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RESEARCH REPORT

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An inventory of dugong aerial surveys in Australia

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NESP Marine and Coastal Hub partners

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This report is available on the NESP Marine and Coastal Hub website: www.nespmarinecoastal.edu.au

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Executive summary

- In Australia, the dugong (*Dugong dugon*) has significant cultural, ecological and conservation value. The species is a *Matter of National Environmental Significance* and is protected under the EPBC Act as a listed migratory and marine species.
- Since the early 1970s various aerial survey methodologies have been used to provide data on the distribution and abundance of the dugong across northern Australia. The survey designs and platforms have evolved through time, and so have the methods to estimate dugong population distribution, sizes and trends.
- An inventory of all dugong aerial surveys across the dugong range in Australia has not previously been compiled making it difficult to obtain a clear understanding of the efforts that have been put to date on surveying dugongs across their Australian range. The existence, locality and accessibility of the data generated from those surveys and their associated reports and/or scientifically peer-reviewed publications are not readily located or available for many surveys.
- This inventory compiles information from all dugong aerial surveys undertaken since the first use of this methodology for dugongs in Australia, including date of survey, approach undertaken to survey, latest abundance estimate, relevant reference and link to publication, data availability and location etc. It also provides spatially-explicit maps to represent survey effort to date across the entire known dugong range in Australia. The development of this inventory has also helped identify similarities and discrepancies in the way dugong population estimates, trends and spatial distribution models have been generated.
- Dugong aerial surveys in Australia date back from the early 1970s with shoreline reconnaissance surveys to assess the presence, distribution and relative numbers of dugongs in the inshore areas around the mainland and islands.
- The first standardised abundance aerial surveys were conducted in the early 1980s with the first survey implemented by Bayliss (1986) in December 1983 in the Northern Territory between the Daly River and Millingimbi.
- With the exception from the surf coast area between Shark Bay and Exmouth Gulf we have found reports of standardised dugong aerial surveys covering all inshore waters from Shark Bay in Western Australia to Moreton Bay near Brisbane. The cumulative number of dugong aerial surveys varies from single baseline surveys (e.g., Kimberley area) to frequently surveyed areas such as the Exmouth Gulf (15 surveys conducted to date) and the Darwin region (22 surveys conducted to date). The high number of surveys conducted in the latter regions is mostly the results of industry-funded programs to assess the distribution and number of dugongs across years and/or seasons and/or tides in areas potentially impacted by coastal industrial activities. These surveys add to time series of regional dugong population assessment surveys conducted every few years.
- Mathematical approaches to account for imperfect detections of dugongs in abundance estimations have evolved through time. The Hagihara method (Hagihara et al. 2014, 2018) is currently the most superior and nationally accepted standard to estimate dugong abundance. Marsh et al. (2019) retrospectively re-estimated dugong abundance using the Hagihara method for all surveys conducted in Eastern Queensland since the

early 2000s. Similar work should be conducted on historical survey data collected in other parts of Australia to aid data comparison and calibration for population trend analysis. Similarly, approaches to assess trends in dugong populations vary across regions/survey events. Providing that the data is available efforts should be put into harmonizing trends analysis (using both frequentist statistics and new Bayesian models) across the country.

- Researchers from different groups across Australia have also used varying approaches to model the density distribution of dugongs using aerial survey data but there has not been an evaluation of how much these methods differ between one another and which method could be adopted as a national standard to enable harmonisation and comparability of results.
- The likelihood of securing funding to increase the number of surveys in large remote areas like the Kimberley to obtain time series necessary for population trends analysis is low. In those instances, cheap, user-friendly and culturally appropriate new approaches should be considered for sea-country monitoring led by ranger groups.

Background

NESP Project 1.20: description and objectives

In 2023, Australia has ~2000 threatened species and ecological communities listed as Matters of National Environmental Significance (MNES). Additional terrestrial and marine species are listed because of Australia's responsibilities under migratory species and bilateral agreements.

The Resilient Landscapes Hub has been charged with leading the cross-hub *'Threatened and Migratory Species and Threatened Ecological Communities'* Initiative to support policy development, program management and regulatory processes to protect Australia's environmental assets in terrestrial, coastal and marine environments. This program of work focuses on planning future research priorities needs and gaps. One of the steps of this program is the undertaking of "desktop reviews of knowledge gaps and research needs from past processes and documents, including how previous research is being used".
The objective of Marine and Coastal Hub project 1.20 - *Scoping Study: Marine and Coastal Threatened Species and Communities* is to identify and co-design prospective research projects that best deliver information that will notably improve the status of key selected threatened species in Australia's marine and coastal environment.

The status of the dugong in Australia

As the only surviving member of the family Dugongidae (Marsh et al. 2011), the dugong (D*ugong dugon*) is a species of high biodiversity value. The dugong is listed as 'Vulnerable' to extinction by the International Union for Conservation of Nature (Marsh and Sobtzick 2015), and anecdotal evidence suggests that dugong numbers have decreased throughout most of their range (Marsh et al. 2011). Significant populations persist in Australian waters, which are now believed to support most of the world's dugongs. Dugongs are listed in Appendix 2 of the Convention of Migratory Species. As a signatory to that Convention, and the associated Dugong Memorandum of Understanding, Australia has international obligations to conserve dugongs in its waters and hence the species is listed as a Matter of National Environmental Significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The status and trends in the distribution and abundance of this species is important information for the management of several World Heritage Areas including the Great Barrier Reef, Ningaloo Coast and Shark Bay.

The evolution of aerial surveys for dugongs and associated abundance estimation methods

First insights into the presence of dugongs and their status around Australia were obtained via interviews with local indigenous and non-indigenous people (e.g., Bertram and Bertram 1973), or reports of dugongs accidentally caught in shark nets (e.g., Heinsohn and Spain 1974). The use of aerial surveys as a mean to determine dugong presence, distribution and relative numbers in Australia started in the early 1970's. These shoreline reconnaissance surveys were based on loosely defined transects following the shoreline near the mainland or around islands (e.g., Prince et al. 1981, Tables 1, 2 and 3). These surveys assumed that seagrass meadows and therefore dugongs only occurred close to the shoreline, an assumption that was later shown to be incorrect.

In the 1980s, aerial survey techniques were further developed with the aim of providing temporal and spatial information on dugong distribution and relative abundance across large spatial scales. These surveys, which were based on the surveys developed for kangaroos by Graeme Caughley made fewer assumptions about dugong distribution than the shoreline surveys and attempted to correct for visibility biases.

These 'standardised abundance surveys' use observers onboard light aircraft counting dugongs over predefined parallel line transects flown at constant altitude and speed (Marsh and Sinclair 1989). Transects of an abundance survey are typically oriented perpendicular to water depth and habitat gradients. All dedicated dugong abundance aerial surveys conducted in Australia have followed the strip transect technique detailed in Marsh & Sinclair (1989). Strip transect sampling follows the same principles as distance sampling except that observers are asked to record all sightings within a strip of defined width on each side of the transect line (for more details see Buckland et al. 2015 and Marsh & Sinclair 1989). It is assumed that all animals within these strips have equal probability of detection. Summary information on the purpose, advantages and disadvantages of shoreline or standardised abundance aerial surveys can be found at http://www.conservation.tools/. Guidelines on the applications of dugong aerial surveys in Australia will also become available in the near future (Department of Climate Change, Energy, the Environment and Water, *in press*).

Estimating the size of dugong populations in coastal waters of northern Australia is challenging due to heterogeneous environmental conditions, dugong diving behaviour and observer performance (Pollock et al. 2006; Dunshea et al. 2020). Standardised abundance aerial survey methods were developed in the 1980s to account for perception and availability biases (Marsh and Sinclair 1989 but also see preliminary work by Bayliss 1986). Since then, population estimates derived from aerial surveys have improved to account for the spatial heterogeneity in availability bias caused by water clarity and sea state conditions (Pollock et al. 2006). More recent refinements have accounted for differences in availability due to water depth and dive behaviour of dugongs (Hagihara et al. 2014, 2018). Recent aerial survey reports have considered the 'Hagihara method' superior to the former observer-survey methods as it makes fewer assumptions than any other technique used to date.

Putting it all together: the need for an inventory of dugong aerial surveys in Australia

Data collected from dugong aerial surveys have been informing the conservation management of dugongs across the country. Nonetheless, a nation-wide inventory of dugong aerial surveys conducted to date in Australia is lacking, making it difficult to assess efforts put into monitoring dugongs, data availability and methods used to estimate dugong population sizes, assess trends and model the species distribution.

