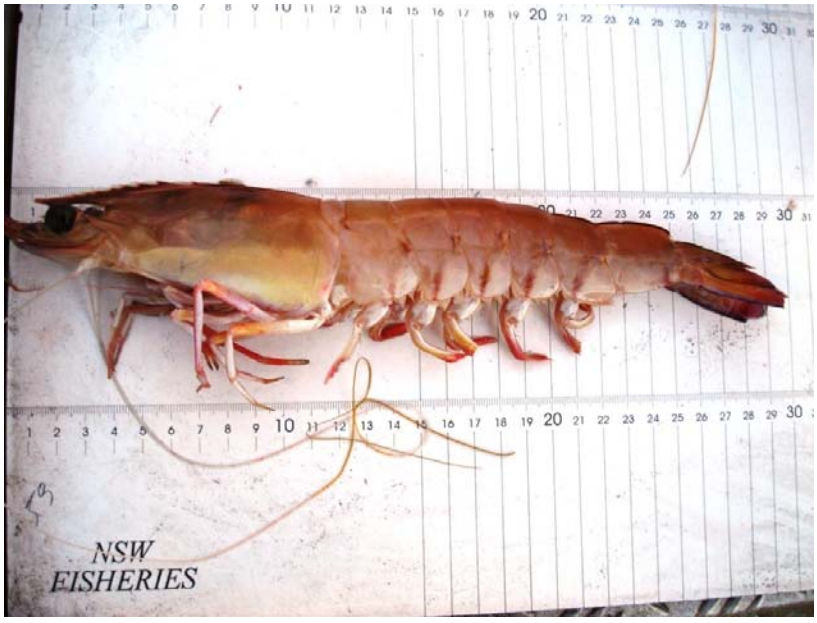
NSW GOVERNMENT
Department of Primary Industries

Estuarine Habitat: Fishery Linkages and Implications for Habitat Restoration Workshop

A report for participants



Published by the NSW Department of Primary Industries (NSW DPI)

Estuarine Habitat: Fishery Linkages and Implications for Habitat Restoration Workshop. A report for participants.

First published February 2018

More information

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Acknowledgments

This report summarises a workshop which presented the research findings of a NSW DPI and University of Newcastle (UoN) research team comprising Matthew Taylor, (NSW DPI), Alistair Becker (NSW DPI), Troy Gaston (UoN), Vincent Raoult (UoN) and Craig Hart (UoN). The workshop was coordinated by Charlotte Jenkins and Kylie Russell (NSW DPI) and chaired by Craig Copeland (NSW DPI).

[Front Cover Image: Will MacBeth, Back Cover Images: NSW DPI]

Foreword

The Estuarine Habitat: Fishery Linkages and Implications for Habitat Restoration Workshop was hosted by NSW DPI and the University of Newcastle on 12 October 2017. The workshop was the culmination of a project started in response to a lack of detailed information about the links between Eastern King Prawn (EKP) and estuarine habitat in NSW. The EKP fishery is one of the most valuable fisheries in NSW. Despite the significance of EKP fisheries in NSW, little was known of their ecology during the estuarine juvenile stages in NSW or about how habitat change has affected productivity.

It has been known for some time that EKP spawn at sea, the larvae drift south on the East Australian Current before moving into coastal estuaries. The tiny prawns spend some months growing in the estuary, before heading out to sea and swimming north; where they continue their growth to full maturity and complete the life cycle.
However, until now there has been little detail about which parts of the estuary are more important to young EKP. Where do they live? What do they feed on? Are mangroves, seagrass, salt marsh or unvegetated habitats more important; or are they all just as critical? Are some river systems more important than others?

The project was a three year study at sites in the Hunter River, Lake Macquarie and the Clarence River. The Fisheries Research and Development Corporation on behalf of the Australian Government provided funding for this work, with the interest, involvement and support of the commercial EKP fishing industry via the Newcastle Commercial Fisherman's Co-operative. A number of other project partners provided additional support to the research program, including Hunter Water, Newcastle Ports Corporation, Origin Energy, Hunter Local Land Services, North Coast Local Land Services, Professional Fisherman's Association, OceanWatch Australia and research partner University of Newcastle.

The workshop was attended by nearly 60 delegates from various State and Local Government agencies, research institutions, Non-Government Organisations and key stakeholders including professional fishers. Special thanks to Dr Troy Gaston for assisting in the organisation of the event.

Contents

Workshop Program

Workshop: Estuarine Habitat

Fishery linkages and Implications for Habitat Restoration

Room X204, Newcastle University City Campus, Newcastle, 12 October 2017

Program

9.00 – 9.10	**Welcome, Workshop Introduction and Objectives** *Craig Copeland NSW DPI*
9.10 – 9.25	**The status of estuarine habitat in NSW** How the NSW coast once looked. *Kylie Russell NSW DPI*
9.25 – 9.45	**Research overview and nursery basics** An introduction to the FRDC project. Understanding nursery habitats for exploited penaeid prawns in NSW estuaries. *Matthew Taylor NSW DPI*
9.45 – 9.55	**Saltmarsh secrets** Direct usage of saltmarsh habitats by exploited species in the Hunter River. Plus insights into DIDSON work on large-bodied species. *Alistair Becker NSW DPI*
9.55 – 10.10	**Saltmarsh surprises** Direct and indirect interactions between saltmarsh habitats and commercially important penaeid shrimp. *Troy Gaston University of Newcastle*
10.10 – 10.25	**What's for lunch?** The contribution of estuarine habitats to the diets of commercially important fisheries species in the Hunter and Clarence Rivers. *Vincent Raoult University of Newcastle*
10.25 – 10.40	**Hexham Happenings** School Prawn (*Metapenaeus macleayi*) abundance and trophic relationships in the recovering Hexham wetland. *Craig Hart University of Newcastle*
10.40 – 10.55	**What's it worth?** The economic value of saltmarsh to fisheries. *Matthew Taylor NSW DPI*
10.55 – 11.00	**Finishing up** Wrapping up the workshop. Moving on from here *Craig Copeland NSW DPI*
11.00 – 11.20	**Refreshments** Followed by ***Growing the fishery! A planning session for coastal habitat restoration*** chaired by *Craig Copeland NSW DPI*

FRDC

NSW Department of Primary Industries

Growing the fishery!

A planning session for coastal habitat restoration

What is currently happening?

Existing programs, activities, management strategies, research

For example:

- Natural Infrastructure Business Case
- Marine Estate Strategy
- Global Ocean Wealth
- Hunter Flood Mitigation Scheme review
- Habitat Action Flagship Program
- Coastal Management – Coast and Estuary Grants Program

What needs to be happening?

In **Research** – what are the key emerging issues? Addressing knowledge gaps.

