

World-acclaimed research on a restocking trial for Black Bream using aquaculture produced fingerlings, which were chemically tagged for identification and monitoring purposes, proved very successful. A total of 220,000 Black Bream juveniles were introduced in 2001 and 2002 at a cost of \( \sim$0.50 \) per released fish. The restocked Black Bream were monitored and followed through to maturity. Because of high survival (i.e. 35% over 12 months and 16% to minimum legal length MLL of 250 mm), the cost of each stocked fish that survived to reach the MLL was estimated to be only \$1.60, exclusive of the cost of monitoring. Monitoring and chemical tagging increased the cost to \$2.19 per fish for each recruit entering the fishery. Restocking of Black Bream in the Blackwood was thus very cost effective and therefore potentially a viable ongoing management option.

The participants at the workshop, when considering the results presented and their implications for management of the Black Bream stocks, made the following observations:

- The limited annual Black Bream recruitment in the Blackwood River Estuary over recent years was not apparent in other permanently open south-western Australia estuaries or indeed in other intermittently open estuaries such as Stokes Inlet, Pallinup River and the Moore River.

- There is some as yet unidentified unique aspect of the current Blackwood estuary environment and its impact on the Black Bream population that has led to limited recruitment since the early 1980s.

- The high survival of restocked fish and subsequent high contributions (in excess of 80%) of these fish to total catches over 3 years, demonstrates that the residual abundance of wild Black Bream in the Blackwood River Estuary is low. Low reported commercial and recreational catches support this view.

- The workshop postulated that failure of recruitment could be a result of environmentally-induced changes which;

  (a) results in unusually high mortality of larval and/or juvenile wild Black Bream, or
produced conditions that were not conducive to spawning and therefore led to very low levels of breeding stock and thus limited ability to generate sufficient eggs and juvenile fish to allow population recovery. Continued fishing of residual stocks will exacerbate this problem.

Management options to provide for the recovery of the black bream fishery in the Blackwood estuary include:

- a temporary cessation of all black bream extraction;
- a significant pulse of restocking at an order of magnitude greater than that undertaken in the research program; or
- an ongoing annual program of lower-level restocking over years.

It was noted that the first two management alternatives were aimed at addressing an inadequacy of breeding stock. An ongoing program of restocking would be necessary if some environmental factor in the river or estuarine system, which affected larval survival or recruitment of wild bream juveniles in early life stages, was irreversible or too costly to effect.

Each of these management options have pros and cons and may need further evaluation which was beyond the scope of the workshop. This could include a level of risk evaluation. However, practically, the earlier that management action is taken, noting normal population lag effects, the greater the benefit and the sooner that Black Bream stocks may return to historical levels.

A one or two year pulse restocking of juvenile black bream into the Blackwood estuary, at a magnitude of scale greater than that which occurred in 2001 and 2002, offers an immediate pathway for adaptive management and potentially greater social and economic benefits. This approach, linked with a program of monitoring and research, could assist in evaluating the following objectives:

(i) Assess and identify any environmental factors affecting larval and early juvenile Black Bream survival in the Blackwood River Estuary.

(ii) Determine timing and optimum sizes for restocking juvenile black bream.
(iii) Identify any density-dependent factors from restocking impacting on survival, growth and recovery of restocked fish into the Blackwood estuary and subsequent contribution to the fishery.

(iv) Assess lower cost options for mitigation of any environmental factors identified impacting on black bream larvae or juvenile survival.

(v) Identify lower cost breeding and hatchery options \textit{in situ} at the Blackwood River Estuary for ongoing restocking in the event that ongoing restocking remains the only viable long-term management alternative.

(vi) Consultation with and involvement of the community in the development of adaptive management solutions for maintaining and improving the Black Bream fishery in the Blackwood River Estuary for community benefit. This could require further assessment of different management and funding options not considered thus far for restocking and environmental mitigation. Options should include various tagging and licensing approaches, which could assist in management, monitoring and fishing.
2. The Workshop Summary

2.1 Restocking in estuarine and marine environments

Stock enhancement and restocking into estuarine and marine environments is a relatively new discipline, marked by the publication of the Blankenship and Leber (1995) paper on responsible approaches to stock enhancement and restocking and the first International Symposium on Stock Enhancement and Sea Ranching (ISSER) in 1997 (Bergen, Norway, Howell et al. 1999). Formal definitions for stock enhancement and restocking are currently being developed following the third ISSESIR in 2006 (Seattle, United States, Bell et al. in prep.). Currently, the working definitions for these terms are:

Restocking - the release of cultured juveniles into wild population(s) to restore severely depleted spawning biomass to a level where it can once again provide regular, substantial yields. This may involve re-establishment of a species where it is locally extinct to rebuild a fishery, or for conservation purposes.

Stock enhancement - the release of cultured juveniles into wild population(s) to augment the natural supply of juveniles and optimise harvests by overcoming recruitment limitation. Note that recruitment limitation is the rule, rather than the exception for marine species with pelagic larvae in open ecosystems, even when spawning biomass is at the desired level (Doherty, 1999; Bell et al., 2005).

From the workshop proceedings, the spawning biomass of the Black Bream population in the Blackwood River Estuary is probably severely depleted and this species warrants consideration as a case for a major restocking program in the Blackwood (see below).

2.2 Black bream in the Blackwood

The Black Bream Acanthopagrus butcheri is an estuarine species that is highly prized by recreational and commercial fishers in temperate Australia. During the workshop, it was reported that over 60% of the people using the Molloy Island Caravan Park and over 50% of recreational fishers interviewed in 2005-06 were seeking to catch Black Bream (Beckley and Prior, this workshop). Recreational fishing on the Blackwood is a major attraction to the
region, with an estimated 10,000 people visiting the Blackwood in 2005-06 to fish on the river (Beckley and Prior, this workshop). In 2005-06, anglers spent an estimated 72,000 h fishing, catching about 132,000 fish and releasing about 70,000 of these fish. Catch rates of recreational fishers in 2005-06 were much lower (only about 10%) than those recorded in 1974 (Caputi 1976, Lenanton 1977, Beckley and Prior, this workshop).

Black Bream is found in many of the estuaries along the west and south coast of temperate Western Australia and from genetic studies, there is little movement of fish between estuaries (Potter et al. in press). This species spawns in the upper reaches of estuaries in southwestern Australia and there appears to be a link between spawning success, juvenile recruitment and the level of freshwater flow in these systems. In the Gippsland Lakes, Victoria, spawning of this species takes place in waters of 20 ppt salinity and the juveniles are found in shallow waters with aquatic vegetation (Hindell, this workshop). It is significant that, in recent years, environmental flows in the Blackwood have typically been lower than in the 1970s, resulting in marine water moving further up the estuary. The estuary has subsequently become more stratified and periods of low dissolved oxygen have been recorded (Robb and Forbes, this workshop, see below).

