

# **CURRENT RESEARCH PROJECTS**

## **– WILD FISHERIES –**

**(Last updated 6 February 2012)**

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## Research Project Description

### Project Title:

Refinement of selective gears for estuarine prawn and squid fisheries  
(Ctu2005/016)

### Principal Investigator:

Dr Matt Broadhurst

### Funding Sources:

NSW Department of Primary Industries and industry funds.

### Objectives:

1. Quantify the selection of various configurations of codends made from mesh sizes between 25 and 29 mm hung on the bar used in stow nets fished in the Clarence River and Wallis Lake.
2. Compare the relative efficiency and selectivity of the recommended composite square-mesh panel and industry-refined modifications to codends used in Broken Bay squid trawls.
3. Compare refinements to existing bycatch reduction devices in the Clarence, Hunter and Hawkesbury rivers.

### Summary:

Several types of small-meshed commercial fishing gears are used to target a range of species throughout NSW estuaries. In addition to the desired catches, many gears retain large quantities of unwanted organisms, termed bycatch. In some fisheries, this bycatch comprises large numbers of small fish, cephalopods and crustaceans, including juveniles of the targeted species.

In recent years, considerable research has been done to modify problematic nets so that they retain less unwanted bycatch. Various physical modifications to gears, termed bycatch reduction devices (BRDs), have been developed and adopted in many fisheries, and especially those targeting prawns. All of these modifications have been designed and developed in close consultation with industries and so the majority are appropriate for the various conditions experienced in the different fisheries. But, because of subtle variations in (i) the key sizes and species targeted, (ii) the types of bycatch and (iii) the fishing methods at different places and times, some modified gears require ongoing refinement. In most cases, these refinements are initiated and developed by the relevant industries.

Industries that recently sought to examine refinements to BRDs for their fishing gears are stow netters targeting school prawns in the Clarence River and Wallis Lake and trawlers targeting squid in Broken Bay and prawns in the Clarence River. Fishers in these estuaries are concerned over the potential for some loss of the targeted species and their sizes and have suggested refined, and/or alternative modifications to their gears. The aim of this research project is to assess the utility of these modifications for reducing unwanted bycatch. This information will facilitate the eventual adoption and legislation of appropriate designs in these fisheries.

## Research Project Description

### Project Title:

Maximising the post-release survival of angler-caught native freshwater fish in NSW – Phase 2  
(Ctu2008/022)

### Principal Investigator:

Dr Matt Broadhurst and Dr Karina Hall

### Funding Sources:

NSW Department of Primary Industries and the NSW Freshwater Recreational Fishing Trust.

### Objectives:

1. Use recreational angling events to develop changes to practices and/or gears that maximise the short-term survival of Australian bass, Murray cod, golden perch and freshwater catfish after release from capture by hook and line.
2. Use recreational angling events and an aquaria experiment to quantify and maximise longer-term survival, while minimising sublethal impacts to the behaviour and reproductive output of golden perch and/or Murray cod after release from capture by hook and line.
3. Promote the adoption and use of solutions identified in (1) and (2) throughout the freshwater angler community.

### Summary:

Freshwater angling is very popular throughout Australia with an estimated total annual catch of up to 5 million fish. More than 40 species are targeted, however, the majority of catches comprise three natives: Australian bass (up to 1.1 million each year), Murray cod (0.5 million) and golden perch (1.8 million). Another important group includes catfishes, and especially the freshwater catfish or tandon (some river stocks are considered vulnerable in NSW). Legally-enforced size and bag limits, combined with a growing awareness by anglers of the need to conserve stocks, mean that the greater majority (up to 78%) of these species are released. Ultimately, to maintain sustainable freshwater angling, most released fish should survive and remain healthy.

Recognition of the need to validate existing catch-and-release practices for Australian bass, Murray cod and golden perch in NSW resulted in a preliminary two-year project (2006 – 2008) funded by the Freshwater Fishing Trust. This work involved various recreational fishing events (including immediate release and live weigh-in tournaments) and aimed to provide the first estimates of the post-release survival of the three key species (catfish were not assessed), and identify some of the main factors influencing any mortalities.

The project revealed considerable variation among the rates of short-term (< 5 days) deaths and their causes; attributable to inherent differences among species, as well as various handling and environmental factors. Irrespective of the conditions examined, Australian bass were the most resilient species, with short-term post-release survival estimated at between 94 and 100%. The few deaths were mostly attributed to the removal of swallowed hooks. By comparison, the survival rates of Murray cod (85%) and some golden perch (73 – 100%) were lower and, in addition to anatomical hook location, clearly influenced by environmental and technical factors that included high water and/or air temperatures for golden perch, and poor design and/or water quality of live-wells for both species. Another potentially-important factor influencing the survival of golden perch (and possibly Australian bass) is depressurization or 'barotrauma', which can cause the protrusion of internal organs in fish caught from deep water (> 10 – 15 m).

Previous work done with other local and overseas species has demonstrated that mortalities caused by the above sorts of factors can be mitigated via simple modifications to angling practices. Specifically, the survival of fish that have ingested hooks might be maximised by releasing them with their lines cut, while fish that have sustained barotrauma can be treated (i.e., vented) in a variety of ways to facilitate their ability to regain

equilibrium prior to release. Further, the development of simple but effective live-wells that maintain water quality can eliminate many of the negative impacts on fish associated with being held onboard prior to release. These types of straight-forward modifications to handling practices could dramatically improve the survival of native fish angled in NSW.

The methods to evaluate which practices maximise the survival of released angler-caught fish generally involve individuals being caught and handled in conventional and modified ways, and then released into replicate cages for monitoring. This standard approach was applied during the preliminary two-year study and while it enabled immediate and short-term mortalities to be estimated, one concern is that because released fish were confined in a cage or tank, they might not have experienced all of the factors that contribute towards longer-term mortality and/or negative physiological impacts. Another concern is that fish were not subjected to multiple catch and release, which can occur during consecutive fishing events/tournaments, and especially those held in impoundments.

Unlike caged fish, individuals that are hooked and then immediately released into the wild may suffer short- or long-term behavioural impairment or a protracted recovery from stress that could (1) reduce their ability to feed, (2) increase their susceptibility to predation and infection and/or (3) impact on their reproductive output. Such effects might be exacerbated in fish that are caught and released several times and have the potential to significantly contribute towards total mortality or undesirable sublethal impacts. To provide an accurate and comprehensive assessment of the fate of key native freshwater species released by anglers in NSW, the potential for these unaccounted effects needs to be determined and quantified. This information can then be used to further improve post-release survival.

Given the above, this project will use both established and alternative techniques (involving tagging) to assess a wide range of factors that influence the short- and long-term mortality of released angler-caught Australian bass, golden perch, Murray cod and freshwater catfish. This information will be used to develop modifications to handling practices that maximise survival while minimising sublethal physiological impacts.

## Research Project Description

### Project Title:

Estimating and maximising the survival of key species released by recreational fishers in NSW – Phase 3  
(Ctu2008/021)

### Principal Investigator:

Dr Matt Broadhurst

### Funding Sources:

NSW Department of Primary Industries and the NSW Saltwater Recreational Fishing Trust.

### Objectives:

1. Use recreational angling events to estimate the short-term survival and key factors contributing towards the mortality of kingfish, blue groper, snapper, blue swimmer crabs, mud crabs and rock lobster after release from capture by recreational fishers.
2. Use recreational angling events and an aquaria experiment to quantify and maximise longer-term survival, while minimising sublethal impacts to the behaviour and/or reproductive output of kingfish, dusky flathead and/or snapper after release from capture by hook and line.
3. Publish and distribute a guide that promotes the adoption and use of best practices identified above, and during previous relevant research, throughout the recreational fishing community.

### Summary:

Recreational fishing is among the most popular aquatic pastimes in Australia. This is evidenced by the large participation rate (almost 20% of the population) and the volume of catches; estimated at nearly 200 million organisms per year in 2000/2001. The perception of recreational fishing, and particularly angling, as a sport rather than a harvesting activity by most participants, combined with legal sizes and bag limits, means large proportions of catches (e.g., 44% of all fish) are released. For such practices to contribute towards the sustainability of recreational fishing, most of the released organisms should survive with few negative impacts.

Concerns over the lack of any information about the fate of key species of fish released by recreational anglers in NSW in the late 1990s led to a multi-phased, 5-year project funded by the Saltwater Fishing Trust initially entitled “Using recreational anglers to maximise the survival of released line-caught fish” (2004 – 2009). Ten species were chosen for this research: mulloway, trevally, yellowfin bream, snapper, sand whiting, luderick, dusky flathead, sand mullet, garfish and tailor.

So far, the results from this work have been quite positive with short-term survival rates estimated at > 70% for most species and clear strategies identified for reducing the few mortalities. For example, based on a relationship between the time spent in onboard holding tanks and the survival of silver trevally, it was recommended that this species should be released as soon as possible after capture. By comparison, anatomical hook location was identified as the main predictor of mortality in several of the examined species, and especially yellowfin bream. Simply by using the largest size hooks possible attached to short traces or a sinker only and hard baits can significantly reduce the rate of deep hooking (i.e., swallowed hooks) and therefore mortality. In cases where hooks are swallowed, cutting the line rather than removing hooks and releasing the fish can dramatically improve survival. By following these simple practices anglers can, in some cases, virtually eliminate immediate and short-term mortalities.

While the completed research will greatly contribute towards improving the survival of released fish and therefore the sustainability of recreational fishing in NSW, it is limited to the species and the particular conditions examined. Additional work is required to examine the post-release fate of other priority fish, including kingfish and blue groper, as well as some of the species already examined across a wider range of conditions. In particular, the work with snapper is limited to mostly undersize individuals angled from shallow



depths. There may be other mortalities to larger individuals which are typically angled from deep water (> 15 – 20 m) and often incur barotrauma.

A further consideration is that most of the above work has only involved assessments of short-term (< 5 days) mortalities. Recent experiments with yellowfin bream and Australian bass (during a related Freshwater Trust funded project) indicate the potential for longer-term impacts to some released fish, which might result in (1) a reduced ability to feed (i.e., due to hook ingestion) or (2) negative impacts on reproductive output. Similar effects have been observed in overseas species (and subsequently mitigated) and therefore warrant closer examination for some of the key species targeted in NSW.

In addition to ongoing research with some species of fish, there is a need to assess the post-release fate of important invertebrates such as blue swimmer crabs, mud crabs and rock lobster. These latter three species are all caught throughout NSW by recreational fishers using range of legal traps; most of which are not particularly selective. Consequently, large numbers (up to between 41 and 68%) are released with unknown fate.

Given the above, this project aims to estimate the short-term post-release survival of kingfish, blue groper, snapper, blue swimmer crabs, mud crabs and rock lobster and longer-term fate of other key species after release from capture by recreational fishers. This information will be considered along with the results of the earlier studies to develop a generic guide describing appropriate protocols for handling released recreational catches in NSW.

## Research Project Description

### Project title:

Utility of beam and multi-rig trawl configurations for reducing environmental impacts in the Clarence River prawn-trawl fishery  
(FSC2007/191)

### Principal Investigator:

Dr Matt Broadhurst

### Funding Sources:

NSW Department of Primary Industries

### Objectives:

Assess the utility of beam trawls and other multi-rig configurations for reducing bycatch and fuel consumption, while maintaining target catches at existing levels in the Clarence River prawn-trawl fishery.

### Summary:

Otter trawling occurs in three rivers in NSW, involves up to 204 small vessels (<10 m in length) and is valued at approximately A\$7 million per annum. Fishers mostly target school prawns, but also catch and discard unwanted small fish, cephalopods and crustaceans (including juvenile prawns considered too small for sale) that are collectively termed 'bycatch'. Concerns over the mortality of large numbers of juveniles of commercially important species led to the development of modifications to the codends of otter trawls designed to reduce unwanted catches. This work culminated in the adoption and in some cases, legislation of several bycatch reduction devices (BRDs).

While BRDs have alleviated many of the concerns associated with trawling, none of the designs are 100% effective and so, at times, catches still comprise at least some unwanted organisms. One method of addressing this remaining component of bycatch is to examine more detailed changes to the operation of trawls and/or other gear configurations that are more selective. A subtle gear alternative that may meet this criterion is the beam trawl.

Beam trawls date back more than 2000 years and represent an early stage in the eventual evolution of otter trawls. Unlike the latter gear, in which the mouth of the trawl is spread by hydrovanes (termed 'otter boards') attached to sweeps, a rigid beam terminating in two parallel sleds (or rollers) maintains the required opening. These different characteristics essentially mean that beam trawls typically have a much narrower overall swept area (because there are no sweeps), reduced contact with the sea bed and, therefore, less drag. Our aims in this project are to determine if such characteristics translate to (i) fewer fish being herded into the path of the trawl (and so less bycatch) and (ii) lower fuel consumption, while (iii) still maintaining target catches in the Clarence River prawn-trawl fishery.

## Research Project Description

### Project title:

Reducing the environmental impacts and improving the profitability of prawn trawling through a structured framework of anterior gear modifications  
(FSC2010/250)

### Principal Investigator:

Dr Matt Broadhurst

### Funding Sources:

NSW Department of Primary Industries and the Fisheries Research & Development Corporation (FRDC Project 2011/010)

### Objectives:

1. Identify anterior gear modifications that reduce the bycatch, drag and habitat impacts of prawn trawls, while maintaining target catches and isolate their mechanisms of action.
2. Using the above, provide a framework and direction for the future refinement of Australian prawn trawls.
3. Investigate the practicality of simple, but appropriate changes identified above under commercial conditions in NSW, and assist this state's fishers and managers in their implementation, adoption and where appropriate, eventual legislation.

### Summary:

Globally, prawn-trawl fisheries are faced with a plethora of sustainability issues beyond the management of their target species; most of which can be separated into three broad categories. First, is the inherent poor size and species selection of conventional gears, with nearly all catching large quantities of unwanted organisms, collectively termed 'bycatch', that are subsequently discarded at sea (often dead). Second, are concerns over the unseen mechanical impacts of prawn trawls on the seabed and the potential damage to benthic habitats. Third, is a more recent but growing economic impetus for improved efficiencies; attributable to the rising cost of fossil fuels and awareness about the socio-economic impacts of climate change. The ongoing viability of prawn trawling in the 21st century requires coherent, technological solutions that solve key problems within these three areas.

