Department of Primary Industries Student Conservation Award

2015 John Holliday Award Applicant Summaries

Far left picture: Sue Holliday, wife of late John Holliday, shaking hands with Brett Pflugrath, winner of the 2015 John Holliday Award for the project 'Downstream fish passage at river infrastructure within NSW: Developing guidelines promoting safe passage of fish'. Scott Hanson, Director General Primary Industries showing congratulations with clap of hands. Far right picture: Members of the Holliday family with Brett.

More information

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DPI Fisheries, a branch of NSW Department of Primary Industries (DPI), is aware of the diverse range of research that is being done each year by university post-graduate students, and encourages the communication of the results of this work to assist the management of fisheries resources and aquatic habitats in NSW.

The John Holliday Student Conservation Award is offered by DPI to encourage post-graduate students to share their research findings on topics of interest to the Department. The winning entrant for the 2015 John Holliday award received a cash award of $3,000. The Award is named in honour of the late Dr John Holliday, a former Senior Conservation Manager who pioneered the Department's involvement in aquatic habitat and fish conservation issues.

The 2015 John Holliday award was open to post-graduate students who were enrolled at an Australian University during 2015 and who undertook fisheries-orientated research work in NSW. The applicant's summaries are listed below.

2015 Winning Entry Summary

Downstream fish passage at river infrastructure within NSW: Developing guidelines promoting safe passage of fish

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The downstream passage of fish through river infrastructure may expose fish to a host of stressors. These stressors include mechanical strike, shear forces, and rapid changes in pressure. When severe, these stressors have been found to cause injuries and/or mortality in fish. To further the understanding of these stressors both field and laboratory research is being conducted. Field work was completed at three hydro structures within New South Wales to quantify the stressors that fish are exposed to while passing downstream through structures. This was completed by deploying a device called the Sensor Fish, which measures acceleration, rotation, pressure, and temperature. Additionally, laboratory studies are being conducted on NSW fish species to determine their injury and mortality rates when exposed to simulated pressures representing downstream passage through river infrastructure. Further laboratory experiments are being conducted to determine the effects of entrainment on fish exposed to simulated hydro- structure pressures. Preliminary results suggest that fish may be more likely to encounter injuries or mortality at some facilities than other. Additionally, increased swimming efforts to avoid entrainment may alter susceptibility to barotrauma in fish when exposed to rapid decreases in pressure associated with hydro-structure passage. Together this research will be used to estimate injury and survival rates of fish passing downstream through river infrastructures. Estimates such as this can aid in the management of current operations of river infrastructure and the design of future instalments to reduce or eliminate their negative impacts on fish.

Other Entry Summaries

The life history characteristics and fishery of teraglin, Atractoscion aequidens, (Family: Sciaenidae) in New South Wales, Australia

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The aim of this study is to support sustainable use of the teraglin, Atractoscion aequidens, fishery in New South Wales (NSW) by describing the current fisheries and investigating relevant aspects of the species' life history and ecology. To date, there has been no detailed study on the life history characteristics of A. aequidens in NSW, severely limiting the development of sustainable management strategies. The effectiveness of current management of A. aequidens is uncertain without detailed knowledge of the life history characteristics of this species, potentially leading to unsustainable fishing of the stock. The existence of geographical and temporal variation in age, growth, and reproductive characteristics will be investigated and compared with information available from southern Queensland and South Africa. The results of the study will be important for future fishery assessments and effective long-term management.

The study is relevant to the Fisheries NSW priority research program, Sustainable Fish Harvest, within the Fisheries Resource Assessment unit. Sustainable fish harvest is imperative to the long-term success and viability of stocks that are commercially and recreationally harvested. Species' basic life history parameters are paramount to establishing the exploitation status and thus effective management for

sustainable fish harvest. The species studied is one that could benefit from the Fishery Enhancement program of the offshore artificial reefs.

Diatom abundance hotspots at the mid-shelf in the Solitary Islands Marine Park (30°S, 153°E), Eastern Australia, create a potential feeding ground for zooplankton and fish.