In **Policy** – how do we better manage the fishery/coastal resources of NSW? Is current policy adequate to face the challenge of sea level rise?

In **Management Action** – what activities are needed? On-ground and otherwise. How will they be funded?

In **Communication** – how do we foster support in the community? How do we get information out to where it matters?

The above points are for open discussion.

All session participants are invited to actively contribute to the session.

Presentation Summaries

The following is a plain English summary of each of the seven presentations delivered at the workshop. For further detail of the research and its findings please see the links to research papers published in peer reviewed journals provided where applicable. A summary of all the research findings is provided in the targeted education brochures; one for professional fishers and one for estuarine land managers (see Appendix A and B).

1: The status of estuarine habitat in NSW. How the NSW coast once looked. *Kylie Russell, NSW DPI*

This presentation provided knowledge on the importance of healthy, connected estuarine systems to fish and other aquatic organisms and the current status and health of estuaries in NSW.

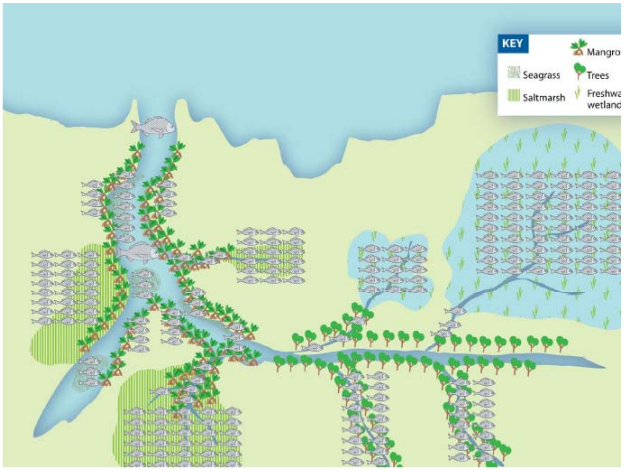
Healthy, intact estuarine habitats including seagrass beds, mangrove forests, saltmarsh, riparian zone vegetation, mud flats and floodplain wetlands which are connected to each other via the natural ebb and flow of the tide helps ensure the estuary can sustain a high carrying capacity of the aquatic organisms which it supports.

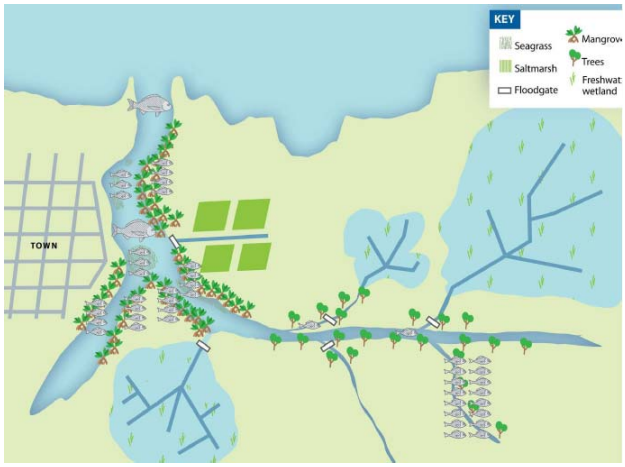
However, it is estimated that since 1950, most estuaries in southeast Australia have lost over a quarter of their saltmarsh with some estuaries losing up to 80% from anthropogenic impacts such as draining and land reclamation. Up to 60% of coastal wetlands and floodplains were lost or highly impacted by 1970. Coastal urbanisation, declines in water quality and sedimentation from catchment runoff have resulted in an 85% loss of seagrass beds in some estuaries, thousands of man-made barriers impede fish the migration patterns of native fish and ongoing grazing and clearing of riverbanks have denuded riparian zones of trees and removed the river's vital buffer which protected it from overland flow.

The cumulative result of these impacts is a heavily impacted estuarine environment that can no longer sustain a high carrying capacity for aquatic organisms.

Habitat restoration and rehabilitation efforts are starting to make positive inroads to improve estuarine habitats and assist in the recovery of native fish populations.

Figure 1: *Slides showing left, an intact, healthy estuary supporting a high carrying capacity of fish versus, right, a heavily impacted estuary supporting a low carrying capacity of fish.*





2: Research overview and nursery basics. An introduction to the FRDC project. Understanding nursery habitats for exploited penaeid prawns in NSW estuaries. *Matthew Taylor, NSW DPI*

Many penaeid prawns (e.g. Eastern King Prawn, EKP) are the subject of iconic, valuable fisheries. Prawns are highly fertile and fast growing. The prawn's basic life cycle and the importance of estuaries to juvenile prawns is widely known however there has been little detail about which parts of the estuary are more important.

The broad research objectives were to quantify estuarine habitat-fishery linkages including identifying important prawn nurseries with a particular emphasis on EKP, to a lesser degree on School Prawn, and a strong focus on saltmarsh habitat. This information was then used to estimate the monetary value of a habitat type (primarily saltmarsh) in terms of fishery productivity. Using this data it is suggested that prawns, and the value of their fishery, can be used to stimulate investment for targeted habitat restoration and rehabilitation activities.

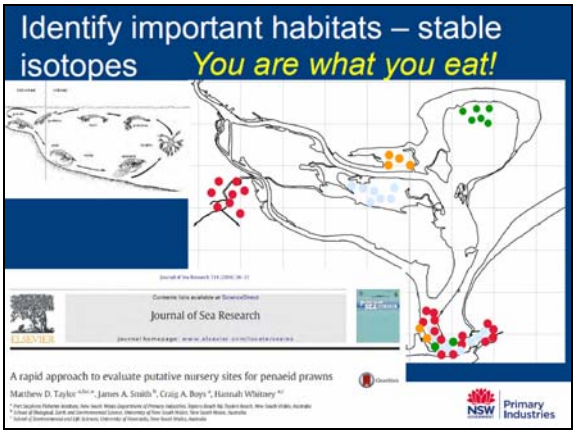
The identification of important habitat types was conducted through the analysis of stable isotopes based on the old adage – you are what you eat! Researchers were able to identify where in the estuary the prawns were sourcing their food by analysing isotopes from the prawns and comparing these against the unique isotope signatures of estuarine plants and algae.

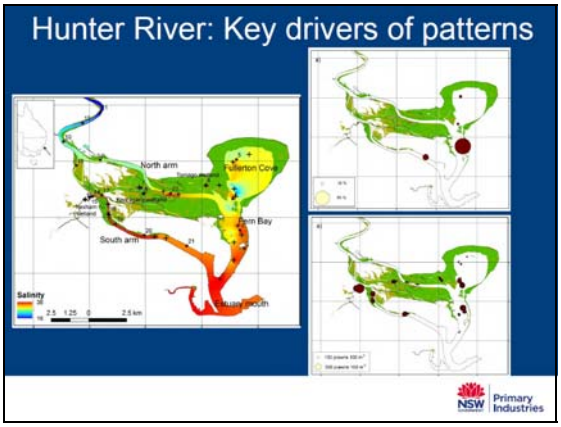
Further analysis was conducted to ascertain the factors, such as distance of habitat from the estuary mouth, salinity levels and connectivity of habitat, influencing habitat linkages.

