Australian Centre for Applied Marine Mammal Science
Final Report
(subclause 9 and Schedule Item 5 of the Funding Agreement)

Project title

A spatially explicit population model to inform negotiations between Traditional Owners and the relevant management agencies about options to manage the dugong fishery in Torres Strait

Activity Period

Period of the activity for which this progress report refers.

2nd October – 15th February

Chief Investigators / Organisation

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1. Activity Summary

The dugong is of the highest cultural value to the Indigenous peoples of Torres Starit where the globally significant dugong population supports a culturally important Indigenous fishery. The fishery is protected by the *Torres Strait Treaty* between Australia and Papua New Guinea which obliges the signatories to 'miminmise any restrictive effects on the traditional activities of traditional inhabitants'.

Aerial surveys for dugongs conducted since the mid 1980s using standardised methodology have provided long-term information on the distribution and abundance of dugongs in the Torres Strait region. We used information collected from six dugong aerial surveys spanning 19 years in conjunction with geostatistical techniques, including universal kriging, to develop a spatial model of dugong distribution and relative density in the Torres Strait. We categorised areas as of low, medium or high ecological value for dugongs in Torres Strait based upon the relative densities integrated across surveys. Our approach assumes that dugong density is a robust index of a region's value for dugongs. The model accounts for temporal changes in the use of various regions by dugongs including movements resulting from events such as seagrass dieback by integration information across surveys.

The resultant spatial model allowed us to quantify the importance of Torres Strait as dugong habitat in the context of the entire east coast of Queensland (south-east Queensland, Great Barrier Reef Region and Torres Strait) using the same technique. The model indicates that 74 % of the total high value dugong habitats and 63 % of the total medium value habitats on the eastern coast of Queensland are in Torres Strait. In addition, a larger proportion of the Torres Strait survey region (36%) is of high value for dugongs than the inshore waters of the Great Barrier Reef region (3%) or the large bays of south–east Queensland (20%).

With co-funding from the Marine and Tropical Research Facility, this information on dugong distribution and relative density is being shared with Torres Strait Islanders via a series of community mapping workshops held at Mabuiag, Boigu, Badu, Yam, Hammond, and Horn Islands. At the workshops, participants are being taught how to use the overlay functions of geographical information systems (GIS) to combine their traditional ecological knowledge, dugong aerial survey information and the model of dugong distribution and relative density. Digital and hard copy format copies of the model have also been provided to the Torres Strait Regional Authority to inform their regional resource management initiatives.

The spatially explicit dugong population model will inform negotiations about shared responsibility strategies for ensuring that the Torres Strait dugong fishery is sustainable. The draft Torres Strait Dugong and Turtle Fishery Strategic Assessment Report commissioned by the Australian government recommends that 'a study be undertaken in association with Islander communities to identify/evaluate alternative mechanisms available at the community level to limit and monitor catch'. This model contributes to the fulfilment of this recommendation by providing Islanders and management agencies with scientifically robust information on the spatial distribution of dugongs in Torres Strait, as the part of the science base for assessing management options such as spatial closures to hunting or limiting the hunting of each community to their own sea country.

2. The Outcomes/Objectives

Objective 1 - Produce an integrated spatial model of dugong distribution and relative density in Torres Strait from data generated by a time series of six aerial surveys conducted between 1987 and 2006 inclusive.

This objective has been achieved. Data from the 2006 dugong aerial survey were integrated with dugong sightings from aerial surveys conducted in 1987, 1991, 1996, 2001, and 2005 to form a common GIS database. Using the method of Grech and Marsh (2007), dugong density (both relative and absolute) was calculated at a grid size of 2km * 2km (Appendix 1). We used the same range of values of dugong density as Grech and Marsh (2007) to categorise dugong management units as low, medium or high ecological value for dugongs in Torres Strait (Appendix 2). Our approach assumes that dugong density is a robust index of a region's conservation value for dugongs. This assumption is justified because: (1) density estimates are regarded as suitable surrogate measurements of habitat use, and (2) no critical habitats for dugongs have been identified other than the seagrass meadows where they spend most of their time. By using the time series of data collected over 19 years, the model accounts for temporal changes in the use of various regions by dugongs including movements resulting from events such as seagrass dieback.