Two of the most recent reviews on the knowledge and gaps on the status of dugongs across Australia include a dugong section in the Australian State of Environment Report (SoE) 2021 (Clark et al. 2021) and the dugong monitoring report developed in the reef 2050 Integrated Monitoring and Reporting Program (RIMReP) established as part of the *Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan)* (Marsh et al. 2019). The SoE states that the conservation status of the dugong is uneven across its Australian range (see Figure 1 prepared for the 2021 State of the Environment report). The RIMReP report on the other hand provides a

comprehensive review on (a) the current understanding of dugong biology and status in the Great Barrier Reef, (2) the adequacy of current dugong monitoring in the Great Barrier Reef, (3) the state of knowledge of the use of new technologies for aerial monitoring of dugongs in the Great Barrier Reef, and (4) priority indicators to monitor dugongs and large in-water turtles in seagrass habitats to 25 metres in the Great Barrier Reef (Marsh et al. 2019).The objectives of this project were to:

- Provide an inventory of all dugong aerial surveys conducted in Australia to date and data accessibility
- Identify dugong aerial survey effort and gaps across Australia
- Identify past and current approaches to estimate dugong abundance, population trends and distribution modelling approaches

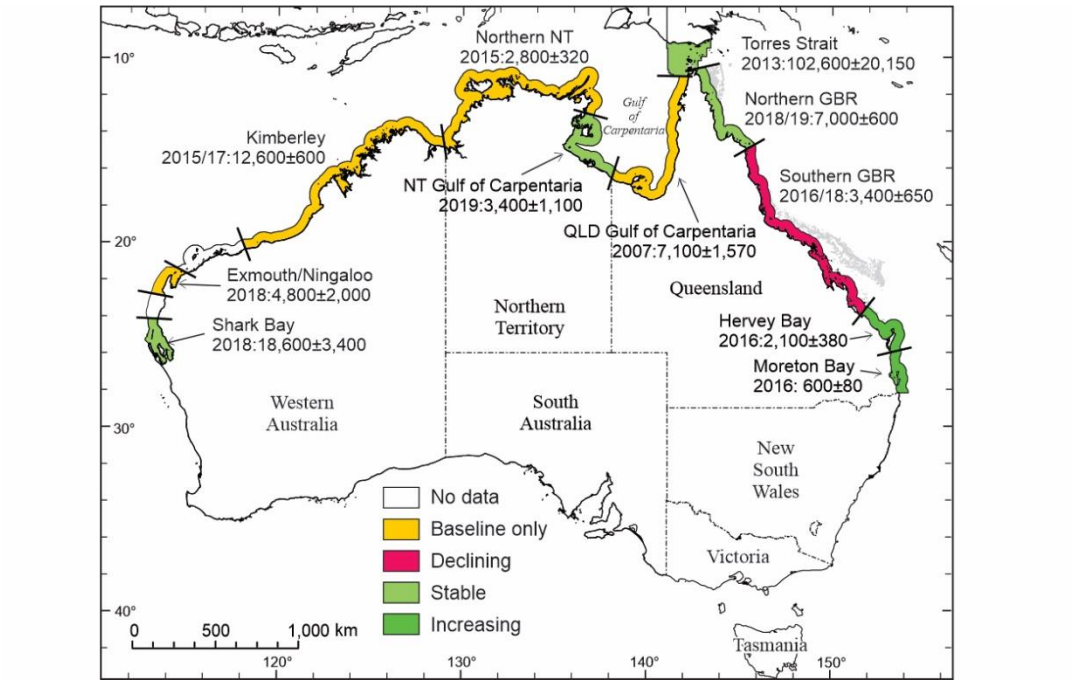

Figure 1. Range map showing the latest estimates of dugong population size and trends of various components of the dugong population in Australia. Extracted from Clark et al. (2021) with permission from Adella Edwards and Helene Marsh.

Study approach & methods

Spatial scope and information search

The spatial scope of this inventory was the known extent of the year-round dugong range in Australia. There are reports of sightings of dugongs beyond this range in summer but these are not included in this review (see Allen et al. 2004) as they may be seasonal or extra-limital.

To ease visual representation and broadly reflect on the strategies of aerial survey implementations within and across state jurisdictions we have split northern Australia into three main regions:

- **Northwest Australia:** from Shark Bay to the north-eastern Kimberley adjacent to the border between Western Australia and the Northern Territory
- **Northern Australia:** from the eastern border of the Northern Territory to Cape York
- **Eastern Australia:** from the Torres Strait down to Moreton Bay.

We conducted a review of the literature and data portals to produce a thorough inventory of all dugong aerial surveys ever undertaken in Australia. If possible, we verified the existence, locality and accessibility of the data generated from those surveys and provided links to dataset, publications (e.g., technical reports, book chapters or peer-reviewed publications) as well as relevant data custodians' contact details. For each identified survey event we recorded the following information:

- **Date of survey:** including information on whether there were repeat surveys.
- **Survey location:** survey region, any targeted survey area, and additional neighbouring areas
- **Survey technique**: definition and acronyms of the various survey approaches are explained in the tables' captions.
- **Estimate of dugong abundance:** when appropriate, data from past aerial surveys were revisited in later studies as a result of improvements in abundance estimation methods. Here we provide the latest estimates found in the literature
- **Reference:** a hyperlink is associated with references for which a digital copy of the publication was found
- **Data availability:** whether the data has been digitised and stored in a repository or is visible in hard copies
- **Spatially-explicit models of dugong density distribution:** whether the dugong distribution was modelled and if so what modelling method was used
- **Data location**
- **Data access**
- **Custodian or relevant contact**

This inventory is synthesised in three main tables (Table 1, 2 and 3), reflecting on the three main regions mentioned above.

Infographics

We developed summary maps to visually represent survey extents and effort across the entire dugong range in Australia (Figures 2-7). The reader should be aware of and cautious about the following:

- Shoreline reconnaissance surveys were presented in sets of maps separate from the standardised abundance surveys because of the difference in their design and intended objectives (Figure 3-4).
- Shoreline reconnaissance surveys conducted in Eastern Australia could not be depicted on a map because of a lack of information found on the extent and locations of where the surveys were undertaken
- The maps showing standardised abundance aerial survey effort are a spatial and quantitative representation of cumulative number of surveys conducted at any location across northern Australia. They do not systematically represent the extent of surveys conducted at regional scales as part of monitoring time series.
- Some standardised abundance aerial surveys conducted over large spatial-scales had sections (i.e. survey blocks) that could not be flown at the time of survey. Our maps do not provide this detail and so we recommend that the reader checks the raw literature to identify survey blocks that may not have been flown.
- Our definition of seasons in the maps are broad: summer, warm and/or wet season are all merged into a single category encompassing the period from October to April. Similarly, winter, dry and/or cool seasons encompass the May to September period.
- Aerial surveys conducted at the local scale but using survey block and design from the broader regional survey design were integrated in the maps in a similar fashion to regional surveys. Contrastingly, local surveys for which we could not assess the design or which used very different designs to those used in regional surveys were marked in the maps using ‘pin-points’.

Results

Evolution of survey and abundance estimate approaches

Dugong aerial surveys in Australia date back from the early 19070s. The first survey dates from September 1974, was conducted in the Townsville region (Queensland) and was reported by Heinsohn et al. (1976). Shoreline reconnaissance surveys (some of which used transect markers to count dugongs) were the main approach to determine the presence, distribution and relative numbers of dugongs in the inshore areas around the mainland and islands (Figure 3 and 4).

The first standardised abundance aerial survey conducted in Australia was implemented by Bayliss (1986) in December 1983 in the Northern Territory between the Daly River and Millingimbi. It was followed in November 1984 by a standardised survey of a section of the northern GBR by Marsh & Saalfeld (1989) who also set the first standardised and later widely used approach to correct for imperfect dugong detections in abundance estimation methods. Prince (1986) reported the first standardised dugong abundance survey conducted in the Roebuck Bay area in the north-western region as part of a regional shoreline reconnaissance survey conducted between the Exmouth Gulf and Darwin. Only minimum counts were generated from the Roebuck Bay survey. The survey of the Shark Bay-Ningaloo-Exmouth gulf regions in July 1989 (Marsh et al. 1994, Preen et al. 1997) provided the first estimates of dugong abundance based on corrected counts using the Marsh and Saalfeld (1989) method in the north-western region.

Survey effort and frequency

The occurrence and frequency of standardised abundance surveys for dugong population monitoring purposes have depended on funding availability. Power analyses based on outputs from time series of surveys conducted in the Great Barrier Reef indicate that the current target of 5-year surveys remain adequate to assess long term changes in the dugong population at regional scales (Marsh et al. 2020). While managers and researchers from across the country have been aiming at following this survey frequency, funding availability has been a limiting factor to conduct dugong monitoring surveys in some regions.

The cumulative number of standardised abundance surveys conducted across Australia varies greatly geographically (Figure 2). Some of the most surveyed areas include the Exmouth Gulf (15 identified standardised abundance surveys, Figure 2 and 6), the Darwin region (22 identified standardised abundance surveys), the Gladstone region within the southern GBR (12 identified standardised abundance surveys, Figure 2 and 7). The higher intensity of surveys in those regions is mostly the results of industry-funded programs to assess the distribution and number of dugongs across years and/or seasons and/or tides in local areas potentially impacted by coastal industrial activities (e.g., Cardno 2014, GPC 2009, RPS 2011) or areas where assessment of dugong distribution and numbers were commissioned as a result of extreme weather events and habitat disturbance (e.g., Preen and Marsh 1995).