Results for the Hunter estuary showed that:

- Recently rehabilitated saltmarsh habitats are important for school prawn.
- The connectivity of habitats supporting a supply of food plus salinity are key drivers for EKP
- The optimal salinity for juvenile EKP was found to be between 25-28 ppt.
- Hexham Wetland was found to be particularly important for EKP.
- Expansive shallow unvegetated habitat and optimal salinity are important.
- EKP demonstrated minimal use of the Kooragang Island area, perhaps highlighting this areas lack of connectivity with the river's south arm
- Freshwater inflows, while good for School Prawn, are bad for EKP

Figure 2: *Extracts from the presentation*





Further reading: Taylor, M., Smith, J. A., Boys, C. A., Whitney, H. 2016. A rapid approach to evaluate putative nursery sites for penaeid prawns. Journal of Sea Research. 114. 26-31.
http://dx.doi.org/10.1016/j.seares.2016.05.004

3: Saltmarsh secrets. Direct usage of saltmarsh habitats by exploited species in the Hunter River. Plus DIDSON work on large-bodied species. *Alistair Becker, NSW DPI*

This presentation provided a synopsis on the study in the lower Hunter River estuary into the direct usage of intertidal saltmarsh habitat by penaeids and the small sub-tidal creeks which meander through marshes. The variation in estuaries was highlighted, noting that most estuaries contain a mosaic of habitats and that not all these habitats are created equal. For example some habitats fulfil a nursery function for certain species better than others. The identification of key juvenile habitat will allow for better targeted management of estuarine habitats.

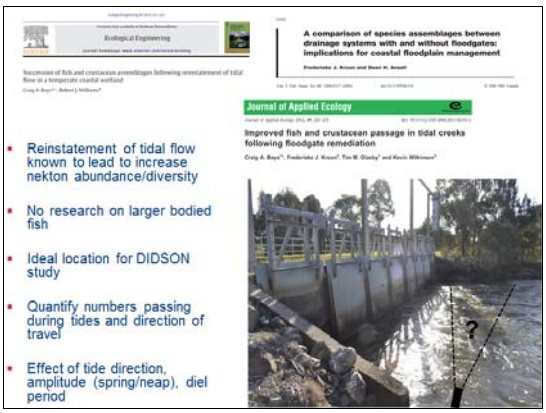
Nocturnal sampling was conducted in intertidal saltmarsh - mangrove habitats in Tomago, Kooragang and Hexham wetlands using fyke nets and in sub-tidal creeks using cast nets. The key findings were explained: intertidal marshes which are only fully inundated during the Spring tide cycle (approximately 30 hours during a lunar month) discharged 12,575 nekton (actively swimming aquatic animals), 50% of which were Freshwater Prawn (*Macrobrachium*). Only eight EKP were captured and 90 School Prawn, providing minimal evidence to support the direct usage of intertidal saltmarshes by these species. Results were consistent across all three wetlands.

In the subtidal creeks, relatively similar abundances of EKP and school prawn were sampled at the edges compared to the middle of the creeks, with densities in a similar range to that previously described from other studies. Collectively there was a high abundance of crustaceans from these habitats. These findings show that although there are penaeids in the system they do not appear to be directly using these habitats in the Hunter estuary.

The researchers were unable to make a direct comparison between the numbers on the marsh to the numbers in the creek due to differences in the sampling methods used. However, the ratio of EKP to School Prawn in the creeks was similar to that found in the intertidal marsh.

The presentation also described a future project which will utilise DIDSON (Dual frequency IDentification SONar) technology to look at fish behaviour and movements. This underwater camera creates video using sound as opposed to light which allows video to be recorded from highly turbid waters (such as estuaries) or at night time with no loss in quality of the footage. The researchers will be placing the DIDSON at floodgates on wetland systems to directly observe and quantify the passage of fish into the wetlands during different stages of the tidal cycle. Recent research has demonstrated that the reinstatement of tidal flow has led to an increase in nekton abundance and diversity in these study wetlands, however no research has been conducted on larger bodied fish.

Figure 3: *Extracts from the presentation*



Further reading: Becker, A & Taylor, M .D., 2017. Nocturnal sampling reveals usage patterns of intertidal marsh and subtidal creeks by penaeid shrimp and other nekton in south-eastern Australia. Mar and Freshwater Res. 68, 780-787

4: Saltmarsh surprises. Direct and indirect interactions between saltmarsh habitats and commercially important penaeid shrimp. *Troy Gaston, UoN*

This presentation described the work conducted in the Clarence River to quantify the direct and indirect interactions between penaeids and habitat in that river system, and answer questions such as where are these organisms living and what food are they relying on. The different habitat types within the Clarence River estuary were highlighted including saltmarsh, mangroves and seagrass, but also the importance of mud and the green 'slime' (Fine Benthic Organic Matter) present on this mud.

The project's aims and relevant methods were described:

1. Undertake a broad-scale assessment of the contribution of several areas across the lower estuary to the adult EKP stock via stable isotope (chemical signature) analysis to identify what areas prawns were coming from.
2. Estimate EKP densities supported by different habitat types in the lower estuary via sled tow sampling at 20 sites across the estuary then mapping software to plot densities.
3. Determine the contribution of primary production to EKP in the lower estuary. Using the results from aim 1, four main areas in the estuary were sampled and the stable isotopes in all available food sources in these areas were analysed to identify what foods the prawns had taken nutrition from.

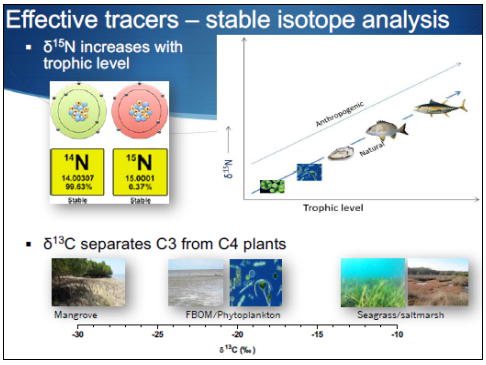
The key findings provided the following conclusions:

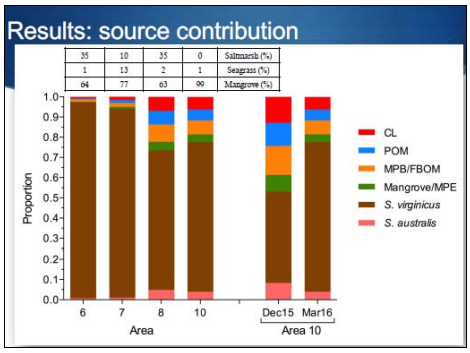
- EKP were the most abundant of benthic organisms sampled.
- The lower estuary was identified as the most important.
- Shallow unvegetated subtidal sediment is an important habitat type but mangrove and saltmarsh adjacent to these habitats and the connectivity between these are still important.