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Phytoplankton are the base of the marine food web and diatoms in particular provide a nutritious food source to higher trophic organisms such as zooplankton and fish. Thus the composition and distribution of phytoplankton dictates the distribution of their predators. Here we report on diatom abundance hotpots over the mid continental shelf in the Solitary Islands Marine Park (SIMP), Eastern Australia, which have been found repeatedly during upwelling conditions (i.e. when cold nutrient rich water is uplifted onto the continental shelf, mixes with light penetrated surface waters and promotes phytoplankton growth). These localised phytoplankton patches may attract predators, creating hotspots of marine life at the mid-shelf. This study provides the first insights into the relationships between phyto- and zooplankton distribution in the SIMP and represents a crucial resource for fisheries and the future planning of zones in a marine park.

Building the ‘blue revolution’: Potential for aquaculture of the sea urchin Tripneustes gratilla in New South Wales

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Providing food to a global human population rapidly approaching nine billion is one of the biggest challenges facing humanity. One solution is to rapidly increase the amount of seafood that is farmed, a ‘blue revolution’. A first step for a blue revolution is to increase the number of different types of seafood that can be grown. Sea urchins are ideal candidates for farming because they have a high-value market in Japan and can be fed on seaweed, instead of fish harvested from the wild. Furthermore demand for sea urchin roe is increasing due to overfishing, which has caused catastrophic ecological impacts in some places. This study aimed to create technology to grow sea urchins quickly and efficiently. In the course of the study, I found some surprising results about what limits growth of sea urchins in culture that has the potential to revolutionise the way sea urchins and other invertebrates are grown in intensive systems. Usually when cultivated at high densities or with limited seawater exchanges, the growth of aquaculture species is thought to slow because they use up most of the available oxygen or their wastes accumulate and slow growth. Instead I found that sea urchins grow slower because there is a decrease in total alkalinity (a measure of the amount of substances in seawater that will neutralise acids) and a build-up of carbon dioxide (CO2) in their culture water. Growth rates of sea urchins in intensive cultures could be increased by removing CO2 or adding carbonate to culture water. This means that sea urchin and other animals that have calcium carbonate shells may now be cultured at far higher densities than previously thought possible.

Species distribution modelling to aid management and conservation of migratory pelagic species

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Defining the oceanic habitats of migratory marine species is important for conservation and fisheries management, particularly when the distribution of these habitats vary temporally. Spatial conservation practices, such as marine park implementation, have rarely been applied to the pelagic zone due to the difficulties in describing and managing such highly dynamic environments. Defining pelagic habitats can be achieved using species distribution models that include physical environmental predictors. As part of my PhD, I have developed species distribution models that describe the seasonal habitats of two pelagic fish (dolphinfish, Coryphaena hippurus and yellowtail kingfish, Seriola lalandi), using 18 years of data from a recreational angler-based catch-and-release fishing program. Novel modelling techniques allowed me to determine the intensity of fish (fish km-2) off the New South Wales (NSW) coast as a function of several oceanographic variables. Four oceanographic variables, including sea surface temperature, were

significant environmental predictors for both dolphinfish and kingfish distributions. Models for both species indicate greater fish intensity off NSW during summer and autumn in response to the regional oceanography, namely shelf incursions by the East Australian Current. This study provides a framework for using recreational fisheries data to create species distribution models, and can be applied to other aquatic species that are targeted by cooperative tagging programs, such as native freshwater fish, tunas, billfish, and sharks. This study can potentially contribute to the future development of species distributions models both here and elsewhere, as effective tools for the management and conservation of aquatic species.

Overcoming obstacles to improved assessment and management of greentail prawns (Metapenaeus bennettae) in NSW

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In New South Wales, M. bennettae 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, no detailed assessments of the status of the resource have been completed in NSW. A lack of contemporary data on both the reproductive biology and growth of M. bennettae (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 M. bennettae as a first step towards improving their assessment and management in NSW. Multiple experiments were carried out using hierarchical sampling techniques to test hypotheses about temporal variation and spawning patterns of greentail prawns in Tuggerah Lake and Lake Macquarie. The most significant pattern observed was that variation in the proportion of mature/ripe females and mean abundance of M. bennettae was often largest at the smallest temporal scales of nights and weeks and contrary to a lot of the literature, lunar phase is not the sole contributor to this pattern of reproductive timing; small-scale variation in reproductive development is also driven by varying levels of turbidity and salinity, water temperature and sometimes the interaction of these variables with lunar phase. Knowing what biotic and abiotic processes that drive reproductive variation is critical to ensure stocks can be kept sustainable.