Since the major survey of the Blackwood in 1974, fish have been surveyed again in the 1990s and since 2002 as part of a trial restocking program in the Blackwood (Potter et al. in press, Jenkins et al., this workshop). These surveys have found very few ‘wild’ juvenile Black Bream. Anecdotal reports from the workshop indicate that fish in spawning condition are present in the estuary. This species is also known to spawn under a variety of conditions once water temperatures reach those required for spawning (Jenkins, Sarre, pers. comm. at the workshop). These reports suggest that the low numbers of juveniles recorded in the Blackwood in recent times may be due to poor survival at the larval or juvenile stages of development. Workshop discussions supported investigating factors contributing to the successful survival and growth of the larval and juvenile stages of Black Bream in the Blackwood and in an estuary on the south coast where healthy populations of bream are currently found, e.g. the Pallinup.
2.3 Environmental conditions in the Blackwood

Extensive sampling of the water quality in the Blackwood has been carried out by the Department of Water over the last five years (Robb and Forbes, this workshop) and provides a basis for comparison with conditions in 1974 (ref from Anne Brierley, this workshop). In general, recent conditions in the region have been characterised by low rainfall and thus also river flow. Marked differences in salinity and dissolved oxygen levels of the surface and bottom waters of the Blackwood have been found over many months, \textit{i.e.} the estuary becomes stratified and poorly mixed for extended periods (Robb and Forbes, this workshop). The very low levels of dissolved oxygen in the bottom waters reported over several months are cause for great concern as they are likely to affect the populations of fish and benthic invertebrates. Although the levels of nitrogen and phosphorus in the system are relatively low, acid discharges have been recorded and the catchment of the Blackwood has extensive areas of acid sulphate soils (Hales, this workshop).

The Blackwood Basin Group has identified the following threats to the system (Hales, this workshop):

1. salinity;
2. exotic/feral fish (redfin, yabbies);
3. increasing sediment and nutrient loads;
4. increasing acidification arising from exposure and disturbance of acid sulphate soils, noting that the Hardy Inlet is surrounded by these soils, particularly along the Scott River, where extensive clearing has taken place; and
5. increasing potential for ground water extraction from the Blackwood catchment.

Overall, the water quality in the Blackwood is poor and has declined significantly since 1974 (Robb and Forbes, this workshop).
2.4 Trial restocking and potential for further restocking

A very successful collaborative FRDC project between Challenger TAFE (Fremantle) and Murdoch University has investigated restocking Black Bream into the Blackwood River (Jenkins et al. this workshop, Potter et al. in press). Mature fish were taken from the Blackwood, spawned and the larvae reared at Fremantle and marked using a chemical mark of the ear-bones (otoliths). A total of 70,000 juvenile Black Bream (70 mm in total length and about 6 months old) were released in 2002 and 150,000 fish (smaller and younger fish) in 2003. The recapture rates of the released fish were very high compared to those of the wild fish (3 to 10 times higher). The released fish also grew well, although slightly slower than wild fish, and reached maturity in the Blackwood, indicating that they are likely to contribute to the spawning stock in the estuary. The costs of producing released fish and monitoring them in the Blackwood have been estimated as AUD$2.19 per fish ($1.60 per fish if they are not monitored). The marks in the fish are still evident 5 to 6 years after marking, showing that the populations could continue to be monitored. The results of the trial restocking are very encouraging and received international recognition of the quality of the work and the potential for restocking to rebuild the Black Bream population at the 3rd International Symposium on Stock Enhancement and Sea Ranching (Jenkins et al. this workshop). The next logical sequence of research to build towards a major restocking program would be to:

1. continue to monitor the 2002 and 2003 releases over the next 2 years;
2. collect and evaluate information on the genetic composition of the wild population and the released individuals;
3. investigate reasons for slower growth and for later and possibly reduced maturation of restocked fish;
4. investigate larval and juvenile survival in the system;
5. discuss with various groups the potential for a major responsible restocking program to:
   a. define objectives;
   b. establish protocols;
   c. identify risks.
2.5 References


Appendix 1: The Workshop Schedule 26 February 2007

The decline of black bream in the Blackwood River Estuary: is restocking an ongoing requirement?

0930 Opening by Dr Patrick Hone - Executive Director Fisheries Research and Development Corporation

0935 Ian Stagles – Chair of the WA Fish Foundation
   Introduce topic and set the scene for the morning

0945 Dr Patrick Hone (Fisheries R&D Corporation)
   Priorities For stock enhancement, fish stocking and stock recovery in Australia

1000 Professor Neil Loneragan (Murdoch University)

1015 Dr Anne Brearley (University of WA)
   Historical insights of the Blackwood River Estuary

1030 Dr Malcolm Robb/Dr Vanessa Forbes (Department of Water)
   Environmental Report on the Blackwood River, including the 2006 fish-kill

1045 Morning Tea

1115 Greg Hales (Blackwood Basin Group)
   Environmental impacts on the Hardy Inlet – a community perspective

1130 Paul Close (Department of Water)
   Managing estuarine systems for biodiversity – the influence of environmental flows

1145 Dr Rod Lenanton – WA Department of Fisheries
   Management of fishing activities in degraded estuaries

1200 Dr Lynnath Beckley (Murdoch University) and Sheryn Prior
   Blackwood River creel survey

1215 Dr Jeremy Hindell (Dept of Primary Industries – Victoria)
   Black bream in the Gippsland Lakes

1230 Greg Jenkins (Aquaculture Development Unit - Challenger TAFE)
   Restocking the Blackwood River Estuary with black bream Acanthopagrus butcheri

1245 Lunch

1345 Ian Stagles/Dr Patrick Hone
   Summary of presentations and scene setting for the workshop

1355 WORKSHOP - Facilitator Dr Bernard Bowen

1630 Summary of the workshop and the next step

1645 Close
Appendix 2: The Workshop Participants

Dr Bernard Bowen (Facilitator)  
Mr Ian Stagles (Chair - WAFF)  
Mr Frank Prokop (Recfishwest/FRDC)  
Dr Anne Brearley (UWA)  
Mr Greg Jenkins (ADU)  
Mr Wally Parkin (WAFF Board Member)  
Mr Matt Barwick (FRDC)  
Mr Barry Dawes (Augusta Rec. fisher)  
Mr Dan Machin (ACWA)

Dr Patrick Hone (ED - FRDC)  
Dr Peter Rogers (Former ED - DOF)  
Mr Richard Stevens (WAFIC/FRDC)  
Dr Steve Blake (WAMSI head)  
Dr Gavin Sarre (CYOC TAFE)  
Mr Trevor Blinco (Chair - ACWA)  
Dr Jeremy Hindell (Victoria DPI)  
Mr Trevor Price (Augusta Com. Fisher)

Professor Neil Loneragan (MU)  
Professor Ian Potter (MU)  
Dr Lynnath Beckley (MU)  
Dr David Morgan (MU)  
Ms Sheryn Prior (MU)  

Professor Norm Hall (MU)  
Mr Dan French (MU)  
Dr Alex Hesp (MU)  
Dr Steve Beatty (MU)

Dr Rod Lenanton (DOF)  
Dr Kim Smith (DOF)  
Mr Ian Curnow (DOF)  
Dr Gary Jackson (DOF)  
Mr Michael Burgess (DOF)

Mr Andrew Cribb (DOF)  
Dr Simon de Lestang (DOF)  
Mr Craig Astbury (DOF)  
Mr Jason Froud (DOF)

Mr Greg Hales (Blackwood Basin Group)  
Ms Jackie Hasler (NRM – Blackwood)  
Dr Malcolm Robb (DOW)  
Dr Vanessa Forbes (DOW)  
Mr Paul Close (UWA)  
Ms Leanne Thompson (DEC)  
Dr Ernie Stead-Richardson (AMRS)

Ms Linda Raynor (Blackwood Basin Group)  
Ms Joanna Hugues Dit Giles (SW Catchments Council)  
Ms Barbara Dunnet (Pres. of Nannup Shire)  
Ms Verity Steptoe (DEC)  
Mr Paul McCluskey (DEC)  
Mr John Lloyd (DEC)
Appendix 3: Presentations/Summaries

The 3rd International Symposium on Stock Enhancement and Sea Ranching 3rd ISSESR
Neil Loneragan

Themes in 3rd ISSESR
(> 300 delegates, 4 days, no parallel sessions)
http://www.searanching.org
1. RS and SE systems and their role in fisheries management
2. When can hatchery releases add value to other forms of management?
3. Institutional and socio-economic issues
4. Release strategies
5. Interactions between wild and released stocks
6. Biological insights from hatchery releases