The areas of highest relative density in the Torres Strait are between Buru and Mabuiag Islands and along the Warrior Reefs (Appendix 1). In contrast to previous assessments, our model indicates that the Torres Strait dugong sanctuary encompasses a large region of high and medium conservation value to dugong (Appendix 2), indicating the potentially significant value of the spatial closure of this region, provided it is effectively enforced. Nonetheless, it must be noted that a potentially significant proportion of the sanctuary has not been surveyed as the region cannot be safely surveyed using light aircraft. The dugong model shows areas of high and medium conservation value at the western limits of the survey region including parts of the sanctuary (Appendix 1). Thus, we believe that: (1) dugong aerial surveys do not cover the entire distributional range of dugongs in the region, and (2) a significant proportion of high value dugong habitat probably already functions as a *de facto* spatial closure because it is beyond the range of Indigenous hunting. It will be important for the Australian government to ensure that dugong poaching by foreign fishing vessels does not occur in this region.

We have previously developed models of dugong distribution and relative density for the Great Barrier Reef World Heritage Area (GBRWHA) and south-east Queensland (Moreton Bay and Hervey Bay). We combined these models with the Torres Strait model to create a continuous distribution map for the east coast of Queensland (Appendix 3). We compared the amount of dugong habitats of high, medium and low conservation value along the east coast of Queensland and found that 74 % of the total high conservation value dugong habitats and 63 % of the total medium value habitats on the east coast of Queensland are in Torres Strait (Appendix 4). In addition, greater proportion of the Torres Strait region is comprised of high value dugong habitats (36 %; Appendix 4) than in the inshore Great Barrier Reef region or south-east Queensland. This analysis shows that dugong habitats in the Torres Strait are the most important along the east-coast of Queensland, and perhaps the world.

Objective 2 - Make statistical comparisons between the spatial model of dugong distribution and relative density with spatial information on seagrass available in GIS format from Dr Rob Coles and his group at the Northern Fisheries Centre to determine if nutrient density is a major forcing factor of dugong distribution and relative density in Torres Strait.

This objective has been achieved. However, we could not detect any significant relationship between the spatial model of dugong distribution and relative density and seagrass nutrient distribution. Of the 168 sites sampled in the 2005 sub-tidal seagrass survey of the Torres Strait, seagrass was present at 56 (33.3%) of the sites. Nutrient profiles (nitrogen and starch) were taken at only 45 sites. 33 of these 45 sites fall within the ~30,500km^2 extent of our model of dugong distribution and relative density. The relationships between dugong relative density, the presence and absence of seagrass and seagrass starch and nutrient concentrations were explored using one-way ANOVA and bivariate correlations. No significant relationships were found between dugong relative density, and: (1) presence/absence of seagrass ($p=0.105$), (2) seagrass nitrogen concentration ($p = 0.848$), or (3) starch concentration ($p = 0.394$). We believe that the likely cause of our failure to detect significant relationships between the distribution of dugongs and seagrass attributes are as follows: (1) the differences in spatial scale and data collection methods of the models of dugong relative density and seagrass nutrient concentrations, (2) the low range of seagrass nutrient concentrations, and (3) the limited number of seagrass nutrient profiles ($n = 33$) within the 30,500km^2 extent of the model.

Sheppard (2007) has recently shown using GPS tracking of dugongs (correct to <10m) and mapping of seagrasses at fine spatial scale (200m) within a single meadow that the relationship between dugong space-use and seagrass nutrient concentrations and biomass is very complex, varying with individual dugong and the tidal and diel cycles. Thus with the benefit of hindsight, it is not surprising the data to which we had access proved unsuitable for unraveling such complex relationships.

Objective 3 - Provide Islander communities and management agencies with this information in an accessible format to inform negotiations about shared responsibility strategies for ensuring that the Torres Strait dugong fishery is sustainable.

Using supplementary funding from by the Marine and Tropical Sciences Research Facility, CI Alana Grech is currently conducting a series of GIS and GPS training workshops at nine communities in Torres Strait (Appendix 5). Six of these communities fall within the extent of the model of dugong distribution and relative density (Mabuiag, Boigu, Yam, Hammond, Horn and Badu Islands; Appendix 1). CI Alana Grech is providing Indigenous counterparts with a comprehensive introduction to all aspects of GIS and GPS, as well as hands-on experience using GIS and GPS. The tools learnt by Indigenous counterparts are being applied in community mapping workshops. These workshops are providing community members with opportunities to plot information of importance to them, including sites of social, economic and environmental significance. CI Alana Grech is integrating the outputs of the community mapping program with the spatial model of dugong distribution and relative density and presenting it in digital and hard copy format to the six participating communities. The Torres Strait Regional Authority (TSRA) has been presented with both digital and hard copy format copies of the model of dugong distribution and relative density. The model provides Islanders and management agencies with scientifically robust information on the spatial distribution of dugongs in Torres Strait, and will contribute to the science base for assessing management options such as spatial closures to hunting or limiting the hunting of each community to their own sea country.