Owing to the visual impact of large quantities of discarded bycatch, the greater majority of the research done to date has been limited to addressing the first category above, and more specifically, reducing unwanted mortalities by modifying the posterior sections (i.e., the codend and extension) of trawls to include bycatch reduction devices (BRDs). While many BRDs have improved selectivity, none are 100% effective, with most reducing bycatch by only around 30%. More recently, for some Australian fisheries, mortalities to the remaining discards have been mitigated through onboard handling practices (such as sorting in water), although a range of environmental, biological and technical factors limit the utility of such changes to fairly resilient species caught in shallow water and by small-scale gears.

Much less research has been done to address the remaining two broad (but inter-related) sustainability concerns associated with the benthic impacts of prawn trawls and their inefficiencies. It is clear, however, that technological solutions to both categories of problems will require changes to the anterior sections of trawls, including their otter boards, ground gear, rigging configurations, designs and materials. Also, because these components ultimately determine the quantity and type of organisms that are caught by trawls, in many cases, their modification should further improve species and size selection.

There is sufficient evidence to demonstrate the utility of simple (and often novel) changes to the anterior sections of trawls for reducing some impacts, but there has not been any attempt at identifying and progressing appropriate categories of modifications beyond isolated experiments. Like for the development of effective BRDs, there needs to be clear delineation of what might be achievable for any particular suite of

changes, followed by adequate comprehension of the key underlying mechanisms of influence. Such an approach is an imperative step towards prioritizing ongoing research and development by scientists and industries.

Given the above, the aims of this four-year project are to identify appropriate categories of modifications to the anterior sections of prawn trawls that reduce their bycatch, fuel consumption and habitat impacts while maintaining their target catches and then, using this information, provide a framework for the future refinement of more environmentally friendly gears. Ultimately, this work will contribute towards improving the social and economic return of Australian prawn-trawl fisheries, while helping to ensure their ongoing sustainability.

## Research Project Description

### Project title:

Fisheries biology and movements of Mangrove Jack *Lutjanus argentimaculatus* in New South Wales  
(FSR2010/262)

### Principal Investigator:

Dr Paul Butcher and Mr Toby Piddocke (PhD student)

*(Note: This is a collaborative project with Southern Cross University)*

### Funding Sources:

NSW Department of Primary Industries and Southern Cross University.

### Objectives:

This project will address knowledge gaps on the fisheries biology and ecology of Mangrove Jack, to support long-term viability of recreational fishing of this species in NSW. The research will be essential for any future stockings of the species in NSW, whether in marine environments or freshwater impoundments. Broadly, the project's objectives are to:

1. Supply biological information for the management of recreational fishing of Mangrove Jack in northern NSW and to enable sampling designs for priority resource assessments;
2. Inform recreational fishers about the biological and ecological traits of sub-tropical Mangrove Jack; and
3. Provide information to assist the success of potential future stocking of mangrove Jack in northern NSW.

### Summary:

The biology of Mangrove Jack in low-latitude waters is known from research in North Queensland, but it is not known whether those findings are reflective of its biology and ecology in sub-tropical waters of northern NSW, more than 1500 km away.

Research conducted near Cairns showed that sub-adult Mangrove Jack migrate from estuaries to coral reefs and can move a few hundred kilometers. Spawning in North Queensland appears to take place offshore and then juveniles travel back inshore to rivers and estuaries. However, although growth rates have been determined for Mangrove Jack in North Queensland, regional differences in growth and size at maturity within a species are common among fish.

In NSW, Mangrove Jack occurs mostly north of Port Macquarie and can be found at large size on reefs off shore. However, surprisingly little research has been done on Mangrove Jack populations in NSW to understand whether their growth, longevity and estuarine migrations are consistent with, or different from, patterns reported from North Queensland. For example, the capture by recreational fishers of some very large fish (over 70 cm in length and weighing over 7 kilograms) in NSW rivers and estuaries raises the possibility that a larger proportion of the population remain in estuaries or near shore areas even as adults. While some of the population may seasonally migrate in and out of estuaries in NSW, it is unknown at what stage this occurs in their development and whether management of recreational fishing can confidently be based upon knowledge about North Queensland stocks. Research on the diet of juvenile and adult Mangrove Jack would aid in understanding seasonal requirements for prey items and, potentially, why animals migrate in and out of estuaries. This research will provide important information on the migration, growth, size-at-age and diet of these fishes in a range of estuaries in Northern NSW.

## Research Project Description

### Project title:

Monitoring of Gamefish and Australian bass fisheries in NSW via competition-based angling  
(FSR2007/185)

### Principal Investigator:

Ms Danielle Ghosn

### Funding Sources:

NSW Department of Primary Industries and the NSW Freshwater Recreational Fishing Trust Fund.

### Objectives:

1. Sample the catch and effort from club-based gamefishing in New South Wales in support of the assessment of billfish, tuna and sharks.
2. Investigate the factors that influence catch and effort from gamefishing in NSW to enable: standardisation of the catch rates of billfish, tuna and sharks; improve catch estimates for the club-based gamefish fishery to support resource allocation.
3. Sample the catch and effort at Basscatch and other freshwater events in support of the assessment of recreational-only Australian bass and freshwater fisheries.
4. Produce project results for the recreational fishing community using the popular fishing media.

### Summary:

This project builds upon the outcomes of the Angling Research and Tournament Monitoring Project (ARTM Project), which was ongoing for several years. In 2006, the assessment components of that project were incorporated into the Recreational Fishing Tournament Assessment Project (hereafter the assessment project), and the managerial components moved into the Recreational Tournament Management Program (hereafter the management project). Over the past year, the assessment project has undertaken a review of the results from the ARTM Project. The outcomes of that review present the future directions for the assessment project.

The review recognised the two longer-term datasets (namely, gamefish and Basscatch) as being invaluable to the management and monitoring of these important recreational fisheries. Both datasets provide data on fisheries that lack information from other sources, making them important for fisheries scientists, fisheries managers and anglers. The review recognised the usefulness of these datasets whilst outlining the steps that could be taken to improve the sampling of these data-collection systems. The improvements required are minor but necessary for the purpose of data validation and standardisation.

This three-year project will refine data collection strategies, implement improved management and reporting procedures and focus on data collection from competition gamefishing and Basscatch events following improved project protocols. These improvements will be based upon the outcomes of the review of the assessment project. Data collection will be focused on catch, effort and biological information using trained casual field-based staff (gamefishing) and an improved catch-card-angler-return system (Basscatch). The project will involve timely consultation with competition organisers prior to events being held and will continue consultation with tournament organisers and managers on their requirements from this project.

## Research Project Description

### Project Title:

Comparative assessment of reproduction and growth of coastal fish and invertebrates  
(FSC2005/165)

### Principal Investigator:

Dr Charles Gray

### Funding Sources:

NSW Department of Primary Industries and the Recreational Fishing Trust.

### Objectives:

5. Describe the distribution and fishery interactions of coastal flatheads, whittings and cephalopods.
6. Determine the age and growth of flatheads, whittings and cephalopods.
7. Determine the reproductive biology of flatheads, whittings and cephalopods.
8. Provide a preliminary assessment of the status of flathead, whiting and cephalopod populations and fisheries in NSW.

### Summary:

Significant recreational and commercial fisheries exist for several species of flathead and whiting in coastal waters of NSW. Very little biological data exists to assist in the management of these resources. Current monitoring is limited to catch and effort information provided by commercial operators.

This study will collect important biological- and fisheries-related data for eastern blue-spotted flathead, northern sand flathead, marbled flathead species, tiger flathead and long spined flathead and trawl whittings. Biological information to be collected includes length at age relationships (for growth estimates), fecundity, time and mode of spawning, and age/size at first maturity. This important information will assist in the management and long-term sustainability of the commercial and recreational fisheries that catch flathead and whittings in NSW.

## Research Project Description

### Project Title:

Observer-based survey of retained and discarded catches from commercial line fishing in coastal waters of New South Wales  
(FSC2006/179)

### Principal Investigator:

Dr Charles Gray and Dr Will Macbeth

### Funding Sources:

NSW Department of Primary Industries and the Commercial Fishing Trust Fund.

### Objectives:

1. Identify and quantify the species composition of the retained and discarded catches from commercial line fishing.
2. Provide estimates of rates of discarding across the line fishery.
3. Quantify interactions with rare and threatened species.
4. Identify interactions with habitat type.
5. Provide feedback to industry and management on the previous four objectives.

### Summary:

The NSW commercial Ocean Trap and Line (OTL) Fishery includes line-fishing methods such as setlining, droplining, handlining, trotlining, longlining and driftlining. In addition to legal-sized individuals of the targeted finfish species, these particular gears are known to catch and discard undersize individuals and other unwanted finfish, collectively termed by-catch. Further, these gears have been identified as having considerable potential interaction with the protected and threatened shark species of NSW.

Currently, discarding in the line-fishing component of the OTL Fishery is poorly understood. Therefore, there is a clear need to identify and quantify the levels of discarding of commercial, non-commercial, threatened and protected species across those line-fishing methods. Greater knowledge of the composition of catches is required to fully understand any potential impacts that the OTL Fishery may pose to such species.

This research project will use observers to accompany commercial line fishers during normal fishing operations and collect scientific data concerning the retained and discarded components of their catches. This will be done according to a scientifically rigorous sampling design over a two-year period, with line-fishing trips to be observed in ocean waters along the entire length of the NSW coast. The data obtained via this research program will be invaluable with respect to providing accurate information for use in the future management of the OTL Fishery and its impacts with the environment.



## Research Project Description

### Project title:

Evaluating the estuarine fisheries resources of NSW  
(FSC2008/197)

### Principal Investigator:

Dr Charles Gray & Dr Doug Rotherham

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

1. Test fishery-independent strategies to evaluate and report on the status of the fisheries resources in NSW estuaries.
2. Quantify and compare between sampling methodologies, estuaries and years the demographic characteristics of key fish species in estuaries in NSW.
3. Recommend protocols for future sampling and reporting.

### Summary:

Estuaries throughout NSW support a diverse range of fish and invertebrates that are subjected to many natural and human impacts, including fishing. To ensure the sustainability of estuarine fisheries resources, accurate data on the status of populations of fish and invertebrates are required. These data have previously come from monitoring commercial catches (i.e., fishery-dependent data). The problem is that in many estuaries, commercial fishing has been removed and so these data are no longer available. Furthermore, data from commercial catches has always been inadequate for assessing the status of fish stocks because no information is provided on undersize fish and species that are discarded or not caught. Modern fisheries management strategies demand consideration of broader ecosystems and biodiversity, not just species that are economically important. So research surveys (i.e., fishery-independent surveys) play an important role in sampling both harvested and non-harvested species of fish and invertebrates in estuaries. Some fishery-independent methods of sampling are now available following an important phase of initial research and development in estuaries of NSW.

Previous assessments of the status of exploited key estuarine fish species (bream, sand whiting, dusky flathead, mullet, luderick) were done in 1995 – 2000 via the monitoring of length and age compositions of commercial catches in selected key estuaries in NSW. These data were used to assess the status of populations at that time, but the status of these species is likely to have changed. So, there is a need to obtain new data, to assess any changes in populations of these key species of fish over the past 10 years.

This project will use a combination of fishery-dependent and fishery-independent sampling to evaluate and report on the status of estuarine fisheries resources of NSW. Previous samplings of the length and age compositions of commercial landings in estuaries still open to commercial fishing will be repeated (this is being done as part of the commercial monitoring program). Fishery-independent sampling will also be done to assess and compare changes in fish populations in estuaries where commercial fishing is now closed. In addition, the value of fishery-independent sampling in assessing key species of invertebrates (e.g., crabs and prawns) will also be examined. These data will be used towards the next Status of Fisheries Resources in NSW (scheduled for 2010), and help design future protocols for the long-term monitoring, evaluation and reporting of estuarine fish and invertebrate assemblages in NSW.

## Research Project Description

### Project title:

Evaluating the recreational fisheries of Recreational Fishing Havens and other key recreationally-fished estuaries in NSW  
(FSR2008/199)

### Principal Investigator:

Dr Charles Gray, Dr Doug Rotherham and Dr Aldo Steffe

### Funding Sources:

NSW Department of Primary Industries and the Saltwater Recreational Fishing Trust Fund

### Objectives:

1. Survey and report on changes in recreational fishing and fish populations in estuaries throughout NSW, focusing on Recreational Fishing Havens.
2. Provide advice on longer-term trends and strategies for on-going evaluations of recreational fishing and fish populations in NSW estuaries to the Recreational Trust, wider recreational fishing community, DPI management and other interested agencies.
3. Disseminate information to recreational anglers and the wider community.
4. Use the data collected to provide resource assessment information and fisheries management advice.

### Summary:

There is a need for on-going long-term assessments of changes in fish populations and recreational fishing in Recreational Fishing Havens as well as other key recreationally-fished estuaries in NSW. Such information is required for maintenance of quality recreational fishing opportunities in NSW estuaries.

Regular on-going creel surveys are required to fully understand changes in recreational fishing through time and between different estuaries. This project will continue on the success of previous surveys to build a better understanding of changes in recreational fishing in key recreational fishing estuaries. The surveys will complement on-going monitoring and assessment of fish populations in NSW estuaries for resource assessments and fisheries management.

This project will continue to obtain new information on recreational fishing which will be used to monitor changes in recreational fishing and provide management, resource scientists and recreational anglers with information they can use to assist the long-term sustainability of quality recreational fishing in NSW.

## Research Project Description

### Project Title:

Movements and ecological interactions of key fish species in estuaries and coastal waters of NSW  
(FSR2008/219)

### Principal Investigator:

Dr Charles Gray

### Funding Sources:

NSW Department of Primary Industries, the NSW Recreational Fishing Saltwater Trust Fund and the Department of Water & Energy.

### Objectives:

1. Identify movements, habitat and dietary interactions of key fish species, including bream, mullet, dusky flathead and mullet in estuarine and coastal waters of NSW.
2. Provide general information on the biology of fish in NSW.

