

Local assessments of marine mammals in cross-cultural environments

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Abstract Biodiversity assessments by research scientists are often logistically difficult and expensive to implement in remote areas. Locally-based approaches have the potential to overcome some of these challenges by capitalising on the knowledge and capacity of local people. Many Indigenous people in northern Australia are custodians of coastal areas that support globally significant populations of tropical marine mammals, including coastal dolphins and dugongs. The objective of our study was to design and implement a locally-based approach in a cross-cultural environment to assess the distribution of marine mammals in the remote waters of the Gulf of Carpentaria, Northern Territory. The study

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was conducted as a partnership between Yanyuwa Aboriginal families, research scientists, government officers and the li-Anthawirriyarra Sea Rangers. We conducted a series of participatory mapping workshops to share and record local observations of dolphins and dugongs. These observations provided the longitudinal information required to inform the design of the first dedicated marine mammal vessel survey in the Gulf of Carpentaria. The vessel surveys found three species of dolphins present in the area (Australian snubfin, humpback and bottlenose dolphins), even though sightings were low; dugongs being much more common. We found that the integrative and locally-based approach built the capacity of both the li-Anthawirriyarra Sea Rangers and research scientists to assess the distribution of marine mammals. If replicated over longer time-frames and coordinated over broader spatial scales, information on distribution and abundance derived from locally-based approaches has the potential to inform the status of marine mammals.

Keywords Locally-based assessments · Monitoring · Indigenous Australia · Cross-cultural research · Dolphins · Dugongs

Introduction

Systematic assessments of biodiversity are central to the development of evidence-based management strategies (Guisan and Thuiller 2005) and the adaptive management of natural resources (Lindenmeyer and Likens 2009). Biodiversity assessments and monitoring by trained research scientists are often logistically, technically and analytically difficult and expensive to implement, especially in developing countries and remote areas (Danielsen et al. 2008). Locally-based approaches overcome some of these challenges by capitalising on the knowledge and capacity of local people (Danielsen et al. 2005). Locally-based approaches are less costly and in some instances are as informative as assessments and monitoring by research scientists (Yoccoz et al. 2003; Gilchrist et al. 2005), and can produce co-benefits for local people such as increased capacity and sustainable livelihoods. Locally-based approaches are usually focused on management issues of greatest concern to local people (Danielsen et al. 2005), increasing the likelihood of the successful implementation of management strategies. Management issues at regional, national and international scales also benefit from locally-based assessments (May 2010). Despite this, local people are frequently overlooked because government, research and management agencies privilege scientific perspectives on monitoring, science and management (Gratani et al. 2011). Even when partnerships between scientists and local people exist, the research process can exclude or marginalize local people when it is incompatible with the more holistic nature of Indigenous ideas about research and management (Barbour and Schlesinger 2012).

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Many Indigenous¹ Traditional Owners² of northern Australia are custodians of vast and often remote sea country³ (Fig. 1) of globally significant biodiversity value (Roberts et al. 2002; Butler et al. 2010) and relatively low human impact (Halpern et al. 2008; Selig et al. 2014). Indigenous people often see caring for coastal waters, islands, reefs, sandbars and seagrass beds as integral to living on their homelands. Associated activities are considered customary responsibilities for country and are frequently expressed through the establishment of dedicated natural and cultural resource management organisations, community ranger groups (Fig. 1) and strategic marine planning (National Oceans Office 2004; e.g., Carpentaria Land Council Aboriginal Corporation 2006; Bradley and Yanyuwa Families 2007). Indigenous natural and cultural resource management organisations and ranger groups are increasingly responsible for the management of northern Australia's globally significant populations of tropical marine mammals including dugongs and coastal dolphins (Kennett et al. 2004). The Australian ranges of these species extend along ~32,000 km of coastline; around eighty percent of this region is in or adjacent to sea country over which Indigenous people have significant legal rights⁴ (see Altman et al. 2007; Fig. 1). Biodiversity assessments and monitoring programmes by trained scientists are logistically difficult and expensive to implement in northern Australia by research organizations alone because of the: (a) large spatial extent and remoteness of the region (Moller et al. 2004); and, (b) problems associated with expeditionary assessments in regions where the weather required for fieldwork is typically only available for a few days at a time. Locally-based approaches have the potential to improve and enhance the assessment of marine mammals in northern Australia by utilizing the expertise, knowledge and capacity of Indigenous people and scientists (Huntington 2000; Kaplan and McCay 2004; e.g., Parrado-Rosselli 2007). To be effective, locally-based approaches must be conducted in full consultation and collaboration with Indigenous natural and cultural resource management organisations, families and ranger groups, to facilitate meaningful and respectful long-term outcomes in this cross-cultural environment (Ens et al. 2012).

The objective of our study was to design and implement a locally-based approach to assess the distribution of marine mammals in the remote Yanyuwa sea country of the southwest Gulf of Carpentaria, Northern Territory (Fig. 1). We focused on dolphins because several dolphin species of conservation concern are poorly known in northern Australia (Parra et al. 2002, 2004, 2006a) and included dugongs, *Dugong dugon*, because they are the most abundant marine mammal in this region (Marsh et al. 2008, 2011) and hold very high cultural significance for the Yanyuwa (Bradley and Yanyuwa Families 2010). Our integrative and locally-based approach resulted in the first dedicated vessel survey for marine mammals in the Gulf of Carpentaria (Fig. 1). We consider the lessons learned from our study to inform locally-based approaches to systematic marine mammal monitoring in remote areas and cross-cultural environments.

¹ We use uppercase 'Indigenous' when referring to Aboriginal and Torres Strait Islander people and lowercase 'Indigenous' when referring to the original inhabitants of other countries.

² Traditional Owners are a group of Aboriginal or Torres Strait Islander people that are directly descended from the original Aboriginal or Torres Strait Islander inhabitants of a culturally defined area.

³ The term 'country' signifies the connection between Aboriginal and Torres Strait Islander people and land and sea, and is often used to describe family origins and associations with particular areas.

