IMOS Integrated Marine Observing System
Animal Tracking Facility

sims sydney institute of marine science

IMOS ATF Acoustic Receiver Loan

Mid-term Report

Date: 19/12/2018

1. Project Title

Effects of food provisioning on smooth stingrays (*Bathytoshia brevicaudata*)
&
Using acoustic telemetry to improve marine reserve design: quantifying multi-species movement patterns in an open coastal environment.

2. Authors

Stingray Provisioning
Project leader: Joni Pini-Fitzsimmons
Supervisors: Dr Nathan A. Knott & Prof. Culum Brown

Multi-Species Movement Patterns
Project leaders: Daniel Swadling & Kye Adams
Supervisors: Prof. Andy Davis, Dr Matt Taylor & Dr Nathan A. Knott.

3. Project Summary

Stingray Provisioning

Food provisioning can have considerable long-term negative impacts on wildlife. It is accepted practice for recreational anglers to discard fish waste into waterways from fish cleaning facilities. Many species, including a range of bird and fish species, forage on these discards, but there has been no assessment of the potential impacts. Importantly, an increased number of fish cleaning facilities are being built to support recreational fishing [1] in the absence of such data. Smooth stingrays (*Bathytoshia brevicaudata*) are common scavengers of fish cleaning waste at boat ramps around Australia. For example, at the Woollamia boat ramp in Jervis Bay, NSW, smooth stingrays have been provisioned fish waste from recreational fish cleaning for over 30 years. In our pilot study, behavioural observations supported by preliminary acoustic tracking showed even this moderate incidental provisioning influenced site use patterns and the rays were observed entering into potentially costly agonistic interactions. In Jervis Bay and Bendalong, NSW, we have a unique combination of locations where smooth stingrays are provisioned fish waste at moderate intensity from the public, as well as locations where the rays are common but are not provisioned, all within a relatively small geographical area. This provides us with the unique opportunity to build on this pilot research to further assess the influence this provisioning has on the site fidelity, movements and overall health of these large charismatic rays within and between control sites and sites where they are provisioned using acoustic tracking. These data will have implications for recreational fisheries management and provide important insights into smooth stingray biology and ecology.

Multi-Species Movement Patterns

Understanding the movement patterns of fish is crucial for the development of effective conservation strategies, such as marine reserves. To be successful in protecting biodiversity, marine reserves must be adequately sized and incorporate the areas frequently visited by fish during daily or life cycle migrations. Reserves may prove inadequate conservation strategies for fish that migrate frequently across reserve boundaries and are therefore exposed to fisheries capture.

Using acoustic telemetry, this project aims to quantify the movement patterns of three species regularly captured in recreational and commercial fishing; *Girella tricuspidata* (luderick), *Acanthopagrus australis* (yellowfin bream) and *Trygonorrhina fasciata* (eastern fiddler ray) at Bendalong, NSW. Specifically, we aim to determine the residency and/or connectivity for each of these three species and assess the implications for the design of marine reserves in open coastal environments. This project will extend on our previous research on the movements of these species in Jervis Bay Marine Park (JBMP), which has reported that each of these species show some degree of residency to certain areas and habitats. However, JBMP is a sheltered coastal embayment and it is not known if these species show the same movement patterns in open coastal settings. Comparing movement data for each species from JBMP and Bendalong will elucidate whether movement patterns vary between coastal embayments and exposed coastal environments. Such a comparison has important conservation value, as it will provide information on the appropriate size and areas to locate marine reserves in each of these settings. This project involves two PhD candidates, Daniel Swadling (tagging luderick and bream) and Kye Adams (tagging Eastern Fiddler rays), contributing data to each of their theses and subsequent publications where IMOS will be recognised for their contribution.

4. Project Aims

Stingray Provisioning

We aim to better understand the impact of food provisioning on smooth stingray movements, behaviour and health. Specifically, we aim to use passive acoustic telemetry to compare smooth stingray movements, site use patterns and behaviours within and between food provisioning sites and control sites to determine spatial differences, as well as during the high (summer – high provisioning intensity) and low (winter – low provisioning intensity) seasons to determine temporal differences.

Multi-Species Movement Patterns

The primary objective of this component of the project is to use acoustic telemetry to quantify fish movement patterns for the following three species; *Trygonorrhina fasciata* (eastern fiddler ray), *Girella tricuspidata* (luderick) and *Acanthopagrus australis* (yellowfin bream). Specifically, we aim to use passive acoustic telemetry to determine:

- The degree of philopatry and residency for each of the three species in an open coastal environment.
- The connectivity between reefs and adjacent habitats in an open coastal environment.