### Summary:

There is considerable interest in the movements of key recreationally and commercially important fish species along the NSW coast. Previous tag and release studies using conventional tags have shown that many key fish species, such as bream, luderick, mullet, sand whiting, move considerable distances along the coast and between estuaries. However, the data obtained from this traditional tagging does not provide data on residence times in particular locations, the actual timing of movements and responses to environmental perturbations. The data provides only a start and end point of travel.

New technologies have been developed and applied elsewhere to track the movements of fish and other aquatic fauna via acoustic tagging. In this study we aim to use such technologies to determine the residence times, habitat associations, movements and linkages of key fish species in estuaries and the coastal zone of NSW. This will take advantage of the 100 plus receivers (listening stations) NSW DPI has already deployed along the coast and in estuaries of NSW. Initially, mullet, flathead and bream will be caught, implanted with acoustic tags and released into the wild in estuaries in NSW. The arrays of listening stations strategically placed in estuaries and coastal waters will be used to detect the movements of these fish.

## Research Project Description

### Project Title:

Feeding and breeding: Rainfall effects on connectivity and fidelity of iconic coastal fishes  
(FSC2009/223)

### Principal Investigator:

Dr Charles Gray & Dr Matt Taylor

*[Note: This is a collaborative project with the University of New South Wales (Prof. Iain Suthers) and the University of Technology, Sydney (Prof. David Booth). The project includes 5 PhD students]*

### Funding Sources:

NSW Department of Primary Industries, the Australian Research Council (ARC Linkage Project LP100100367), the University of New South Wales, the University of Technology, Sydney and the NSW Saltwater Recreational Fishing Trust Fund.

### Objectives:

1. Determine fine- and broad-scale estuarine, coastal and temporal movements of iconic fish in relation to their hydrographic and bathymetric habitats.
2. Evaluate fish movements in the context of source-sink dynamics derived from the earstone (otolith) microchemistry.
3. Determine the importance of patch size and landscape ecology for iconic estuarine fishes, and evaluate the existence of metapopulation structure from habitat fidelity.

### Summary:

Large predatory fish are of great significance to recreational anglers, not only for their trophy status but also for their disproportional fecundity and contribution to future fishing. Remarkably, the distribution and movements of large estuarine fish in estuaries and the coastal ocean are unknown, despite their importance to the national economy. We will determine the role of freshwater discharge and oceanography on the coastal and estuarine habitat requirements, movements and home ranges of mulloway, flathead, bream, whiting and estuarine rays from the scale of hours to years, and extend these findings to evaluate population sub-structuring and connectivity in the context of a changing climate.

## Research Project Description

### Project title:

Profiling the biology and fishery of rock blackfish (*Girella elevata*) in the Sydney Region  
(FSR2009/231)

### Principal Investigator:

Dr Charles Gray and Mr Jerom Stocks (PhD student)

[Note: this is a collaborative project with the University of NSW]

### Funding Sources:

NSW Department of Primary Industries, the Saltwater Recreational Fishing Trust Fund and the University of NSW.

### Objectives:

1. Investigate and provide new information about the biology and demographic characteristics and fishery of rock blackfish in the Sydney Region.
2. Describe the fishery for rock blackfish.
3. Disseminate information on the biology and fishery of rock blackfish to recreational anglers and the wider community.
4. Use the data collected to provide resource assessment information and fisheries management.

### Summary:

Rock blackfish (*Girella elevata*) is a relatively common fish that inhabits nearshore coastal waters along eastern Australia and is particularly associated with rocky reefs. The species is often targeted by recreational anglers from rock platforms and is not taken by commercial fishers.

Very little is known about the biology and ecology of rock blackfish to assist with developing management plans for its sustainable harvesting. There is also very limited information on the recreational fishery for the species.

The aim of this study is to obtain the relatively basic, but complex, biological and fisheries-related information on rock blackfish so to provide advice on the future management of the species. Specifically, the project will provide new information on the biology (reproduction, age, growth, population structure, movements) and fishery (where, when, sizes retained and released, catch rates) of rock blackfish in the Sydney Region. The information collected will be provided to recreational fisheries managers and resource assessment scientists and be synthesised for publications for consumption by the recreational angling community.

## Research Project Description

### Project title:

Primer development and assessment of population structure of dusky flathead and sand whiting  
(FSC2010/240)

### Principal Investigator:

Dr Charles Gray and Dr Doug Rotherham

[Note: This is a collaborative project with Prof. David Ayres and Dr David Roberts at the University of Wollongong]

### Funding Sources:

NSW Department of Primary Industries and the University of Wollongong

### Objectives:

1. Develop genetic primers for dusky flathead and sand whiting.
2. Publish results.

### Summary:

Dusky flathead (*Platycephalus fuscus*) and sand whiting (*Sillago ciliata*) are heavily harvested by recreational and commercial fishers and treated as single fisheries stocks in NSW. Aspects of the life history of both species suggest that populations could be genetically subdivided. This study aims to develop 10 polymorphic microsatellite loci (i.e. molecular tools), and then use a population genetic survey of flathead and sand whiting within estuaries in NSW to examine the extent of spatial distribution of genetic variation in both. This research would provide preliminary information on structure and connectivity of east coast dusky flathead and sand whiting populations.

## Research Project Description

### Project Title:

Population connectivity of dolphin fish and kingfish and associations with FADS along the east Australian coast  
(FSC2011/282)

### Principal Investigator:

Dr Charles Gray & Dr Matt Taylor

*[Note: This research is being done as a PhD project at the University of NSW by Stephanie Brodie]*

### Funding Sources:

NSW Department of Primary Industries, the NSW Saltwater Recreational Fishing Trust and the University of New South Wales.

### Objectives:

1. Examine the connectivity and movements of dolphinfish and kingfish (inshore-offshore, north-south) using acoustic telemetry of fish around FADS;
2. Determine the influence of the strengthening EAC and other oceanographic processes on fish movements using data from BLUElink Reanalysis (BRAN);
3. Inform recreational fishers about the biological and ecological traits of both species, and
4. Provide information to assist management of FAD fisheries in NSW.

### Summary:

Fish Aggregation Devices (FADs) are used worldwide to enhance fishing opportunities. NSW DPI operates a very successful FAD program, with 25 FADs deployed between spring and autumn each year along the NSW coast. Dolphinfish and kingfish are the predominant species associated with NSW FADS and they form the basis of a recreational FAD fishery. Dolphinfish and kingfish will be tagged with acoustic transmitters as part of a research study investigating their movements, population structure and associations with NSW FADS. Acoustic receivers will be attached to 20 FADS so that the movements of each tagged fish can be tracked through time. These data will be used to examine how long fish associate with individual FADS, the connectivity of fish between different FADS, and environmental and oceanographic influences on their movements and FAD associations. The data collected will be incorporated with recreational fisher length distribution data to give researchers a comprehensive understanding of the biology of these species, allowing for the effective management of these important FAD fisheries.

## Research Project Description

### **Project Title:**

NSW Contribution to National Fishery Status Reports  
(FSC2011/288)

### **Principal Investigator:**

Dr Charles Gray

### **Funding Sources:**

NSW Department of Primary Industries and the Fisheries Research & Development Corporation (FRDC Project No. 2011/513).

### **Objectives:**

Provide NSW data for inclusion in the first National Fishery Status Report.

### **Summary:**

A national report on the status of key wild catch Australian fish stocks, focusing on commercial and recreational target species, is being prepared. The National Fishery Status Reports will be a government produced instrument designed to simplify comparison of the status of key wild capture fish stocks around Australia. This information will be available for the general public, policy makers and industry to make informed decisions in relation to the actual health of various stocks. The reports will also provide important and accurate information for international organisations. NSW Fisheries is a main contributor to this report.



## Research Project Description

### Project title:

BIOMAS 2.0: Upgrade to the bio-economic fisheries modelling system  
(FSC2011/270)

### Principal Investigator:

Dr Matt Ives

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

Upgrade the BIOMAS modelling tool with the following features:

- a user interface to enable the tool to be easily used by other scientists;
- enable the tool to use multiple-processors;
- ensure the tool is capable of modelling any type of species, fishing fleet and area.

### Summary:

The primary goal of data collection on exploited fish stocks is to enable the development of some form of credible stock assessment. Ideally, enough information will be collected to enable management strategy evaluations on the stock, providing guidance to management on future decisions. However, in many fisheries management agencies the ability to rapidly and cost-effectively build and run such management strategy evaluation models is as much an impediment as the lack of data.

The BIOMAS software provides users with the ability to rapidly develop age and length-based dynamic population models for the exploration of alternative fisheries management strategies. The system is theoretically capable of incorporating any number of species, fishing fleets and spatial areas in a single model. Further complexity is provided with the ability to implement environmental effects on stocks as well as the tracking of economic costs and revenue from fishing activity. The BIOMAS 2.0 upgrade will include an enhancement to the user-interface to enable scientists to easily build and run models as well as improvements to the systems speed and flexibility.

## Research Project Description

### Project Title:

Study of ghost fishing in the NSW Rock Lobster fishery  
(FSC2006/173)

### Principal Investigator:

Dr Geoff Liggins and Dr Steven Montgomery

### Funding Sources:

NSW Department of Primary Industries, the Fisheries Research & Development Corporation (FRDC Project No. 2007/038), the NSW Commercial Fishing Trust Fund and NSW Rock Lobster fishers.

### Objectives:

1. Assess the mortality of lobsters due to ghost fishing of traps in the deep-water component of the fishery.
2. Develop and test alternative methods for the setting of traps and deployment of head-gear to reduce mortalities of lobsters resulting from ghost fishing and theft.
3. Design and test modifications to traps that facilitate the escape of lobsters from lost traps prior to mortality.

### Summary:

Ghost fishing occurs when fishing gear is lost or abandoned but continues to kill fish. It has been shown internationally to be significant in several crustacean fisheries, namely red king crab, Dungeness crab and spiny lobster. Ghost fishing needs to be quantified because it is a component of fishing mortality and if not considered will bias any estimates of fishing mortality that are used in dynamic models to assess the impact of management scenarios. Further, any losses from ghost fishing are undesirable from economic and conservation perspectives.

If ghost fishing is occurring then ways to alleviate the impact need to be found. For example, in trap fisheries overseas degradable pins or sacrificial panels are used in traps and pots. If the fishing gear is lost, then a part of it corrodes with time so that captured animals can escape from the gear.

The NSW rock lobster fishery is valued at \$AUS 5 million at first point of sale. The fishery is managed by a suite of input controls and annual, individual catch quotas. In 2006-07 the fishery landed 109 t of eastern rock lobster, 98% of the Total Allowable Commercial Catch of 112 t, from 134,460 trap lifts. The fishery targets what is considered locally to be a 'boutique' seafood and so this species brings high prices on local markets. It extends along the entire coast of NSW and out to the edge of the Continental Shelf. The Fisheries Management Strategy for the rock lobster fishery has been assessed under the NSW Government's *Environmental Planning and Assessment Act 1979*, the *Fisheries Management Act 1994* and the Commonwealth Government's *Environment Protection & Biodiversity Conservation Act*. An outcome from this assessment process was concern about the potential for ghost fishing by large rectangular traps set on mid-shelf and deep water grounds. Between 2004 and 2006 NSW DPI did a small scoping study to determine whether ghost fishing occurred in the NSW rock lobster fishery. The conclusion from this preliminary research was that ghost fishing may be responsible for a loss of around 12% by weight of the commercial catch from the lobster population. Hence, ghost fishing appeared to be significant and therefore, studies investigating methods to alleviate the impact of ghost fishing needed to be done.

This project addresses the need to investigate further the occurrence of ghost fishing by measuring the accumulation and condition of lobsters in traps that are set to simulate lost traps that are ghost fishing. In a second experiment, the time taken for conventional and experimental lobster traps (that include a "sacrificial panel" designed to rust out after approx. 6 months) are compared. It is expected that conventional traps will last about 12–15 months but that the sacrificial panels will corrode, to allow escape of lobsters, after 6–8 months. This project also addresses the need to reduce the loss of traps and lobsters that occurs when the

head-gear of traps (rope and floats) is cut off by commercial shipping, other fishing vessels, is vandalized or stolen. Acoustic release mechanisms would allow lobster fishers to keep the head-gear of their traps submerged below the water surface and release the floats to the surface “at call”, when the fisher sends an acoustic signal to the release device. This project includes a review of available acoustic release technologies, trials of their application to lobster gear and a cost-benefit analysis of their use.

## Research Project Description

### Project Title:

Estuarine Artificial Reefs Research Program  
(FSR2005/155)

### Principal Investigator:

Dr Michael Lowry

### Funding Sources:

NSW Department of Primary Industries and the Recreational Fishing Saltwater Trust

### Objectives:

1. Determine differences in the number, size and species composition of fish assemblages among large and small artificial reefs;
2. Determine differences in the number, size and species composition of fish assemblages between artificial and natural reefs ;
3. Relate differences in the variables measured (number, size and species composition of fish) to changes in physical variables such as temperature, current speed/direction, turbidity and salinity;
4. Evaluate the effectiveness of baited underwater video (BUV) techniques for assessing fish populations around artificial reefs within estuaries;
5. Investigate the effect that physical variables such as size of reef, depth of reef, and distance from existing reef have on the fish assemblage associated with the artificial reef;
6. Transfer knowledge regarding construction, deployment and monitoring of artificial reefs to other suitable locations; and
7. Work with the relevant authorities in the development of site selection, design, construction and monitoring criteria which will facilitate an extension of the estuarine program into offshore waters.

### Summary:

In January 2000, the NSW government released the “Sustaining our Fisheries” consultation paper, which suggested that funds generated from the sale of the general recreational fishing licence could be used to, among other things, construct artificial reefs in NSW. Specifically, the paper stated, “artificial reefs could be constructed in estuarine, inshore and offshore waters to enhance recreational fishing”. This project is designed to provide relevant authorities with the required information regarding the impact of artificial reefs and assesses the potential for a more extensive artificial reefs program.