Restocking and Stock Enhancement Australia and ISSESR
• Australia
  - 1990/91 – CSIRO workshop; 2000 ASFB workshop; 2006 FRDC workshop (rec. fishing)
  - Flathead and whiting (Qld); prawns, black bream (WA); mulloway (NSW); oyster (Tasmania);
    abalone, scallops...
• ISSESR
    http://www.seaenrichment.org

Outcomes
• Importance of:
  - stakeholder involvement and consultation to define objectives (e.g. red drum, blue crab)
  - modelling, multi-disciplinary approaches (conf. blue crab, lobster, mulloway)
  - rigorous experimental approaches to improve survival and evaluate success (black bream)
• Restocking in China
  - Scale of operations (numbers and species)
  - scallop, sea cucumber, abalone, shrimp, clams, oysters, crabs, fish, jellyfish, and seaweeds

Definitions
Restocking and stock enhancement
the release of cultured juveniles into wild population(s)
• Restocking
  - ... to restore severely depleted spawning biomass to a level where it can once again provide regular, substantial yields
• Stock Enhancement
  - ... to augment the natural supply of juveniles and optimize harvests by overcoming recruitment limitation

Restocking, Stock Enhancement and Fishery management

WESTERN AUSTRALIAN FISH FOUNDATION ABN 15-258-462-880
Mr Ian Stagles (Chair), PO Box 362, Mount Hawthorn, WA, 6915, Telephone 08 9244 3411, fax 08 44501737, email: ians@enlire.net
Little is known about the ecology of Hardy Inlet and the possible effects of the mining proposal on it. No scientific references can be found relating to this particular estuary and only limited research has been done in other possibly comparable areas. Most of this latter work has been specific to particular organisms rather than the overall structure and balance of the estuary system.

The study had two primary objectives:

Short term: 'To attempt to predict the probable effects of mining and dredging in the estuary and environs'.

Long term: 'To understand the working of the Blackwood estuary ecosystem as the basis for studying issues about the management of similar other estuaries of south-western Australia'.

Studies undertaken and coordinated by Hodgkin were primarily a general assessment of the estuary ecosystem. A separate report, 'The anticipated Effect of dredging in the Blackwood Estuary' was prepared by the Estuarine and Marine Advisory Committee (EMAC) and submitted to the EPA.
Winter river flow

Summer 'tidal' influence (astronomic & barometric pressure)

- Inlet and basin about 30% salinity i.e. slightly less than seawater
- Water column mixing - winds in main basin (resuspension of sediment)
- Late wind mixing in remainder of system. Some mixing due to tidal flows creating turbulence
- Stratification surface to bottom - most extreme to Alexander Bridge 10% at surface and bottom 25% for five months
- Temperature - seasonal changes with some solar heating in shallow basin. Heating of deep tidal river; sun heats low salinity surface water & cools at night (well mixed), but upper salty water also warmed and moves upstream by tidal flows, trapped and does not mix and cool.
- Oxygen (poorly studied) and deoxygenation only below halocline in tidal river in summer. CSIRO 1945-1952 Alexander Bridge, Rockfield & Spencer 1953, 1955, 1956

The water

Nutrients in Water & Sediments

- Phosphorus and Nitrogen relatively low concentrations during summer saline state
  - high during winter freshwater phase
- Sediment nutrient's high relative to water column throughout the year
- Plant communities large mineral-nutrient pool
Identification, description and quantification of the role of fringing vegetation

**Rushes (Juncus kraussii)** 300-1,300 g m\(^{-2}\) yr\(^{-1}\) or 1,000-4,500 tonnes dry weight

**Paperbarks (Melaleuca sp.)** 430 g m\(^{-2}\) yr\(^{-1}\)

**Samphires (Sarcocornia)**

Little Juncus or Melaleuca detritus in water - presumed trapped in situ

Build up of organic matter and nutrients. Potential for discharge of nutrients when disturbed.

**Ecological Groupings**

**Benthic**:
- 55 species of which 42 resident (breeding)
  - Confined to the tidal river and basin (3 species)
  - Throughout the estuary (9 species)
- 3 polychaete worms
- 1 bivalve mollusc
- 3 amphipod crustaceans
- 1 shrimp
- 1 insect (Midge)
- Only Lower Basin (4 species)

**Rush fauna** (5)

**Greatest number species downstream (marine)**

**Decrease species upstream**

**Upstream increase in species with incursion of marine water**

**Individual species:** habitat & biology

**Algae**
- Not abundant, except for spring & summer blooms of Stonewort Lamprothamnium (Swan Lakes & Deadwater) washed into lower estuary
- Green algae Cladophora & Chaetomorpha which grow excessively in (Swan, Peel & Walpole) were never abundant in the Blackwood
  - Why? Adequate light for growth
  - Absence due to short saline phase & lack of hard substrates
- No mention of nutrients

**Seagrasses**
- Swan grass Ruppia in shallows & Deadwater (like Wilson Inlet) Lepilama
- Ribbon weed Potamogeton (Molloy Is.) Halophila decipiens (deep treat)
- Absence of Halophila ovalis (species in west coast estuaries, Albany & coastal bays)

**Phytoplankton**
- Mainly dinoflagellates
- No blooms in three years
- Low concentrations in open water Chlorophyll a 1.98 µL\(^{-1}\)
- Sediments higher Chlorophyll a concentrations
- Attributed to low nutrient concentrations when light flux high and water flowing

**Macroscopic plants**
- twenty species,
  - most obvious summer marine phase, patchy, small biomass
  - Ruppia 700-1,900 tonnes (dry weight) yr\(^{-1}\), Juncus 1,000-4,500,
  - Paperbark (Melaleuca) 800 tonnes yr\(^{-1}\) - organic material > detritus,
- Only Ruppia grazed (invertebrates, fish & birds) (Congdon & McComb 1981)

**Invertebrates**

**Stepped Venus clam or cockle Koelzylia scalarina** - common in the lower Blackwood estuary. Also found in south coast estuaries and occurred in west coast estuaries 3,500-6,000 years ago.

E.P. Hodgins
Fish

57 species 1974-75
more in common with other south coast estuaries than those of west coast
Lesmom 1974, 30 species - some not caught in 1974-75 survey

Groupings
Stenohaline marine: water of 30-40‰ 17 sp e.g. Flathead, Mulloway
Euryhaline I: seawater to 15‰ 6 sp e.g. garfish, spot (3), old wife
Euryhaline II: seawater to 3‰ 11 sp e.g. Aus. herring, Trevally, flounder (2)
Euryhaline III: seawater to <3‰ 18 species most abundant (bulk biomass) Euryhaline II & III.

Various considerably tolerant of reduced salinity.
Some Stenohaline marine species summer saline phase e.g. garfish.
23 of Stenohaline Euryhaline I species, essentially marine that use estuary as sheltered marine situation when salinity is favourable.

Two crab species and one prawn not common. Recruitment know to vary.

HOW FISH USE ESTUARIES

Resident species
Migratory waders
Waterfowl numbers increase over the summer months as inland waters dry out.
Part of much larger populations.