5. Level of Achievement

Overall project

In July we deployed the 10 acoustic receivers loaned to us from IMOS around Bendalong, NSW. This was in collaboration between Joni Pini-Fitzsimmons of Macquarie University, Daniel Swadling and Kye Adams of Wollongong University and Nathan Knott and Gwenael Cadiou NSW DPI Fisheries in Huskisson, NSW using the NSW DPI vessel MPV Seadragon. In November, the positioning and condition of the receivers and moorings were checked by Daniel Swadling and Kye Adams from Wollongong and it was confirmed that they were holding position well and were undamaged.

Stingray Provisioning

In August, we tagged 15 smooth stingrays with external acoustic transmitters (Vemco V9-2H pingers). This includes 5 rays from Bendalong (provisioning site), 5 from Woollamia boat ramp (provisioning site) and 5 from Murrays Beach boat ramp (control site). Callala bay was removed as a second control site due to time and weather constraints during fieldwork. The remaining 3 sites give a spectrum of food provisioning (Bendalong = high-level provisioning; Woollamia = moderate incidental provisioning; Murrays = no provisioning) as opposed to a control vs provisioning site design, and we feel this spectrum will allow us to still satisfy the project aims.

Multi-Species Movement Patterns

In August and September, we tagged 10 luderick and 5 fiddler rays at sites around Bendalong with internal acoustic transmitters. The luderick were tagged with Vemco V9-2H tags and the fiddler rays were tagged with Vemco V13-2H tags. Thirteen additional luderick have been tagged at sites within Jervis Bay which stand some chance of being detected on the Bendalong receivers. All luderick were caught using hand lines while fiddler rays were captured by free-divers. The tagging of Yellowfin Bream will not be included due to limited funding.

6. Methods

Project timeline

Year	Dates	Tasks	Status
2018	May	Obtained receivers	Completed
		Planned deployment	Completed
		Prepared moorings	Completed
	July	Deployed receivers	Completed
	August – September	Deployed acoustic tags for both studies	Completed
	November	Receiver position & condition checked	Completed
2019	February – March	Download data, replace batteries and re-deploy	Planned
		Upload data onto IMOS database	Planned
	April – September	Analyse data	Planned
	October	Retrieve receivers & moorings	Planned
		Download data & upload to IMOS database	Planned
	November	Return receivers to IMOS	Planned
	November – December	Analyse data	Planned

Receiver deployment

The receivers provided by IMOS-ATF were deployed in May 2018. The positions of each receiver are illustrated in Figure 1 and details are given in Table 1. Each mooring consisted of approximately 80 kg of railway lines cut into 100 cm sections as weights. 16mm rope was threaded through plastic tubing which was then placed through holes in the centre of the railway sleepers and spliced together. A loop was spliced on the other end of the mooring rope to attach a large polystyrene float. The float was also cable-tied to the rope and NSW DPI fisheries tags were attached for security purposes. Mooring ropes ranged from 2m to 6m in length depending on the estimated depth and complexity of the deployment sites. These lengths were selected to maximise the line of sight of receivers to their surrounds and avoid collision with boats travelling overhead. A schematic of the receiver moorings is given in Figure 1. It is noteworthy that this mooring design has been successfully used for the 50+ acoustic receivers in the Jervis Bay array.

Prior to deployment, receivers were coated with anti-foul and wrapped in plastic to prevent excess bio-fouling. Each receiver was placed with the hydrophone facing up approximately mid-way down the mooring rope using 5 industrial cable ties.

A guide rope was looped through the moorings float before lowering the moorings into the water from the side of an NSW DPI Fisheries vessel. Each mooring was checked by Nathan Knott and Gwenael Cadiou freediving to ensure they were positioned correctly on an even substratum and not tangled. It was noteworthy that one receiver mooring required repositioning, so the guide rope was looped through the float hole and used to pull the mooring back on board before being re-deployed