The surf coast between Shark Bay and Exmouth Gulf has not been surveyed in recent times despite questions around the use of this region as a movement corridor for migrating dugongs

(Gales et al. 2004, Figure 5). The entire Kimberley region has only been surveyed once (Bayliss and Hutton 2017, Figure 6) and so only baseline information about dugong distribution and abundance is available in this region.

Dugong population trends analyses

The availability and veracity of dugong population trends analyses reflect the limitations in obtaining data over the long term, as explained above, but also on how and what data was recorded at the time of survey and the analytical approach used to assess trends. For example, Sobtzick et al. (2014) used data corrected using the Marsh and Sinclair (1989) methodology and frequentist statistics to test for significant trends in dugong abundance in the northern GBR since the time series of surveys began in 1987. The differences between surveys were not significant. However, Sobtzick et al. (2014) emphasised that these results should be interpreted with caution because of the difficulty in detecting significant trends in marine mammal populations using this approach unless the trends are large (Taylor et al 2007). In view of this difficulty, Rankin and Marsh (in Marsh et al. 2020) used Bayesian modelling approaches to conduct a trend analysis of the data from the 2006 and 2013 surveys relevant to an optimised survey design and additional data on environmental conditions that were only consistently collected since 2006. The Bayesian approach appears superior to the frequentist approach largely because it incorporates multiple sources of uncertainties including expected frequencies for transects in dugong habitats where no dugongs were seen in a specific survey (for details see Marsh et al. 2020). This approach is relatively new and thus has not yet been used on data collected from surveys conducted in regions other than east Queensland (Table 3).

Spatial modelling of dugong density distribution

Spatial modelling techniques emerged long after the start of dugong aerial surveys (which pre-dated GPS technology), partly explaining why many datasets collected from aerial surveys were not used in modelling approaches. Models of dugong distribution were never attempted for aerial surveys conducted in the northern region (Northern Territory and Gulf of Carpentaria). Models of dugong distribution from surveys conducted in the northwest region were mostly generated using kernel density methods (e.g., Bayliss and Hutton 2017, Table 1). GIS-based kriging methods (originally inspired from Grech et al. 2011) were adopted in all surveys conducted in eastern Australia since 2005, providing comparative maps of dugong density distribution across the time-series of surveys (Table 3). Recently general additive models (GAMs) were trialled on data collected from small-scale observer surveys (Hodgson et al. 2020) and drone surveys (Cleguer et al. 2021, Table 1). GAMs have the potential to become a superior method to kriging methods as they have the ability to account for environmental variables recorded beyond the data recorded on transect and to extrapolate and correct dugong numbers for availability bias across the entire survey area as opposed to the kriging that uses dugong counts corrected for availability bias as source data and extrapolate based on a set search radius distance.

Restrictions on data access

Some data custodians we contacted have not responded. Most data for which access could not be granted are the result of historical data that have never been digitised and thus are only visible in hard copies of publications. Others are withheld by private industrial companies or consultancy agencies.

Perspectives

This project inventoried all dugong aerial surveys ever conducted in Australia. Given the huge spatial extent and numbers of surveys conducted for dugongs in Australia we hope that this inventory will be used as a one-stop-shop to provide at least some preliminary information to future researchers, managers and policy makers, and members of the Australian community on when, where, how many times dugong aerial surveys were undertaken in any region with the Australian dugong range. The inventory also provides a preliminary idea of how the data was analysed to generate dugong abundance estimates and distribution models and whether the data is actually available and accessible and how to access it.

The inventory identifies discrepancies and/or gaps in survey effort as well as the way dugong aerial survey data have been analysed. Below we provide suggestions on how these discrepancies and gaps could be addressed in future work:

- **Evolution of survey and abundance estimate and trends analysis**
  - While our inventory includes completed and published work on the use of different aerial imagery approaches (e.g., Hodgson et al. 2013, Cleguer et al. 2020, 2021) this document does not include reflections and recommendations on the necessary work to transition to these new techniques as this is being addressed in a separate study (Cleguer et al. ongoing).
  - We found that the Hagihara method has been accepted as the new standard for dugong population estimates and it was used to estimate population sizes in all of the last dugong population surveys conducted across the country after the method was published (e.g., Bayliss et al. 2018, Griffiths et al. 2020, Marsh et al. 2020). Marsh et al. (2019) retrospectively re-estimated dugong abundance using the Hagihara method for all surveys conducted in Eastern Queensland since the early 2000's (because the necessary extra data on environmental conditions were not collected during the earlier surveys as explained above). Similar work would need to be conducted on historical survey data collected in other parts of Australia to aid data comparison and calibration for population trend analysis.
  - Bayesian modelling approaches similar to that used by Marsh et al. (2019, 2020) should be applied to datasets from other regions where they have not been used to harmonise analysis across all regions.

- **Spatial modelling of dugong density distribution**
  - Current approaches to model the density distribution of dugongs using aerial survey data vary greatly but there has not been an evaluation of how much these methods differ between one another and which method should be adapted as a standard (providing the source data is also collected using a standard approach). As a result, comparing the outputs and making inferences from these different models is currently impossible. We therefore suggest that current modelling methods need to be reviewed and evaluated in light of the data collected in modern aerial surveys methods (including perspectives for modelling work based on aerial imagery data) with the aim to identify a method that could be standardised at the national level.

- **Survey effort and frequency**
  - We concur with Bayliss and Hutton (2017)'s observation from their analysis of the baseline dugong aerial surveys conducted across the Kimberley that *"because of costs, funding for repeat surveys is likely to only come around every 15-20 years if that, a time frame that doesn't suit monitoring trends for early warning detection, nor to assess seasonal shifts in distribution and abundance, important knowledge gaps in the present study"*. In their report, Bayliss and Hutton (2017) provide recommendations for investigation of alternative and complementary approaches to monitor dugong populations in the Kimberley at various spatial and temporal scales. These include: (1) the design of regular and standardised boat-based monitoring programs, (2) investigating the use of drones (or helicopters) for local surveys, (3) the design of a long-term repeat abundance aerial survey for each sea country within the Kimberley that integrates local survey data (the previous two points), (4) investigate the use of close-kin genetics study to assess absolute population size in areas where it is logistically appropriate to obtain adequate random sample-sizes.
  - Once validated, approaches to gauge dugong population health through body condition assessment using small drones may become a valuable population assessment tool.
  - Our recommendation is that a consortium of scientific experts, managers, and representatives from the Kimberley Indigenous Salt Water Aboriginal Group should gather to review all of the above options, weigh their advantages and disadvantages, assess their complementarity, and determine what interest, capacity and cultural acceptance there is within the communities in the Kimberley to better plan future dugong population assessment work in the region.

- **Restriction on data access**
  - Some datasets with dugong information were hard if not impossible to access or verify. These datasets were for most produced as part of industry-funded projects and some even have been lost as a result of change in company names, restructures, change of staff (e.g., RPS 2011). Efforts should be put towards enticing industry partners and consultancy companies to design plans for the public release of dugong aerial survey data to mitigate the risk of data loss and increase the benefit of data usage from interested users such as government agencies, researchers but also members of the public.