The findings demonstrated that prawn recruitment is driven by where these habitats are located. Saltmarsh featured highly in EKP diet (up to 97% in prawns sampled from certain areas) and was described as 'disproportionately' important to EKP. Carbon from saltmarsh is mobile in an estuarine system due to the daily influx and egress of the tide. Mangrove did not show up as a strong nutritional source for prawns.

The presenter concluded that there are significant implications for these findings in the future management of estuarine habitat including the targeted protection and restoration of saltmarsh in the Clarence River estuary.

Figure 4: *Extracts from the presentation*





Further reading: Taylor, M .D., Becker, A., Moltschaniwskyj, N.A., Gaston, T. F. 2017. Direct and indirect interactions between lower estuarine mangrove and saltmarsh habitats and a commercially important Penaeid shrimp. Estuaries and Coasts. DOI 10.1007/s12237-017-0326-y

5: What's for lunch? The contribution of estuarine habitats to the diets of commercially important fisheries species in the Hunter and Clarence Rivers. *Vincent Raoult, UoN*

(At time of writing the findings from the Clarence River and some from the Hunter River are in preparation, therefore only a selection of those from the Hunter study are summarised here)

This presentation provided an insight into the contribution of estuarine habitats in the Hunter River estuary to other commercially important species including Sea Mullet and Yellowfin Bream in the context of energy provision through food availability.

The presenter highlighted that by understanding where a fish's energy is coming from then effectively, if you restore those habitats, you can increase food availability for those organisms and potentially increase productivity in response.

The project's aim was to determine the contribution of primary producers (mangroves, seagrass, saltmarsh, epiphytes and phytoplankton) to commercial fisheries in the Hunter River i.e. what habitat/plants do these fishes get the bulk of their energy from?

The method for addressing this aim was described, which included sampling commercially caught fish from around Fern Bay in the lower estuary, and analysing stable isotopes from the muscle tissue of these fishes and then comparing the analysis to that from primary producers. Using a model, the contribution of each primary producer to nutrition in each commercial species sampled was identified.

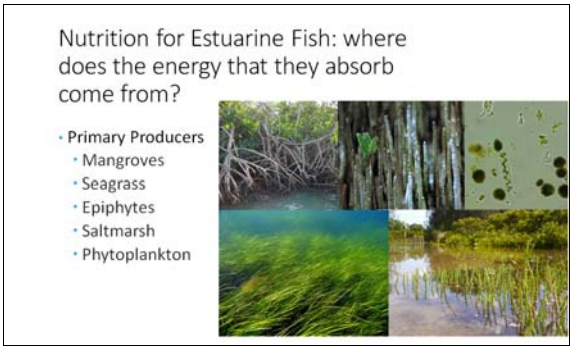
Key features of the Hunter River estuary were described: it has the largest wetland system in coastal NSW, it has a strong dominance of mangroves, it has some saltmarsh but there is no seagrass. There are also a large number of restoration efforts underway in this system.

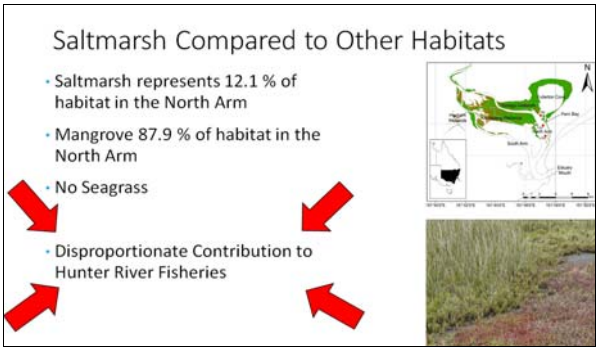
The findings presented showed that although saltmarsh only represents a small amount of the aerial coverage of habitat in the Hunter estuary (12.1% compared to mangrove 87%), it provides a disproportionately large contribution of the energy absorbed by many commercially important fish species in the Hunter River.

These findings differ from other studies which largely reported seagrass provided the highest contribution to diet and generally found a low contribution from saltmarsh. It was explained that there is a potential overlap in the chemical signatures of seagrass and saltmarsh, however, with the Hunter lacking seagrass the researchers could confidently identify the chemical signatures reported in this study came from the saltmarsh.

The presenter concluded that saltmarsh is providing a significant amount of nutrients for fisheries species in the Hunter River. Further study is underway to identify if saltmarsh is providing a food substitute for seagrass in systems where seagrass beds are limited and to separate the isotopes signatures of these different plants. The implication of saltmarsh restoration having a positive flow on benefit for commercial fisheries production was highlighted.

Figure 5: *Extracts from the presentation*





6: Hexham Happenings. School Prawn (*Metapenaeus macleayi*) abundance and trophic relationships in the recovering Hexham wetland. *Craig Hart, UoN*

This presentation provided a synopsis of a study to quantify School Prawn (*Metapenaeus macleayi*) abundance and the drivers of those abundance patterns within Ironbark Creek, Hexham wetland in the lower Hunter River estuary. The School Prawn (SP) fishery is the fifth largest catch in NSW however numbers have declined by 25% since the 1970s.

The presenter highlighted the importance of estuarine wetlands to commercial and recreational fisheries in Australia and specifically the key ecological role of saltmarsh habitat in the provision of nursery habitat for Penaeidae, such as SP. Human disturbance on coastal wetlands has been significant, demonstrated by a 50% decline in global saltmarshes. The installation of floodgates on Ironbark Creek as part of flood mitigation efforts during the 1970s led to the degradation of Hexham wetland and wetland habitat and the reduction in abundance and diversity of valuable commercial and recreational fish and crustacean species.

In 2008 the Hexham Swamp Rehabilitation Project was launched which included remediation of the Ironbark Creek floodgates to restore tidal flushing to the wetland. Previous studies have sampled juvenile fish and crustacean populations both up and downstream of the floodgates however, until now the quantification of fisheries value has not been conducted.