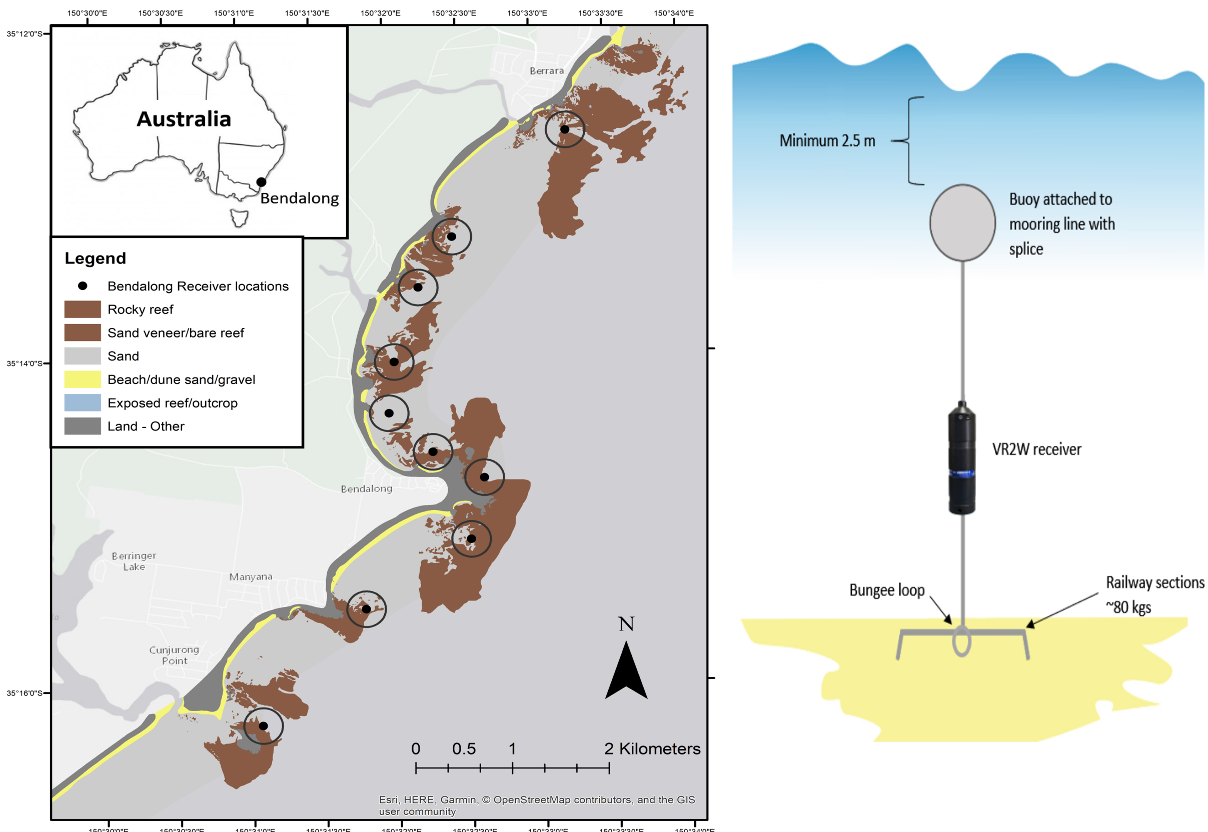

Figure 1. Positions of the 10 acoustic receivers, donated by IMOS-ATF, for the Bendalong Acoustic Receiver Array and schematic of receiver moorings used (adapted from Fetterplace, Lachlan. (2018). Acoustic Tracking Images and Figures. 10.6084/m9.figshare.6216596.v1).

Receiver maintenance

To confirm the moorings held their position and showed no sign of deterioration, they were checked 4 months after their initial deployment by Daniel Swadling and Kye Adams freediving. The moorings had not moved, and all receivers, mooring lines and floats were in good condition.

Acoustic tagging

Stingray Provisioning

Acoustic tagging of smooth stingrays took place in August & September. Smooth stingrays were chummed into the study site and tagged externally with Vemco V9-2H acoustic pingers tethered to Domeier umbrella-style dart tags into the wing musculature. Five smooth stingrays were tagged at each of the 3 study sites – Boat harbour beach in Bendalong, and Murray's boat ramp and Woollamia boat ramp in Jervis Bay.

Multi-Species Movement Patterns

Five Fiddler Rays were tagged in August 2018. Individuals were chummed using crushed pilchards and caught by hand by trained freedivers. Individuals had Vemco V13-2H acoustic transmitters surgically implanted within their peritoneal cavity.

Ten Luderick were tagged during August and September 2018. These fish were caught using hook and line with *Ulva spp.* as bait. Individuals had Vemco V9-2H acoustic transmitters surgically implanted within their peritoneal cavity.

A summary of all acoustic tag deployments for this project is given in Table 2.

Data analysis

Stingray Provisioning

The following analyses will be conducted for tagged stingrays as individuals and as groups (within sites and between sites) within and between days, months, seasons (winter = low-intensity provisioning; summer = high-intensity provisioning) and years (2018-19 & 2019-20).