⁴ For more information, see *Aboriginal Land Rights (Northern Territory) Act 1976*; *Australian Native Title Act 1993*; and *Northern Territory of Australia v Arnhem Land Aboriginal Land Trust D7 (2007)* (the 'Blue Mud Bay case').

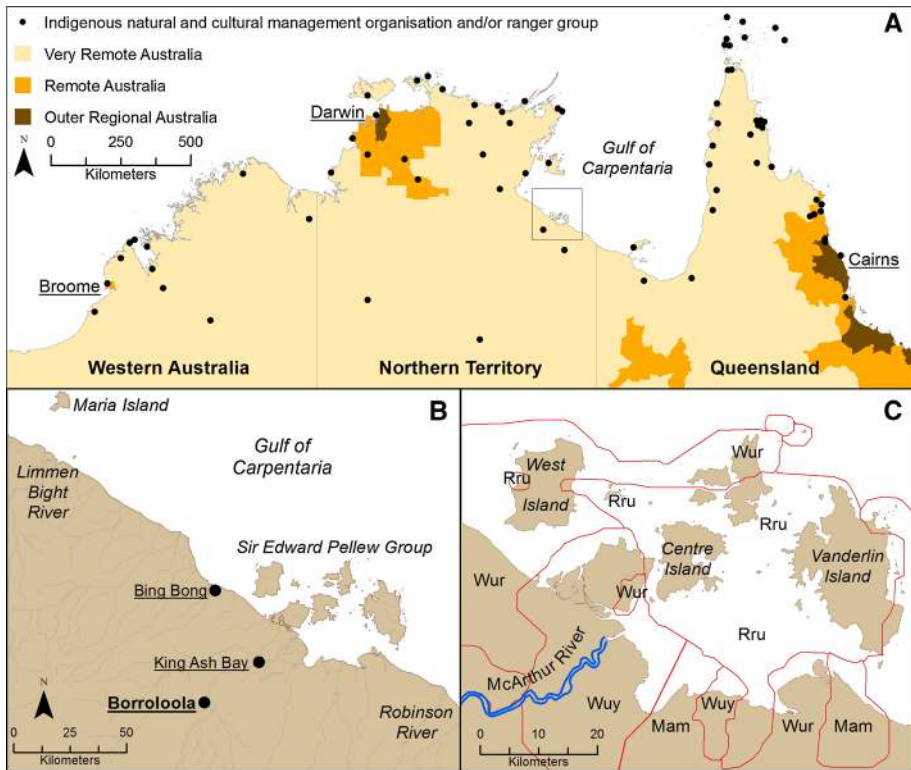


Fig. 1 **a** The locations of Indigenous natural and cultural resource management organisations and/or ranger groups in the remote and very remote regions of northern Australia (Australian Bureau of Statistics 2006). The study region is within the box. **b** Map of the sea country of the Yanyuwa people in the Gulf of Carpentaria, Northern Territory showing major settlements and drainage lines. The waters around the Sir Edward Pellew Group were the major region of interest in this study. **c** The islands of the Sir Edward Pellew Group and Yanyuwa clan boundaries (*Wur* Wurdaliya, *Wuy* Wuyaliya, *Rru* Rrumburriya, *Mam* Mambaliya-Wawukarriya)

Methods

Study area and species

The study area is located predominantly in Yanyuwa country and stretches along ~270 km of coastline (~900 km including the offshore islands) of the Gulf of Carpentaria in the Northern Territory, Australia (Fig. 1). Yanyuwa sea country itself extends from the vicinity of Rosie Creek to slightly east of the mouth of the Robinson River and includes the waters surrounding the Sir Edward Pellew Islands, the Yanyuwa heartland. In addition, the Yanyuwa Families and li-Anthawirriyarra Sea Ranger Unit (under the auspices of a Memorandum of Understanding with the Mara language group) also share responsibility for country in and around the Limmen and Roper Rivers and these coastal tracts also formed part of the study area. The region has a tropical climate and two seasons: the wet (November to April) and dry season (May to October). The four Yanyuwa clan groups in the region are the Wurdaliya, Wuyaliya, Rrumburriya and Mambaliya-Wawukarriya; their clan boundaries all include extensive tracts of sea country (Fig. 1).

The sea country of the Yanyuwa people is within the northern Australian range of the dugong (Grech et al. 2011) and three species of inshore dolphins: the Australian snubfin dolphin, *Orcaella heinsohni* (hereafter snubfin dolphin); a new as-yet-unnamed species of humpback dolphin, *Sousa* sp., (hereafter humpback dolphin) (Mendez et al. 2013); and the bottlenose dolphin, *Tursiops* sp. Dolphins and dugongs have significance to the Yanyuwa people, who now mainly live in the township of Borroloola, located on the McArthur River, about 50 km upstream from the Gulf of Carpentaria (Fig. 1). All species of dolphins and the dugong are important Ancestral beings with Dreaming places, and are celebrated in the extensive ceremonial song lines that also travel through the coastal and islands area (see Bradley and Yanyuwa Families 2010).

The snubfin dolphin was described as a new species in 2005 and occurs only within the waters of northern Australia, and Papua New Guinea (Beasley et al. 2005). Recent morphological and genetic studies on humpback dolphins indicate that Australian populations represent a different species potentially endemic to northern Australia and Papua New Guinea (Mendez et al. 2013). The Action Plan for Australian Mammals 2012 lists both of these dolphin species as insufficiently known but suspected to be endangered or vulnerable (Woinarksi et al. 2014). Worldwide, snubfin and humpback dolphins are listed as near threatened under the International Union for Conservation of Nature—Red List of Threatened Animals, and dugongs are listed as vulnerable to extinction. At a national level, snubfin and humpback dolphins and dugongs are listed as a marine and migratory species under the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and are protected under various pieces of legislation in each State and Territory.