Food and Feeding

Fish Biology

Reproduction and recruitment
The cobble is thought to breed in the Swan and other estuaries but there is no evidence that it can do so under the more extreme conditions of the Blackwood.
Black bream: It should be noted that although the time and place of breeding is not known with certainty and no juveniles of this true estuarine species were caught, it almost certainly breeds in the estuary, probably in the upper reaches where young fish live among snags along the margins of the tidal river and are inaccessible to the sampling techniques used.
Favoured nursery ground by many common species, even though many common species spawn in it. Juvenile fish...a large proportion of the seine net catches - Importance of Deadwater

Fishing industry - commercial and recreational

Recreational: black bream (281), yellowfin (13 t), Aust. Herring (9 t)

Birds of the Blackwood

Use of food resources throughout the year
Lane 1975, Hodgkin, 1978 Courtesy DoE

Why was the Blackwood study Special & Different?
First of this Scope - Range of expertise
Examined and synthesised information already available
New research by many different specialist & community involvement
Regular interaction between researchers
Unlike the Peel-Harvey and other studies since, there were no major environmental changes or decline in health of the system already evident (save comment on salinity disturb)
Foundations ongoing work of Hodgkin 25 + years - estuary form and evolution.
Development of Government Agencies expertist and responsibilities

Following consideration of the EMAC report on the Anticipated Effects of Dredging the EPA recommended that the dredging and mining applications should not be approved.
The mining company advised the Department of Mines that it did not wish to contest the various objections and, on its recommendation, the Mining Warden refused the applications on the 12 January 1977.
Similar mining undertaken at Beenup north of the Scott River subsequently developed, closed and the area currently undergoing rehabilitation.
**SWANLAND: Griffith Taylor (1915)**

Temperate region in Western Australia with a rainfall over 10 inches (250 mm) per annum.

Mediterranean Climate - Winter rainfall

Total phosphorus in the estuaries of Swanland.

- Pane: Total nitrogen and Chlorophyll graphs are similar but the rank orders of estuaries differ - dependant on the catchment soils and landuse.
- **BUT ESTUARIES RECEIVE NUTRIENTS NATURALLY**
- **THEY ARE PRODUCTIVE SYSTEMS - FISHERIES**
- **GETTING THE BALANCE**

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**Beenup Mine on the Scott River tributary of the Blackwood River, 2003**

Mining ceased in 1999 following problems with acid sulfate soils. The site is being rehabilitated.

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**Lake Dumbleyung, Blackwood River Catchment, October 1974**

E.P. Hodgkin

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**Dr Ernest Pease Hodgkin - "Hodge"**

Born: Madagascar 1908

Died: Perth, Western Australia 1998

Educated in England

Work in Malaria on mosquitoes as vectors of malaria

WW II moved Kuala Lumpur to Singapore

Mary and 4 children evacuated to Peronandie

Ernest interned in Changi Civilian Prison Postwar at UWA - Ernest Zoology Dept.

Mary Anthropology Dept.

Retirement? 1974

Consultant & Collaborator:

Science of nutrients & algal blooms,

Estuarine Study Series 'Blue Books',

Member of the EP, Chairman of the Museum Board
Stages of isolation

- **Permanently Open** (Wilson, Brookes, Harvey, Hardy, Nomalup, Princess Royal, Oyster Harbour)
- **Seasonally Open-Closed** (Wilson, Brookes, Irwin)
- **Normally Closed** (Intermittently Open) (North: Bowes, South-East: Beaufort, Wellstead, Gordon, Fitzgerald, Dempster, Hamersley, Oldfield, Stokes)
- **Permanently Closed** (Salt lakes) (Culham, Jerdacuttup)

**Implications**

Oceanic exchange - role of fish, solute flow of water, build-up of salt and exclusion.

Types of algae, invertebrates & animals

Technical reports

- Dynamics of estuaries, J. Imberger, H.J. Agnew, J. Billings, & J. Wallace
- Hydrography, Johnstone
- Biological Studies, Congdon, R.A. & McCorrib, A.J.
- Macroinvertebrates, Jonos, Wallace, J.
- Hydrography, Wallace, J.
- Ecology of fish, Commercial Catchments: Lenanton, R.C.
- Water Quality, J.K.
- Estimation of catch by anadromous and Potamodont Fish: 1974-75: Lenanton, R.C. & Congdon, R.
- Survey of the Historical Usage of the South Coastal Estuaries: Copland, N. & Lenanton, R.C.
- Dynamics of Environmental Change of Augusta: Frawley, K.J.
- Towards Environmental Change in the Blackwood River Area: Wodtke, B.E.
- Augusta, Survey May 1975: Bayley-Jones, C.R.
- Recreation versus Sand Mining: A community survey: Fulbrook, F.A.
- Biological and Environmental Impact of the Naturaliste-Hardy Inlet and Blackwood River: Geel, Survey
- Anticipated Effects of Dredging in the Blackwood River Estuary: Estuarine & Marine Advisory Committee

Chapter 6

Hardy Inlet and estuaries of the Naturaliste-Leeuwin Ridge

Drawn by Thomas Turner, 1851

Courtesy Art Gallery of Western Australia

The report 1974-75

BLACKWOOD CATCHMENT

Climate Geomorphology Hydrogeology vegetation of the catchment Flora of the river

THE ESTUARY - PHYSICAL FACTORS

Geomorphology Hydrographic survey Sediments River Flow Tides and other Water level changes Dynamics of the estuary Hydrology

BIOLOGICAL ASPECTS

Character of the biotic environment Objectives of the study estuarine habitats

Trophic level of the estuarine fauna Vegetation and plant macrophytes Zooplankton Detritus and the smaller benthic fauna Non-resident aquatic macrofauna Waterbirds-Man An ecological assessment Single species studies

SOCIAL ASPECTS

Demographic data

The resident population Tourism and tourism cultural: human impact on the environment
Hardy Inlet Condition Summary
Dr Malcolm Robb

Current information on the Hardy Inlet shows the system to be eutrophic (nutrient enriched) and under stress, suffering symptoms of stratification and deoxygenation, increased algal growth, with the occurrence of potentially toxic algae and fish deaths. Specific areas in the Inlet that are a concern are the upper reaches of the Inlet around Molloy Island and the estuarine reaches of the Blackwood River.

Conditions of concern for the Inlet highlighted in this document include: sources of nutrients from the Blackwood and Scott River catchments, sources of nutrients released from the organic rich sediments, the increase in macroalgae along the shores of urban impact areas, sedimentation around the mouth of the Inlet, reduced flow into the Inlet (drying climate), fish kills and potentially toxic algae.

Survey and process understanding studies of biotic (plant and animal) response and sediment enrichment from organic loading and nutrient enrichment are required in conjunction with assessment of social values of the local community. Capture of this information type is required before a complete assessment of the current condition of the Inlet and predictions for the future can be made.

The drying climate in conjunction with increased water abstraction is exacerbating the symptoms of organic loading. For example water levels in, and flows from, the Scott River are at historical lows and the water is clear of tannin colouring. With the lack of flushing and increased light penetration algal growths are occurring in the vicinity of Molloy Island, possibly in response to septage discharge from the island.

Low flows from the Blackwood and increased salt water intrusion is leading to increased density stratification which has the effect of preventing wind mixing of oxygen through the water. The organic rich sediments consume oxygen when they break down leading to low oxygen (hypoxia) or no oxygen (anoxia) in reaches above Molloy Island resulting in fish deaths and the growth of potentially toxic dinoflagellates which favour stratified conditions. Management Actions should focus on reducing losses of nitrogen, phosphorus and organic matter from the catchment. Resource condition targets for Total Nitrogen (TN) and Total Phosphorus (TP) can be set for the catchment. Immediate attention should be given to taking the residents of Molloy Island off septic tanks.

For the estuary resource condition targets can be set for oxygen in the area from Molloy Island upstream and algal occurrence in the vicinity of Molloy Island. It is recommended that studies on sediment nutrient accumulation and release be made from which resource condition targets for denitrification can be set as a measure of the success in reducing nutrient and organic loading.