- Home ranges of individuals using:
  - minimum convex polygon (MCP) as estimate of extent of home range;
  - 50% and 95% fixed kernel as estimate of space use within home range; and
  - Minimum Linear Dispersal (MLD) – distance between tagging location and furthest receiver on which each stingray is detected.
- Residency patterns, site fidelity and preferred sites of individuals using:
  - Continuous Residence Times (CRT) – periods of time individual stingrays are detected at a given receiver until it is detected at another receiver or the blanking period is exceeded (banking period to be determined);
  - Residency Index (RI) – number of days an individual is detected at a given receiver divided by the number of days individual was at liberty;
  - Roaming Index (ROI; movements within the array) – Proportion of receivers an individual was detected at relative to the number of receivers within the array (Bendalong and Jervis Bay).

Multi-Species Movement Patterns

- Home ranges of individuals
- Diurnal movement patterns
- Site fidelity within the array calculated using a residency index (number of detection days for each fish on any receiver/number of total possible detection days) and the Minimum Linear Dispersal (MLD) of each individual. Linear regressions will be used to test for relationships between the residency index and MLD with body length.
- Habitat connectivity for luderick between reefs will be calculated using a Network Analysis.

7. Results

We have no results at this stage as the data are still being collected, with receivers not scheduled for download until early 2019.

8. Discussion

As mentioned above, we cannot discuss our results at this stage as we are still waiting for the preliminary data.

9. Outputs

This project is part of the PhD theses of Joni Pini-Fitzsimmons, Daniel Swadling and Kye Adams. As such, these data will form a major component of these theses and result in a number of peer-reviewed publications in leading journals. The findings will be communicated at domestic and international conferences focussed on animal behaviour, fish biology and fisheries science. IMOS-ATF and SIMS will be prominently acknowledged in all outputs.

10. Acknowledgements

- IMOS-ATF
- NSW DPI Fisheries, Huskisson for their support of staff, equipment (MPV Sea dragon) and consumables
- Department of Biological Sciences, Macquarie University for financial and general support of Joni's research
- Holsworth Wildlife Research Endowment – Equity Trustees Charitable Foundation and Ecological Society of Australia for their financial support of Joni's research and Kye's research
- Seaworld Research and Rescue Foundation for their financial support of Daniel's research and Kye's research
- Ecological Society of Australia - Student Research Award for supporting Daniel's research

11. References

1. NSW DPI (2016). Recreational Fishing Trusts Investment Plan 2015/16-2017/18

TABLE 1: SUMMARY OF RECEIVER DEPLOYMENTS

			DEPLOYMENT						SERVICE		RECOVERY	
Receiver ID	**Serial Number**	**Station Name**	**Date** *(UTC)*	**Time** *(UTC)*	**Site Name**	**Bottom Depth** *(m)*	**GPS coordinates** *(decimal degrees)*		**Date** *(UTC)*	**Time** *(UTC)*	**Date** *(UTC)*	**Time** *(UTC)*
	120760	B1	24/7/18	2:42	Berrara/ Cudmirrah	8	-35.21086	150.55399				
	114547	B2	24/7/18	2:35	Monument North	6.2	-35.22144	150.54079				
	120734	B3	24/7/18	2:23	Monument Reef	7	-35.22651	150.53682				
	122582	B4	24/7/18	2:15	Flatrock Reef	9.8	-35.23399	150.53387				
	160873	B5	24/7/18	2:01	Washerwoma n North	7.1	-35.23916	150.53314				
	114571	B6	23/4/18	23:10	Boat Ramp	4.7	-35.24316	150.53801				
	114556	B7	23/4/18	23:31	Bendalong Point N	10.3	-35.24584	150.54379				
	114534	B8	23/4/18	23:53	Bendalong Point S	9.2	-35.25205	150.54213				
	113132	B9	24/7/18	0:10	Inyadda Point	8.2	-35.25892	150.52997				
	114589	B10	24/7/18	4:44	Green Island	12.5	-35.2705	150.5179				