Currently there are four sets of artificial reef structures deployed in NSW waters. Reefs constructed of Reef Ball modules have been deployed in Lake Macquarie (December 2005), Botany Bay (June 2006), St Georges Basin (February 2007) with the final deployment in Lake Conjola (November 2008). Preliminary results of the Lake Macquarie reefs indicate that large numbers of a diverse range of species are attracted to artificial reefs. A comparison between artificial and naturally occurring reefs indicate similar catch rates of key recreational species with a larger mean size identified for fish captured on artificial reefs. Results also indicate that the use of baited underwater video (BUV) is an appropriate method for monitoring fish populations on artificial structures and provides a cost effective means of carrying out future monitoring programs associated with artificial structures.

The artificial reefs research program has provided a detailed assessment of the interaction of artificial reefs and fish communities within estuaries. This information has provided the basis for the extension of artificial reefs approved for Lake Macquarie and the construction of additional reef systems within Merimbula Lake. The knowledge and experience gained in the deployment and monitoring of the estuarine artificial reefs will be critical to the deployment and monitoring of the proposed offshore artificial structures.

The results of this program will benefit recreational fishers and enhance the quality of their fishing by:

- providing information to anglers regarding changes in the number of fish and type of fish that are attracted to artificial reefs and how these patterns vary between locations and time;
- providing information regarding the impact of artificial reefs on local fish populations; and
- provide relevant authorities with the information needed to assess applications for any extension of the artificial reef program.

## Research Project Description

### Project Title:

Fish Aggregation Device (FAD) Monitoring Program  
(FSR2008/222)

### Principal Investigator:

Dr Michael Lowry

[Note: This is a component of a larger project on FADs which is administered by NSW Department of Primary Industries's Fisheries & Compliance Division]

### Funding Sources:

NSW Department of Primary Industries and the Recreational Fishing Saltwater Trust Fund.

### Objectives:

1. Assess the effectiveness of underwater video (UV) techniques for assessing fish populations associated with FADs.
2. Determine differences in the number, size and species composition of fish assemblages between FADs in the Sydney region.
3. Investigate the relationship between fish communities and the depth and distance from FADs.
4. Relate differences in the biological data collected (number, size and species composition of fish) to changes in physical variables such as temperature, current speed/direction, turbidity and salinity.

### Summary:

The NSW DPI Fish Aggregating Devices (FADs) have become popular fishing locations for many recreational fishers. FADs attract seasonal pelagic fish from the warm East Australian Current (EAC) and provide anglers with alternative fishing opportunities. The main target species located at FADs are mahi mahi (*Coryphaena hippurus*). These fish are an excellent recreational game species due to their rapid growth and early maturity.

The reasons that pelagic fish aggregate around FADs is a topic that has attracted considerable scientific debate. While, it has been suggested that some species (e.g., striped marlin – *Tetrapturus audax*) will not aggregate around a FAD unless prey is present, other species including yellowtail kingfish (*Seriola lalandii*) are attracted to the structure of the FAD alone, possibly for use as a resting place or geographical reference point for feeding or school recomposition. NSW DPI has been proactive in the monitoring of the FADs by conducting research into the species present and how the catch rates of these species are affected by environmental variables such as water temperature and ocean currents. However very little is known about how fish communities respond to variations in depth and distance from FADs.

NSW DPI has now expanded the research component associated with FADs by deploying cameras on and around these structures to record the species present, size class, and fish behaviour at a variety of depths. Data can be collected continuously over days providing the opportunity to record some of the more "rare event" species known to be associated with FADs. Information flowing from this study will provide an improved understanding of how FADS act to influence the fish communities associated with them and provide a more detailed knowledge of how depth, distance and environmental variables such as water temperature and current speed affect the distribution of species associated with FADs.

## Research Project Description

### Project Title:

Offshore Artificial Reefs Research Program  
(FSR2007/182)

### Principal Investigator:

Dr Michael Lowry

### Funding Sources:

NSW Department of Primary Industries and the Recreational Fishing Trust.

### Objectives:

1. Relate differences in the variables measured (number, size and species composition of fish) to changes in physical variables such as temperature, current speed, direction, turbidity and salinity.
2. Investigate how design factors i.e., height of reef and location of reef modules within the reef set affect number size and species composition.
3. Assess the effectiveness of underwater video (UV) techniques for assessing fish populations associated with OARs.
4. Investigate the usefulness of ultrasonic telemetry as a methodology for determining patterns of behaviour of species recruiting to OARs.
5. Transfer knowledge regarding construction, deployment and monitoring of artificial reefs in other suitable locations.
6. Utilise results to better understand of how artificial reefs function ecologically and physically across spatial and temporal scales.
7. Provide information to anglers regarding changes in the number of fish and type of fish that are attracted to artificial reefs and how these patterns vary between locations and time.

### Summary:

Currently there are three sets of artificial reef structures deployed in NSW waters. Reefs constructed of reef ball modules have been deployed in Lake Macquarie (December 2005), Botany Bay (June 2006) and St Georges Basin (February 2007). Preliminary results of the Estuarine Artificial Reefs Monitoring Program indicate that large numbers of a diverse range of species are attracted to estuarine artificial reefs. A comparison of observations between artificial and naturally occurring reefs within Lake Macquarie indicates that catch rates of key recreational species are similar, but the mean size of fish captured on artificial reefs is larger. Initial results also indicate that the use of baited underwater video (BUV) is an appropriate method for monitoring fish populations on artificial structures and provides a cost effective means of carrying out future monitoring programs associated with artificial structures.

Techniques developed as part of the estuarine artificial reefs program will be adapted to provide a monitoring framework that would be suitable for structures deployed offshore. Improved underwater video technology will be utilised to monitor fish populations around the offshore structures. This technology dramatically extends camera deployment times improving both the cost effectiveness of monitoring and precision of observations. The monitoring program will also work in conjunction with Australian Acoustic Tagging and Monitoring System (AATAMS) to track the movements of fish tagged with acoustic tags between offshore artificial reefs and AATAMS arrays.

The results of this program will benefit recreational fishers by (i) providing relevant authorities with the required information to assess applications for an extension of the artificial reef program (ii) contribute to strategies which will maximise the return to anglers by providing information regarding the most cost effective way of designing and deploying OARs and (iii) provide information to anglers regarding changes in the number of fish and type of fish that are attracted to OARs and how these patterns vary between locations and time.

## Research Project Description

### Project title:

Observer-based surveys in the commercial large-shark fishery and ocean prawn-trawl fishery of New South Wales  
(FSC2009/224)

### Principal Investigator:

Dr William Macbeth and Dr Charles Gray

*[Note: this is a collaborative project with Macquarie University]*

### Funding Sources:

NSW Department of Primary Industries and the NSW Commercial Fishing Trust Fund.

### Objectives:

1. Identify and quantify the species and size composition of retained and discarded catches associated with: (i) targeted commercial fishing for large sharks; and (ii) ocean prawn trawling; in NSW waters.
2. Estimate rates of discarding in each of the above fisheries.
3. Quantitatively assess the change in levels of bycatch from the early-1990s OPT observer survey to this survey.
4. Collect biological information and samples to help understand the biology of elasmobranchs (sharks and rays) being retained or discarded in each fishery.
5. Quantify interactions with any rare and threatened species.
6. Identify interactions with habitat type where possible.
7. Educate fishers in the field identification of shark and ray species using the field identification guide published and distributed by NSW DPI.
8. Provide feedback to industry and management on the progress of the project.

### Summary:

The NSW commercial Ocean Trap and Line Fishery (OTLF) permits the use of a range of line-fishing methods to catch finfish in NSW waters. These methods include the use of setlines and trotlines (i.e. mid-water and bottom-set longlines) to target large sharks – a part of the OTLF carefully regulated to protect shark stocks. In 2008/09 intensive observer-based research into this shark fishing, which involved NSW DPI scientists accompanying commercial fishers at sea during their normal fishing activities to collect detailed information about their fishing operations and catches, found that the main shark species retained for sale included various types of whaler and hammerhead sharks. In order to effectively monitor catches of sharks and, indirectly, the shark populations being exploited, continued observer-based research is required. This project is continuing the observer-based research into targeted line-fishing for large sharks within the OTLF and hence building on the foundations laid in 2008/09 by: (i) identifying and quantifying the levels of capture (and subsequent retention or discarding) of commercial, non-commercial, threatened and protected shark species in the fishery; and (ii) collecting biological data and samples associated with these species where possible. This work will be of great value to fisheries managers in their future management of the OTLF.

A major issue for the NSW commercial ocean prawn-trawl fishery (OPTF; part of the Ocean Trawl Fishery – OTF) is the extent and mortality of 'bycatch', which refers to the non-target organisms that are incidentally caught and then discarded overboard. An observer-based research project done in the early-1990s by NSW DPI scientists found that these bycatches include juveniles of the targeted species (eastern king prawn) and other commercially important species of fish (e.g., trawl whiting), crustaceans (e.g., Balmain bugs) and cephalopods (e.g., octopuses); along with many non-commercial species. Subsequent research conducted by NSW DPI scientists during the 1990s and 2000s led to the development and introduction into the OPTF of a number of modifications to trawls that reduce the extent of these bycatches. The current project includes a



two-year observer-based survey in the OPTF that will essentially be a repeat of the early-1990s research. This will provide updated information about retained catches and levels of discarding in the OPT fishery and will also enable a direct measurement of the benefits associated with the introduction of bycatch-mitigation measures via a direct before-after comparison between the current survey and the 1990s survey.

## Research Project Description

### Project title:

A biological basis for fishery management strategies for Carcharhinid sharks commercially exploited in New South Wales waters  
(FSC2009/233)

### Principal Investigator:

Dr William Macbeth and Pascal Geraghty

[Note: this is a collaborative project with Macquarie University]

### Funding Sources:

NSW Department of Primary Industries, the NSW Commercial Fishing Trust Fund and Macquarie University.

### Objectives:

1. Improve our understanding of aspects of the biology of the five most important commercially exploited Carcharhinid (whaler) shark species in NSW waters – *Carcharhinus plumbeus*, *C. obscurus*, *C. brevipinna* and *C. limbatus*.
2. Formulate progressive fishery management strategies for the NSW large-shark fishery based on the abovementioned biological findings.
3. Provide feedback to industry and management on the progress of the project.

### Summary:

The level of understanding of the catch of sharks by commercial fisheries in NSW has traditionally been very poor. A large increase in the annual catch of large whaler sharks (Family Carcharhinidae) between 2004/05 and 2006/07 in coastal waters off northern New South Wales (NSW) by fishers in the NSW Ocean Trap and Line Fishery (OTLF) highlighted the urgent need for research into commercial shark fishing in NSW waters and into the local biology of the shark species being caught.

In response, NSW DPI researchers undertook extensive onboard, observer-type sampling throughout the NSW shark-fishing fleet during 2008/09 as part of the Commercial Shark-fishing Observer Program (CSOP). Scientists accompanied commercial fishers during their normal shark-fishing operations to: 1) record detailed data concerning their fishing methods; 2) collect data concerning species, length, sex and sexual maturity from all sharks caught; and 3) collect biological samples (vertebrae for age and growth studies and flesh for population genetics studies) where possible. The CSOP revealed that the majority of the catch of large sharks in NSW waters during that period comprised the whaler sharks: sandbar shark (*Carcharhinus plumbeus*); dusky shark (*Carcharhinus obscurus*); spinner shark (*Carcharhinus brevipinna*) and common blacktip shark (*Carcharhinus limbatus*). The amount of biological data and samples collected has provided an important opportunity to gain a local perspective on the basic biology of these species, including age and growth, reproduction and population genetics.

NSW Department of Primary Industries is currently collaborating with Macquarie University in the support of a PhD project that will provide: (i) a thorough study of targeted commercial fishing for large whaler sharks in NSW waters; and (ii) detailed information concerning the local biology of sandbar shark, dusky shark, spinner shark and common blacktip shark. This will be done using data and samples collected as part of recently-completed NSW DPI observer-based research projects and will employ the latest analytical technologies for examining age, growth, reproduction and population genetics of sharks. The suite of information obtained will then be used to develop biology-based fishery management strategies to protect these shark populations from future overfishing.

## Research Project Description

### Project Title:

Stock assessment and related research for the eastern rock lobster, *Jasus verreauxi*  
(FSC2000/018)

### Principal Investigator:

Dr Steve Montgomery

### Funding Sources:

NSW Department of Primary Industries and industry funds.

### Objectives:

1. Complete annual collection and analysis of catch and effort data from the commercial fishery using a daily log-book program.
2. Estimate the size-distribution of the commercial catch of lobsters using an observer-based survey.
3. Estimate magnitude and spatial and temporal variability of by-catches and by-product species from lobster trapping (as a component of the observer survey).
4. Continue annual survey of the recruitment of pueruli to near-shore waters on the NSW coast.
5. Continue fishery-independent surveys of the relative abundance of spawning lobsters and those longer than 180mmCL.
6. Further develop the structure of the biomass dynamics model and the length-structured model of the lobster population.
7. Combine available information (from fishery-dependent and -independent sources) into a framework for stock assessment and evaluate alternative harvest strategies (based on biomass dynamics, age- and length-structured models) for annual stock assessments.

### Summary:

The fishery for eastern rock lobsters extends the length of the coastline of NSW and is harvested by both commercial and recreational fishers. This fishery is managed according to the “Fisheries Management (Lobster Share Management Plan) regulation 2000”, under the “Fisheries Management Act 1994”, administered by NSW DPI. The resource is managed as a single unit stock along the coast of NSW and an annual TAC (total allowable commercial catch) is set. The current value of the fishery is approximately \$4.5 million (at first point of sale). Trapping is the main commercial fishing method and occurs from shallow near-shore waters out to the edge of the continental shelf (at 200 m depth). Recreational fishers are restricted by a possession quota (currently 2 lobsters per person) and are limited to the use of a single trap per person. Both the commercial and recreational fisheries are subject to a legal minimum (104 mm carapace length) and maximum (180 mm CL) lengths and there is a prohibition on the taking of female lobsters carrying eggs.

Virtually nothing was published about the biology of the eastern rock lobster population off eastern Australia until NSW DPI began to investigate the level of exploitation of the species in 1986. In 1986, research by NSW DPI suggested that the size of eastern rock lobster population had been reduced to levels that were of concern. This work also provided information about the size at onset of breeding.