Figures and Tables

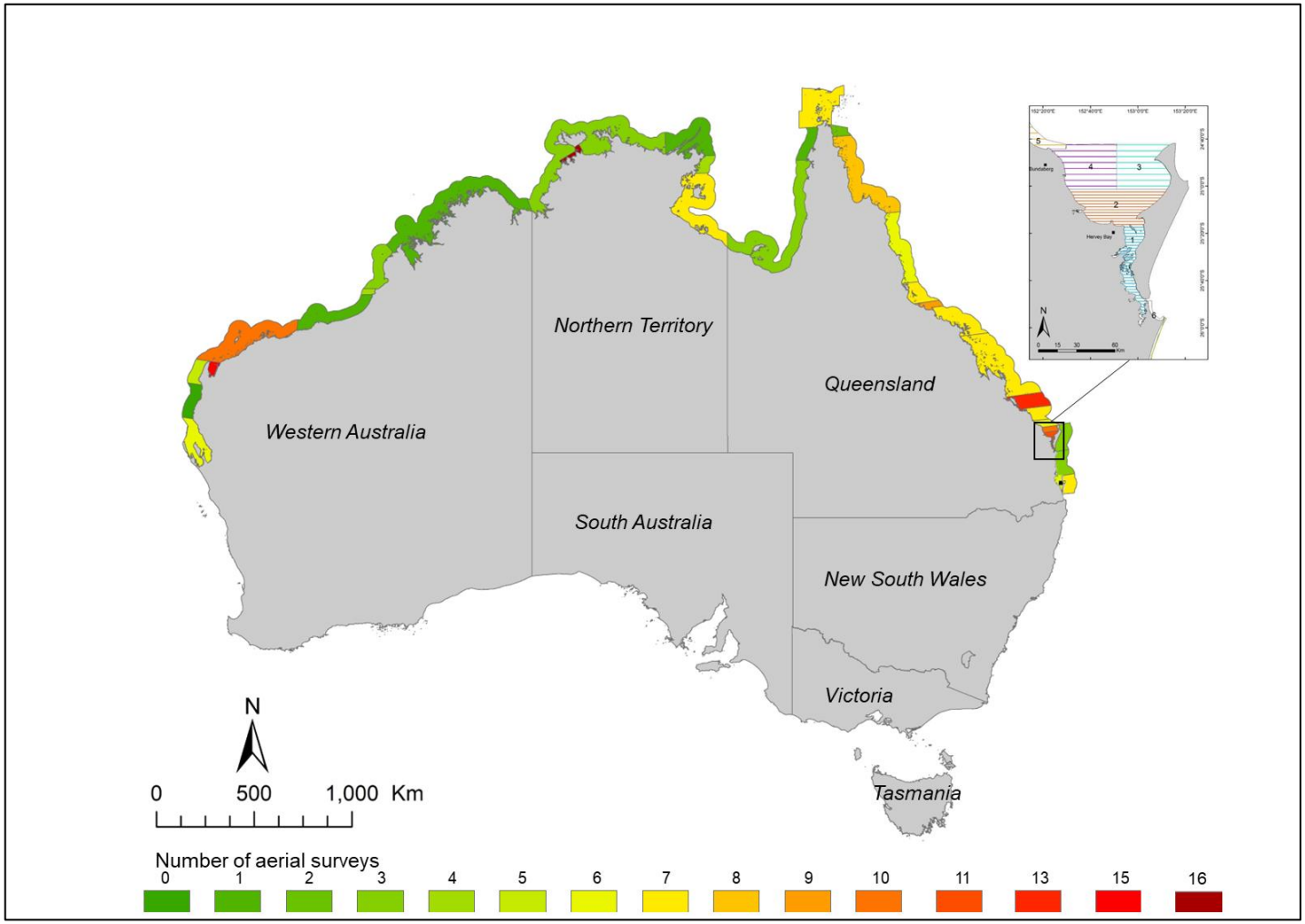

Figure 2. Cumulative number of standardised dugong aerial surveys conducted across Australia. Offshore boundaries of survey cover are not to scale and were increased for most surveyed areas to ease visualisation. The insert in the figure provides a visual example of the design of standardised dugong aerial survey transects and blocks.

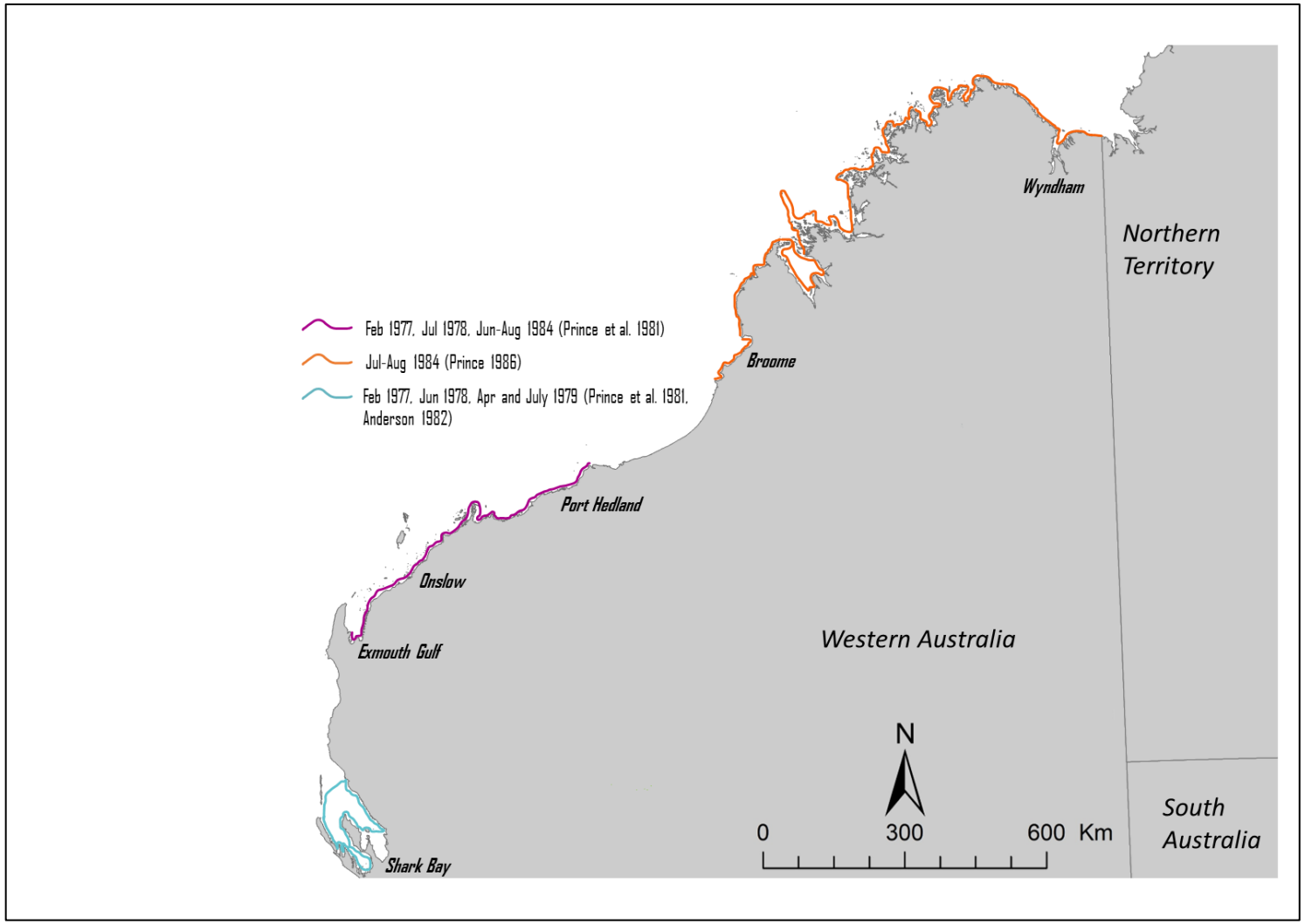

Figure 3. Shoreline dugong reconnaissance surveys conducted in the northwest region of Australia,1977-1986.