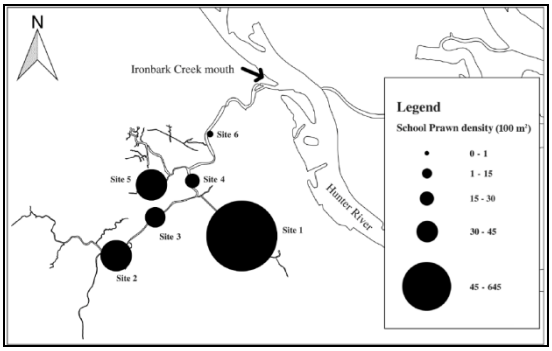
The study aimed to determine the spatial variability in density of commercially important SP populations within the Hexham wetland. If the restoration effort has been successful in increasing juvenile SP populations, then it was anticipated there should have been a high abundance in the tidal creeks throughout the wetland. The study's data could be used to provide industry and fisheries with estimates in population value, and managers with an assessment of wetland repair to support investment in further repair activities.

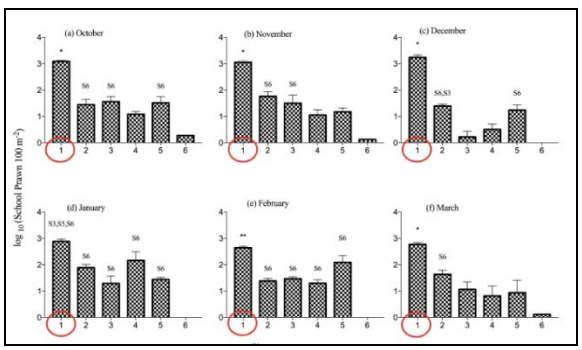
Sampling was conducted using a modified seine net at 6 sites in Ironbark Creek over a period of 6 months. The findings showed juvenile SP density levels greater than any previous study undertaken in the area. However, the results also showed a highly disproportionate abundance across sites, yet consistent across the monthly sampling events. For example, site 1 had the largest SP abundance, yet the lowest dietary proportion of the saltmarsh plant *Sporobolus virginicus*. Dietary sources including mangrove and

This difference may relate to the dominance of *P. australis*, and the scarcity of mangrove and saltmarsh plants at site 1 compared to other sites.

The presenter concluded that the study has shown the likelihood that Hexham wetland may be contributing strongly to annual SP recruitment within the Hunter River and demonstrates the importance of conservation and restoration effort to the wetland. As the recovery of Hexham wetland continues the benefits to estuarine species throughout the entire Hunter River is likely to increase. Ongoing sampling of the population was recommended and further investigations into water quality and hydrological flow to better understand associated impacts within the wetland.

Figure 6: *Extracts from the presentation*





7: What's it worth? The economic value of saltmarsh to fisheries. *Matthew Taylor, NSW DPI*

This presentation provided a synopsis of how the research outcomes were extended to estimate the potential economic value of estuarine habitat and benefits from its restoration.

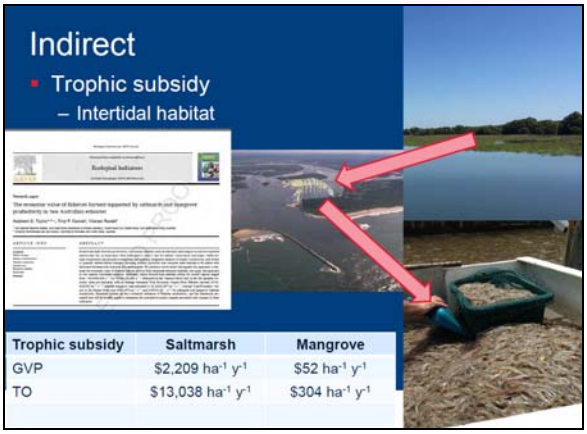
The researcher's data on contributions of saltmarsh and mangrove to the biomass of penaeid shrimp (and other fish species) as modelled from stable isotope composition for the Hunter and Clarence estuaries, was used to apportion the commercial harvest biomass that was derived from each of these habitats. Using a complex equation they then used a simple market value for each species at first-point-of-sale to establish the Gross Value of Production. Using an economic multiplier, this Gross Value of Production could then be converted to Total Economic Output (i.e. the potential economic value).

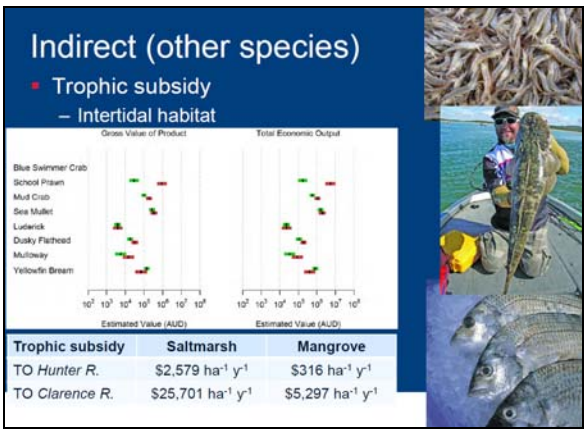
The model enabled the identification of quantifiable direct (recruitment) and indirect (trophic) linkages of different estuarine habitat types. Significantly, these results provided an avenue for the determination of estimates of the monetary value associated with estuarine habitats in NSW to be calculated for the first time.

Here's what they found:

- Saltmarsh in the Clarence River had by far the greatest economic value per unit-area, with an average estimated Total Economic Output (from fisheries harvest) of over $25,000 per hectare per year, whereas mangrove was estimated to be approximately $5,000 per hectare per year.
- The Average Total Economic Output in the Hunter River was approximately $2,500 per hectare per year for saltmarsh and just over $300 per hectare per year for mangrove habitats.
- The value of trophic subsidy appears to be greater than recruitment subsidy.
- Restoration and rehabilitation activities will enhance both trophic and recruitment subsidies. These activities have the potential to result in a commensurate revenue increase for the fishery of tens of thousands of dollars per hectare per year.

Figure 7: *Extracts from the presentation*





Further reading: Taylor, M.D., Gaston, T and Raoult V. 2018. *The economic value of fisheries harvest supported from saltmarsh and mangrove productivity in two temperate Australian estuaries*. Ecological Indicators. 84. 701-709. http://dx.doi.org/10.1016/j.ecolind.2017.08.044

Feedback from the Growing the Fishery Planning Session for Coastal Habitat Restoration

As a direct consequence of the research project's significant findings, the project's extension staff recognized the potential opportunity the workshop presented to translate the findings into current and projected management actions for the NSW coast.

The following information is collated contributions provided by workshop participants based on a series of discussion points developed by the workshop coordinators.