The role of genetic diversity in the conservation of threatened seagrass meadows in New South Wales

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Seagrass communities are an extremely important and valuable part of coastal ecosystems globally that are declining at alarming rates (Waycott et al. 2009). To conserve and manage seagrasses and the ecosystem services they provide, it is necessary to know the distribution, diversity and connectivity of seagrass communities; how seagrass populations vary in productivity and ecosystem functioning; how they respond to environmental stress; and ultimately, how we can optimise the process of restoring damaged seagrass systems to ensure their survival and fitness in the long-term.

My research confirms that populations of Posidonia australis in New South Wales, Australia are currently under significant threat from anthropogenic activities and are prime candidates for restoration. I quantified genetic diversity and phenotypic variation within and among P. australis meadows across their full distribution on the east coast of Australia. Further, I showed that increased genetic diversity of P. australis meadows can increase the likelihood of resilience to short-term stress, and improve restoration efforts.

Behavioural ecology of the critically endangered grey nurse shark (Carcharias taurus) and the interaction with scuba diving tourism off eastern Australia

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The critically endangered grey nurse shark (Carcharias taurus) off eastern Australia is the focus of a non-consumptive, economically important marine wildlife tourism (MWT) industry centred on scuba diving with the sharks. This industry has been identified as a potential threat to the continued survival and recovery of the species. Legislative guidelines and a national code of conduct for scuba diver behaviour were

developed to mitigate adverse impacts of MWT on the sharks. This research assessed the putative impacts of scuba diving MWT on grey nurse shark behaviour and the efficacy of management strategies across differing life-history stages and aggregation sites. Underwater visual census documented primarily low-activity swimming behaviours in sharks during interactions with MWT scuba divers of varying demographics and revealed absolute diver compliance with management guidelines. This research indicated that existing management strategies are effective at protecting the east Australian population of grey nurse sharks from MWT disturbance. Consequently, the grey nurse shark scuba diving MWT industry in its current form is ecologically and economically sustainable.

Direct age determination of a subtropical freshwater crayfish model (redclaw, Cherax quadricarinatus) using ossicular growth marks

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Recent studies have reported that direct determination of crustacean age is possible. This study demonstrates the value of direct-ageing methods using a subtropical freshwater crayfish model (redclaw, Cherax quadricarinatus). C. quadricarinatus ossicles were not moulted externally. Repeatable age estimates were procured from pterocardiac ossicles. Ossicular regions grow isometrically and an evidence-based protocol for the count origin is presented. C. quadricarinatus growth was best described using a von Bertalanffy model. Maximum age (3+) corroborated

indirectly-obtained longevity estimates and did not correspond to moult history. The recording of past events was demonstrated by calcein retention during a one year period. The deposition of an apparently complete annual cycle beyond the calcein (in a large adult) provided the first direct evidence for annual periodicity, but further research is needed for a definitive validation. The ability to procure directly-obtained validated ages will have a substantial global impact on fisheries and conservation management.

Climate change alters aggressive interactions between the invasive Eastern Mosquito fish and Australian Bass juveniles

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Understanding interactions between non-native and native species is critical in controlling invasive species. Although aggressive interactions are predicted to shift under climate change, no previous studies have examined how they are mediated by multiple abiotic stressors in aquatic ecosystems, such as temperature and salinity. In this study I subjected a ubiquitous invasive freshwater species, the Eastern Mosquito fish (Gambusia holbrooki) and juveniles of an ecologically and economically important native, Australian Bass (Macquaria novemaculeata), to four combination treatments of temperature (21 °C and 28 °C) and salinity (15 ‰ and 35 ‰), scoring inter-specific aggression. For both species, aggression increased with elevated temperature, but only when salinity remained relatively low (28 °C and 15 ‰), not high (28 °C and 35 ‰). These results indicate the effect of future climate change on biotic interactions between these Eastern Mosquito fish and Australian Bass juveniles will be complex and vary across distinct water bodies. Specifically, Bass may experience greater inter-specific aggression from this invasive species in systems where water temperatures increase and where salinity remains relatively low and stable.