This research was the foundation for the implementation of management by total allowable catches and individual catch quotas. Further research investigated methods for monitoring the relative abundance of post-larvae (pueruli), juvenile and adult lobsters. Since 1995-96, NSW DPI has provided annual stock assessments for this species. These assessments have been supported by on-going monitoring programs and the commencement of: (i) dedicated tagging studies to collect information on growth and movements of the eastern rock lobster and (ii) independent surveys to collect information on the abundance and size-distribution of the recruits to the population and the spawning stock.

Annual assessment of the eastern rock lobster resource provides advice about the total allowable commercial catch for the species. The current assessment is based upon fishery-dependent catch and effort data and models of the lobster population and fishery. The pattern in annual estimates of biomass (using these models) is one of a long-term decline from the late 1880's through to 1992-93. Coincident with major management initiatives in 1993 and 1994, the long-term decline in biomass was halted and, since 1994-95, estimates suggest that biomass has increased.

Development of the model of the lobster population (that includes more detailed information about the biology of the animal and specifically considers the sizes of lobsters in the stock) represents a major focus of research. This model is being used to assess the status of the stock with respect to both the exploited and spawning biomasses. Current research sub-programs are collecting information that will support the ongoing development of models of the eastern rock lobster population.

## Research Project Description

### Project Title:

Reducing uncertainty in the assessment of the Australian spanner crab fishery  
(FSC2003/139)

### Principal Investigator:

Dr Steve Montgomery

*[Note: This is a collaborative project which is being led by Dr Ian Brown at the Queensland Department of Primary Industries]*

### Funding Sources:

NSW Department of Primary Industries, the Queensland Department of Primary Industries and the Fisheries Research and Development Corporation (Project No. 2003/046).

### Objectives:

Develop a common methodology for monitoring and assessing the Australian spanner crab stock.

### Summary:

The Australian spanner crab fishery, valued at around \$12 million, operates in southern Queensland and northern NSW coastal waters. Queensland accounts for 85%, and NSW 15%, of the annual catch of approx. 2000 t. Most of this product is exported live to Asia. Recent evidence indicates that the fisheries in both States are exploiting the same genetic stock, but procedures for monitoring, assessing and managing the fisheries differ. This project will compare the survey methods that have been developed by Queensland and NSW with the aim of recommending a “whole-of-stock” approach for monitoring and assessment.

Queensland's component of the fishery has been subjected to a detailed environmental assessment to meet the requirements of Environment Australia. In his letter of approval, however, the Minister for the Environment and Heritage made certain recommendations to be addressed before the next Commonwealth review. These included (i) “making arrangements with NSW to establish joint monitoring and assessment of the shared stock of spanner crabs with a view to developing future collaborative management arrangements” and (ii) “continuing work to develop a stock assessment model based on sound biological data, and an analysis of the impact of effort creep on the current total allowable commercial catch setting process and management responses”. The NSW fishery that harvests spanner crabs, the Ocean Trap and Line Fishery, is expected to undergo a similarly rigorous environmental assessment in 2004. This current project (funded by Queensland Department of Primary Industries, NSW Department of Primary Industries and FRDC) will generate outcomes that enable joint monitoring and assessment arrangements for the spanner crab stock to be developed.

Different methods were used to survey spanner crab stocks in NSW and Queensland. This project will complete two surveys that enable quantitative comparison of these methods.

Survey (1): In 2004/05, the NSW survey will be repeated with 4 out of 5 transects and 6 out of 12 months of the original NSW surveys (that were completed during 1988-1989 and 1997-1998). At the same time, a fifth transect will be completed off southern Queensland using the NSW design. These surveys shall be replicated at three depths, with using three sets of ten traps. These ten traps will randomly alternate between the highly selective nets used in Queensland surveys with the more broadly selective nets used in the NSW surveys. Differences in trap baiting method will also be examined. This survey shall be replicated during the year at intervals of two months and include Apr 2005 and Jun 2005 (months which bracket the Queensland surveys in May 2005, see Survey (2)).

Survey (2): The Queensland Long Term Monitoring Programme's (LTMP) fishery independent survey will be extended into NSW waters. In May 2005, the Queensland research vessel Tom Marshall will extend the survey range for spanner crabs to include the sites of the NSW transects from Survey (1). A 6 x 6 minute grid will be placed over the five NSW transect locations and 15 randomly selected sites will be surveyed. The QDPI LTMP survey will be repeated in southern Queensland and northern NSW in May 2006, May 2007, May 2008 and May 2009. This will provide continuity to the time-series should the LTMP survey be adopted in NSW. In 2006, the survey will include some additional checks of the relative selectivities of the NSW and Queensland style gears. In 2008 and 2009, bycatches from the sampling will also be collected and reported (as per LTMP procedures) as well as spanner crabs. These bycatches may include very small numbers of fish and invertebrates.

Results from these two surveys will enable a comparison and calibration of the two survey methods. Once this information is available, qualitative and quantitative cost-benefit analyses will be completed to understand the advantages and disadvantages of the two approaches. A combination of the two methods could well be determined to be the optimal basis for ongoing monitoring and assessment of the shared NSW and Queensland spanner crab stock.

## Research Project Description

### Project Title:

Development of a DNA based aging technique for use in fisheries assessments  
(FSC2008/193)

### Principal Investigator:

Dr Steve Montgomery

*[Note: This is a collaborative project that is led by Dr Jenny Ovenden at the Queensland Department of Primary Industries & Fisheries]*

### Funding Sources:

NSW Department of Primary Industries, the Fisheries Research & Development Corporation (Project No. 2007/033), the Queensland Department of Primary Industries & Fisheries and the University of Queensland.

### Objectives:

1. Evaluate a variety of laboratory methods for estimating telomere length.
2. Taking a staged approach to species selection, the objective is to characterise the relationship between age and telomere length in species that are most likely to yield positive results.
3. If objective 2 is achieved, the project will characterise the relationship between age and telomere length in other species and test the robustness of the relationships to external variables.
4. Evaluate the usefulness of the relationship between age and telomere length for selected species in terms of the requirements for fisheries stock assessment.

### Summary:

Knowledge of the age structure of fisheries populations and individual growth rates are crucial to accurate population modeling and assessments of the sustainability of a stock. Vertebrates have hard structures, such as otoliths or vertebrae, which can be examined for evidence of incremental growth and hence age. However, the majority of invertebrate species do not have hard structures that can be used to infer growth which means that alternative approaches must be used. Furthermore, using hard structures to calculate growth is often lethal for the animal, which means that these methods cannot be used for vulnerable or threatened species as individuals cannot be sacrificed.

DNA based aging methods using telomeres (short, tandem repeats of DNA at the end of chromosomes) have the potential to revolutionise fisheries management by offering an instantaneous snap-shot of a stock's age structure through time. Moreover, this approach is theoretically applicable to all fish species and does not rely on destructive sampling. As each cell duplicates itself during the normal tissue repair process, repeat units of telomeric DNA are lost. Consequently the length of the Telomere reduces with the age of the animal and so has the potential to be used as a surrogate for aging an individual.

Recent studies have used the technique to age humans, mice and zebra-finches. In a collaborative project, scientists from the Queensland Department of Primary Industries & Fisheries (QDPI&F) and NSW Department of Primary Industries successfully showed that the carapace length of school prawns was correlated with their telomere length. This pilot work also addressed technical problems that are not encountered when working with DNA from vertebrates.

NSW DPI is again joining with QDPI&F in a project to build on the earlier pilot work. It will be particularly relevant to (1) invertebrate fisheries where there is no straightforward method of measuring individual growth rates, (2) teleost fisheries where it may augment methods of aging hard structures, and (3) species of high conservation status where the animal cannot be sacrificed. Other collaborating agencies involved in the project are the University of Queensland, Tasmanian Aquaculture and Fisheries Institute and the Australian Fisheries Management Authority.

Improving the accuracy of fisheries stock assessments is an important research and development priority for the NSW State Government and both commercial and recreational fisheries. By developing telomeric aging technology, we are likely to see an increase in the speed, accuracy and certainty of aging over current methodologies.



## Research Project Description

### Project title:

Study on the faunal assemblage on collectors for lobster larvae  
(FSC2008/210)

### Principal Investigator:

Dr Steve Montgomery

### Funding Sources:

NSW Department of Primary Industries and the University of New South Wales.

*[Note: This is a collaborative project with UNSW – Honours project]*

### Objectives:

Quantitatively describe the fauna found on collectors for rock lobster larvae.

### Summary:

Collectors are used by NSW Department of Primary Industries to monitor levels of larval recruitment to the eastern rock lobster population each year. Several collectors are set between July and February at each of Coffs Harbour, Tuncurry, Sydney and Ulladulla to monitor this recruitment. The collectors not only attract larval lobsters but also a diverse range of other animals. NSW Department of Primary Industries in conjunction with the University of New South Wales (UNSW) is doing a one year study to quantify the assemblages of animals that settle on the 'collectors'.

It is important to have an understanding about how the lobster larvae interact with the other species on the collectors because such interactions may be affecting the levels of recruitment of larval lobsters on collectors and therefore biasing the information collected.

Also the collectors offer an opportunity to study the recruitment patterns of other animals that settle on coastal reefs and so collect information about recruitment processes amongst marine organisms off the coast of NSW. This information will be used to ascertain whether there are any associations between physical environmental factors such as ocean currents and wind direction and the occurrence of different animals on the collectors. Such information will contribute to our understanding about recruitment processes of marine animals and about the impacts of climate change upon marine populations. This research is being done as part of an Honours project through UNSW.

## Research Project Description

### Project Title:

Determining the age of cephalopod species from waters off NSW  
(FSC2008/220)

### Principal Investigator:

Dr Steven Montgomery

### Funding Sources:

NSW Department of Primary Industries.

[Note: This is a collaborative project with the University of Technology, Sydney]

### Objectives:

1. Validate the age of commercially important cephalopod species.
2. Determine the age of commercially important cephalopod species.
3. Model the growth of commercially important cephalopod species.

### Summary:

Species of octopus, squid and cuttlefish belong to the class of animals known as the cephalopods. These are a valuable component of the catch of the commercial fisheries of NSW and their prominence has increased over the past decade to the point now where these seafood resources contribute around \$3.1 million to total seafood production each year. Landings of cuttlefish, squid and octopus, have fallen in most years since at least 2000-01, prompting the Department's Resource Assessment Group to recommend that stock assessments on the cephalopods are needed.

Many species comprise the commercial catch of cephalopods off NSW, but of these *Sepia rozella*, *S. Hedleyi* (cuttlefish), *Octopus australis*, *O. tetricus* (octopus) and, *Sepioteuthis australis*, *Nototodarus gouldi* (squid) make up the bulk of the catch. There is a dearth of information about the biology of particularly these cuttlefish and octopus species and this has prevented any formal stock assessments being done. One important piece of information that is needed for a stock assessment is the age structure of the population. This permits studies on growth, recruitment and mortality. Recent studies have suggested that two hard parts found in most cephalopods offer the best opportunity for accurately aging cephalopods. Statoliths are small paired calcareous structures found in the cranium and stylets are paired elongated structures found in the mantle musculature near the base of the gills. Statoliths have been used successfully to age squid and with mixed success to age cuttlebones. The statoliths from octopus have proven difficult to age but there has been some success using stylets. Before such structures can be used for aging animals though it must be demonstrated that a ring is being deposited upon the hard structure in a consistent periodic pattern, a process known as age validation. This is usually done by raising animals in the laboratory or by mark-recapture studies.

This project will systematically develop and validate an aging technique for each of the main commercially important cephalopods. Once a technique has been developed for a species then an age determination study will begin. The first species to be investigated will be the sand octopus *Octopus australis* which contributes around 48% by weight to the commercial landings of octopus each year. Also, one year of samples from fishery independent surveys off the Clarence River are available for this species and the Tasmanian Aquaculture & Fisheries Research Institute (TAFI) has developed techniques for aging *Octopus pallidus*. It is hoped that this technology can be transferred to aging *O. australis* and then the other commercially important cephalopods in NSW. The results from this project will provide the essential ingredients for doing stock assessments on the main species of cephalopods and so contribute to assessing the status of these stocks.

## Research Project Description

### Project Title:

Data capture and analysis for the Protective Beach Meshing Program  
(FSR2000/013)

### Principal Investigator:

Dr Vic Peddemors

### Funding Source:

NSW Department of Primary Industries.

### Objectives:

1. Obtain the maximum biological information from sharks and non-target animals caught by the meshing contractors.
2. Establish and maintain a database of catches.
3. Collaborate with other agencies in research on sharks.
4. Assess developments in methods of deterring sharks from beaches.
5. Produce regular reports on the meshing program for public information.

### Summary:

Meshing of the Sydney beaches for the purpose of protecting swimmers was commenced in 1937 and has continued to the present with a break of 3 years during World War II. The program was extended to Newcastle and Wollongong in 1949, and to Central Coast beaches in 1987. Before the program started there were a number of fatal shark attacks on Sydney and Newcastle beaches. Shark attacks on meshed beaches were reduced from 27 in the three decades prior to meshing, to two attacks (one fatal) after meshing started. There has not been a fatal attack on a meshed beach since 1951. The program aims to cull populations of large aggressive sharks adjacent to metropolitan beaches, and thus minimise the potential for shark attacks on swimmers.

There is a paucity of scientific information about sharks, which are a very important component of the marine ecosystem. It is difficult to collect data on sharks, and it is important to ensure that full information is recorded and analysed for all of the sharks and bycatch of the Protective Beach Meshing Program. The improvement of species identification, the checking, storage and analysis of data from the program are being addressed by this project.

## Research Project Description

### Project Title:

Wobbegong shark movements in a NSW Marine Protected Area (MPA)  
(FSC2008/208)

### Principal Investigator:

Dr Vic Peddemors

*[Note – this is a collaborative project which is administered by the Sydney Institute of Marine Science]*

### Funding Sources:

NSW Department of Primary Industries, the Sydney Institute of Marine Science, Macquarie University, the NSW Department of Environment & Climate Change, the Sydney Aquarium and Defense Maritime Services.