What is currently happening? (Existing programs, activities, management strategies, research, and resources)

- Marine Estate Management Strategy – a new approach to managing the marine estate in NSW as a single continuous system for the greatest well-being of the community. It aims to maximise current and future economic, social and environmental benefits of the Marine Estate.
- Natural Infrastructure Business Case – NSW DPI led Business Case development with consultants KPMG. If successful the Business Case will support the delivery of significant on-ground investment in estuarine habitat restoration that would both benefit the Marine Estate but also the Government's Strategic Plan for addressing climate change.
- Global Mapping Ocean Wealth project – funded by The Nature Conservancy, seeks to put a value on marine habitats and gain an insight into the value people gain from the natural environment and improve management strategies.
- Lower Hunter Flood Mitigation Scheme (LHFMS) review – review of the scheme which was designed in direct response to the 1955 flood. The review will look at the costs and benefits of the current management of the LHFMS from a triple bottom-line perspective, including the environmental impacts.
- Habitat Action Flagship Program – investment from the NSW Recreational Fishing Trust administered by Aquatic Habitat Rehabilitation, NSW DPI
- Coastal Management – Coast and Estuary Grants Program, significant investment in improved management actions in NSW estuaries for local Councils with an approved Estuary/Coastal Zone Management Plan.
- Hunter focus workshop on Estuarine Vegetation Migration predictions in the Lower Hunter Estuary due to Climate Change and implications for restoration, land tenure, and RAMSAR values of the estuary.
- Water Research Laboratory research on estuarine salt plumes.
- Blue Carbon, provision of potential incentives to retire areas of land for saltmarsh accretion.
- Biodiversity Conservation Act and the implications for biodiversity offsets in State Significant Developments.
- Infrastructure Investment Program – significant investment from the Australian Government to boost economic growth and prosperity, increase productivity and support thousands of jobs.

- National Landcare Program - the Australian Government's commitment to protect and conserve Australia's water, soil, plants, animals and ecosystems, as well as support the productive and sustainable use of these valuable resources.
- Updated habitat mapping of coastal estuaries, such as marine vegetation, being undertaken by Aquatic Ecosystem, NSW DPI
- Community networks, links to Citizen Science and large potential for targeted communication opportunities e.g. Australian Mangrove and Saltmarsh Network, Seagrass Watch.
- Local Government Environmental Levies – introduction of rate rises in the form of an Environmental Levy to allow targeted investment in a local government area's natural environment e.g. Ballina Shire Council.

What needs to be happening?

In **Research** – what are the key emerging issues? Addressing knowledge gaps.

- Quantifying the total ecosystem service benefits of investing in estuarine habitat restoration and rehabilitation activities.
- Studies to ascertain the full impact of restoring tidal flows to historic floodplain wetlands e.g. Fullerton Cove
- Prioritisation assessment of coastal catchments to identify critical areas for best outcome of strategic investment.
- Social mapping – identify the key stakeholders, social structure, groups and organisations in a region to support the development of targeted participation tools and resources
- Additional estuarine habitat-fishery linkages research. Each coastal system operates differently as demonstrated by the research outcomes presented at this workshop, e.g. Clarence versus Hunter.
- Quantification of social and cultural benefits from estuaries and estuarine habitat.
- Identification of each estuary's relative contribution to fishery production (New Zealand example provided, which demonstrated that not all estuaries are equal) and the implications of this for targeting investment in restoration and rehabilitation activities.
- Species specific migration history e.g. research on Mulloway analysing elemental chemistry of otoliths. Valuable knowledge to assist in targeted stakeholder engagement.
- Nutrient plume size versus estuary size.

In **Policy** – how do we better manage the fishery/coastal resources of NSW? Is current policy adequate to face the challenge of sea level rise?

- Review of Estuary Management Plans provides an opportunity for updating a plan to enhance or modify management actions as new knowledge and information becomes available. Issues regarding getting Plans approved were raised.
- Saltmarsh on private land is currently not protected under the Fisheries Management Act 1994. Saltmarsh on public (Crown) land is covered.
- Foreshore structure contractors identified as not following recommended processes. Registry of preferred i.e. trained, contractors recommended.

- The objects of the Water Management Act 2000 are to provide for the sustainable and integrated management of the water sources of NSW. Chapter 2, Part 3, Division 4 of the Act (in s26(c)) provides for the development of Drainage Management Plans that must deal with the ecological impacts and impacts on water quality of drainage works, however these parts of the Act are not 'turned on'.

In **Management Action** – what activities are needed, on-ground/other? How will they be funded?

- Whole-of-system approach to floodplain management based on the model recently employed in the Shoalhaven estuary. Identification of critical sub-catchments coupled with strategic focus of rehabilitation efforts.
- Further improvements of tidal flow to the Hexham Swam complex e.g. removal of the earthen block bank dam at the historic Iron Bark Creek outlet.
- Acknowledgment of the cultural connectivity to landscapes and the adoption of inclusive consultation and working parties in management action initiatives. This was highlighted as having a positive flow-on effect in garnering support for ongoing maintenance of on-ground works.
- Enhanced engagement of industry in management action programs e.g. aquaculture and commercial fisheries. The Wallis Lake project working with local oyster farmers was highlighted as a good example.

In **Communication** – how do we foster support in the community? How do we get information out to where it matters?

- Improved capacity building in floodplain land managers e.g. farmers for the benefits of active floodgate management
- Enhanced knowledge of social structure in a community – translating social mapping data into improved communication with key stakeholders and the general public.
- Support for the commercial and recreational sectors to demonstrate shared benefits for both groups. The model of the NSW Fish Habitat Partnership was mentioned as a demonstration of the willingness of different parties to come together for shared beneficial outcomes.

Workshop images and feedback

Feedback from the Workshop included:

"Great gathering this morning! Very interesting and couldn't be more timely with the current emphasis on business cases. Thank you for all the effort getting the research results presented today and also for what would have been years of work getting this research designed, funded and completed. I look forward to seeing the story version suitable for reading by the executive!"

"This morning was fantastic – thanks again."

"I just wanted to send through my feedback on the workshop last week. The workshop was really well facilitated and was a great opportunity to gain insight to the current research by DPI and the University of Newcastle. It was also beneficial to collectively discuss industry challenges and opportunities in the planning session. Please pass on my thanks to those involved and providing the valuable opportunity. "

Attachments

Work shop handouts –

a) EKP Research Summary Product for Land Managers

Eastern King Prawn Habitat

Managing land to grow more prawns

Photo credits: left, Doug Beckers; middle, Scott Nichols; right, Matt Taylor.

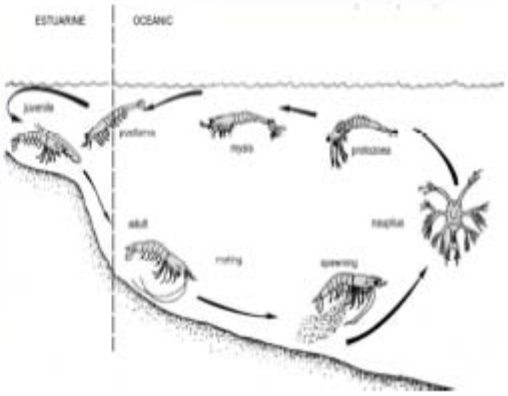
We now know more than ever about the ways in which healthy habitat and good quality water benefit Eastern King Prawn, helping them survive adversity and thrive in the good times. In NSW, the Clarence, Hunter and Lake Macquarie estuaries are particularly important for Eastern King Prawn. All of these estuaries have lost some of the essential habitat that helps sustain prawn populations, however, in recent years work has started to repair the damage and return important areas to a more natural state. Prawns are just starting to take advantage of these improved conditions, which is good news for the prawns, the commercial fishery and the local coastal communities they support.