Critical stream habitats for Murray crayfish (Euastacus armatus) in upland New South Wales

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Murray crayfish (Euastacus armatus) are an ecologically important species that is now threatened in all state and territories of the Murray-Darling Basin. While relatively well studied in lowland streams, we have a poor understanding of their upland distribution and habitat preferences, which hinders our ability to develop effective recovery plans. In this study, I used snorkel surveys to determine the habitat preferences of Murray crayfish across two major scales (mesohabitats spanning 10-200 metres, and microhabitats <1m) within an upland section (400-500 metres ASL) of the Goodradigbee River, New South Wales. Murray crayfish displayed strong selection towards pool and glide mesohabitats with deeper water, and streambed microhabitats dominated by boulders. While Murray crayfish were seen to occupy areas of low

flow velocity, seasonal flushing are likely to be critical in maintaining their preferred deep, boulder-dominated stream habitats.

Linking genes to climate: Understanding how oysters can adapt to ocean acidification

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Climate change is increasing the acidity and temperature of the world's oceans. Oysters are particularly threatened by this scenario because the integrity of their shells and other physiological systems are hampered by shifts in water chemistry. Although adaptation to climate change is possible for many marine species, the molecular basis for such condition is largely unknown. My PhD research aims to discovery the biological mechanisms that provide heritable protection against the deleterious effects of climate change in oysters. Specifically, I am exploring the differential responses to climate change stressors of Sydney rock oysters that have been selectively bred by the NSW Department of Primary Industries. By comparing the intracellular responses of selective breeding lines with those of wild-type (non-selected) oysters, I am identifying the intracellular processes that are responsible for adaptation to ocean acidification. My data will provide a functional framework to underpin breeding programs designed to minimise the impacts of climate change, safeguarding the species and the oyster aquaculture in the face of the imminent threat of global environmental change.

The influence of future ocean warming and acidification on trophic drivers of kelp abundance in NSW temperate reefs

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The project I completed for my honours examined the effects of increased temperature, a lowered pH, and the interaction of these on key species interactions that may impact on kelp habitat. Three experiments were used to determine if these was changes to competition (kelp and algal turf), herbivory (kelp and urchins) and predation (urchins and lobsters). I found that competition was altered as algal turfs benefited from CO2 and a lack of shading. Predation and herbivory was impacted by temperature, with urchins eating more kelp and lobster eating less urchins in warm treatments. Kelp forests are highly productive habitats which support high biodiversity and many commercially and recreationally important species. The impact of changing marine climate on species interactions that impact upon kelp may remove kelp habitat before kelp is impacted by these changed conditions.

Assessing sub-tidal habitats and biodiversity in the Eastern Port of Port Stephens

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The Port Stephens estuary is an important location for commercial and recreational fishing and within the estuary sub-tidal habitats at depths of more than ten metres had not previously been fully described. A broad scale assessment of estuarine habitats in the Eastern Port of Port Stephens was therefore conducted, based on aerial photography and towed video transects, covering an area exceeding 50 km2.

The study identified nine distinct habitats occurring within the Eastern Port of Port Stephens. Maps showing the geographical extent of these habitats were generated identifying extensive new areas of macroalgae and filter feeders, and providing valuable information on the distribution of critical Dendronephthya australis soft coral habitat, along with details of changes to the distributions of seagrass species.

In addition an assessment of fish biodiversity within these habitats was commenced, and to date 72 sub-tidal visual censuses have been conducted, identifying 118 species of fish. Censuses are ongoing, and will continue over a two year period, thereby allowing examination of seasonal variations in habitat use by fish species.

This study provides important new data on habitats and fish biodiversity within Port Stephens, which should be used to inform future zoning reviews for the Port Stephens- Great Lakes Marine Park. Improved zoning will ensure a better level of protection for sub-tidal habitats within the Eastern Port of Port

Stephens, and thereby help to preserve biodiversity of the fish species that occur within, and rely upon, these habitats for food and shelter.