### Objectives:

The primary objective of this research is to understand the effects of releasing captive-bred wobbegongs on conspecific and heterospecific species within a marine reserve. Passive and active acoustic telemetry will be used to investigate movements and residency times of various iconic species prior and post release of spotted wobbegongs within the Cabbage Tree Bay and Bronte-Coogee Aquatic Reserves.

1. Determine the natural abundance and distribution of wobbegong sharks within the Cabbage Tree Bay Aquatic Reserve (CTBAR).
2. Track the movements of wobbegong sharks resident within the CTBAR and Bronte-Coogee Aquatic Reserve (BCAR).
3. Track the movements of captive-bred wobbegong sharks within the CTBAR and BCAR.
4. Monitor the success of released captive-bred wobbegong sharks in assimilation into the wild.
5. Assess the impacts of releasing captive-bred wobbegongs within CTBAR by comparing movement patterns and residence times of the resident wobbegongs prior and after release of captive-bred wobbegongs.

### Summary:

Wobbegong sharks are an iconic Australian species, yet little is known about their movements and use of different habitat types. Wobbegong sharks have been subjected to intensive fishing pressure and it is therefore important to understand the ability of marine protected areas to assist them in regaining their foothold as a top predator. This project is initially using SCUBA surveys to determine the abundance and distribution of wobbegong sharks living in the Cabbage Tree Bay Aquatic Reserve (CTBAR) off Shelly Beach, Manly.

To monitor the movements of wobbegong sharks throughout the day and night, five underwater acoustic listening stations have been deployed within the CTBAR. Ten of the 'local' wobbegongs will be captured and internally fitted with an acoustic tag to allow their tracking, much like the big cats of the African savannahs. To enable identification of these ten sharks, small external yellow spaghetti tags will be inserted near their dorsal fin. This is the first time that such an intensive study on wobbegong shark movements has been undertaken within an aquatic reserve and will assist in ensuring future reserves are designed with these charismatic species in mind.

The Sydney Aquarium has recently successfully bred wobbegong sharks in captivity. Following surgical implantation of acoustic tags into ten of these captive-bred sharks, they will be released into the CTBAR. This is the first time that a study is investigating the effects of releasing marine apex predators into the wild. This pioneering research will allow monitoring of the success of these sharks to assimilate into the CTBAR wobbegong shark community, and how they interact with the 'locals'. Successful re-introduction into the wild

is critical to allowing captive breeding programs to contribute to the conservation of species, particularly of marine predators like the wobbegong shark.

Through conducting this study at a popular dive site such as off Shelly Beach, Manly, the project will heighten public awareness of conservation research and the role of wobbegong sharks in the environment.

## Research Project Description

### Project Title:

Shovelnose ray (Rhinobatidae) commercial fishery catch and biology  
(FSC2008/217)

### Principal Investigator:

Dr Vic Peddemors

[Note – this is a collaborative project which is administered by the University of Sydney]

### Funding Sources:

NSW Department of Primary Industries and the University of Sydney.

### Objectives:

1. Determine the status of Rhinobatidae catch in NSW trawlers.
2. Describe the reproductive biology and cycle of shovelnose rays.
3. Identify the maternal-fetal relationships throughout embryonic development.

### Summary:

Approximately 120 tonnes of ‘shovelnose ray’ or ‘fiddler ray’ are landed each year in NSW. It is believed that shovelnose rays may be at high risk from such high levels of fishing pressure (NSW DPI, 2005). Although these catches include at least three species, the catch composition in the fisheries is currently unknown as historically, fiddler rays (*Trygonorrhina* sp. A), shovelnose rays (*Aptychotrema rostrata*) and the white spotted guitarfish (*Rhynchobatus australiae*), have been grouped together in landing reports as ‘fiddler shark’. This has led to them being categorized as having an uncertain stock status for all species in NSW (NSW DPI, 2005). By taxonomically identifying the three species landed from fishing vessels, the project will contribute to knowledge of species composition for this little known, but important group of rays.

Shaping management and conservation initiatives for abundant sharks and rays requires the acquisition of specific details of their reproductive parameters (Wetherbee and Cortes, 2004). All reproductive information will be collected through sampling the catches landed through the Sydney Fish Market. As even the basic reproductive biology has not been published for any species like these in NSW this project will achieve an important milestone in developing future sustainable management.

Additionally, this project will house live animals at the Cronulla Fisheries Research Centre of Excellence aquarium to investigate the physiology of growing pups from this interesting species. The project will describe the incubation environment in which a live-bearing shark or ray develops. The oxygen environment and how oxygen is utilised and transferred throughout development is one of the most important factors in offspring survival and fitness. Looking at how the embryo develops and how oxygen is exchanged will contribute to our understanding of shark pup metabolism and the evolution of bearing live young instead of laying eggs within the sharks and rays.

## Research Project Description

### Project Title:

Mechanics of shark bite  
(FSC2010/264)

### Principal Investigator:

Dr Vic Peddemors

*[Note: This is a collaborative project with the University of NSW]*

### Funding Sources:

NSW Department of Primary Industries and the University of NSW

### Objectives:

1. Develop an understanding of how different sharks bite and the mechanics behind their bite.
2. Construct 3-D models of shark jaws and their muscles to determine their mechanical performance.
3. Compare the bite of shark species exhibiting different tooth structure to understand the behaviour and forces involved in shark attack.
4. Determine ontogenetic changes in bite ability in a potentially dangerous shark, the bull shark.
5. Develop a rapid assessment model to assist in determination of sharks involved in shark attack.

### Summary:

Few species inspire as much fear and fascination as sharks, and this infamous reputation is especially true for great white, tiger and bull sharks. So strong is this morbid, often misguided obsession with dangerous sharks that the docile grey nurse shark was hunted to near extinction in parts of Australia simply because it looked like a “man-eater”.

Although much public and scientific interest surrounds feeding behavior in sharks, how the jaws are adapted for hunting is unknown. Our research uses sophisticated engineering software to create three-dimensional computer models of the jaws of four shark species (the great white, tiger, bull and grey nurse shark) to examine how these species hunt and kill prey. These sharks possess characteristic tooth shapes believed to reflect dietary preferences, and it is unknown how the structure of the jaws themselves influences prey selection. Great white, tiger and bull sharks are also of particular interest as they are large and potentially dangerous sharks, hence insight into how their jaws work will be of significant importance to managing shark attacks.

As great white and grey nurse sharks are listed as threatened species, further knowledge of how they bite will also benefit management programs for the protection of these and other shark species. Grey nurse sharks are especially vulnerable to interactions with recreational fishing gear resulting in deep-hooked animals with injuries believed to be contributing to their mortality. A better understanding of the different biting mechanisms for species representative of the tooth variety found in large pelagic sharks may therefore also assist in the development of fishing practices that enable more successful release of sharks from hooks currently used in the recreational and commercial fisheries of Australia.

## Research Project Description

### Project title:

CritterCam deployment on sharks off NSW  
(FSC2010/258)

### Principal Investigator:

Dr Vic Peddemors

### Funding Sources:

NSW Department of Primary Industries, National Geographic, the University of New England and the National Marine Science Centre

### Objectives:

1. Determine the movements and habitat use of sharks in NSW estuaries and coastal waters.
2. Assess the behaviour of sharks and correlate these to environmental conditions.
3. Determine the period of post-release recovery before sharks can be considered to display natural behaviour.
4. Discover predatory behaviour and feeding success of sharks.
5. Investigate the diel behavioural patterns exhibited by sharks.

### Summary:

Shark behaviour fascinates both the public and researchers trying to unravel the mysteries of these much-maligned predators. World-wide, response to shark attack is headline news yet almost nothing is known how these animals use their environment and potentially increase their interaction with humans.

Through the use of an animal-borne camera system developed by National Geographic (known as Crittercam) NSW DPI scientists will, in an Australian first, obtain a sharks' perspective of the world around it.

Through analysis of the video material collected by the camera-carrying shark and correlation with detailed tracking data, including swimming speed, depth, acceleration and GPS location, this project will assess how sharks behave in different habitats and hopefully provide new data on foraging activities. This information will contribute to the ongoing NSW DPI bather safety information campaign, e.g., SharkSmart.

Impacts of commercial and recreational fishing activities have led to shark populations being decimated in many oceans, but often these catches are the result of unwanted bycatch in the fishery. In many cases, fishers discard this unwanted catch, dead or alive, yet we have no knowledge of the ability for large sharks to recover from capture-related stress. Through tracking CritterCam-carrying sharks and correlating their behaviour with blood biochemistry collected from these animals, NSW DPI researchers will be able to determine the time required for sharks to overcome capture stress and start behaving 'naturally'. In turn, this will enable calculation of post-release success for large sharks.

NSW DPI is conducting research into the movements of sharks in NSW coastal and estuarine waters. The data acquired from the CritterCam will contribute to developing confidence in the data currently collected through remote telemetry tracking via arrays of underwater listening stations in our estuaries and along the coast. Additionally, these data will provide more detailed 24-hour tracking information enabling fine-scale assessment of shark movements and behaviour in relation to habitat and sea conditions.

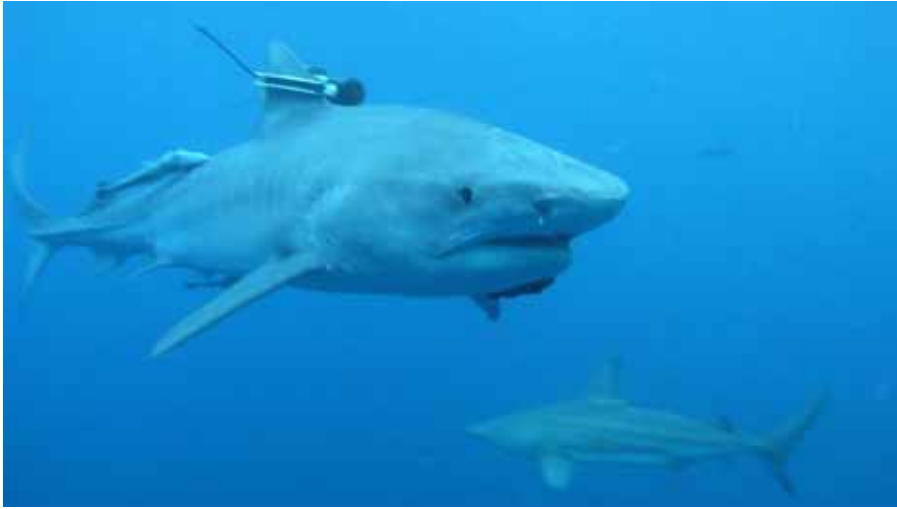




**Photo 1.** CriterCam electronics including fin clamp and release burn-wire.



**Photo 2.** Dr Peddemors deploying CriterCam through free-diving on a tiger shark in South Africa.



**Photo 3.** Tiger shark carrying a CritterCam interacting with a blacktip shark.



**Photo 4.** CritterCam view showing habitat.



**Photo 5.** “It’s behind you” – CritterCam film showing tiger shark approaching divers.

## Research Project Description

### Project title:

Development of methodology suitable for aerial shark surveys  
(FSC2010/265)

### Principal Investigator:

Dr Vic Peddemors

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

1. Compare the ability of fixed wing and helicopter aircraft to detect sharks in NSW coastal waters.
2. Assess the effect of swimming depth on sightability of sharks.
3. Determine the effect of environmental conditions on sightability of sharks.
4. Determine the strip width suitable for aerial shark surveys.

### Summary:

Aerial surveys for sharks have received substantial media coverage. This has led to the public belief that they offer a substantial increase in safety for beach-goers. However, no data exist to verify their effectiveness in finding sharks. Added to this, the current use of both helicopters and fixed-wing aircraft by commercial companies complicates assessment of their usefulness.

This research project aims to develop a methodology suitable for aerial surveys of sharks in NSW coastal waters. The ability to see replica sharks at different depths underwater will be assessed in various different environmental conditions, including changes in wind-related sea surface (sea state), depth of the seabed and water turbidity. Different replica shark silhouettes will be used to check whether the shape of the shark affects its sightability.

This information will then be used to determine the maximum distance away from the aircraft that sharks could be seen. This will enable researchers to develop a 'strip-width' that aerial observers should search in when flying along the coast searching for sharks.

These data will substantially improve current aerial surveillance methods and the ability of shark-spotter aircraft to find sharks in NSW coastal waters. This will improve confidence when analyzing the effectiveness of aerial surveys in providing additional bather safety.

This is the first time that inanimate replicas are being used in developing marine aerial survey methodology.

## Research Project Description

### Project title:

Biology and fishery of angel sharks and sawsharks in NSW  
(FSC2010/268)

### Principal Investigator:

Dr Vic Peddemors

[Note: This research is being done as a PhD project at Macquarie University]

### Funding Sources:

NSW Department of Primary Industries and Macquarie University.

### Objectives:

1. Describe the fishery for angel and sawsharks off NSW and relate catches to environmental variables to better understand their catchability, with the view to incorporating this knowledge into future fishery management practices.
2. Determine the growth rates, reproductive patterns, diets and distributions of four species (*Pristhiophorus nudipinnis*; *Pristhiophorus cirratus*; *Squatina australis*; *Squatina albipunctata*) of sawshark and angelshark caught in the ocean trawl fisheries of NSW.
3. Using modeling, assess whether oceanographic changes following climate change will affect the fishery for angle and sawsharks in NSW.

### Summary:

Angelsharks and sawsharks are found in NSW waters and are caught in significant numbers by trawling, yet little is known about their general biology or the current status of their stocks. Two of the four NSW species were only officially named in 2010. Both these shark groups have been highlighted by the NSW DPI resource assessment process as urgently requiring further research to enable assessment of their stocks and the NSW fishery for them.

Combining an analysis of catch data from both the ocean trawl fishery and the NSW shark meshing program with sampling of whole animals from trawl catches, these species' biological characteristics will be determined (growth rates, diet, reproductive biology). This will enable scientists to assess the populations' current status and whether fishery management regulations are required to ensure a viable industry and sustainable fishery for years to come.