3. Appropriateness

Objective 1 - The method used to create a spatially explicit dugong population model is published in the peer-reviewed journal *Applied GIS* (Grech and Marsh, 2007). Applications of this approach are also in press in the international journals *Aquatic Conservation* (Grech et al. in press) and *Conservation Biology* (Grech and Marsh in press). Thus our approach to create a model of dugong distribution and relative density in the Torres Strait has been validated as scientifically robust using peer review.

Objective 2 - The approach used to quantify a relationship between dugong distribution and seagrass nutrient density in Torres Strait was not appropriate due to the varying spatial scales, limited seagrass nutrient information and data collection methods of the seagrass surveys. The problems with the seagrass data set did not become apparent until we attempted to analyse these data.

Objective 3 – By conducting GIS training and community mapping workshops in the Torres Strait, the capacity for Islander communities to use geographical information collected by western scientists has been increased. It was appropriate to deliver the model of dugong distribution and relative density to each community through workshops as it provided an opportunity for community members to have their concerns addressed directly and learn how to use the model in conjunction with their own traditional ecological knowledge via a GIS-based decision support system.

4. Effectiveness

This activity has effectively met its objectives by successfully creating a model of dugong distribution and relative density in the Torres Strait, exploring the relationship between dugong density and seagrass nutrient content; and delivering this information in an accessible format to communities of the Torres Strait and the Torres Strait Regional Authority.

References

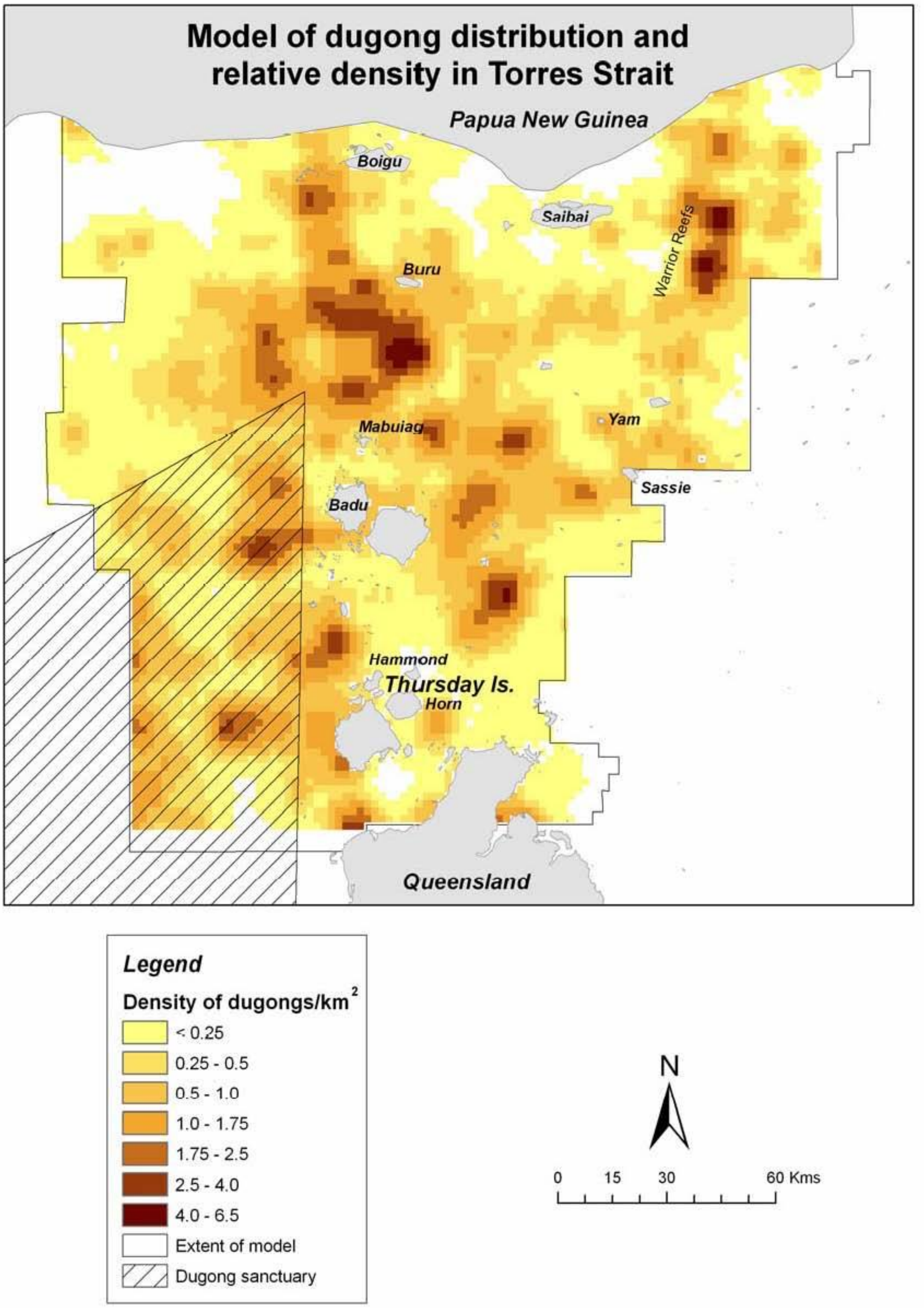
Grech, A, Marsh, H. 2007. Prioritising areas for dugong conservation in a marine protected area using a spatially explicit population model. *Applied GIS*, **3**(2): 1-14.