Participatory mapping workshops

This study was instigated by a multi-disciplinary research team who shared a common interest in the status of populations of dugongs and snubfin and humpback dolphins. The research team included the li-Anthawirriyarra Sea Rangers of Borroloola, the Yanyuwa Families, and research scientists and government officers with expertise in: cross-cultural literacy; marine mammal surveys in remote areas; and geographic information systems (GIS). The roles and responsibilities of each of the partner organizations and groups (including the research institutions, the Yanyuwa community, Northern Territory Government and li-Anthawirriyarra Sea Ranger Unit) were detailed in a research partnership agreement and human ethics permit. The development of the research partnership agreement was an iterative process between all partners (Fig. 2), and was negotiated to ensure a clear understanding regarding: survey and data gathering protocols; data access arrangements; data storage and use of the data by each group; and, the key products from the study (e.g., training manuals, databases, education materials etc.). The research partnership agreement and human ethics permit were designed to protect Yanyuwa knowledge, ensure appropriate regional and national data standardization, and establish protocols for the vessel surveys, data sharing and management. The research partnership agreement also outlined which data were to be retained within the Yanyuwa community and/or shared with external agencies, including government agencies and other Indigenous communities, and under what conditions.

Acknowledging that a questionnaire-based approach (e.g., Moore et al. 2010) has been successful in other contexts, we decided to use an alternative approach that we considered more appropriate to our objectives. We used a series of participatory mapping workshops to share and record the knowledge and observations of Traditional Owners, rangers,

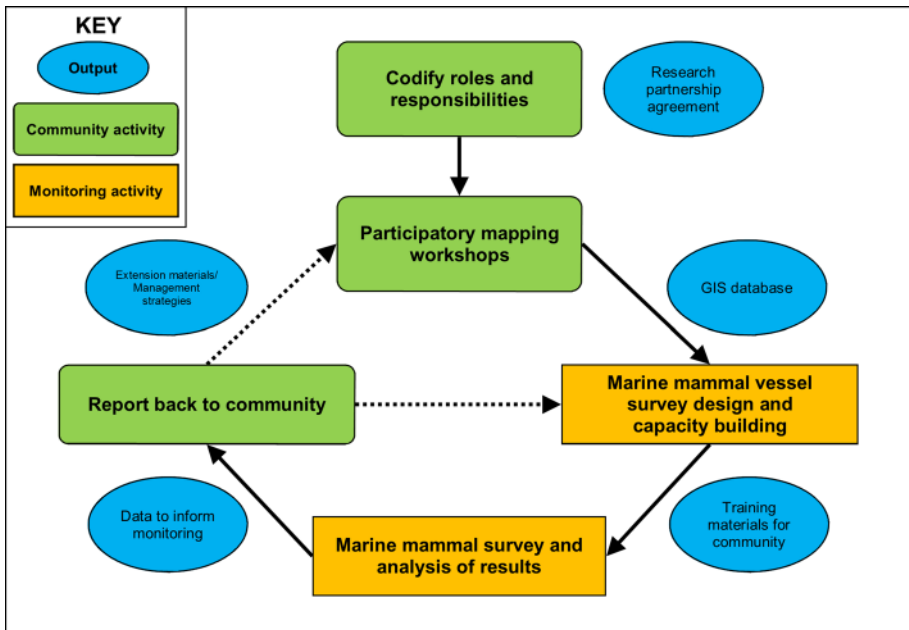


Fig. 2 A collaborative process to monitor marine mammals in Yanyuwa sea country. The various stages of the process are numbered sequentially and indicated by *rectangles* for monitoring activities and *rounded rectangles* for community activities; *rounded shapes* represent the outputs derived from each stage. *Solid arrows* show the direction of the process, and *broken arrows* show possible pathways

research scientists and other members of the local community. The workshops were conducted as a group because: (1) a group approach aligns well with the principles of Indigenous Australians who typically view community values as more important than individual values (Fogarty and White 1994); (2) singling out the observations of individual participants can lead to discomfort and embarrassment; and, (3) it allowed senior male rangers and senior women to speak to more junior male and female rangers and encourage them to share their knowledge.

Participatory mapping workshops were held at Borroloola (Fig. 1) in June 2009 to share and record information relevant to the monitoring of coastal dolphins and dugongs in Yanyuwa sea country. Four separate workshops were held with: (1) Yanyuwa Traditional Owners and the li-Anthawirriyarra Sea Rangers; (2) recreational fishermen; (3) commercial fishermen; and, (4) rangers from the Northern Territory Parks and Wildlife Commission. The workshops were organized by the li-Anthawirriyarra Sea Rangers in partnership with the research scientists and conducted in accordance with cultural protocols. Workshop participants were identified and invited by the li-Anthawirriyarra Sea Rangers and research scientists to attend one of the four workshops.

The four workshops were facilitated by Bradley, an anthropologist, who has a long-standing and trusted relationship with the Yanyuwa Families. The facilitation of the workshop with Traditional Owners was assisted by a female anthropologist trusted by the Yanyuwa women. The research scientists gave a series of verbal and PowerPoint presentations at the start of the workshops to share their knowledge on coastal dolphins, dugongs and marine mammal surveys in remote areas. This knowledge was also

summarised in a poster format and available for the entire workshop. At this time, the facilitator and research scientists explained the context, purpose and nature of the workshops and the written consent form, and invited each participant to complete the form. The workshops were held in English, Aboriginal English, Kriol and Yanyuwa. Yanyuwa was used when amplification of meanings and understandings was required for participants whose second or third language was English. All of the li-Anthawirriyarra and Northern Territory Parks and Wildlife Commission rangers, and recreational and commercial fishers, had very good English. The research team knew that gender issues were important and, as is often the way in Australian Indigenous communities, women sat together and worked with the female cultural broker throughout the community workshop. However, women and men heard each other's information as several of the senior women have sons and daughters who are rangers and there was a lot of cross-group communication in English and Yanyuwa. All of the four workshops were conducted as a group exercise and observations provided by individual workshop participants were not recorded.