## Research Project Description

### Project Title:

Integrating fishery-independent and -dependent data for improved sustainability of fisheries resources and other aspects of biodiversity  
(FSC2008/211)

### Principal Investigator:

Dr Doug Rotherham

### Funding Sources:

NSW Department of Primary Industries and the Fisheries Research & Development Corporation (FRDC Project No. 2008/004)

### Objectives:

1. Evaluate the effectiveness of a standardised fishery-independent sampling strategy compared with sources of fishery-dependent data (e.g., data from commercial and recreational fisheries) for assessing fisheries resources and biodiversity.
2. Investigate the extent to which fishery-independent data reduce uncertainty in the management of estuarine fisheries resources and lead to decisions that are more reliable and robust.
3. Examine the values of fishery-independent sampling for use across estuaries with different management regimes (e.g., estuaries open and closed to commercial and recreational fishing; marine parks) and for assessing the impacts of immediate environmental perturbations (e.g., floods, pollution) and those in the future (e.g., impacts of climatic change on the dynamics of populations of fish and diversity of fish assemblages).

### Summary:

Recent shifts in resource-management have required so-called sustainable “ecosystem-based” management of fisheries, which requires reliable data about harvested stocks, by-catch and other species (to assess effects on biodiversity). The well-known problems of data from commercial fisheries indicate that fishery-independent sampling is much more robust to provide the required information. The problem remains, however, that it has not yet been demonstrated how efficient it is and how more useful to arrive at appropriate managerial decisions to use the data from independent sources. This is one important impediment to “take-up” of appropriate data by managers of fisheries. This need can only be filled by making planned comparisons between decision-making based on “traditional”, fishery-based data and decisions made when better data are incorporated. To compare these approaches requires incorporating fishery-independent data (i.e., collected contemporaneously with traditional, fishery-dependent data) into the process of decision making.

An experimental approach will be used to test the relative value of different sources of data for the assessment and management of estuarine fisheries resources and biodiversity in NSW. Fishery-independent sampling tools have already been developed in a previous project funded by the Fisheries Research and Development Corporation (2002/059) and will be implemented across a number of estuaries with different management regimes (i.e., open and closed to commercial/recreational fishing). Data from commercial and recreational fisheries (i.e., catch and effort data, port monitoring of landings, creel surveys of recreational fishing) will also be collected simultaneously in these estuaries. The costs and benefits of each type of data and their managerial response can then be tested over equivalent spatial and temporal scales. This will provide a scientific basis for determining the most appropriate mix of fishery-independent and -dependent data for improving the sustainability of fisheries resources and biodiversity in estuaries of NSW.

## Research Project Description

### **Project title:**

Solving bycatch and discard problems in NSW's recreational mud crab fishery  
(FSR2010/249)

### **Principal Investigator:**

Dr Doug Rotherham

### **Funding Sources:**

NSW Department of Primary Industries and the NSW Recreational Fishing Trust Fund.

### **Objectives:**

Solve the problem of bycatch (primarily yellowfin bream) and discarding of undersize mud crabs in recreational traps using experimental manipulations of trap design.

### **Summary:**

Mud crabs are a popular species of crab targeted by recreational fishers using traps in estuaries and rivers of NSW, particularly along the mid to far-north coast. Recreational catches of mud crabs are large and can often exceed commercial landings.

Recent research in the Bellinger/Kalang River (NSW) identified that large numbers of juvenile, yellowfin bream were incidentally caught (known as 'bycatch') in a common design of a recreational crab trap. This is a problem because recreational fishers are not permitted to retain fish caught in crab traps. Further, fish and undersize crabs may be injured or killed by the process of being caught, handled and released (also known as 'discarding') from traps. Ghost fishing by lost or unattended traps also has the potential to result in high levels of mortality of fish, crabs and other organisms.

Much research in Australia and elsewhere in the world has solved problems of bycatch and discarding in commercial and recreational fisheries. Traps are a versatile fishing gear that can be designed to target certain species and sizes of crabs through various modifications (e.g. mesh size, shape, escape gaps, soak time). The aim of this study is to test whether placing escape gaps into recreational crab traps and/or increasing the size of mesh used in the gear, will reduce the retention of yellowfin bream and undersize mud crabs. Reducing bycatch and discards is necessary to improve the management and sustainability of fisheries resources.

## Research Project Description

### Project Title:

Overcoming obstacles to improved assessment and management of greentail prawns (*Metapenaeus bennettiae*) in NSW  
(FSC2011/285)

### Principal Investigator:

Dr Doug Rotherham and Ms Caitlin Kesby

[Note: This research is being done as an MSc project at the University of NSW by Caitlin Kesby]

### Funding Sources:

NSW Department of Primary Industries, the Fisheries Research Development Corporation (as part of FRDC Project No. 2008/004) and the University of New South Wales.

### Objectives:

1. Examine short-term temporal variation in the reproductive biology and size structure of populations of greentail prawns in order to design appropriate sampling strategies.
2. Use fishery-independent and -dependent sampling strategies to examine aspects of the reproductive biology and growth of greentail prawns in Tuggerah Lake.
3. Describe the commercial fishery for greentail prawns and evaluate the effectiveness of fishery-independent and -dependent sampling strategies for on-going assessments of greentail prawns in NSW.

### Summary:

The greentail prawn, *Metapenaeus bennettiae* (Racek and Dall, 1965), previously known as the greasyback prawn, is found in marine, estuarine and freshwater habitats of eastern Australia between Rockhampton in Queensland and Gippsland Lakes in eastern Victoria. Unlike other species of prawn (i.e., king and school prawns), greentail prawns are able complete their entire lifecycle within shallow coastal lagoons.

In New South Wales, greentail prawns are targeted primarily by commercial fishers during early summer. In the last decade, however, average annual commercial landings have decreased by more than 50 %. Despite this pattern, no detailed assessments of the status of the resource have been completed in NSW. A lack of data on both the reproductive biology and growth of greentail prawns (e.g., growth rates, estimates of mortality, size at maturity and times of spawning, etc.) continue to be obstacles to improved assessments of the resource.

The aim of this research is to redress the lack of information on the reproductive biology and growth of greentail prawns and recommended appropriate data-collection programmes for future studies and on-going assessments of greentail prawns in NSW.



## Research Project Description

### Project Title:

Resource Assessment and Monitoring of Commercially Harvested Species  
(FSC2003/123)

### Principal Investigator:

Dr Kevin Rowling

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

1. Design and implement a resource assessment process to determine exploitation status of FMS listed species and exchange this information with Management Planning in a manner consistent with FMS reporting requirements.
2. Produce an annual summary of stock status indicators for all key FMS species at relevant spatial and temporal scales. These indicators will include: commercial landings, commercial catch per unit of effort, length composition, and (where possible) age composition and preliminary estimates of total mortality. Augment these indicators with information from the other projects including fishery independent surveys and surveys of recreational fisheries if the information is available.
3. Design and implement a resource assessment intranet for the distribution and communication of stock status indicators for all key FMS species. This intranet should also provide: indicators and trigger points used for FMS reporting; rules and interpretations of key indicators; citations relevant to key FMS species; a list of managerial events required to interpret historical data and access to fragmentary electronic files of relevance to stock status.
4. Collect length (and age samples where relevant) samples for key FMS species considered that are considered a sampling priority. This priority is based upon the risk assessments presented in the EIS and socio-economic values associated with these species. For fiscal year 2005/06, these species include: sea mullet, yellowfin bream, snapper, yellowtail scad, yellowtail kingfish, mud crabs, bonito, Australian salmon, pilchards, sand flathead, teraglin, red mullet, rubberlip morwong, silver sweep, Balmain bugs, pipis and flounders. This list will be reviewed at the end of each fiscal year.
5. Collect length and/or age samples from commercial catches of species subject to a 'Recovery Program' in any commercial FMS. At the time of writing, this list includes: sea garfish, silver trevally and eastern gemfish.
6. Develop user-friendly data entry and retrieval systems for the AgeLength database. Enter and store the length composition and biological data resulting from this project in this database. Continue to migrate relevant legacy data into this system.
7. Produce a "Status of Fishery Resources 2006/07" by the 31 December 2007.

### Summary:

This project addresses most of commitments for resource assessment and monitoring made by the NSW DPI within the Fishery Management Strategies for commercial fisheries (except the Lobster and Abalone Fisheries). These commitments include the assessment, monitoring and/or reporting of up to 100 species, therefore innovative and efficient systems will need to be designed and implemented. The general strategy of how to engage with these challenges was outlined in 'A Framework for the Assessment of Harvested Fish Resources in NSW' (Scandol, 2004). This project implements the key goals from that framework, which include:

Definition and implementation of a process for assessing the exploitation status of harvested species: This project manages the internal scientific deliberation used to specify the exploitation status of harvested species identified in the Fisheries Management Strategies. This process also includes consultation with the

industry-based Catch and Effort Working Group and exchanges the indicators and trigger points relevant to resource assessment to fisheries management in a timely manner.

Specification and analysis of indicators: Numerous indicators are available to infer exploitation status. This project specifies the algorithms used to calculate the indicators and manages these algorithms in a controlled environment so that the calculations can be repeated efficiently and accurately. These indicators are kept 'up-to-date' so that NSW DPI scientists can monitor fish stocks. This project calculates and presents the following indicators; commercial landings; commercial catch-per-unit-effort; length composition; and, where possible, age composition and mortality.

Implementation of monitoring programs: Sampling the length and age composition of commercial landings is a cost-effective strategy to monitor mortality and recruitment. Furthermore, these data are a crucial complement to catch per unit effort data. The sampling strategies are refreshed at the end of each fiscal year, but in 2005/06 detailed monitoring will be continued for 9 important species (sea mullet, yellowfin bream, snapper, yellowtail scad, gemfish, mud crabs, bonito, Australian salmon and pilchards). Monitoring will be commenced (or recommenced) for a further 12 species or species groups (sea garfish, yellowtail kingfish, silver trevally, bugs, pipis, sand flathead, teraglin, flounder and red mullet) and a number of species will be monitored in connection with another research program studying trap and line species (rubberlip morwong, pearl perch, pigfish, tarwhine and maori wrasse).

Develop a warehouse for fisheries data: Efficient and secure management of data will be crucial to the long-term success of this, and other, assessment and monitoring projects. This project continues the development of databases for length, age and other biological data, and migrates legacy datasets from unsupported or inappropriate software systems.

Develop reporting systems for assessments: An innovative new reporting system has been developed by this project: the Resource Assessment System. This intranet application gives (or will give) Departmental officers access to stock-status indicators such as landings, catch-per-unit-effort, length/age composition and mortality; as well as images, species composition, exploitation status, growth-curves, survey results, links to other web-sites, references and management history. An updated 'Status of Fisheries Resources' will be published in 2007 that summarises content from the Resource Assessment System and other sources.

## Research Project Description

### Project Title:

Application of the CSIRO Ecosystem Model *Atlantis* to NSW and comparison of *Atlantis* with the UBC Model *EcoSpace*  
(FSC2004/141)

### Principal Investigator:

Dr James Scandol

[Note: This is a collaborative project with CSIRO (Marine) and the University of British Columbia]

### Funding Sources:

NSW Department of Primary Industries, CSIRO Marine Research and the University of British Columbia.

### Objectives:

1. Implementation of the *Atlantis* modelling software with boundaries relevant for NSW Department of Primary Industries and as agreed with the University of British Columbia team. The model should be bounded 1-2° north of the Queensland border and 1-2° south of the Victorian border and should extend approximately to the eastern boundary of the Australian Fishing Zone.
2. Training for up to three scientific personnel from NSW Department of Primary Industries so that they are familiar with the *Atlantis* model. This training will include basic instruction for users who want to extend the scenario development.
3. Definition of methods and creation of tools that enable the comparison of output from *Atlantis* and *Ecospace* using simple graphical and statistical methods.
4. Training for PhD student (Robyn Forrest) on the use of *Atlantis* and the methods used to compare *Atlantis* with *Ecospace*.

### Summary:

As part of a strategy to implement Ecosystems-Based Fisheries Management, NSW Department of Primary Industries has, in collaboration with the University of British Columbia (UBC), begun developing spatial ecosystem models using “*Ecospace*” modelling software.

This new project is an important extension to the UBC project that also creates a new collaborative link with CSIRO Marine Research. CSIRO has developed an independent ecosystem model (*Atlantis*) that, when compared with the UBC “*Ecospace*” model, will provide an important test of the consistency of ecosystem models. Such models predict the consequences of alternative policies on ecosystems and the human values associated with ecosystems. If ecosystem models with independent pedigrees conclude that the same policies are likely to be effective to achieve particular goals, then decision-makers can be far more confident in these models and their results.

Specifically this project will deliver an implementation of the CSIRO *Atlantis* model with boundaries relevant for NSW Department of Primary Industries. The project will also train up to three scientific personnel from NSW Department of Primary Industries so that they can use and interpret the *Atlantis* model. Furthermore, methods will be developed that enable the comparison of results from *Atlantis* and *Ecospace* using simple graphical and statistical tools.

## Research Project Description

### Project title:

Movements and biology of coastal sharks in NSW  
(FSC2007/186)

### Principal Investigator:

Dr Amy Smoothey, Dr Vic Peddemors and Dr Charles Gray

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

1. Investigate the movements of bull sharks in coastal and estuarine areas of NSW.
2. Quantify the length composition of retained catches of sharks associated with the targeted commercial shark fishing in the northern NSW Estuary General fishery.
3. Collect biological information and samples to help understand the biology of bull sharks along the coast of NSW.

### Summary:

A range of commercially and recreationally harvested species of shark, including the bull shark (*Carcharhinus leucas*), dusky whaler (*Carcharhinus obscurus*) and other whaler sharks (*Carcharhinus spp.*), inhabit estuaries and coastal waters of NSW. For most species, very little is known about the general biology and ecology of these animals in these waters. Understanding how spatial movements of individual sharks affect a populations' distribution pattern and temporal dynamics across a wide range of scales in relation to their physical and biotic environment, is essential if we are to manage sharks in the face of increasing human-induced pressures.

Bull sharks are known to frequent estuaries in summer, when attacks on humans have occurred; although, other species of whalers may also be involved in such interactions. This research is the first to study these animals (particularly the bull shark) in NSW. Using acoustic telemetry and satellite tags, live animals will be caught, tagged and released into the wild to determine their patterns of movement. An array of listening stations strategically placed in estuaries and coastal waters will be used to monitor their movements within and between estuaries.