Grech, A. and Marsh.H. in press . Rapid assessment of risks to a mobile marine mammal in an ecosystem-scale marine protected area. *Conservation Biology.*

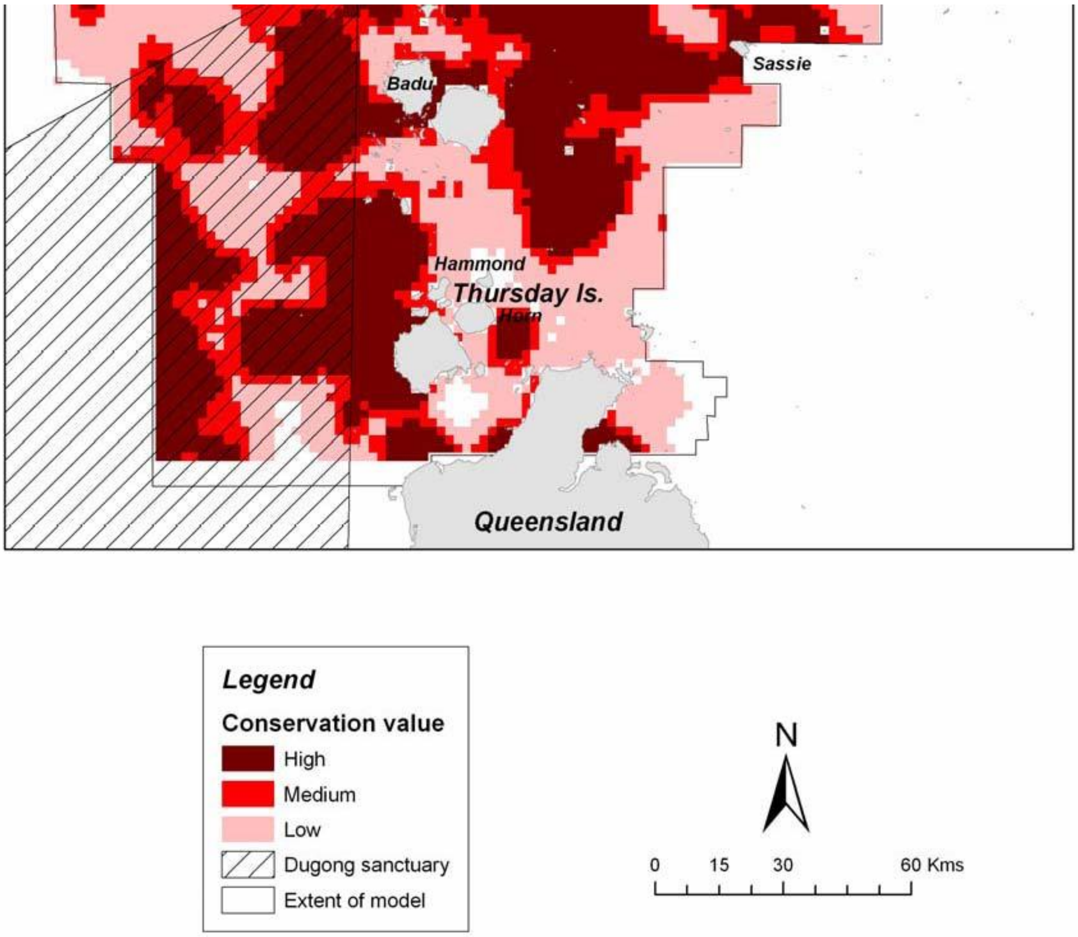
Grech, A., Marsh, H. and Coles, R in press.. A spatial assessment of the risk to a mobile marine mammal from bycatch. *Aquatic Conservation.*

Sheppard, J.K. 2007. The Spatial Ecology of Dugongs: Applications to Conservation Management. Unpublished PhD thesis James Cook University., Townsville.