Surveys of seagrass and macroalgae coverage, depth distribution and condition should be made to understand the plant response and vulnerability of the estuary and possibly to develop targets. Maintaining the biodiversity of fringing vegetation communities is important. Approximately 78% of the Hardy Inlet catchment (Blackwood River catchment and the Scott Coastal Plain) has been cleared. The Blackwood River catchment and the Scott coastal plain are both heavily modified by land-use and economic activity, including a diverse suite of agricultural activities, such as vegetable and fruit production, cut flowers, cropping and stock farming.
Progressive clearing of the catchment and changes in land use have changed the characteristics and quality of river flow in the catchment of the Hardy Inlet. Conditions of concern in the catchment include contributions of nutrients, sediments and salt loads to river flow which reaches the Inlet, a reduction in flow as a result of groundwater abstraction and land use practises that increase the risk of exposure of acid sulphate soils.

Fish kills from low oxygen land and nuisance algal growth can be expected for the foreseeable future under low flow conditions. Only concerted effort in substantially reducing nutrient and organic loading to the estuary will ameliorate the deterioration of the estuarine water quality. Much of this effort is catchment based. Immediate attention should be given to taking the residents of Molloy Island off septic tanks.
Thank you and Questions
Environmental Threats

- **Salinity**
  - Over 1 million tonnes per year.
  - Investigations occurring into release of hypersaline water from Lake Dumbleyung.

- **Feral Fish**
  - Redfin, Yabbies on the way (salinity will drive demographics).

- **Nutrients**
  - Sand plugs filling in river pools and habitat.
  - Natural process exacerbated by land practices.

- **Acidity**
  - Hardy Inlets surrounded by ASS.

Typical Drainage Line in SCP

Acid drainage Scott Coastal Plain
Urban drains, dry weather

Urban drains, wet weather

Caring for Water - 1

Investigation of Options to Reduce the Risk of Closing of the Blackwood River Mouth:
- To prepare an Report detailing the options available for a permanent mouth opening at the Hardy Inlet.
- Indicating that the River mouth will close off in summer, resulting in flooding of the Upper Blackwood Park and some widespread residential flooding. To reduce this risk, the study will propose flow regimes to reduce the risk of Mouth closures. As well as identify the preferred site for an opening.
- To provide recommendations to Key Stakeholders, including the Shire of Augusta Margaret River and Dept Planning and Infrastructure, on the preferred option.
- The consultancy will communicate widely with all stakeholders, including the community, to provide economic benefits of a permanent opening.

Location of current projects to protect the Blackwood Estuary
Caring for Water -2
Improving Water Quality in the Scott River and Hardy Inlet

1. Water quality improvement and management and on-ground works:
   - River restoration focusing on creek stabilisation and reducing erosion.
   - Working with landholders and regulators to assist in the effective implementation and monitoring of agricultural Best Management Practices to reduce or eliminate nutrients leaching from farms.
   - The work will also target some rural drainage issues.

2. DSS and Monitoring:
   - To establish, operate and maintain an integrated monitoring program.
   - To develop and refine a DSS for the Scott Coastal Plain.
   - To develop decision support tools and catchment scale specific to the area and also provide training for land managers and support personnel.

Other Programs in the Scott
Acid Sulphate Soils:
- Review existing management projects to establish Best Management Practices.
- Augment existing soil testing to establish baseline conditions and repeat over time to monitor efficacy of treatments.
- Audit BMP implementation and conduct farm-scale nutrient balance studies and landuse to feed into DSS.
- Promote and implement small catchment pilot projects to demonstrate BMPs.
- Water quality monitoring for small catchments to examine efficacy of BMPs.
- Promote BMPs through workshops.
- Demonstration sites.
- Written materials.

Thank you
Greg Hales
Program Manager

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Freshwater inflows influence natural biological, physical and chemical attributes of an estuary.

Influences directly influence abiotic conditions. Biotic response to flow-related changes in conditions.

Relationships between inflow dynamics, estuarine conditions and resources are fundamental to EWRs.

Understanding the cause and effect links between these characteristics underpin EWRs.

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The full range of natural inter- and intra-annual variation of hydrological regimes are critical in sustaining the full native biodiversity and integrity of aquatic ecosystems.
Principles of Ecological Water-Requirements:

(a) Basic Requirements

- Species richness and diversity
- Assemblage structure (marine, estuarine and freshwater focus)
- Spawning and recruitment processes
- Population age/size structure
- Spatial distribution in relation to abiotic conditions (salinity gradients) and critical thresholds (e.g., dissolved oxygen) and availability and diversity of structural habitats
- Temporal variability

(b) Prioritising Ecological Water-Requirements

- Freshwater inputs
- Hydrometric water quality
- Critical thresholds (e.g., salinity, sediment)
- Habitat diversity and abundance
- Water temperature, dissolved oxygen

Environmental Water-Requirements of Black Bream (II)

- Holistic approach focusing on Black Bream as an end-point goal may be most appropriate
- Integrates physical, chemical, hydrological and ecological processes throughout several trophic levels in an estuary

Logistical Considerations

- Often presented with an opportunity to manage threats to high value ecosystems/assets and at low levels of risk
- Usually significant constraints on time and investment (Typically 12 months, $50K)
- Results in a requirement for management decisions in a knowledge poor environment
- Multiple impacts on the quality and quantity of freshwater inputs
- Multiple management agencies

Key Components of an Approach to determine WFRs of Black Bream

- Determine flow alteration of an ecological risk from other catchment influences
- Include expert panel to identify functional flow components
- Assess flow alterations (natural, current and future flow scenarios)
- Acknowledge that flow responses will likely include effects of non-linear shifts (magnitude and timing of flow)
- Assess risk and uncertainty of flow alterations to sustainability of Black Bream including influencing species and resources
- Prioritise high risk scenarios and develop conceptual/empirical models
- Establish specific management objectives
- Implement monitoring as part of adaptive management approach
- Establish targeted research to address priority flow ecology risks and particularly mechanisms leading to observed ecological responses

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Management of Fishing Activities in Degraded Estuaries

Rod Lenanton
Josh Brown
Sue Turner
Research Division
Department of Fisheries
Government of Western Australia

Background
- Identification of "Blackwood/Hardy Inlet" issues came from public submissions from FMP 131 (1999) - "Management direction for WA's estuarine and marine embayment fisheries"
- This led to the release of FMP 169 (2004) - "Hardy Inlet Estuary Fishery Management issues and options"
- Other key sources of information:
  - Fish and Fisheries 3, 291-316.

Application of Fisheries Management Tools
- 4 major steps involved in the decision to modify or introduce management arrangements to restore depleted finfish resources:
  1. Review of all information on the ecosystem, species, stock and fishery
  2. Comparison and identification of appropriate management tools
  3. Implementation of the chosen approach
  4. Monitoring and further refinement of management

Outline
- Management of estuarine finfish resources
- "Decision rules" for the application of fisheries management tools to restore depleted estuarine finfish stocks
- Examples of the approach used to manage some Western Australian estuarine finfish resources in WA
- Some issues to consider in the ongoing management of the Blackwood River Estuary finfish stocks

Management of Estuarine Finfish
- The "traditional" assessment of the status of marine finfish stocks usually assumes that the environment/habitat is not degraded
- However assessment of the status of estuarine/inland stocks must, by definition include consideration of the condition of the fish habitat, which in most cases is degraded to some extent (i.e. stocks below optimum productivity)
Comparison of Fisheries Management Tools

Management of WA Estuarine Finfish
Commercial Fishing
- West Coast Estuarine Interim Managed Fishery
- Swan, Peel Harvey & Blackwood River Estuaries
- Effort Reduction
  - Latent effort
  - Real effort related to declining abundances in part due to degraded habitat
  - Adjustment to catch shares
Recreational Fishing
- Rec fishing is regulated, but explicit catch levels unmanaged