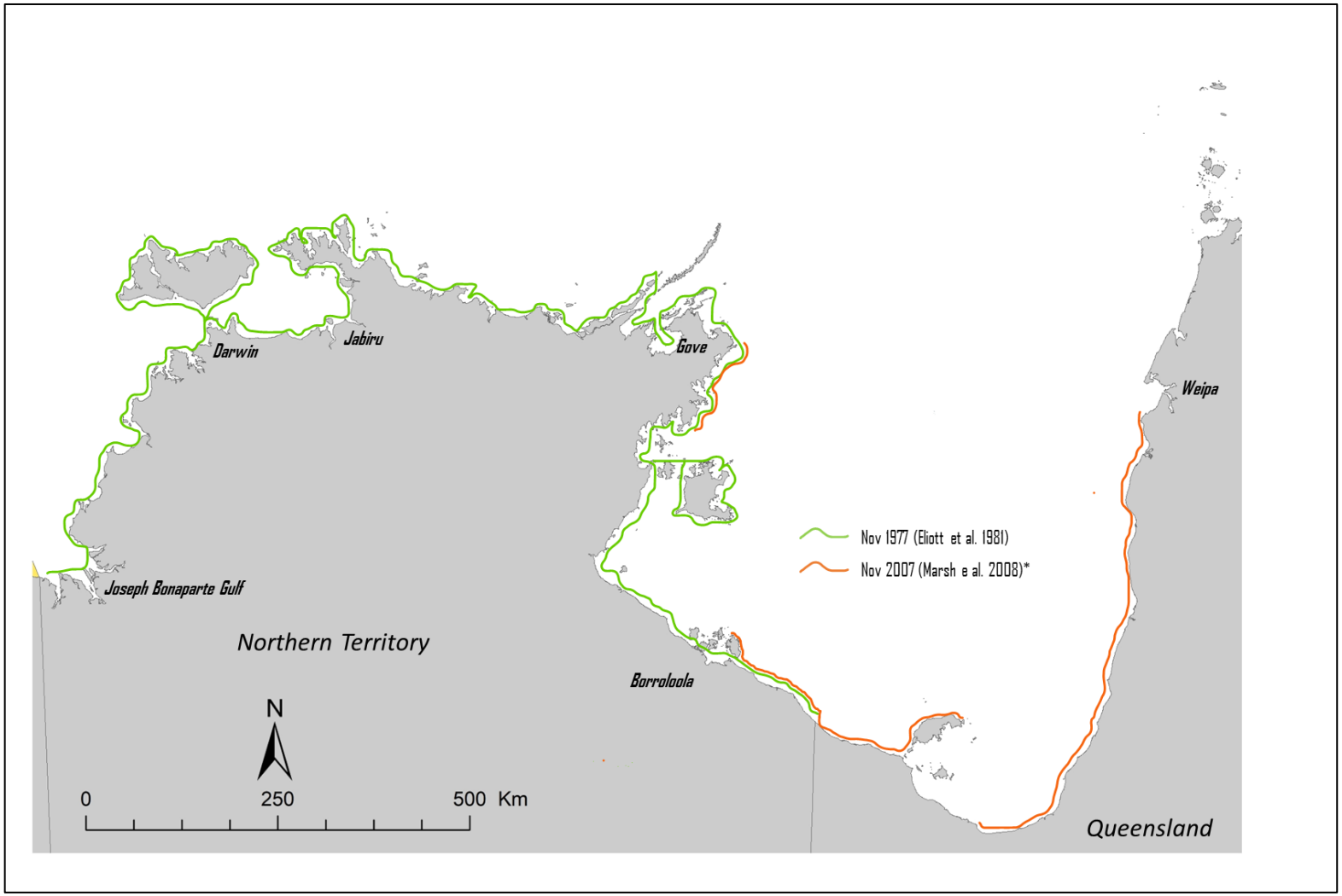

Figure 4. Shoreline dugong reconnaissance surveys conducted in the northern region of Australia,1977-2007.

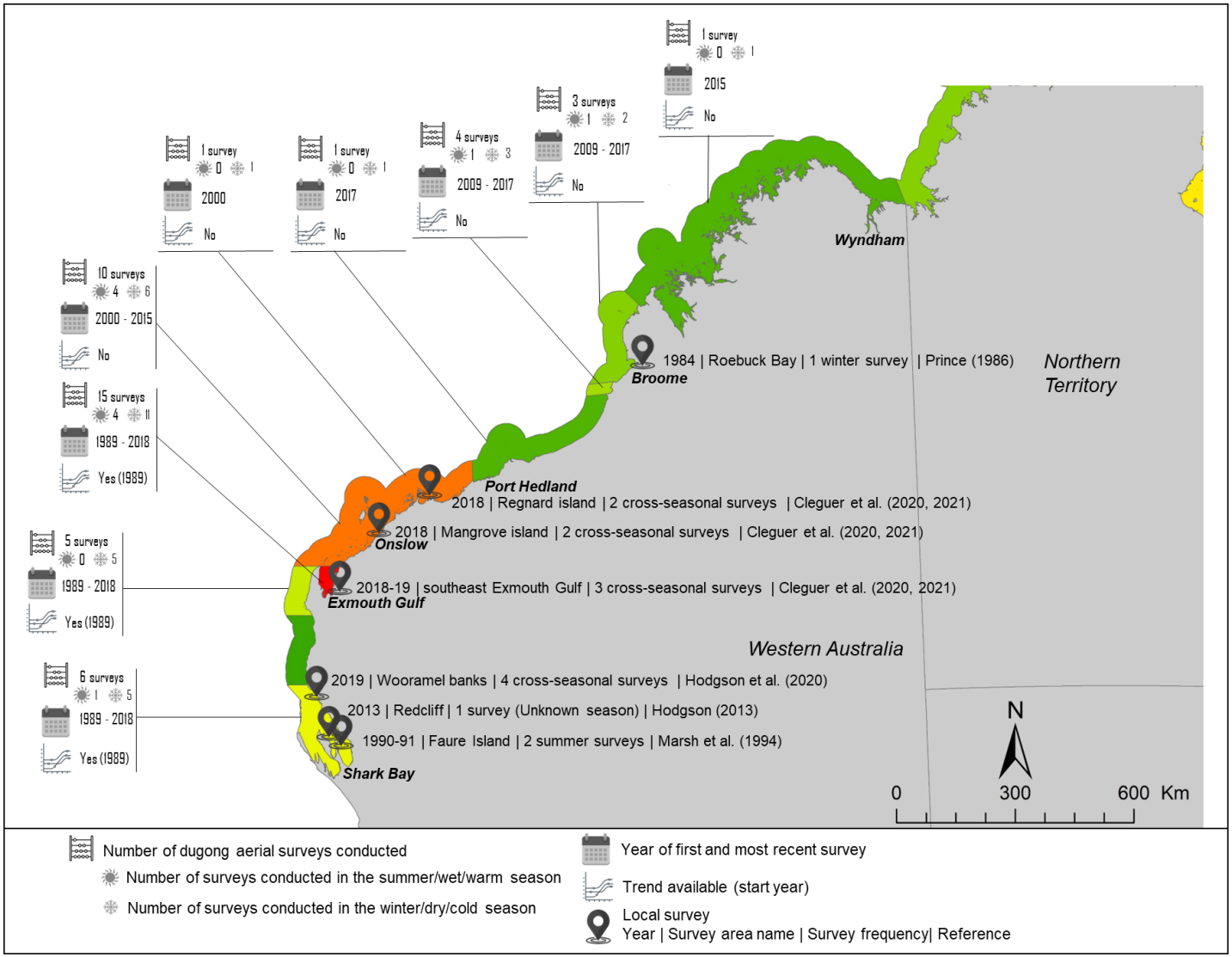

Figure 5. Number, seasonality, and time-range of standardised dugong aerial surveys conducted in northwester Australia to date.

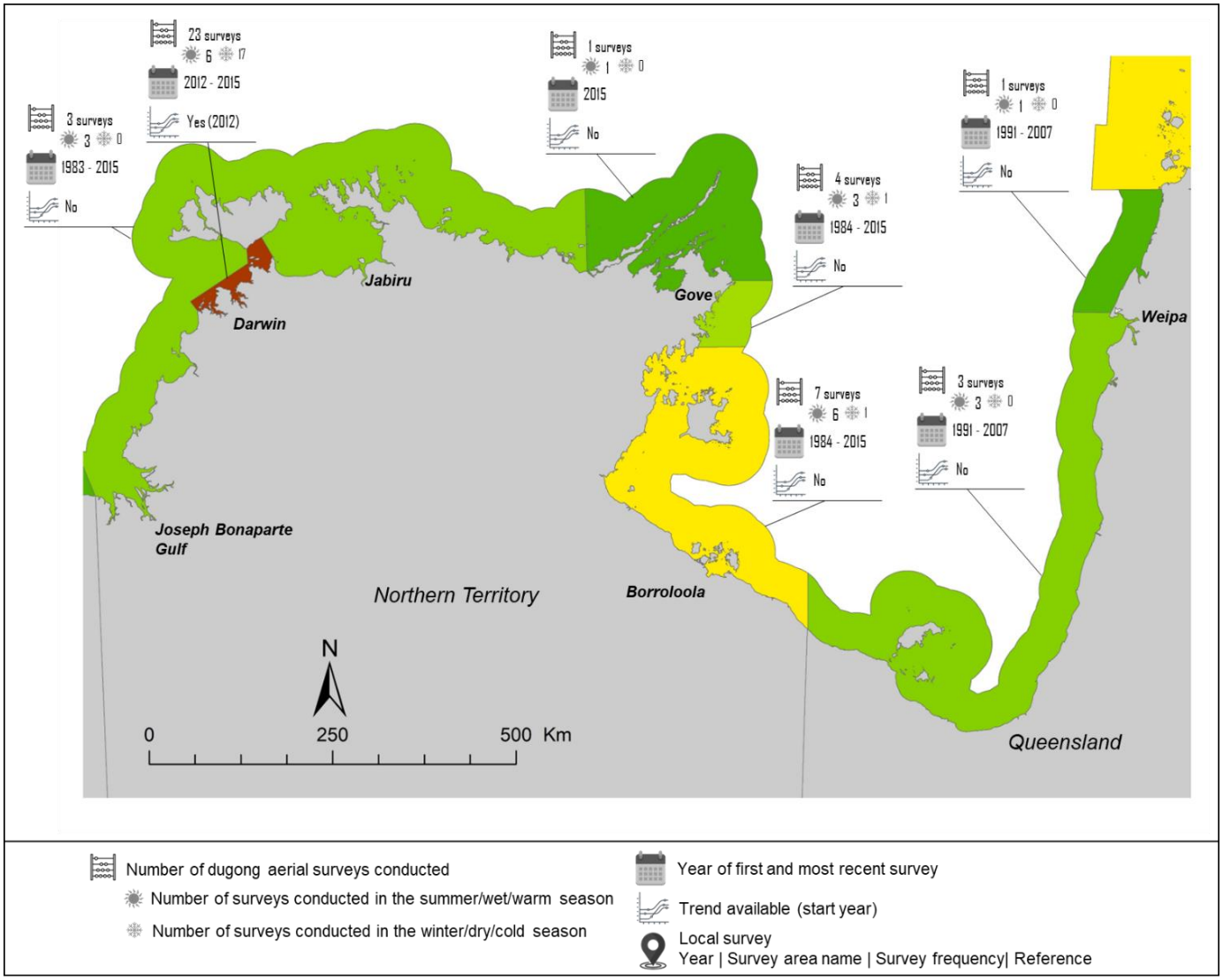

Figure 6. Number, seasonality, and time-range of standardised dugong aerial surveys conducted in northern Australia to date.