The most important habitat for juvenile Eastern King Prawn (EKP) is the estuary. Juvenile prawns depend on nursery areas in estuaries to grow to adulthood, before moving out to sea to complete their life cycle. The healthier the mangrove and saltmarsh habitat the greater the carrying capacity of the estuary to support and grow more prawns. However, until now there has been little detail about which parts of the estuary are more important to young EKP. Researchers have spent several years using a combination of methods, including specialised research sled nets and chemical 'signatures', to identify where the prawns came from, what they had been eating and where their food was from. This is what they found out.

Good juvenile EKP habitat

- An estuary has different areas that are potential habitat for juvenile EKP. Where EKP are found depends on currents, salinity, and food availability.
- Ideal habitat areas have a supply of food, the salinity isn't too low, and the temperature isn't too cold.
- Shallow sand flats with low currents and marsh channels that are submerged across all tides are ideal. In some estuaries, the juveniles are more abundant along the littoral zone of shallow, muddy creeks near mangroves, while in others they were found mainly on seagrass beds.
- Stable temperature and salinity are best. Rapid declines in temperature and salinity levels, such as what can happen during flood events, can result in juveniles dying and any survivors generally don't grow well.
- Young EKP have a varied diet, eating plant material, crustaceans, microorganisms, small shellfish, and worms. Much of their nutrition is derived from saltmarsh habitats and is transported to the subtidal waters where the prawns live.
- Estuaries need to be connected to wetlands, saltmarsh areas and floodplains. Cutting-off tidal flows and draining wetlands reduces food availability and has had a significant impact on EKP populations. Restoration of more natural tidal flows is having a positive impact on EKP.

Eastern King Prawn (EKP) spawn at sea in waters off northern NSW and southern Queensland. The larvae develop as they drift south on the East Australian Current before moving into coastal estuaries. The tiny prawns spend 2 to 3 months over summer growing in the estuary, before heading back out to sea and swimming northwards; where they continue their growth to full maturity and complete the breeding cycle.



Supported by good land management

Understanding the nursery value of different areas within an estuary, and the processes that make some areas more valuable than others, allows managers to:

1) prioritise areas for rehabilitation that are likely to result in the greatest benefits for EKP

2) consider factors that may increase nursery value when engineering rehabilitation works

3) estimate the potential outcomes of different rehabilitation scenarios.

Keep it all connected

- **Hydrological connectivity** in estuaries needs to be maintained or restored. This includes both connections along creeks and rivers to the ocean, and connections to floodplain wetlands, both saltwater and freshwater.
- **Tidal flow** should be as natural as possible. Tidal flushing ensures food supply from saltmarsh and mangroves, helps maintain stable salinity, and enables prawns to move into and out of habitats as their suitability changes or as the prawns' needs change.

Protect Seagrass

- Reduce the impacts of **marine infrastructure** on seagrass beds. For example, replace traditional moorings with environmentally friendly designs to reduce scour.
- **Water quality** affects seagrass. Good quality water means less algal growth on the seagrass, higher productivity and greater resilience to flood and other adverse events.
- Turbidity and sedimentation can reduce the productivity of seagrass. Fencing waterways to better manage livestock access, controlling erosion and managing urban stormwater helps **reduce sedimentation** and nutrient loads to the estuary.

Give Saltmarsh room

- Saltmarsh **wetlands** are an important source of food for juvenile EKP. These areas also protect estuary foreshores by absorbing the energy of wind and wave action and providing a natural buffer that helps minimise erosion and play a major role in carbon sequestration.
- As sea level rises, **mangroves** and saltmarsh migrate landward. Areas where these plants can retreat, with sea level rise need to be identified and protected to allow mangroves and saltmarsh to adapt.

Saltmarsh has a significant economic value. For example, in the Clarence River, the fisheries harvest derived from saltmarsh productivity is around $25,000 per hectare per year.

Case study: The Hunter – rehabilitation in action

Shallow estuarine areas in the lower estuary are high value habitat for juvenile EKP, highlighting the likely impact of the extensive loss of this habitat through land reclamation. Before floodgates were installed in the early 1970s, Hexham swamp was considered to be the main EKP nursery for the Hunter River and as far as Brisbane. In the 1920s, locals saw a stream of EKP 50cm wide and 50cm deep coming past the Heads and out to sea for over 7 miles towards the north. Between the 1950s and 1990s, approximately 21 ha of channel habitat and 1426 ha of saltmarsh were lost in the lower Hunter. This could equate to a loss of 100,000 to 500,000 emigrating prawns each year.

Rehabilitation projects have been restoring hydrological connectivity of saltmarsh and mangrove habitats to the estuary, thus allowing tidal flushing and recruitment of important species.

Monitoring indicates that prawns are moving into the recently rehabilitated habitat around Hexham with the reopening of the floodgates on Ironbark Creek. When the floodgates were closed, the numbers of EKP were negligible. Commercial catches increased after the first gate was opened and have further increased now that all the floodgates are open.

EKP are being found much further into the tributary, with strong recruitment occurring. This provides the first clear demonstration of the impact of restoring connectivity with estuarine wetlands for commercial species of prawns in New South Wales.

Researchers used a combination of methods to understand where the prawns were in each of the estuaries, and what they had been eating. Specialised research sled nets were used to capture early juvenile prawns. Researchers were able to identify where in the estuary the prawns were sourcing their food by analysing isotopes from the prawns and comparing these against the unique isotope signatures of plants and algae that grow within the estuary.

About the project

Commercial fishers have provided many anecdotal reports of the extensive use of estuarine swamps by young EKP prior to wetland degradation, and of the adverse effects of freshwater inundation and lowering of salinity in estuarine nurseries on the growth and abundance of prawns. However there has been a lack of quantitative research on the early estuarine stages of EKP in NSW to support this. Quantitative knowledge on the use of estuarine nurseries by EKP is essential to accurately value coastal wetland habitats, and assess the benefits of rehabilitation.

This project is supported by funding from the Fisheries Research and Development Corporation on behalf of the Australian Government, with significant in-kind support from NSW Department of Primary Industries. Additional funding is being provided by the Hunter and the North Coast Local Land Services, as well as Hunter Water, the Newcastle Ports Corporation, and Origin Energy. The project is supported by the NSW Professional Fisherman's Association, the Newcastle Commercial Fishermen's Co-operative and OceanWatch.