Management of WA Estuarine Finfish
- Dawesville Channel construction designed to improve “quality” of the estuarine environment
- System became more marine
- Reinforced further by climate change
- Shift towards marine species
- Severely compromised recreational amenity as a result of the dominance of blowfish
- Ongoing “status” of fish stocks is often a consequence of non-fisheries (e.g. urban/rural/environmental) management issues

Management of Fish Resources of the Blackwood

Some key issues that need to be considered:
- Update the views of all stakeholders/community since FMP 169 (2004)

Management of Fish Resources of the Blackwood
- Management arrangements must lie within the broad framework of the objects of the Fish Resources Management Act, 1994
  - Need to develop specific fishery management objectives for the Blackwood. However, the requirements of other Acts (DEC) need consideration
- The commercial sector under formal (administrative) management plan with performance built around target catch range and the sustainability of key indicators (black bream, cobbler & King George whiting)
  - The recreational sector is regulated, but explicit catch levels unmanaged.
Management of Fish Resources of the Blackwood

• Do we need to recover stocks of any of the key species? commercial catch

Management of Fish Resources of the Blackwood

Blakl Br eam CPUE

Management of Fish Resources of the Blackwood

• "Habitats" within the Blackwood River System need restoration
  - We need to have a better understanding of the fish/habitat interrelationships, and what impacts this will have?

Management of Fish Resources of the Blackwood

How large is the black bream breeding stock?

Management of Fish Resources of the Blackwood

Length structure of DoF recreational angler's log book catch - Black bream in various rivers and estuaries, 2004 - 06.
Some Conclusions

- To a large extent, the dominant influences on fish resources in estuaries are a consequence of the impact of users other than fishers.
- Nevertheless, we must endeavour to manage all of the fish resources sustainably within an EBFM framework.
- The pilot stock enhancement trial has been technically successful.
- Recruitment generally is not an issue at the moment for most WA black bream stocks. The Blackwood stock appears to be the exception.
- Need a better understanding of the environmental factors driving recruitment.
- The final choice of management direction is one for the community.
Black bream in the Blackwood: 2005-06 recreational fishing creel survey

Lynnath E. Beckley and Sheryn P. Prior
Centre for Fish & Fisheries Research, Murdoch University, 90 South Street, Murdoch, Western Australia 6150

The status of the recreational fishery in the Blackwood Estuary, south-western Australia, was quantitatively assessed via a boat-based creel survey from September 2005 to August 2006. Sampling was stratified by both season and day-type and, in total, was conducted on 144 days over the 12-month period. Daily sampling consisted of a count of number of anglers throughout the estuary (for fishing effort), and surveys of catches by boat-based and shore-based recreational anglers.

In total, interviews were completed with 1,212 angling parties. The retained catch of 2,631 fishes comprising 17 species was dominated by yellow fin whiting (47%) and Australian herring (17%). Although black bream only constituted 6% of the catch it was the most frequently targeted species (27%). Only 41% of the boat-based angling parties and 37% of the shore-based angling parties surveyed had retained fish at the time of interview. Nevertheless, compliance with minimum legal length regulations was found to be an issue, particularly for Australian salmon and King George whiting.

Fishing effort was greatest during summer and over the Easter period, when there were influxes of tourists to the region. More anglers were recorded on weekends and public holidays than weekdays in every month of the year except for December and January. Fishing from boats was recorded throughout the estuary, while shore angling was mainly concentrated in accessible locations near Augusta.

The overall catch rate was 0.835 (±0.044) fish retained/angler/h. Mean catch rate for black bream was 0.032 fish retained/angler/h but for those specifically targeting black bream it was higher at 0.092 fish retained/angler/h. Total annual fishing effort was estimated to be 71,565 angling hours and total harvest was calculated to be 61,311 fishes. Approximately 8 tonnes of fish was harvested from the Blackwood Estuary by recreational anglers over the survey period, of which 1.26 tonnes was black bream.

Comparison with a similar 12-month creel survey conducted in the Blackwood Estuary in 1974-75 (Caputi 1976) showed some major differences. Catches were much lower in 2005-06, with the total estimated harvest (number of fish) less than a quarter of the previous study. Black bream dropped from the third most abundant species in the catch in 1974-1975 to sixth in 2005-2006. Although total annual fishing effort in the two surveys was remarkably similar, there was more shore-based effort in 2005-2006. The overall catch rate for 1974-75 was almost five times greater than the overall catch rate recorded in 2005-06.

Although coastal fish stocks in Western Australia are known to exhibit inter-annual variations in abundance, and effects of fishing in estuarine areas are difficult to distinguish from human-induced changes to the environment, the marked decline in the recreational catch and catch rates in the Blackwood Estuary over the past three decades is cause for serious concern.
Black Bream in the Gippsland Lakes
Dr Jeremy Hindell

The Gippsland Lakes system is one of Australia's largest estuaries. The Gippsland Lakes support valuable recreational and commercial fisheries. The most important species supporting these fisheries is black bream.

Commercial catch figures suggest that the black bream population is in decline. Recreational catch figures also support this. It is thought that the decline is related to recruitment failure – either because of spawning or larval/juvenile survival failure. There are some sectors of the fishery, however, that believe catches have decreased as a result of fish moving to areas where they are harder to catch. For the commercial fishery, this means up the rivers, where commercial fishing is not allowed.

A large acoustic telemetry program was initiated to determine the degree to which fish were likely to use the rivers versus the lakes. Thirty acoustic receivers were placed at strategic locations throughout the lakes system. Sixty fish were implanted with acoustic transmitters. The study was run over two years.

Results are preliminary, but there are several main findings:
1. Black bream survive surgery well – low mortality
2. Fish move extensively throughout the Gippsland lakes – some fish are moving more than 3000 km in a year
3. Fish move throughout the estuarine regions of rivers, and often move between rivers
4. During the study period, fish spent an average of 70% of their time in the rivers.

So, it is plausible that reduced commercial catches could be a reflection of fish spending more time up the rivers during a period of drought. However, most recreational catch is taken in the rivers, and this has also declined – despite fish spending more time in the rivers. It is likely, therefore, that the population of bream has declined.

Reasons for the decline are unknown, but it is thought that early life-history failure due to unfavorable environmental conditions is a primary candidate. A new research program has been launched to investigate links among freshwater flows, water quality and early life-history dynamics.

There is community and political interest in stocking of Victorian estuaries, based on the expectation that stocking will help to sustain wild fish populations and/or enhance recreational fishing opportunities. Stocking in Victorian waters is subject to:
• 1999 National Policy for the Translocation of Live Aquatic Organisms (to which Victoria is a signatory)
• Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria (released jointly by DPI and DSE in December 2003), which require adequate and balanced risk assessment to identify and minimise the potential adverse impacts of stocking, and a need to monitor the outcome of stockings – not only to measure any impacts, but also to measure survival and subsequent benefits to recreational fishing.

20,000 juvenile black bream were released at three sites in the Gippsland Lakes during April 2004. This was the first known release of cultured black bream into Victorian public waters. Fish were produced by PIRVic from Lake Tyers broodstock. The Minister's media release indicated 'it was a trial to determine the benefits of bream stocking, and that it was the 'first
step in a long term program' to ensure adequate supplies of bream in the Gippsland Lakes for both recreational and commercial fishing'.