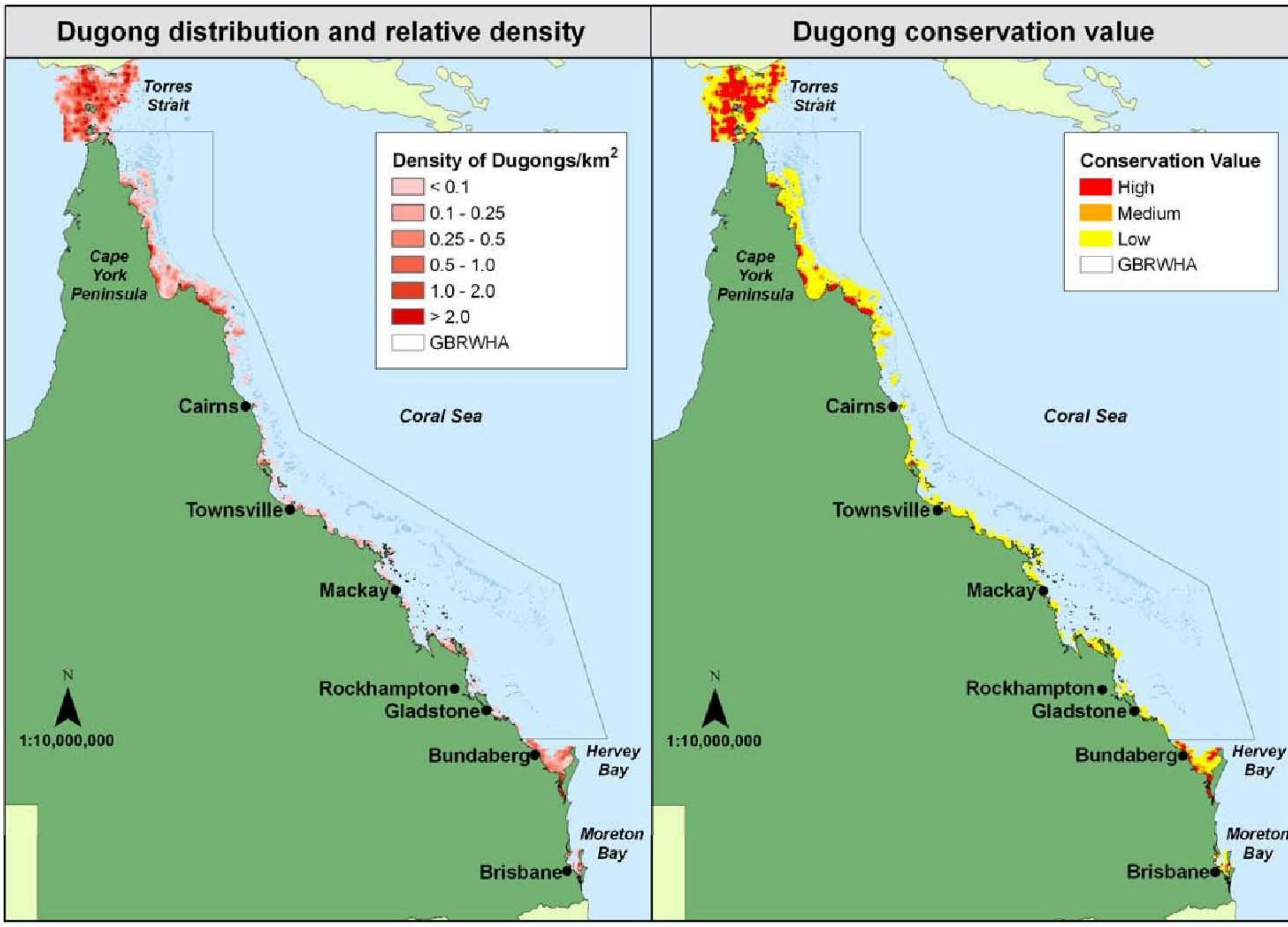
Appendix 1: Model of dugong distribution and relative density in Torres Strait based on the dugong sightings from aerial surveys conducted in 1987, 1991, 1996, 2001, and 2005.