The results of the research are summarised in the Project Updates and detailed methods and data have been published in scientific journals. Both the updates and details of the papers published are available on the project website, www.dpi.nsw.gov.au/fishing/habitat/rehabilitating/ekp, or contact Dr Matt Taylor, NSW DPI Fisheries.

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b) EKP Research Summary Product for Commercial Fishers

Eastern King Prawn Habitat

Growing your fishery, naturally

We now know more than ever about the ways in which healthy habitat and good quality water benefit Eastern King Prawn, help them survive adversity and thrive in the good times. This resilience will help sustain an important commercial fishing industry and provide consumers with a much-loved seafood.

The most important habitat for Eastern King Prawn (EKP) is the estuary. In recent years, work has started to repair estuaries and return them to a more natural state. Prawns are just starting to take advantage of these improved conditions, which is good news for the prawns, the commercial fishers and local towns involved in the prawn fishery. Researchers have spent several years using a combination of methods, including specialised research sled nets and chemical 'signatures', to identify where the prawns came from, what they had been eating and where their food was from. This is what they found out.

- *Food + not too much freshwater + warm water is ideal.*
- *Rapid declines in temperature and salinity are not good.*
- *An estuary is not one big habitat: prawns live in the patches where conditions are favourable.*
- *Much of the food eaten by juveniles is coming from saltmarsh habitats.*

Good juvenile EKP habitat

- Ideal habitat areas are places within estuaries where there is a supply of food, the salinity isn't too low, and the temperature isn't too cold. Shallow sand flats with low currents and marsh channels that are submerged across all tides are ideal, particularly in the lower estuary.

- Stable temperature and salinity are best. Juvenile EKP do not like rapid declines in temperature and salinity levels, such as what can happen during flood events. More tend to die and the survivors generally don't grow well. This helps explain why commercial fishers tend to notice fewer, and smaller, EKP in wetter years.

- An estuary has many different habitats. Where EKP are found seems to depend on currents, salinity, and food availability.

- In some estuaries, the juveniles are more abundant along the edges of shallow, muddy creeks near mangroves, while in others they were found mainly on seagrass beds.

- Young EKP have a varied diet, eating plant material, crustaceans, microorganisms, small shellfish, and worms. Much of their nutrition is derived from saltmarsh habitats and is transported to the subtidal waters where the prawns live.

- Estuaries need to be connected to wetlands, saltmarsh areas and floodplains. Cutting-off tidal flows and draining wetlands reduces food availability, which can impact on EKP populations. Restoration of more natural tidal flows is producing benefits for juvenile EKP.

The Hunter – rehabilitation in action

The contribution of the Hunter River estuary as a juvenile EKP nursery depends on the area of habitat available. Shallow estuarine areas in the lower estuary are of high value, highlighting the likely impact of the extensive loss of this habitat through land reclamation. In the lower Hunter, approximately 21 ha of channel habitat and 1426 ha of saltmarsh were lost between the 1950s and 1990s. This could equate to a loss of several hundred thousand emigrating prawns each year. Rehabilitation projects have been reconnecting marsh and mangrove habitats to the estuary, thus allowing tidal flushing, restoration of saltmarsh and recruitment of important species. Monitoring indicates that prawns are moving into rehabilitated habitat around Hexham with the reopening of the floodgates on Ironbark Creek. When the floodgates were closed, the numbers of EKP were negligible. Catches increased after the first gate was opened and have further increased now that all the floodgates are open.

EKP are now being found much further into the tributary, with strong recruitment occurring. This is significant because it provides the first clear demonstration of the impact of restoring connectivity with estuarine wetlands for commercial species of prawns in New South Wales.

Before floodgates were installed in the early 1970s, Hexham swamp was considered to be the main EKP nursery for the Hunter River and beyond, even as far as Brisbane. In the 1920s, locals saw a stream of EKP 50cm wide and 50cm deep coming past the Heads and out to sea for over 7 miles towards the north.

The Clarence Estuary – the importance of Saltmarsh

Juvenile EKP were found 8-12 km from the mouth of the estuary in the main channel and north arm. Important areas were adjacent to saltmarsh and mangrove habitats in this region of the estuary. Saltmarsh grass was the dominant source of food supporting the growth of juvenile EKP, and mangroves were not as important for providing food. The areas of saltmarsh and seagrass in this estuary have both decreased substantially due to development. 64% of all saltmarsh has been lost - just 290 ha remain.

There were very few EKP found in the southern channels of the estuary, despite there being abundant habitat and appropriate salinity. This could be because these areas are not well connected to incoming tides due to a large training wall. There is suitable habitat and more natural tidal flow could boost the local EKP population.

Saltmarsh in the Clarence River has a significant economic value. The fisheries harvest coming from saltmarsh productivity yields around $25,000 per hectare per year.

The distribution of mangrove (green) and saltmarsh (yellow) in 2009 (top) compared to 1942 (bottom) near the mouth of the Clarence River.

Lake Macquarie – wind and seagrass

In Lake Macquarie, there is an abundance of seagrass important for juvenile EKP. However, seagrass beds in the northern basin received greater numbers of recruits than other areas. The supply of recruits was greatest in several shallow seagrass covered embayments on the eastern edge of the estuary, about 2 –3 km past the end of the entrance channel. EKP were largely absent from the south-western area of the lake. Very young EKP initially enter the system on the flood tide and are carried along the entrance channel by the strong tidal currents. At the end of the entrance channel, the wind conditions during the recruitment season transport the prawns from the end of the entrance channel into the northern basin. So, both wind and tide are important factors influencing which habitat areas in Lake Macquarie the prawns use. Habitat rehabilitation efforts do not usually take drivers of connectivity like seasonal wind into account. For the EKP, seagrass rehabilitation efforts (such as replacement of swing moorings with seagrass friendly moorings) could prioritise areas between 6 and 9 km from the estuary mouth to maximise any benefits for EKP.

Researchers used a combination of methods to understand where the prawns were in each of the estuaries, and what they had been eating. Specialised research sled nets were used to capture early juvenile prawns. Researchers were able to identify where in the estuary the prawns were sourcing their food by analysing isotopes from the prawns and comparing these against the unique isotope signatures of plants and algae that grow within the estuary.

About the project

Fishers have provided many anecdotal reports of the extensive use of estuarine swamps by young EKP prior to wetland degradation, and of the adverse effects of freshwater inundation and lowering of salinity in estuarine nurseries on the growth and abundance of prawns. However there has been a lack of quantitative research on the early estuarine stages of EKP in NSW to support this. Quantitative knowledge on the use of estuarine nurseries by EKP is essential to accurately value coastal wetland habitats, and assess the benefits of rehabilitation.

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