Future proposals to stock bream in the Gippsland Lakes (or any other Victorian public waters) must be:
- subject to a comprehensive risk analysis and evaluation
- accompanied by an adequate monitoring program to evaluate the benefits of stocking and to assess the effectiveness of translocation management measures designed to minimise identified risks
- used as a research tool to help improve understanding of the habitat and environmental factors that may be contributing to poor spawning success or recruitment of wild bream stocks.
Results from acoustic tracking

- All fish survived surgery – and, high survival after release (> 90%).
- All fish moved among rivers, and therefore spent at least some time in the lakes.
- Fish moved extensively throughout the Gippsland Lakes.
- Movements > 3000 km/year common.
- Patterns of movement change with habitat (e.g. Large Woody Debris), diel and seasonal periods.

So...has the population of black bream declined?

- Bream are spending the majority of their time up the rivers – probably because of reduced freshwater inputs.
- But, fish regularly move into the lakes (probably to feed), and some fish spend extended periods in the lakes system.
- Possible that these movement patterns could reduce commercial catches (no commercial fishing in the rivers), but recreational catches and fishery independent survey results also suggest a decline in fish abundance (or catchability).
- Plausible that bream populations have declined.

New research program funded through ARC Linkage program.
- Key State management agencies as industry partners.
- Strategic partnership between University of Melbourne and PIRVic scientists.
- 4 year, $700k research program.
- Modelling estuarine hydrodynamics.
- Assessing patterns of movement of juvenile and adult fishes.
- Identifying spawning locations and estimating reproductive output.
- Monitoring recruitment patterns, growth and survival of post-settlement stages.
- Not just confined to bream – also includes other estuarine species.

Freshwater flows

Habitat and estuarine health

Fishes

Fisheries sustainability

Influence of changes in the environment likely to be significant – but needs further research.

River use > Lake use


Freshwater flows

Habitat and estuarine health

Fishes

Fisheries sustainability

Influence of changes in the environment likely to be significant – but needs further research.

River use > Lake use

Policy for Restocking in Victorian estuaries

- Community and political interest in stocking of Victorian estuaries
- Expectation that stocking will help to sustain wild fish populations and/or enhance recreational fishing opportunities
- Stocking in Victorian waters is subject to:
  - 1999 National Policy for the Translocation of Live Aquatic Organisms (to which Victoria is a signatory)
  - Guidelines for Assessing Translocations of Live Aquatic Organisms in Victoria (released jointly by DPI and DSE in December 2003)
- Adequate and balanced risk assessment to identify and minimise the potential adverse impacts of stocking
- There is also an identified need to monitor the outcome of stockings - not only to measure impacts, but also to measure survival and subsequent benefits to recreational fishing.

Acknowledgements

- Fisheries Victoria - including regional staff
- Bureau of Rural Sciences - Land and Water Australia
- Victorian Recreational Fishing Licence Trust
- East Gippsland Catchment Management Authority
- Barry (Doc) McKenzie
- Nicholson Angling Club
- 20,000 juvenile black bream were released at three sites in the Gippsland Lakes during April 2004
- First ever known release of cultured black bream into Victorian public waters
- Fish were produced by PIR from Lake Tyers larviculture
- Minister’s media release indicated it was a trial to determine the benefits of bream stocking and that it was the ‘first step in a long term program’ to ensure adequate supplies of bream in the Gippsland Lakes for both recreational and commercial fishing
- Future proposals to stock bream in the Gippsland Lakes (or any other Victorian public waters) must:
  - Be subject to a comprehensive risk analysis and evaluation
  - Be accompanied by an adequate monitoring program to evaluate the benefits of stocking and to assess the effectiveness of translocation management measures designed to minimise identified risks
  - Be used as a research tool to help improve understanding of the habitat and environmental factors that may be contributing to poor spawning success or recruitment of wild bream stocks
Restocking the Blackwood River Estuary with Black Bream

Mr Greg Jenkins

Increases in commercial and recreational fishing pressure in recent decades have led to over-exploitation of many valuable fish species. This problem in estuaries has sometimes been exacerbated by the detrimental effects that have occurred in these systems through adverse anthropogenic changes. Species whose entire life cycle is restricted to estuaries, such as the recreationally and commercially-important Black Bream in Western Australia, are especially vulnerable as their numbers are unlikely to be enhanced by recruitment from outside the estuary. The impact that fishing can exert on a species, such as Black Bream, which is restricted to estuaries, is demonstrated by the fact that the relative abundance of the older individuals of this species is less in estuaries subjected to a substantial amount of fishing than in those in which fishing is far more restricted (Sarre and Potter, 2000).

The sole commercial fisher and regular recreational fishers in the Blackwood River Estuary consider that the abundance of Black Bream in this system has declined in recent times. This view is supported by the fact that the numbers of Black Bream we obtained through extensive sampling in the Blackwood River Estuary were far lower than those caught during a detailed study of the fish fauna of this estuary in the 1970s (Lenanton, 1977). Widespread concern that the numbers of Black Bream had declined in the Blackwood River Estuary resulted in the initiation of a carefully-designed research program aimed at determining whether it would be feasible and economically worthwhile to stock Black Bream in this large and important estuary.

Our initial sampling demonstrated that Black Bream is largely found in the riverine component of the Blackwood River Estuary and particularly in its upper reaches. The abundance in those upper reaches is greatest in spring. As spawning occurs in this season, and the samples from these upper reaches contained many maturing, mature and spent Black Bream, it is concluded that A. butcheri migrates some distance upstream as it matures and spawns mainly in those upstream waters of the estuary in spring.

For our restocking research, 56 females and 50 males were collected from the Blackwood River Estuary to act as brood stock for producing juveniles for restocking this estuary. The otoliths (ear bones) of the cultured juveniles were tagged by immersion of the fish in a solution of alizarin complexone (ALC). The resultant pink stain on the otoliths of cultured Black Bream was still clearly visible more than three and a half years after the otoliths had been tagged with ALC. The cultured individuals were certified as disease free prior to release into the upper reaches of the Blackwood River Estuary in which Black Bream had previously been identified as being most abundant. The fish were introduced at several sites over a distance of c. 20 km.

The maximum total length and age of wild Black Bream caught during our study was 440 mm and 31 years. The latter age is the maximum yet recorded for any estuary in Western Australia. Analysis of our length-at-age data demonstrated that, on average, the individuals of the wild population of Black Bream reach total lengths of 143, 200, 244, and 279 mm at the end of their first, second, third, and fourth years of life, respectively. This represents a particularly rapid rate of growth for this species in a Western Australian estuary. The lengths of the stocked fish at ages 1 to 4 were 119, 182, 219 and 242 mm, respectively, which were less than those for wild fish of those ages. Comparisons of mean lengths at successive age intervals confirm that wild Black Bream grow more rapidly than stocked Black Bream. However, the growth of Black Bream stocked in the Blackwood River Estuary is still
substantial, as is illustrated by the fact that it is greater than that of wild stocks of this species in some other Western Australian estuaries (Sarre and Potter, 2000).

The average length of the females and males of wild Black Bream at first maturity were 178 and 155 mm, respectively. After adjustment to take into account the fact that a number of the larger stocked Black Bream had not reached maturity, the average length of the females and males of stocked Black Bream at first maturity were 202 and 189 mm, respectively. Thus, stocked Black Bream do not typically reach maturity until they have attained a larger size than wild Black Bream. The majority of females (84%) and males (94%) of wild Black Bream attained maturity by the end of the second year of life, whereas only 75 and 54% of the females and males of stocked Black Bream had reached maturity by the end of their third year of life. Some stocked fish will require further years to reach maturity and some may never achieve maturity.

The stocked Black Bream, that were cultured and released in 2001 and 2002, survived well and comprised 75 and 92% of catches of Black Bream of the 2001 and 2002 year classes, respectively.