Appendix 2: Model of the ecological value of dugong habitats in Torres Strait based on the dugong sightings from aerial surveys conducted in 1987, 1991, 1996, 2001, and 2005.



Sassie
Badu
Hammond
Thursday Is.
Horn
Queensland
Legend
Conservation value
High
Medium
Low
Dugong sanctuary
Extent of model
N
0
15
30
60 Kms



Appendix 3:. Models of dugong distribution and relative density and ecological value based on aerial surveys since the mid 1980s along the east coast of Queensland.

Appendix 4

Table 1: Proportion (%) of the area surveyed for dugongs on the east coast of Queensland which was classified as high, medium or low ecological value to dugongs, and that occurs in Torres Strait, inshore Great Barrier Reef World Heritage Area (GBRWHA) and south-east Queensland (SEQ), respectively. **able 1:** Proportion (%) of the area surveyed for dugongs on the east coast of Queensland which was classified as high, medium or low ecological value to dugongs, and that occurs in Torres Strait, inshore Great Barrier Reef World Heritage Area (GBRWHA) and south-east Queensland (SEQ), respectively.

	Total Area (km^2) Total Area (km^2)**	*High High*	*Medium Medium*	*Low Low*
Torres Strait	*27232*	74 63 26		
GBRWHA	*32066*	16 23 67		
SEQ	*5496*	9	14	7

* areas surveyed and rated as high, medium and low ecological value for dugongs, respectively.

Table 2: Proportion (%) of Torres Strait, inshore Great Barrier Reef World Heritage Area (GBRWHA) and south-east Queensland (SEQ) habitats that have been surveyed for dugongs and classified as high, medium and low conservation value dugong habitats.

	*Total Area (km^2)**	*High*	*Medium*	*Low*	*No Value*
Torres Strait	*30482*	36	19	34	11
GBRWHA	*70355*	3	3	39	54
SEQ	*6715*	20	19	43	18

* total area surveyed

	Day	**Date**	**Task**
	Wednesday	6-Feb	*GIS/GPS training*
	Thursday	7-Feb	*Community mapping*
	Friday	8-Feb	*Community mapping*
	Saturday	9-Feb	
	Sunday	10-Feb	
	Monday	11-Feb	*GIS/GPS training*
	Tuesday	12-Feb	*Community mapping*
	Wednesday	13-Feb	
	Thursday	14-Feb	
	Friday	15-Feb	*Liaise with TSRA*
	Saturday	16-Feb	
	Sunday	17-Feb	
	Monday	18-Feb	*GIS/GPS training*
	Tuesday	19-Feb	*Community mapping*
	Wednesday	20-Feb	
	Thursday	21-Feb	*GIS/GPS training*
	Friday	22-Feb	*Community mapping*
	Saturday	23-Feb	
	Sunday	24-Feb	
	Monday	25-Feb	*GIS/GPS training*
	Tuesday	26-Feb	*Community mapping*
	Wednesday	27-Feb	
	Thursday	28-Feb	*GIS/GPS training*
	Friday	29-Feb	*Community mapping*
	Saturday	1-Mar	
	Sunday	2-Mar	
	Monday	3-Mar	*GIS/GPS training*
	Tuesday	4-Mar	*Community mapping*
	Day	**Date**	**Task**
	Wednesday	5-Mar	
	Thursday	6-Mar	*GIS/GPS training*

	Friday	7-Mar	*Community mapping*
	Saturday	8-Mar	
	Sunday	9-Mar	
	Monday	10-Mar	*GIS/GPS training*
	Tuesday	11-Mar	*Community mapping*

Location
Mabuiag
Mabuiag
Mabuiag
Boigu
Boigu
Boigu
Boigu
Thursday Is.
Thursday Is.
Thursday Is.
Thursday Is.
Yam
Yam
Yam
Yorke
Yorke
Yorke
Darnly
Darnly
Darnly
Darnly
Murray
Murray
Murray
Badu
Badu
Badu
Badu
Location
Thursday Is.
Hammond Is.
Hammond Is.
Horn Is.
Horn Is.
Horn Is.
Horn Is.

Appendix 5: Itinerary for GIS and GPS training and community mapping workshops in Torres Strait