## Research Project Description

### Project Title:

Development of cost-effective methods for monitoring and assessing spatial management options for recreational fisheries in NSW  
(FSR2008/200)

### Principal Investigator:

Dr Aldo Steffe

[Note: This project consists of two doctoral projects – University of Western Sydney and Griffith University, Queensland]

### Funding Sources:

NSW Department of Primary Industries, the NSW Recreational Saltwater Fishing Trust Fund, the University of Western Sydney and Griffith University (Queensland)

### Objectives:

*PhD project 1: Linkages between habitats and recreational effort and catch in the Greater Sydney region.*

Develop a Geographic Information System (GIS) that integrates our current knowledge of habitat distributions within the Greater Sydney Region with detailed data on recreational effort and catch.

*PhD project 2: Development of a cost-effective monitoring system for boat-based recreational fishing effort using web cams and artificial neural network software.*

Investigate the use of video technology (web cams and artificial neural networks) for long term monitoring of recreational fishing effort at large access points along the coast of NSW.

### Summary:

This project seeks to address two major areas of concern for recreational fishers and fisheries managers. It consists of two separate doctoral projects which are designed to:

- (1) enhance the analyses being generated by the current project “Recreational fishing surveys in the Greater Sydney Region” and;
- (2) use cutting edge technology to develop a cost effective way of monitoring recreational boat-based fishing effort over large geographical scales.

*PhD project 1: Linkages between habitats and recreational effort and catch in the Greater Sydney region.*

The recent zoning outcomes in the newly established Port Stephens and Batemans Bay Marine Parks have created controversy within the recreational sector. Much of this conflict may have been avoided if statistically rigorous information describing the patterns of recreational fishing effort and catch had been available and overlaid onto detailed habitat maps. This type of information is crucial for achieving a better understanding of the impacts of different zoning options on recreational fishers and fisheries. This project intends to develop a Geographic Information System (GIS) that integrates our current knowledge of habitat distributions within the Greater Sydney Region with the detailed data on recreational effort and catch that is being generated by the current Trust-funded survey program “Recreational fishing surveys in the Greater Sydney Region”. This work will provide a visual representation of complex information on maps that can then be used to gain better management outcomes for recreational fishers whilst still achieving conservation objectives.

*PhD project 2: Development of a cost-effective monitoring system for boat-based recreational fishing effort using web cameras and artificial neural network software.*

Quantitative assessments of recreational catch and effort are needed to evaluate the sustainability of our fisheries resources. The main challenge faced by fisheries agencies throughout the world is how to obtain

estimates of recreational effort in a cost-effective way over large geographical scales (e.g., statewide and national scales). The development of this type of monitoring system has great potential for providing continuous coverage of coastal boat-based fishing effort at minimal cost. At present, this type of monitoring requires direct observation of boat movements by people located at selected vantage points. The deployment of web cameras to record recreational boat movements moving into and returning from our marine fisheries along the NSW coast will remove the need for direct human observation and thereby greatly reduce the cost of data collection. Further, the use of artificial neural network software provides a solution to the processing and interpretation of the thousands of hours of video that will be generated by this work. In short, the artificial neural network software can be used to examine video records and be trained to classify and enumerate different boat types (e.g., trailer boats, yachts, jet skis, trawlers) and identify their direction of travel past an observation point. This project will also assess the feasibility for expanding this monitoring system to routinely collect boat-based marine recreational fishing effort information at major estuary mouths and ports throughout NSW. This type of information is needed to provide a better understanding of the importance and possible impacts of recreational fisheries along the entire coast of NSW.

## Research Project Description

### Project Title:

Assessment and monitoring of pilchard landings from the vessel Delamere  
(FSC2006/169)

### Principal Investigator:

Dr John Stewart

### Funding Sources:

NSW Department of Primary Industries.

### Objectives:

1. Monitor the quantities, sizes and ages of pilchards landed by the vessel Delamere.
2. Use onboard observers to document fishing operations, by-catch and interactions with protected species.
3. Compile information on the quantities of pilchards observed by spotter-plane and the Delamere's sonar.
4. Investigate the utility of using previously collected egg samples and the daily egg production method to estimate the biomass of pilchards off NSW.

### Summary:

Commercial landings of pilchards (*Sardinops sagax*) in NSW are to be monitored in terms of quantities, sizes and ages. This assessment is for pilchards landed by the fishing vessel Delamere under a permit issued by the NSW DPI for the years 2006 to 2008. In conjunction with routine monitoring, observers onboard the fishing vessel will document their fishing operation, including retained and discarded catches and interactions with threatened species. This observer work will be in association with that being done by AFMA as part of their Small Pelagic Fishery assessment. The information collected during this project will be used to assess the sustainability of increased landings of pilchards by this fishing vessel, and will provide an opportunity for improved cross-jurisdictional management between NSW and the commonwealth.

## Research Project Description

### Project Title:

Diagnostic Radio-ichthyology: Using CT scans to explore the effects of barotrauma on fish  
(FSC2007/190)

### Principal Investigator:

Dr Doug Ferrell and Dr John Stewart

*[Note: this is a collaborative project with Assoc. Prof. Sandra Diamond at the University of Western Sydney]*

### Funding Sources:

NSW Department of Primary Industries and the University of Western Sydney.

### Objectives:

The pilot project aims to determine key effects of barotrauma (trauma caused by catching deep-water fish and releasing them at the surface) on fish health and survival by comparing CT scans of:

- two species of fish (snapper and mullet) caught at different depths;
- fish caught by two methods of fishing (snapper caught by traps versus by line);
- physical abnormalities of individuals with results of tests for behavioural impairment.

### Summary:

This research project will be done in collaboration with Dr Sandra Diamond at the University of Western Sydney as the principal investigator. The project aims to determine key effects of barotrauma (decompression trauma) on snapper (*Pagrus auratus*) and mullet (*Argyrosomus japonicus*) by using X-ray computerised tomography, known as CT scans, to look at physical abnormalities caused by the rapid reduction in pressure as fish are brought to the surface from depth. The project will also test basic reflex behaviours of decompressed fish so we can compare behavioural impairment with physical abnormalities. Correlations between behavioural and physical effects will help to pinpoint sublethal impacts of decompression trauma on fish, and to find predictive markers for estimating the probability of survival for each individual fish.



## Research Project Description

### Project title:

Movement patterns and stock structure of Australian sardine (*Sardinops sagax*): Implications for future assessment and management  
(FSC2009/225)

### Principal Investigator:

Dr John Stewart

*[Note: This is a collaborative project which is led by Dr Tim Ward at the South Australian Research & Development Institute]*

### Funding Sources:

NSW Department of Primary Industries, the Fisheries Research & Development Corporation (Project No. 2009/021), the South Australian Research & Development Institute, the University of Adelaide and the the University of New South Wales.

### Objectives:

1. Assess the costs/benefits of establishing eastern and western zones in the South Australian Sardine Fishery.
2. Assess the degree to which estimates of spawning biomass from northern NSW and southern Queensland waters reflect the size of the entire eastern Australian sardine stock.

### Summary:

The fishery for sardines (Australian pilchards) off New South Wales is one of the few rapidly expanding commercial fisheries in the state. The NSW Department of Primary Industries is working with the fishing industry to ensure that the sardine fishery is developed sustainably and generates substantial employment in regional areas. Currently, sustainable harvest levels are calculated from biomass estimates derived from northern NSW; however a large proportion of the sardine population is located in southern NSW. This collaborative research project between NSW DPI, the University of New South Wales, the University of Adelaide and the South Australian Research and Development Institute, aims to understand the stock structure of sardines along eastern Australia. Stock structure will be determined using a variety of methods associated with the fish's otoliths (ear-bones) which include variations in their shape and chemical composition. The results will be used to refine methods for estimating the biomass of sardines and ultimately in ensuring the sardine fishery in NSW is managed in a profitable and sustainable manner.

## Research Project Description

### Project title:

Assessment of barotrauma and its mitigation measures on the behaviour and survival of offshore species in NSW  
(FSC2009/226)

### Principal Investigator:

Dr John Stewart

*[Note: this is a collaborative project with Dr Sandra Diamond at the University of Western Sydney and includes two Honours projects]*

### Funding Sources:

NSW Department of Primary Industries, the Saltwater Recreational Fishing Trust Fund and the University of Western Sydney.

### Objectives:

1. Describe the success of different barotrauma mitigation treatments in enabling fish to return to their preferred depths following catch and release.
2. Describe long-term survival and movements of large snapper following catch & release.
3. Describe the physiological responses of fish to barotrauma and its mitigation treatments.
4. Use information from the above objectives to assist in the development of a NSW policy on the best practice for releasing barotrauma affected fish.

### Summary:

Releasing fish following their capture is a practice designed to enhance the sustainability of fish stocks. However, fish that are captured from even quiet shallow waters will suffer from barotrauma – injury that is caused by the rapid depressurisation that occurs when they are brought to the surface. This study is investigating the severity of these injuries in key offshore species in NSW, including the iconic snapper and mulloway. The research will involve both field and laboratory components. The field component will involve observing the behaviour and survival of fish following their capture from various water depths and subsequent release. These observations will be done using state-of-the-art acoustic tagging technology. This technology will enable observations to be made of the fish in their natural conditions and of the immediate impacts of fish release methods such as venting (allowing gas in the swim bladder to escape) and release weights that are used to return the fish to the sea floor. Some snapper will be tagged with long-term acoustic tags to monitor their behaviour and movement throughout the year. The laboratory experiments will involve building a specialised hyperbaric chamber in the Cronulla Fisheries Research Centre's aquaria facility. This chamber will enable well designed manipulative experiments to be done. These experiments will simulate the pressure change experienced by fish when captured in the wild and will enable scientists to assess the effect on the fish's physiology.

## Research Project Description

### Project title:

The life history characteristics and fishery of teraglin, *Atractoscion aequidens*, (Family: Sciaenidae) off the coast of New South Wales, Australia  
(FSC2010/263)

### Principal Investigator:

Dr John Stewart and Ms Anne-Marie Hegarty

(Note: This is a collaborative project with the University of Technology, Sydney)

### Funding Sources:

NSW Department of Primary Industries and the University of Technology, Sydney.

### Objectives:

1. Undertake a literature review on research that has been done on *A. aequidens* and related species.
2. Assess the commercial and recreational fishery for *A. aequidens* in NSW using historical and current catch information and statistics.
3. Quantify the age composition and growth rates of *A. aequidens*, investigating hypotheses concerning spatial and temporal differences between locations and sexes.
4. Determine the reproductive features of *A. aequidens* in NSW including batch fecundity, oocyte development, spawning period, and length and age at maturity.
5. Compare and contrast the above life history characteristics of *A. aequidens* in NSW with the South African and southern Queensland populations and with other Sciaenids.
6. Develop a validated otolith ageing protocol, using otoliths.
7. Estimate the instantaneous rate of total mortality, natural mortality and fishing mortality of *A. aequidens* in NSW.
8. Estimate the optimum size of first capture based on yield per recruit analyses.
9. Analyse the gut contents of *A. aequidens* to determine the principal prey species.
10. Discuss the implications of the findings of this study for the management of fisheries catching *A. aequidens* in NSW waters.

### Summary:

*Atractoscion aequidens* (teraglin) is a member of the family Sciaenidae and is found in Australian waters from Montague Island in the south to southern Queensland in the north. The species also occurs off Angola and South Africa. In NSW, *A. aequidens* are targeted by the Ocean Trap and Line commercial fishery and significant numbers are also taken by the recreational fishery. Despite the importance of *A. aequidens*, very little is known about the species' life history characteristics and population dynamics off eastern Australia. Long-term declines in commercial fishery landings (Scandol *et al.* 2008) and the possible susceptibility of localised depletions due to schooling behaviour, has raised concerns in NSW that *A. aequidens* fisheries may be subject to overfishing.

This study will describe the fisheries and investigate the life history characteristics and ecology of *A. aequidens* by sampling at three key locations on the NSW coast. The existence of geographic and temporal variation in age, growth, reproductive strategies and diet of *A. aequidens* will be investigated in NSW and these parameters will also be compared with information available from southern Queensland and South Africa. The results of the study will provide the necessary information for the effective long-term management of the species.

## Research Project Description

### Project title:

Eastern king prawn and mulloway stocking research  
(FSC2011/272)

### Principal Investigator:

Dr Matt Taylor

*(Note: This is a collaborative project with the University of New South Wales)*

### Funding Sources:

NSW Department of Primary Industries the NSW Recreational Fishing Trust Fund, the Victorian Fishing Trust Fund, the University of New South Wales and the Queensland University of Technology.

### Objectives:

1. Conclude monitoring of stocked fisheries in NSW.
2. Finalise development of genetic approaches to identifying stocked mulloway and eastern king prawns in NSW.
3. Endeavour to use microsatellite markers to resolve the genetic stock structure of eastern king prawn off eastern Australia.
4. Develop an experimental framework (beyond-BACI design) for monitoring the success and impacts of eastern king prawn stocking.
5. Apply this framework to assess trophic and community changes associated with a pilot stocking in Lake Tyers.
6. Conduct empirical measurements of productivity, growth and survival, bioenergetics, growth efficiency and angler harvest; to assist in the estimation of appropriate stocking rates for eastern king prawns in landlocked lagoons in south-eastern Australia.

### Summary:

Stock enhancement involves the release of fish and/or prawns to supplement natural recruitment of larvae and juveniles from wild stocks. Experience has shown that organisms survive better and are less inclined to leave the release area when they are released at densities at which the ecosystem can support. Whilst models exist to predict stocking density for fish, models to predict stocking density for invertebrates are still in their infancy and require empirical bioenergetic measurements for further development. In addition, experimental and genetic protocols for assessing the impact of stocking on both prey assemblages and habitats, and also in terms of growth and survival of released organisms are lacking. This project will use genetics and experimental ecology to assess the impacts and contribution of stocked previously mulloway and prawns to the ecosystem, wild stocks, and the fisheries for these species. The project will also extend these data to help estimate stocking rates for eastern king prawns in coastal lagoons in south-east Australia.