In summary, this study has demonstrated that the abundance of Black Bream in the Blackwood River Estuary was enhanced markedly through the introduction of restocking, cultured fish. The Black Bream is a particularly suitable candidate for restocking estuaries in south-western Australia as it is confined to these systems and thus any stocked fish are unlikely to migrate to other estuaries. The ease and relatively low cost estimated for culturing Black Bream, the hardiness of this species and its restriction to its natal estuary make the restocking of Black Bream an economically viable and valid proposition when a stock of this species has become highly depleted. Thus, such restocking provides a further tool for fisheries managers to use to sustain the stocks of Black Bream in Australian estuaries.
Black Bream biology

- Euryhaline (fresh to > 60 ppt)
- Relatively long-lived and slow growing
- Reaches sexual maturity at ~2 years old and ~190mm
- Opportunistic feeder
- Spawns upstream from late spring to early summer
- Successful recruitment is affected by environmental conditions in a changing world
- Black Bream remain within their natal estuary and is therefore potentially vulnerable to overfishing.

Black Bream culture in Western Australia (since 1992)

- Initial culture trials for aquaculture training and restocking.
- Semi-intensive green-water culture method
- Cost-effective culture with 80-90% surviving to 30 mm
- Hatchery manuals published in 1999 and 2003
- Development of ‘hands-on’ short course for culture

Gill netting used by Dr Lenanton in the 1970’s.
Nets set parallel to banks.

Altered gill netting method for 2000
Nets set perpendicular to bank

WHY RESTOCK THE BLACKWOOD?

- Gill netting used by Dr Lenanton in the 1970’s.
- Sampling by Fisheries WA in the early 1970s yielded large numbers of black bream.
- Fishers consider black bream to have declined greatly in abundance.

The results of our sampling indicate that the abundance of black bream has declined.

Black Bream is the most popular recreational fish species in WA estuaries.
Sampling by Fisheries WA in the early 1970s yielded large numbers of black bream.
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Gill netting used by Dr Lenanton in the 1970’s.
Nets set parallel to banks.

Altered gill netting method for 2000
Nets set perpendicular to bank
Trial restocking of Black Bream in the Swan River in 1995

Project Aims

- Determine whether restocked Black Bream will survive in the Blackwood River Estuary
- Determine whether the growth and length and age at maturity of the restocked fish would be the same as those of wild fish

Culture Objectives

1. Collect 100 black bream for broodstock
2. Produce 200,000 juvenile black bream
3. Tag the juvenile bream to enable monitoring to assess the effectiveness of the restocking

Culture and Tagging

106 brood stock were collected from the Blackwood River
220,000 juvenile Black Bream were produced

CHEMICAL MARKERS

Alizarin complexone, Alizarin red, Oxytetracycline
Otolith marking trials determined that the best mark was produced by Alizarin complexone.
Monitoring

Progress of restocked black bream were monitored every three months using gill and seine nets.

Monitoring results

Catch rates of wild and stocked fish

Environment

Note: Mediterranean climate, winter rains, dry summers.

Monitoring results

Number of fish

Overall catches of wild and stocked fish

Wild fish

Stocked fish

Year class

2001

2002

75%

92%

70,000 - 60 mm juveniles were released in 2002

150,000 - 30 mm juveniles were released in 2003

75,000 - 60 mm juveniles were released in 2001

75,000 - 30 mm juveniles were released in 2002

Catch rates of wild and stocked fish

Species

Seasons

Warm water

Cool water
Cost per fish that survives to reach legal size

For culture, tagging, release and limited monitoring
$2.05

For culture and release only
$1.60

Conclusions

Growth of wild and stocked fish

Conclusions

Length at maturity of wild and stocked fish

Conclusions

As Black Bream remain in their natal estuary, restocking will contribute to future generations of the stock.

Conclusions

Stocking of cultured black bream can greatly increase the abundance of a depleted stock in WA estuaries.

Although the stocked fish did not perform quite as well as the wild stock, they still performed better than wild stocks in some other estuaries.
Research required

Utilise the 'unique' opportunity of having identifiable cultured fish that are now 5 to 6 years old.

- Is the genetic composition of the restocked fish representative of the wild stock?
- How do the cultured fish perform over the typical life span of the species (reproduction and growth)?
- Others?

Research required

As restocking appears to be an inevitable future fisheries management strategy in estuaries, what are the implications of this study?

What protocols are required for future restocking (hatchery, release, monitoring, research)?

As the estuary is undergoing constant change due to anthropogenic influences, is the precautionary approach to restock?

What other research is required to facilitate the use of restocking as a management option?

What caused the decline?
Appendix 4: Additional Workshop Notes

Biological
What is the problem in the Blackwood?
Recruitment? Investigate all existing catch data and find if it is a stock/recruitment problem.
What is the size of the breeding stock?
Should restocking be an ongoing program?
Significance of the environment?

Is the poor state of the environment limiting larval survival? If so, then restocking is needed. It was noted that the restocked black bream in the Blackwood are spawning.

What is different about the Blackwood to other south-west estuaries? It was noted that it is deeper than other estuaries, the banks are steeper and it has little shallow wetlands associated with it. The upper reaches where spawning is likely to occur are unique in that they have steep sided banks. It was also noted that the black bream population structure is different in the Blackwood to other estuaries.

It was agreed that there is a critical need for research into the low level of recruitment. All of the existing data should first be complied and examined in an effort to determine the level of the stock depletion.

Black bream are hardy, have high numbers of eggs, have a very high survival rate in the hatchery in comparison to other species, are opportunistic feeders and hatchery released juveniles have a high survival in the wild. Is larval survival the bottleneck?

Research focus
- Location of spawning (in the Swan Estuary, and in Victoria they spawn in about 20 ppt);
- Environmental conditions at the spawning sites (shallow water?, weed?, is suitable habitat available?- waters behind Molloy?)
- Available food for larvae (ie copepods)
- Contrast with the highly productive Pallinup;
- Can you enhance habitat for larval survival;
- Can you improve the clarity of the water in the Blackwood;
- What are the constraints on recruitment?

Options for a stocking program and its monitoring
1 Restocking and monitoring to recover populations to historical (1970’s) levels
2 Stop fishing for black bream – but at what cost to the Augusta community?

Other Research questions
- What is the level of the wild black bream stocks and is there a good genetic basis for broodstock for restocking
- Are other species in decline in the Blackwood?
- Is there a change from the 1970’s from Rupia to macroalgae?
- 30% reduction in rainfall (environmental flow) over last 30 years, will it reduce further and to what effect?
Social

- What are the social values to the community for restocking and the recreational fishery?
- It was suggested that 50-60% of people fish for black bream in the Blackwood.
- The black bream fishery attracts people to the region.
- When there are low populations of black bream in the Blackwood then people visit other locations instead – such as Walpole for fishing.

Economic

- Rutledge – suggests that it costs $5 to stock a barramundi but it can return $191 to the community to catch.
- It was noted that the cost that can be attributed to each caught fish is closely linked to the survival of the juveniles –0 and that black bream had demonstrated high survival.
- Multipliers for stocking and recreational fishing examples can be found in USA and Australia.
- Nichols (DOF) data for economic return to wild capture communities suggest ~ 5:1.
- Lynnath’s creel survey shows some economic data associated with both locals and tourists for the region for fishing.
- Conservation cost?

The essential elements of large scale restocking

- Genetics, should you use large broodstock numbers and retain them over time or use a smaller group that are captured every year?
- Large-scale O/S production for restocking uses more natural systems such as ponds.
- What is the optimal size at release, best timing and other release strategies?
- How many fish and over how many years to restock?
- Objectives of the restocking – catch rates?
- Who is going to pay? Will it be economically sustainable and under what form of management?
- Fitness of hatchery black bream (lower growth, reproductive fitness)?