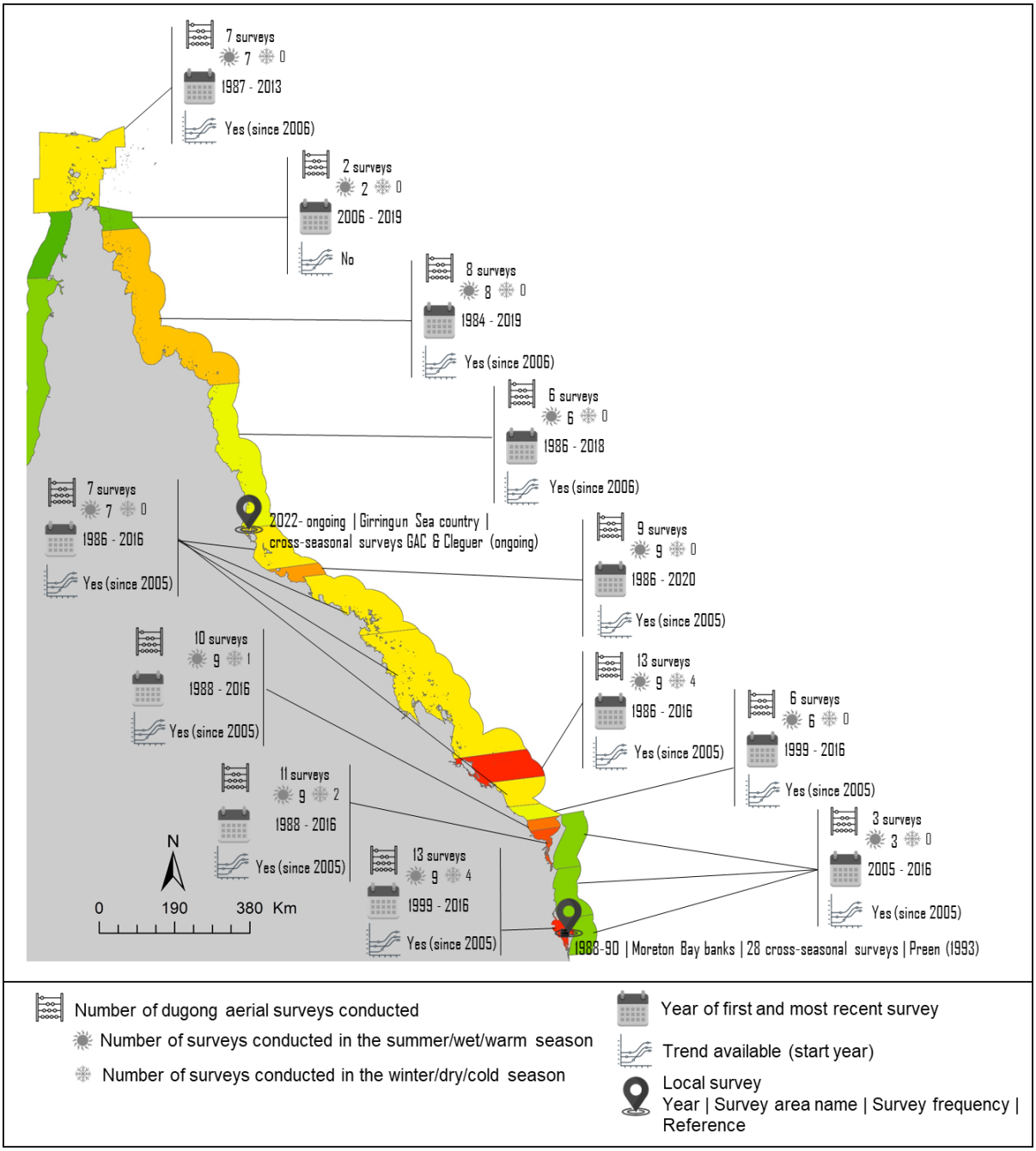

Figure 7. Number, seasonality, and time-range of standardised dugong aerial surveys conducted in Eastern Australia to date.

Table 1. Inventory of dugong aerial surveys conducted in northwest Australia. The table is organised by region (The Gascoygne region including Shark Bay, Ningaloo, Exmouth Gulf-Pilbara, and the Kimberley region) and by date of survey within regions. Bold superscripted numbers (^{0,1,2,3,4}) indicate which methods was used to estimate dugong abundance (uncorrected numbers, Bayliss 1986, Marsh and Sinclair 1989, Pollock et al. 2006, and Hagihara et al. 2014, 2018 respectively). Bold superscripted letters (^{a,b,c}) indicate which spatial modelling method was used to generate models of dugong density distribution (Kernel density as in Bayliss and Hutton 2017, kriging as in Grech et al. 2011, generalized additive models as in Cleguer et al. 2021 respectively). Acronyms: SRS: shoreline reconnaissance survey, SOOAS: Standardised occupied observer abundance survey, SOIAS: Standardised observer and imagery abundance survey, SUAS: Standardised unoccupied abundance survey.

Month-year of survey (number of repeats)	Specific survey area	Additional area	Survey techni que	Dugong abundance estimate	Reference	Data availability	Dugong density modelled and available	Data location	Data access	Custodian - relevant contact
Gascoygne region - Shark Bay										
Feb-77	Entire bay's coastline	Exmouth Gulf to De Grey River (Pilbara)	SRS-OOS	Na	Prince et al. (1981)	Not digitised, hard copy only	No	Unknown	Unknown	Unknown
Jun-78	Section of the bay	-	SRS-OOS	Na	Prince et al. (1981)	Not digitised, hard copy only	No	Unknown	Unknown	Unknown
Apr-79	Section of the bay	-	SRS-OOS	Na	Prince et al. (1981)	Not digitised, hard copy only	No	Unknown	Unknown	Unknown
Jun-79 to Jul-79 (6)	Section of the bay	-	SRS-OOS	Na	Anderson (1982)	Not digitised	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jul-89	-	Ningaloo and Exmouth Gulf	SAS-OOS	10,146 (±SE 1,665)[2]	Preen et al. (1997), Marsh et al (1994)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au

Nov-90 & Jan-91 (2)	Section of the bay (Faure Sill and Faure Island)	-	SAS-OOS	3,265 (±SE 545; Nov 1990) - 5,236 (±SE 1,237; Jan 1991)[2]	Marsh et al. (1994)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jun-94	-	Ningaloo and Exmouth Gulf	SAS-OOS	10,529 (±SE 1,464)[2]	Preen et al. (1997)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jul-99	-	Ningaloo and Exmouth Gulf	SAS-OOS	13,929 (±SE 1,652)[2]	Gales et al. (2004)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Feb-02	-	-	SAS-OOS	11,021 (±SE 1,357)[2]	Holley et al. (2006)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
May/Jun-07	-	Ningaloo and Exmouth Gulf	SAS-OOS	9,347 (±SE 1,204)[3]	Hodgson (2007)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au

Sep-10	Offshore from Redcliff	-	DS, trials	Not estimated (dugong detection trials)	Hodgson et al. (2013)	Digitised and available	No	Lead investigator	Request can be made to the lead investigator	h.hodgson@murdoch.edu.au
Jun-18	-	Ningaloo and Exmouth Gulf	SAS-OOS	18,555 (±SE 3,396)[2,3,4]	Bayliss et al. (2018)	Digitised and available	Yes[b]	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Feb-19, Apr-19, Sep/Oct-19 (3)	Wooramel banks	-	SAS-OOS	Minimum uncorrected dugong counts	Hodgson et al. (2019)	Digitised and available	Yes[c]	Proponent and/or researcher's own database	Request can be made to Harvest Road Pty Ltd. An external request for information needs to be signed.	h.hodgson@murdoch.edu.au, (proponent email address unknown)
Gascoygne region - Ningaloo										
Jul-89	-	Shark Bay and Exmouth Gulf	SAS-OOS	634 (±SE 127)[2]	Preen et al. (1997), Marsh et al (1994)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jun-94	-	Shark Bay and Exmouth Gulf	SAS-OOS	968 (±SE 320)[2]	Preen et al. (1997)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au