Integrated Marine Observing System

Animal Tracking Facility

sims sydney institute of marine science

TABLE 2: SUMMARY OF TAG RELEASES

TAG			SENSOR				ANIMAL			RELEASE				
ID	Serial Number	Model	Type	ID code	Slope	Intercept	Species	Size (cm)	Sex	Date *(UTC)*	Time *(UTC)*	Location	GPS Coordinates *(decimal Degrees)*	
A69-1602-9177	1297395	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	9/9/18	5:32	Bendalong	-35.244584	150.538737
A69-1602-9182	1297400	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	6/9/18	7:30	Murrays	-35.125680	150.751602
A69-1602-9183	1297401	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	8/9/18	3:36	Woollamia	-35.025584	150.666668
A69-1602-9184	1297402	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	5/9/18	5:02	Murrays	-35.125680	150.751602
A69-1602-9185	1297403	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	9/9/18	2:28	Bendalong	-35.244584	150.538737
A69-1602-9186	1297404	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	9/9/18	3:31	Bendalong	-35.244584	150.538737
A69-1602-9187	1297405	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	7/9/18	4:20	Woollamia	-35.025584	150.666668
A69-1602-9188	1297406	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	M	3/9/18	5:45	Murrays	-35.125680	150.751602
A69-1602-9189	1297407	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	1/9/18	7:18	Woollamia	-35.025584	150.666668
A69-1602-9190	1297408	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	3/9/18	7:50	Murrays	-35.125680	150.751602
A69-1602-9191	1297409	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	M	5/9/18	7:25	Murrays	-35.125680	150.751602
A69-1602-9192	1297410	V9 2H	PINGER				**Lost tag**	Unknown		23/8/18	4:23	Bendalong	-35.244584	150.538737
A69-1602-9193	1297411	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	25/8/18	6:35	Bendalong	-35.244584	150.538737
A69-1602-9194	1297412	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	25/8/18	6:53	Bendalong	-35.244584	150.538737
A69-1602-9195	1297413	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	7/9/18	6:16	Woollamia	-35.025584	150.666668

A69-1602-9196	1297414	V9 2H	PINGER				*Bathytoshia brevicaudata*	Unknown	F	7/9/18	6:30	Woollamia	-35.025584	150.666668
51897	1253015	V9	PINGER				*Girella tricuspidata*	FL= 29 TL =30.5	Unknown	8/8/18	6:30	South Bendalong Cliff	-35.249561	150.540459
51898	1253016	V9	PINGER				*Girella tricuspidata*	FL= 29.6 TL= 31	Unknown	9/8/18	0:30	South Bendalong Is.	-35.250582	150.54005
51911	1253029	V9	PINGER				*Girella tricuspidata*	FL= 32.5 TL = 34.5	Unknown	9/8/18	2:25	South Bendalong Is.	-35.250582	150.54005
51903	1253021	V9	PINGER				*Girella tricuspidata*	FL= 27.5 TL= 28.7	Unknown	8/9/18	6:40	Middle Cove	-35.246308	150.541563
51895	1253013	V9	PINGER				*Girella tricuspidata*	FL= 31.2 TL= 33.1	Unknown	8/9/18	8:05	Middle Cove	-35.246308	150.541563
51894	1253012	V9	PINGER				*Girella tricuspidata*	FL= 30.9 TL= 31.7	Unknown	8/9/18	8:05	Middle Cove	-35.246308	150.541563
51899	1253017	V9	PINGER				*Girella tricuspidata*	FL= 35 TL= 36	Unknown	9/9/18	8:06	Middle Cove	-35.246308	150.541563
51893	1253011	V9	PINGER				*Girella tricuspidata*	FL= 30.9 TL= 31.5	Unknown	9/9/18	8:04	Middle Cove	-35.246308	150.541563
51901	1253019	V9	PINGER				*Girella tricuspidata*	FL= 32.3 TL= 33.7	Unknown	9/9/18	8:28	Middle Cove	-35.246308	150.541563
51900	1253018	V9	PINGER				*Girella tricuspidata*	FL=32 TL = 33.1	Unknown	9/9/18	8:28	Middle Cove	-35.246308	150.541563
57521	121943	V13	PINGER				*Trygonorrhina fasciata*	80	F	6/8/18	4:00	Bendalong	-35.234504	150.530048
57513	1219535	V13	PINGER				*Trygonorrhina fasciata*	74	M	7/8/18	3:57	Bendalong	-35.244792	150.535721
57515	1219537	V13	PINGER				*Trygonorrhina fasciata*	95.5	F	8/8/18	2:00	Bendalong	-35.233069	150.531527
57518	1219540	V13	PINGER				*Trygonorrhina fasciata*	82.5	M	10/8/18	0:32	Bendalong	-35.237676	150.53057
57512	1219534	V13	PINGER				*Trygonorrhina fasciata*	71.5	F	6/8/18	3:15	Bendalong	-35.234391	150.529999
57521	121943	V13	PINGER				*Trygonorrhina fasciata*	80	F	6/8/18	4:00	Bendalong	3-5.234504	150.530048