We used a participatory mapping approach to record the observations of dolphins and dugongs and their habitat use during the workshops. Satellite images of Yanyuwa sea country at two scales (1:300,000 and 1:1,000,000, Fig. 1) were downloaded from Google™ Earth. We used satellite images for the participatory mapping as topographic maps and navigational charts of the region did not show important environmental features (e.g., sand banks, beaches and seagrass meadows). We also used very large (A0) hard-copies of the satellite images so that multiple participants could discuss and work together on the same map. Participants were supplied with a range of colour-coded stick-on dots of 0.75 cm diameter to stick to the hard-copy maps at approximate locations where they had observed dolphins and dugongs throughout their lifetime (Fig. 3). The research team recorded verbal information provided by participants on the hard-copy maps (e.g., species name and whether the sighting was a pod of animals etc.). Information on cetaceans was recorded to the species level when workshop participants were confident in their identification. Workshop participants had access to large colour photographs of dugongs, the three species of dolphins, and pictorial marine mammal identification keys reproduced from Marsh (2008) to assist them in their species identification. At the end of the workshops, the facilitator went through the information collected during the workshop and negotiated the protocols for its further use in the study. The research partnership agreement (Fig. 2) was slightly modified to reflect this advice.

The workshop participant's information was transcribed into a digital format so that it could be directly processed by a computer and used alongside other sources of digital data. We took digital photographs of the hard-copy maps and transferred them to a computer in a JPEG file format. The photographs were digitally aligned (geo-rectified) with a map of the same area in ArcGIS® 9.2 (Environmental Systems Research Institute 2006). The colour-coded stick-on dots, showing where participants had observed dolphins and dugongs, were converted (digitized) to a digital format in ArcGIS® 9.2.

In addition to the workshops, observations of dolphins and dugongs were obtained from three sources: aerial surveys of dugongs conducted by research scientists (Marsh et al. 2008); the field notebooks of John Bradley (April 1980–October 2008); and Traditional Owner Steve Johnston. Johnston recorded his observations with the assistance of the li-Anthawirriyarra Sea Rangers and the same participatory mapping approach used during the workshops. Bradley and Johnston's data were digitized in ArcGIS® 9.2. The aerial survey data was already in a digital format.



Fig. 3 Photograph of li-Anthawirriyarra Sea Rangers using colour-coded stick-on dots and hard-copy maps of satellite images to record their observations of dolphins and dugongs (Borroloola, Northern Territory, June 2009)

All of the digital information on dolphin and dugong observations in Yanyuwa sea country was stored in a GIS database; protocols for storing the information reflected the research partnership agreement. The GIS database stored the observations of 15 Traditional Owners of Yanyuwa sea country, nine non-Traditional Owners, and the outputs of dugong aerial surveys collected by research scientists in 1994 and 2007. The GIS database also included spatial layers of topography (e.g., rivers, streams and coastline), Yanyuwa clan boundaries (Fig. 1), and satellite images of sea country from Landsat 8 and GoogleTM Earth. The GIS database and hard-copy maps were stored at the li-Anthawirriyarra Sea Rangers' office in Borroloola.

A follow-up community workshop was held in March 2010 at Borroloola to report back on outcomes of the first workshop and the November 2009 vessel survey. The workshop was organized by the li-Anthawirriyarra Sea Rangers in partnership with the research scientists. The workshop was facilitated by the cultural broker and conducted in accordance with cultural protocols. The objective of the follow-up workshop was to provide a summary of the outputs of the participatory mapping workshops and the first vessel survey, discuss potential monitoring strategies, and to identify issues associated with the research partnership agreement, especially the key products and extension materials from the study. The workshop was attended by four Traditional Owners, nine li-Anthawirriyarra Sea Rangers (seven of whom were also Traditional Owners), and the research scientists.

Vessel surveys

The li-Anthawirriyarra Sea Rangers and research scientists used the GIS database containing the collated digitized information on dolphin and dugong observations to inform the design of the standard shipboard survey and line transects (Buckland et al. 2001). The GIS database and logistical, technical and local knowledge of the research team were also used to assist in the optimisation of survey resources and time. The line transects covered most of the areas identified as dolphin habitat by workshop participants (Figs. 4, 5). In addition, transects were placed to cover regions outside the key dolphin areas identified in the GIS database to ensure a representative coverage of the study area. Transect lines were orientated East–West and spaced approximately 4 km apart. The East–West orientation was selected as it crossed the depth gradient between islands within the survey region. Systematic line placement and spacing was used as it results in greater precision of abundance estimates, even spatial distribution of sampling effort, and uniform coverage probability (Du Fresne et al. 2006; Thomas et al. 2007). The sampling was stratified from a randomly chosen starting point as this is the most effective means of stratifying sampling effort in remote areas. The locations of transects were not re-randomised between surveys because we aimed to minimise the transect effect. The aim was to survey each transect line once during every survey period, depending on suitable weather conditions (i.e., <Beaufort 4, swells < 1.5 m). The survey was designed to cover both the coastal and offshore waters of the Sir Edward Pellew Island Group area of the Yanyuwa sea country (Fig. 1).

The vessel surveys were implemented as a partnership between the li-Anthawirriyarra Sea Rangers and the research scientists. A dedicated data recording sequence to record data on survey conditions, survey effort and marine mammal sightings was developed for the handheld Nomad field computer using CyberTracker-based GPS software (<http://www.cybertracker.org/>). CyberTracker software is used by multiple ranger groups across northern Australia (Ansell and Koenig 2011) and was therefore identified as the most appropriate tool for recording sighting information. Sea Rangers were trained by the research scientists in vessel survey methods and use of the CyberTracker sequence prior to the first survey.