Jul-99	-	Shark Bay and Exmouth Gulf	SAS-OOS	163 (±SE 48) [2]	Gales et al. (2004)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
May/Jun-07	-	Shark Bay and Exmouth Gulf	SAS-OOS	tfs	Hodgson (2007)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jun-18	-	Shark Bay and Exmouth Gulf	SAS-OOS	231 (±SE 156)[2,3,4]	Bayliss et al. (2018)	Digitised and available	Yes[b]	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Gascoygne region - Exmouth Gulf and Pilbara										
Feb-77	-	Shark Bay coastline, Exmouth Gulf to De Grey River (Pilbara)	SRS-OOS	Na	Prince et al. (1981)	Not digitised, hard copy only	No	Unknown	Unknown	Unknown
Jul-78	-	Shark Bay coastline, Exmouth Gulf to De Grey River (Pilbara)	SRS-OOS	Na	Prince et al. (1981)	Not digitised, hard copy only	No	Unknown	Unknown	Unknown

Jun-84 to Aug-84	-	Exmouth Gulf to Darwin	SRS-OOS	Na	Prince (1986)	Not digitised	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jul-89	-	Shark Bay and Ningaloo	SAS-OOS	1,062 (±SE 321)^2	Preen et al. (1997), Marsh et al (1994)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jun-94	-	Shark Bay and Ningaloo	SAS-OOS	1,006 (±SE 494)^2	Preen et al. (1997)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jul-99	-	Shark Bay and Ningaloo	SAS-OOS	174 (±SE 82)^2	Gales et al. (2004)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Apr-00	-	Up to De Grey River	SAS-OOS	2,141 (±SE 381)^2	Prince (2001)	Unknown	No	Unknown	Unknown	Unknown

2009-2010	-	Nearshore and offshore waters near the Wheatstone Project area	Unknown	Unknown	Jenner et al. (2010)	Unknown	No	Unknown	Unknown	Unknown
May/Jun-07	-	Shark Bay and Ningaloo	SAS-OOS	704 (±SE 354)[3]	Hodgson (2007)	Digitised and available	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Aug-10	-	Up to Montebello islands	SAS-OOS	287 (95% CI: 176-340; Wheatstone survey area); 1760 (95% CI: 1369-2088; Exmouth Gulf)[3]	RPS (2011)	Georeferenced data lost. Raw data available in report	No	Unknown	Unknown	Unknown
Apr-13 to May-13	-	Up to Barrow island	SAS-OOS	1,180 (±SE 413)[3]	Sobtzick et al. (2014)	Digitised and available	Yes[b]	Proponent and/or researcher's own database	Request can be made to Chevron Australia Pty Ltd. An external request for information needs to be signed.	PdeLestang@chevron.com ; andys@chevron.com
Oct-13	-	Up to Barrow island	SAS-OOS	1,052 (±SE 435)[3]	Sobtzick et al. (2014)	Digitised and available	Yes[b]	Proponent and/or researcher's own database	Request can be made to Chevron Australia Pty Ltd. An external request for information needs to be signed.	PdeLestang@chevron.com ; andys@chevron.com
May-15 & Oct-15	-	Up to Montebello islands	SAS-OOS	Unknown	Hodgson et al. (2015)	Unknown	Unknown	Proponent and/or researcher's own database	Request can be made to Chevron Australia Pty Ltd. An external request for information needs to be signed.	PdeLestang@chevron.com ; andys@chevron.com; a.hodgson@murdoch.edu.au
Aug-18 to Nov-18	-	-	SAS-OOS	Marine megafauna survey with focus on whales. Minimum uncorrected dugong counts available	Irvine & Salgado (2019)	Unknown	Unknown	Unknown	Unknown	Unknown

Jun-18	-	Shark Bay and Exmouth Gulf	SAS-OOS	4,599 (±SE 1959)[2,3,4]	Bayliss et al. (2018)	Digitised and available	Yes[b]	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
May-18, Nov18, Jun-19	South-East section of the Gulf	Mangrove island and Regnard island	SAAS-DS	46 (95% CI: 33.5 - 64.9; Jun-19); 102 (95% CI:52.2 - 201.9; May-18)[4]	Cleguer et al. (2020, 2021)	Digitised and available	Yes[c]	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Kimberley region										
Jun-84 to Aug-84	Roebuck Bay	Exmouth Gulf to Darwin	SAS-OOS	Minimum uncorrected dugong counts	Prince (1986)	Not digitised	No	Database of the Department of Biodiversity, Conservation and Attractions, Western Australia and researcher's own database	Request can be made to the Department of Biodiversity, Conservation and Attractions, Western Australia. A data sharing agreement will be required before data can be provided.	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Mar-09	Dampier Peninsula (Cape Bossut to Cape Leveque)	-	SAS-OOS	930 (±SE 301)[3]	SKM (2009)	Unknown	Yes[a]	Unknown	Unknown	holly.raudino@dbca.wa.gov.au ; kelly.waples@dbca.wa.gov.au
Jul-09	Dampier Peninsula (Cape Bossut to Cape Leveque)	-	SAS-OOS	1,774 (95% CI: 1,351 – 2,195)[3]	RPS (2010)	Georeferenced data lost. Raw data available in report	No	Unknown	Unknown	Unknown
Sep-09	Dampier Peninsula (Cape Bossut to Cape Leveque)	-	SAS-OOS	1,708 (95% CI: 1,188 – 2,205)[3]	RPS (2010)	Georeferenced data lost. Raw data available in report	No	Unknown	Unknown	Unknown

Sep/Oct-17	-	-	SAS-OOS	10,513 (±SE 497)[3]	Bayliss & Hutton (2017)	Digitised and available	Yes[a]	Link	Online request to Data WA	Unknown
May-17	-	-	SAS-OOS	2,087 (±SE 197)[3]	Bayliss & Hutton (2017)	Digitised and available	Yes[a]	Link	Online request to Data WA	Unknown

Table 2. Inventory of dugong aerial surveys conducted in northern Australia. This table was not organised by region because of the several changes in the spatial extents of the surveys across the territory. Bold superscripted numbers (^{0,1,2,3,4}) indicate which methods was used to estimate dugong abundance (uncorrected numbers, Bayliss 1986, Marsh and Sinclair 1989, Pollock et al. 2006, and Hagihara et al. 2014, 2018 respectively). Bold superscripted letters (^{a,b,c}) indicate which spatial modelling method was used to generate models of dugong density distribution (Kernel density as in Bayliss and Hutton 2017, kriging as in Grech et al. 2011, generalized additive models as in Cleguer et al. 2021 respectively). Acronyms: SRS: shoreline reconnaissance survey, SOOAS: Standardised occupied observer abundance survey, SOIAS: Standardised observer and imagery abundance survey, SUAS: Standardised unoccupied abundance survey.

Month-year of survey (number of repeats)	Specific survey area	Survey technique	Dugong abundance estimate	Reference	Data availability	Dugong density modelled and available	Data location	Data access	Custodian - relevant contact
Nov-77	Entire Northern Territory coastline	SRS-OOS	Na	Elliot (1981)	Not digitised, hard copy only	No	Na	Na	Na
Dec-83	Daly River-Millingimbi	SAS-OOS	38,000 (SE not provided)[1]	Bayliss (1986)	Not digitised, hard copy only	No	Na	Na	Na
Aug-84	Northern Territory waters of the Gulf of Carpentaria	SAS-OOS	min 16,816 (±SE 2,946)[1]	Bayliss & Freeland (1989)	Not digitised, hard copy only	No	Na	Na	Na
Feb-85	Northern Territory waters of the Gulf of Carpentaria	SAS-OOS	min 16,846 (±SE 3,257)[2]	Bayliss & Freeland (1989)	Not digitised, hard copy only	No	Na	Na	Na
Dec-91	Wellesley Islands and adjacent coastline (Northern Territory waters of the Gulf of Carpentaria (Northern Territory waters of the Gulf of Carpentaria)	SAS-OOS	4,067 (±SE 723)[2]	Marsh & Lawler (1993)	Not digitised, hard copy only	No	Na	Na	Na