Three vessel surveys were conducted during November 2009, and May and November 2011 using the 6.59 m Stabicraft (in Survey D) of the li-Anthawirriyarra Sea Rangers. The May 2011 survey was organised at the request of Traditional Owners at the follow-up community workshop in 2010. They requested additional vessel surveys to verify whether the low number of dolphins sighted during the November 2009 vessel survey was a seasonal effect. The May 2011 survey coincided with unfavourable weather and strong south-easterly winds, making seas too rough to complete some transect lines, necessitating an additional vessel survey in November 2011.

The transect lines were surveyed only during acceptable weather conditions to minimize the chance of overlooking dolphins and dugongs. All surveys took place between 06:00 and 14:00 h, after which the weather usually deteriorated due to strong inshore sea breezes. While the boat was moving at a speed of 10–14 km/h along a transect line, a team of three observers located on top of the viewer platform (3 m from water height), searched for marine wildlife ahead and on each side of the boat with the aid of 7 × 50 binoculars fitted with a compass and reticule markings. Once dolphins were sighted, survey effort was suspended and dolphins were approached slowly to within 10–20 m to confirm the species' identification, assess school size and age composition, record water depth and water temperature, and take photographs of individual animals for photo-identification. Information collected for dolphin sightings included horizontal angle to sighting from transect

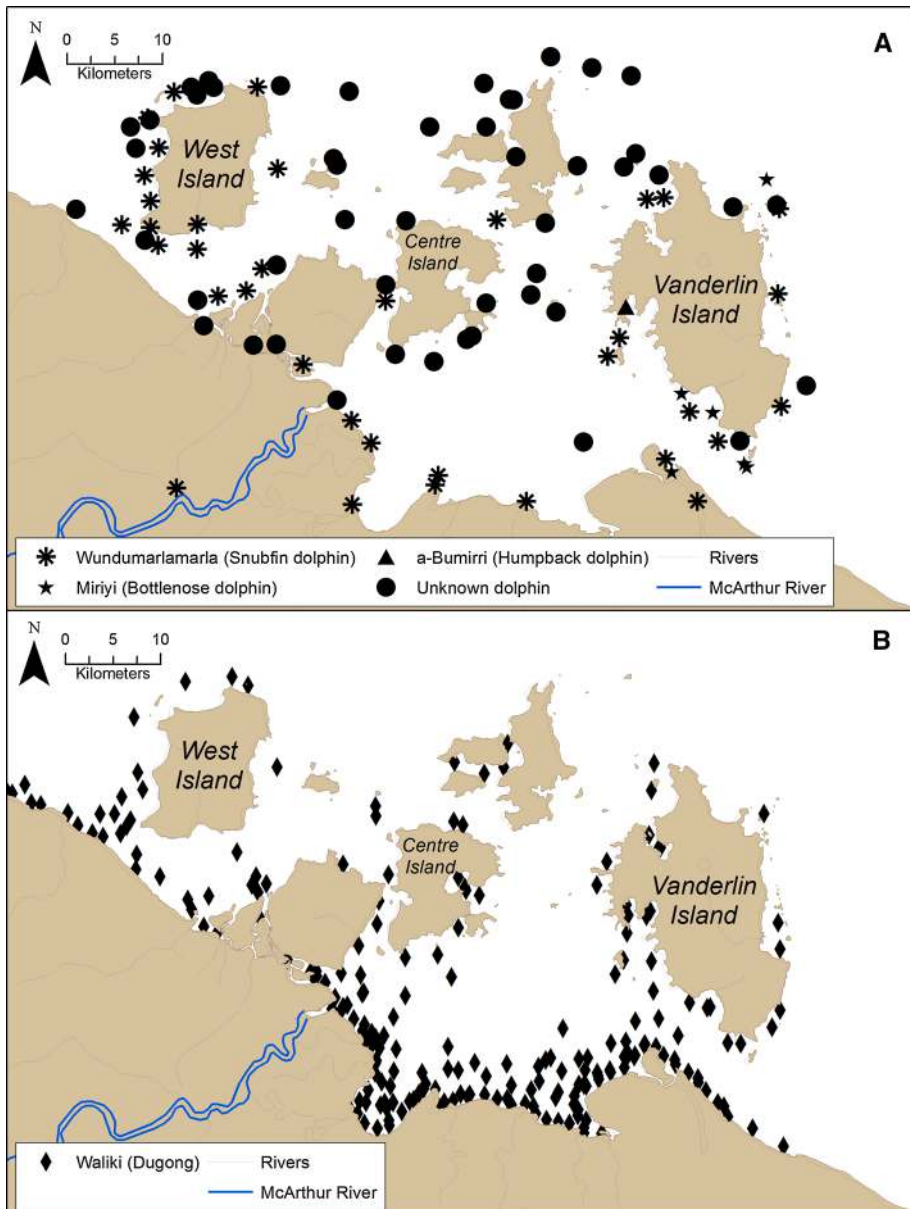


Fig. 4 Map of the Yanyuwa sea country showing the location of observations of: **a** dolphins; and, **b** dugongs, recorded at the participatory mapping workshops, Borroloola, Northern Territory, in June 2009

line, number of reticles from the horizon/land to the observed dolphin school, and boat bearing. Sightings details were recorded pre- and post-closing mode. Survey effort resumed at the site on the transect when closing mode began. Survey effort was not suspended for dugongs, and sighting details for dugongs were recorded in passing mode (Barlow 1997).

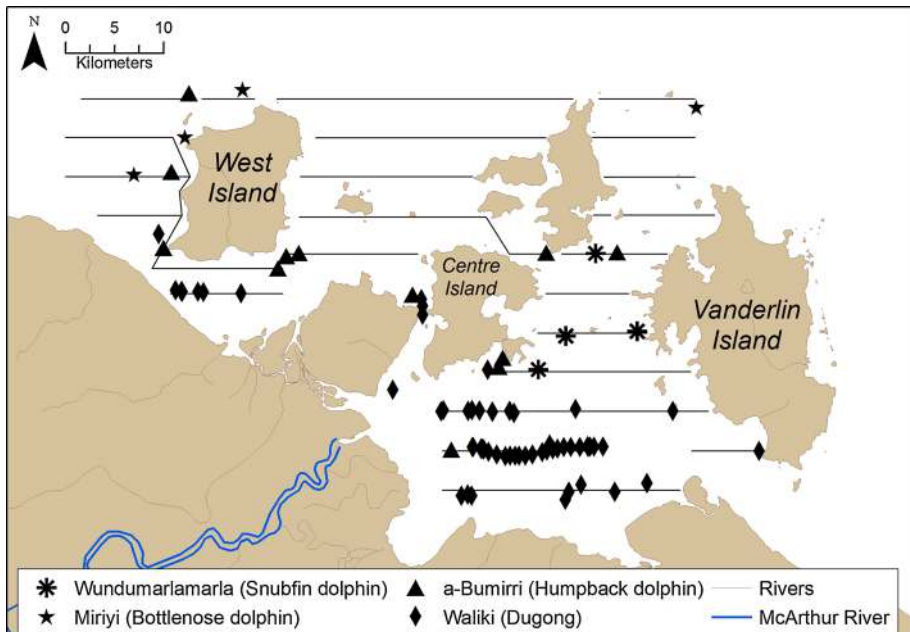


Fig. 5 Location of sightings of dolphin and dugong groups made by the li-Anthawirriyarra Sea Rangers and research scientists during the three vessel surveys in November 2009 and 2011 and May 2011. The planned transects are presented here rather than the actual GPS tracks because the tracks of the vessel movements, when the survey effort suspended, complicated the picture. The correspondence between the planned transects and the GPS tracks was excellent

The digital outputs of the vessel surveys, including sightings and transects, were stored in a GIS database. The average and shortest distances to the closest landmass and river/creek mouths for each species were calculated using ArcGIS[®] 9.2. The digital information on dolphin and dugong distributions from the participatory mapping workshops were overlaid with the outputs of the vessel surveys in ArcGIS[®] 9.2 to visually compare the similarities and differences between the two.

Results

Participatory mapping workshops

The participatory mapping workshops recorded the observations of dolphins and dugongs from: (1) nine Traditional Owners and seven li-Anthawirriyarra Sea Rangers (four of whom were also Traditional Owners); (2) two recreational fishers; (3) one commercial fisher; and, (4) three rangers from Northern Territory Parks and Wildlife Commission (including one Traditional Owner). Other people present during the workshops were the research scientists, including two cultural brokers and four experts in marine mammal monitoring, and five observers.

We found that using large satellite photographs and stick-on dots to record the observations of dugongs and dolphins was a very effective method for Traditional Owners, the li-Anthawirriyarra Sea Rangers, commercial fisherman and rangers from the Northern

Territory Parks and Wildlife Commission. The functionality of the process was confirmed when the li-Anthawirriyarra Sea Rangers successfully used the same technique to record the observations of Traditional Owner Steve Johnston outside of the community workshops. The workshop participants contributed a substantial amount of spatial information, including over 500 sightings (Table 1; Fig. 4), with some observations dating back 50 years.

The collated digitized information from the participatory mapping workshops showed a scattered distribution of observations of dolphins around much of the Sir Edward Pellew Islands (Fig. 4a). The snubfin dolphin observations tended to be widely distributed, especially in the inshore waters and had been occasionally sighted in the rivers. The observations of humpback and bottlenose dolphins were confined to the waters surrounding Vanderlin Island. Dolphins that were unable to be identified to a species level were more often observed in offshore areas than known species. Most reports of dugongs were located inshore and around seagrass habitats and mudflats (Fig. 4). There was good agreement between the dugong observations from workshop participants and the high density dugong areas previously identified using dugong aerial surveys (Grech et al. 2011; Marsh et al. 2008). Similarly, the location of snubfin and humpback dolphin observations reflected the habitat preferences identified for these species in other studies (Parra 2006; Parra et al. 2006b; Cagnazzi et al. 2013).

Vessel surveys

A total of 830 km of transect line were surveyed in the study area during the three vessel surveys (Table 2; Fig. 5). Most transect lines were run latitudinally as planned, however on days where weather conditions were unsuitable for open water surveys, some lines were run parallel to the coastline (i.e., west coast of West Island during May 2009 surveys). Over the three surveys, we sighted a total of 24 groups of dolphins (0.02 groups/km of survey effort), and 141 dugongs (0.16 groups/km of survey effort) (Table 2). Bottlenose dolphins were sighted off the west coast of West Island and north of Vanderlin Island. Humpback dolphins were sighted in waters close to the coast around West Island and between Centre Island and Vanderlin Island. Snubfin dolphins were also sighted very close to the coast in waters between Centre Island and Vanderlin Island. Most dugongs were sighted close to the coast (Table 2) between Mule Creek and Fat Fellows Creek (Fig. 5). The three vessel surveys suggested that the density of each of the three coastal dolphin species using this region were small. The low number of dolphin sightings precluded the use of distance sampling methods to estimate abundance (Buckland et al. 2001). However, photographs were taken of individual dolphins whenever possible to lay the foundations for a possible future mark-recapture study.

Extension materials

The Traditional Owners and li-Anthawirriyarra Sea Rangers provided advice to the research team on appropriate extension materials. The Traditional Owners requested that the extension materials detailed clan boundaries (Fig. 1), and the traditional linkages including the Yanyuwa names (Figs. 4, 5) of marine wildlife. A Microsoft® PowerPoint presentation on the project's outputs was developed for the rangers to customize to a range of audiences including Traditional Owners, school children, the general public and government agency staff. Two posters were developed to return information about the

Table 1 A summary of the sources of coastal dolphin and dugong observations used to design marine mammal vessel surveys in Yanyuwa sea country

	Traditional owners/li-Anthawirriyarra Sea Rangers	Commercial and recreational fishers	Northern Territory Parks and Wildlife Commission Rangers	Bradley's field notes	Dugong aerial surveys 1994, and 2007
<i>Marine mammal sightings</i>					
Snubfin dolphin	×	×		×	×
Long-nosed dolphin (<i>Sousa, Tursiops</i>)	×	×	×	×	×
Humpback dolphin	×			×	
Unidentified dolphin	×				×
Unidentified whale	×				
Dugong	×	×	×	×	×
Dugong large herd	×	×	×	×	×
<i>Marine mammal strandings</i>					
Snubfin dolphin	×				
Baleen whale	×				
False killer whale	×				
Pilot whales	×				
Unidentified whale	×				
Dugong	×				
<i>Marine mammal habitats</i>					
Seagrass	×			×	
Enhalus	×			×	
<i>Spatial extent of information</i>					
Yanyuwa sea country	×	×	×	×	×
Limmen Bight region	×				×

The sources included information obtained during the 2009 participatory mapping workshops in Borroloola, Northern Territory (Traditional Owners/li-Anthawirriyarra Sea Rangers, commercial and recreational fishers and Northern Territory Parks and Wildlife Commission Rangers) and information from research scientists (anthropologist John Bradley's field notes and dugong aerial surveys conducted in 1994 and 2007)

Table 2 Sightings of dolphins and dugongs during the three vessel surveys in November 2009 and 2011 and May 2011, including information on the number of survey days, total hours surveyed, total length of transects surveyed while on effort (km), and geospatial locations of sightings relative to the closest landmass and river/creek mouths

Survey information	Total number of groups (individuals)				
	Bottlenose dolphin	Humpback dolphin	Snubfin dolphin	Unidentified dolphin	Dugong
November 2009 (8 days, 22.3 h, 341 km)	1 (5)	4 (10)	2 (10)	2 (2)	11 (21)
May 2011 (3 days, 17.7 h, 168 km)	1 (6)	2 (2)	1 (4)	–	1 (2)
November 2011 (5 days, 36.3 h, 321.4 km)	2 (11)	5 (16)	1 (10)	3 (3)	40 (118)
Totals	4 (22)	11 (28)	4 (24)	5 (5)	52 (141)
Average distance to closest landmass (km) and standard error	7.5 (3.2)	4.1 (1.1)	2.1 (0.6)	6.1 (1.8)	6.5 (0.3)
Shortest distance to closest landmass (km)	2.2	0.2	0.8	0.8	1.4
Average distance to river/creek mouth (km) and standard error	11.5 (5.7)	9.0 (1.7)	17.3 (1.9)	15.1 (2.6)	8.1 (0.3)
Shortest distance to river/creek mouth (km)	2.8	2.9	14.4	6.4	3.2

project and the marine mammals of the Yanyuwa sea country to the Yanyuwa people, especially school children. In addition, manuals were developed to detail the spatially-explicit approach to recording knowledge (Grech and Marsh 2010) and the data recording sequence for the Nomad data logger and CyberTracker-based GPS software (Beasley et al. 2010). All outputs were provided to Traditional Owners and the li-Anthawirriyarra Sea Rangers.

Discussion

Systematic assessments of marine mammals are central to the development of arrangements for their conservation and sustainable use. In remote areas and cross-cultural environments, marine mammal assessments are challenged by lack of information, logistical capacity, weather, cost and effective communication and collaboration between local people and scientists. This study was able to overcome these challenges by developing a collaborative process (Fig. 2) that harnessed the knowledge and capacity of Indigenous people to survey coastal dolphins and dugongs in remote northern Australia. The integrative and locally-based approach resulted in the successful design and implementation of the first dedicated vessel survey of marine mammals in the Gulf of Carpentaria. The participatory mapping workshops and vessel surveys confirmed that all three species of dolphins that occur in the coastal waters of northern Australia also occur in the sea country of the Yanyuwa people (Figs. 4, 5) and substantiated the importance of Yanyuwa sea country for dugongs.

There were several similarities between the observations of workshop participants (Table 1; Fig. 4) and outputs of the vessel surveys (Fig. 5). Dugongs were abundant in both datasets and observed close to the coast, whilst dolphins were scattered through the region. However, there were some differences in dolphin distributions. There were relatively few humpback dolphin observations (2 groups) recorded during the participatory mapping workshops, whilst vessel surveys sighted 11 groups across the region. Observations of snubfin dolphins recorded during the participatory mapping workshops occurred across the region including the McArthur River (which was not surveyed by vessel) and coastal waters off the mainland and West, Centre and Vanderlin Islands. In contrast the vessel surveys sighted very few snubfin dolphins and only between Centre and Vanderlin Islands. The vessel surveys also sighted more dugongs in open waters, especially between Vanderlin and Centre Islands. The observations recorded during the participatory mapping workshops is reflective of the ‘boat paths’ or routes that are taken by Yanyuwa people to move between sites. The Yanyuwa people’s boats are much smaller than the boat used for the vessel surveys, and in many ways these ‘paths’ reflect the transport corridors used when dugout canoes were the main form of transport.

The vessel surveys provided the Yanyuwa community with an improved understanding of the current distribution of dolphins within their sea country. The low number of dolphins observed during the three vessel surveys, and the community’s own observations of the recent absence of snubfin dolphins in rivers, are of major concern to the Yanyuwa people (Bradley *personal communication*). The outputs of this study were used by the Yanyuwa community to inform the Draft Plan of Management and Monitoring Evaluation Reporting and Improvement (MERI) Plan associated with the designation of the Yanyuwa Indigenous Protected Area (li-Anthawirriyarra Sea Ranger Unit et al. 2011).

This study was able to overcome some of the inherent power inequalities in collaborative research (Barbour and Schlesinger 2012) because the Yanyuwa community had explicit control over the research process (Fig. 2). Control was established during the development of the research partnership agreement that codified the roles and responsibilities of all partner groups. The agreement addressed questions that are central to the implementation of participatory mapping workshops identified by Abbott et al. (1998), such as: who participates in whose mapping, who owns the map, where is it kept and who has access and why? The research partnership agreement was continually referred to and updated throughout the study, especially during community activities. It was an important document as it created trust between the Yanyuwa Families and scientists.

The collaborative research process also built the capacity of both the li-Anthawirriyarra Sea Rangers and scientists to study marine mammals in Yanyuwa sea country. Working closely with scientists increased the ability of the li-Anthawirriyarra Sea Rangers to systematically assess coastal dolphins and dugongs using scientific techniques. By actively participating in the design and implementation of the vessel surveys, the rangers' appreciation of the scientific process also increased over the course of the study. The research scientists gained insight on the value of integrating their knowledge of marine mammals with the knowledge of Indigenous people and ranger groups, and the challenges associated with studying rare and cryptic species in remote areas.

The process of cross-generational transfer of knowledge is very important to the Yanyuwa community (Bradley et al. 2011). The support from interage and intersex groups during the participatory mapping workshop was therefore integral to its effective implementation. The workshop also demonstrated to the Yanyuwa community that their knowledge is respected and valued in natural resource management and reinforced the importance of the work conducted by the li-Anthawirriyarra Sea Rangers. In contrast, the non-Indigenous recreational fishers were wary of disclosing their observations in a workshop environment. It was difficult to ascertain how much of the data provided by the recreational fishers was constrained by their concerns about inadvertently reporting illegal fishing activities. Reducing the non-response bias from recreational fishers in future studies will require assurances of confidentiality, such as anonymous online participatory mapping (e.g., Tulloch 2007).

Our study adds to the increasing body of evidence demonstrating the value of local knowledge in assessing the distribution of species (e.g., Moller et al. 2004; van der Hoeven et al. 2004; Anadon et al. 2009; Ziembicki et al. 2013). Vessel surveys, such as those described here, provide snapshots of information on the presence and relative abundance of marine mammals over a relatively small area ($\sim 100 \text{ km}^2$). Mark-recapture analysis provides knowledge of the distribution, abundance and demography over areas similar to vessel surveys but over longer time frames (years) (e.g., Parra et al. 2006a; Ansmann et al. 2013; Cagnazzi et al. 2013). Aerial surveys (e.g., Marsh et al. 2008) provide similar snapshots to vessel surveys over a much greater area ($\sim 100,000 \text{ km}^2$), but are limited in their ability to detect dolphins at a species level, particularly in coastal turbid waters. Integrating the observations of Yanyuwa community and others with the sightings derived from scientific methods provided a longitudinal context that suggested dolphins may have occurred over a wider area in the past. We recognise that a limitation of our study was that workshop participants did not identify the year and/or decade associated with their observations of marine mammals, preventing an assessment of change in abundance of coastal dolphins and dugongs over time (e.g., Ziembicki et al. 2013). Future studies of marine mammals in Indigenous sea country would be enhanced by such an analysis if appropriate data could be obtained.

Both the snubfin and humpback dolphins have been recently nominated for inclusion on the list of threatened fauna under the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The required assessments have not been possible because of lack of information. Long-term standardised collection of data is critical in determining the spatial and temporal patterns of distribution and abundance of snubfin and humpback dolphins throughout their range in Australia, especially the remote areas. This study produced the broad-scale species occurrence data required for the design and implementation of a marine mammal monitoring regime in such areas. The knowledge and participation of the Yanyuwa community and li-Anthawirriyarras Sea Rangers was critical for the success of the vessel surveys, and we believe that the involvement of other Indigenous communities and ranger groups will enhance the success of surveys for coastal marine mammals throughout the coastal waters of northern Australia.

This study documents the incipient phase of a relationship building exercise between the Yanyuwa community, rangers and scientists. This study is the first step in a much larger process, with the ultimate goal of deeper knowledge sharing as the relationship evolves, and long-term monitoring and management by local people. However, the current survey methodology and present levels of investment will not provide the trend information required to formally assess the status of snubfin and humpback dolphins in a management time-frame (Gerrodette 1987; Taylor et al. 2007). The study successfully delivered three vessel surveys in Yanyuwa sea country, but systematic surveys of marine mammals have not been conducted by the li-Anthawirriyarras Sea Rangers since 2011. At present, there is no funding available for Indigenous ranger groups to integrate systematic surveys of dolphins into their work plans. Cryptic species such as coastal dolphins are also difficult to monitor using locally-based approaches (Danielsen et al. 2005). Building the capacity of ranger groups to conduct these surveys, including access to boats and training in monitoring tools (e.g., CyberTracker and line-transect survey or mark-recapture techniques), will require a substantial investment by multiple stakeholders over a time-frame longer than this study. We believe that assessing the status of snubfin and humpback dolphins at a national level necessitates: (1) the development of survey designs and methods to specifically monitor occurrence, distribution and abundance by Indigenous rangers; and, (2) the adequate support of Indigenous communities and ranger groups from government and trained research scientists to conduct these surveys, including high standards of observer training and data management.

Conclusion

Australian governments and others are increasingly investing in various initiatives to provide education, training and employment opportunities for Indigenous people (Altman 2007; Preuss and Dixon 2012) whilst also ensuring the protection and conservation of Australia's biodiversity (May 2010). As a result of such initiatives, the capacity and influence of Indigenous organisations and ranger groups far surpasses that of non-Indigenous organisations in the remote regions of northern Australia (Fig. 1). The legal imperatives of Australian Indigenous people in the management of their coastal waters, together with their existing Traditional management responsibilities and the logistical potential offered by the burgeoning workforce employed by ranger groups are compelling. In addition, the Native Title Act and the Aboriginal Land Rights (Northern Territory) Act 1976, provide a further imperative for research agencies to work in partnership with Indigenous people and ranger groups in Australia. Our research demonstrates that it is cost-

effective to use processes such as the one described here, with the addition of ongoing systematic surveys conducted by Indigenous ranger groups. We believe that the process could easily be adapted to other cross-cultural environments and remote areas as an important contribution to the assessment and monitoring of marine mammals.

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