Nov-94	Northern Territory waters of the Gulf of Carpentaria	SAS-OOS	Unknown	Saalfeld & Marsh (2004)	No	Na	Na	Na	Na
Dec-97	Queensland coastal waters of the Gulf of Carpentaria	SAS-OOS	4,266 (±SE 657)[2]	Marsh et al. (2000)	Not digitised, hard copy only	No	Na	Na	Na
Nov-07	Queensland and Northern Territory waters of the Gulf of Carpentaria	SAS-OOS	12,438 (±SE 1,951)[2,3]	Marsh et al. (2008)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
May-12 to May-14 (22)	Darwin Harbour and surrounding inshore waters	SAS-OOS	95 - 273 (baseline phase), 41 - 274 (during dredging)[2,3]	Cardno (2014)	Digitised and available	No	Unknown	Request to be made to INPEX-operated Ichthys LNG venture. Conditions of data usage include acknowledging funding source and review of draft publication	jamie.carle@inpex.com.au; joshua.corbett@inpex.com.au
Nov-14	Northern Territory waters of the Gulf of Carpentaria	SAS-OOS	5,877 (±SE 768)[2,3]	Groom et al. (2015)	Digitised and available	No	Database of the Department of Environment, Parks and Water Security, Northern Territory Government	Request to be made to the Department of Environment, Parks and Water Security. Data issued under Creative Commons Licence Attribution 4.0 - point data available to download from https://nrmaps.nt.gov.au/nrmaps.html	Tony.Griffiths@nt.gov.au
Nov-15	Entire northern Territory coastal waters	SAS-OOS	8,176 (±SE 958)[2,3]	Groom et al. (2017)	Digitised and available	No	Database of the Department of Environment, Parks and Water Security, Northern Territory Government	Request to be made to the Department of Environment, Parks and Water Security. Data issued under Creative Commons Licence Attribution 4.0 - point data available to download from https://nrmaps.nt.gov.au/nrmaps.html	Tony.Griffiths@nt.gov.au
Oct-19	Northern Territory waters of the Gulf of Carpentaria	SAS-OOS & OIS	3,390 (±SE 1,092)[3,4]	Griffiths et al. (2020)	Digitised and available	No	Database of the Department of Environment, Parks and Water Security, Northern Territory Government	Request to be made to the Department of Environment, Parks and Water Security. Data issued under Creative Commons Licence Attribution 4.0 - point data available to download from https://nrmaps.nt.gov.au/nrmaps.html	Tony.Griffiths@nt.gov.au

Table 3. Inventory of dugong aerial surveys conducted in eastern Australia. The table is organised by region (Torres Strait, northern Great Barrier Reef, urban coast of the Great Barrier Reef, Hervey Bay-Great Sandy Strait and Moreton Bay) and by date of survey within regions. Bold superscripted numbers (^{0,1,2,3,4}) indicate which methods was used to estimate dugong abundance (uncorrected numbers, Bayliss 1986, Marsh and Sinclair 1989, Pollock et al. 2006, and Hagihara et al. 2014, 2018 respectively). Bold superscripted letters (^{a,b,c}) indicate which spatial modelling method was used to generate models of dugong density distribution (Kernel density as in Bayliss and Hutton 2017, kriging as in Grech et al. 2011, generalized additive models as in Cleguer et al. 2021 respectively). Acronyms: SRS: shoreline reconnaissance survey, SOOAS: Standardised occupied observer abundance survey, SOIAS: Standardised observer and imagery abundance survey, SUAS: Standardised unoccupied abundance survey.

Month-year of survey (number of repeats)	Specific survey area	Additional area	Survey technique	Dugong abundance estimate	Reference	Data availability	Dugong density modelled and available	Data location	Data access	Custodian - relevant contact
Torres Strait										
Nov-87	-	-	SAS-OOS	13,319 (±SE 2,136)^{2}	Marsh & Saalfeld (1988, 1991)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Mar-88	Section of Torres Strait	-	SAS-OOS	6,511 (±SE 1,190)^{2}	Marsh & Saalfeld (1988, 1991)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov–Dec 1991	-	-	SAS-OOS	24,225 (±SE 3,276)^{2}	Marsh & Lawler (1992), Marsh et al. (1997b)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
XX-93	Section of Torres Strait	-	SAS-OOS	Unknown	Marsh et al. (1996)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
XX-94	Section of Torres Strait	-	SAS-OOS	Unknown	Marsh et al. (1996)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-96	-	-	SAS-OOS	27,881 (±SE 3,126)^{2}	Marsh et al. (1997a)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

Nov-01	-	-	SAS-OOS	13,465 (±SE 2,152)[2,3]	Marsh et al. (2004)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-05	Section of Torres Strait	Moreton Bay, Hervey Bay, Southern and cenral sections of the GBR	SAS-OOS	4,251 (±SE 819)[2,3]	Marsh et al. (2006)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-06	-	nGBR and a section of Hervey Bay	SAS-OOS	84,389 (±SE 13,797)[2,3,4]	Marsh et al. (2007)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-11	-	-	SAS-OOS	83,372 (±SE 14,693)[2,3,4]	Marsh et al. (2011)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-13	-	Includes nGBR	SAS-OOS	102,519 (±SE 20,146)[2,3,4]	Sobtzick et al. (2014)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Northern GBR										
Nov-74	Cape York region	-	SRS-OOS	Na	Heinsohn et al. (1976)	Not found	No	Na	Na	Na
Mar/Apr-75	-	Hervey Bay, sGBR and Gulf of Carpentaria coastline	SRS-OOS	Na	Ligon (1976)	Not digitised, hard copy only	No	Na	Na	Na
Nov-84	Cape Bedford to Hunter Point	-	SAS-OOS	2,542 (±SE 634)[2]	Marsh & Saalfeld (1989)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-85	Cape Bedford to Hunter Point	-	SAS-OOS	8,110 (±SE 1,073)[2]	Marsh & Saalfeld (1989)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov–Dec 1990	Cape Bedford to Hunter Point	-	SAS-OOS	10,471 (±SE 1,578)[2]	Marsh et al. (1993)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-95	Cape Bedford to Hunter Point	-	SAS-OOS	8,190 (±SE 1172)[2]	Marsh & Corkeron (1996)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

Nov-2000	Cape Bedford to Hunter Point	Central GBR	SAS-OOS	9,730 (±SE 1,485)[2,3]	Marsh & Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-06	Cape Bedford to Hunter Point and Hunter Point to New Castle Bay (zig zag transects)	Torres Strait and a section of Hervey Bay	SAS-OOS	8,449 (±SE 1,803)[2,3,4]	Marsh et al. (2007)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-13	Cape Bedford to Hunter Point	Torres Strait	SAS-OOS	6,133 (±SE 1,097)[2,3,4]	Sobtzick et al. (2014)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-19	Cape Bedford to Hunter Point and Hunter Point to New Castle Bay (inshore/offshore parrallel transects)	Central GBR	SAS-OOS	6,970 (±SE 1,581)[2,3,4]	Marsh et al. (2020)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Urban coast of the GBR										
Sep-74	Townsville region	-	SRS-OOS	Na	Heinsohn et al. (1976)	Not digitised, hard copy only	No	Na	Na	Na
Mar/Apr-75	Na	Hervey Bay, nGBR and Gulf of Carpentaria coastline	SRS-OOS	Na	Ligon (1976)	Not digitised, hard copy only	No	Na	Na	Na
Nov-86	Mackay-Capricorn Section	-	SAS-OOS	1,024 (±SE 170)[2]	Marsh & Saalfeld (1990)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Sep–Oct 1987	Cape Bedford to Mackay	-	SAS-OOS	1,532 (±SE 273)[2]	Marsh & Saalfeld (1990)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-92	Cape Bedford to Bundaberg	Hervey Bay	SAS-OOS	590 (±SE 165)[2]	Marsh et al. (1994)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

Nov-94	Mission beach to Bundaberg	Hervey Bay	SAS-OOS	824 (±SE 331)[2]	Marsh et al. (1996)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-99	Mission beach to Bundaberg	Hervey Bay and sections of Moreton Bay	SAS-OOS	3,993 (±SE 641)[2]	Marsh & Lawler (2001)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-05	Cape Bedford to Bundaberg (include combination of zigazag and inshore/offshore parrallel transects)	Hervey Bay, Moreton Bay and a section of Torres Strait	SAS-OOS	1,558 (±SE 300)[2,3,4]	Marsh et al. (2006)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov to Jul 2008 (6)	Gladstone area	-	SAS-OOS	No estimate	GPC (2009)	Digitised and available	No	Request can be made to GPC representatives.	Request can be made to GPC representatives.	Unknown
Nov-11	Cape Bedford to Bundaberg	Hervey Bay and Moreton Bay	SAS-OOS	537 (±SE 223)[2,3,4]	Sobtzick et al. (2012)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-16	North Hinchinbrook to Bundaberg	Hervey Bay and Moreton Bay	SAS-OOS	2,822 (±SE 600)[2,3,4]	Sobtzick et al. (2017)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-20 (2)	Cleveland & Bowling Green Bay	-	SAS-OOS	Unknown	Marsh et al. (Unpublished)	Digitised	Unknown	JCU staff external Hard drive, and Port of Townsville database (?)	Request can be made to JCU and Port of Townsville representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Alana OBrien <aobrien@townsville-port.com.au>
Hervey Bay & Great Sandy Strait										
Mar/Apr-75	Na	GBR and Gulf of Carpentaria coastline	SRS-OOS	Na	Ligon (1976)	Not digitised, hard copy only	No	Na	Na	Na
Jul–Aug 1988	Exclude area from Baffle Creek to Burnett Heads	-	SAS-OOS	2,206 (±SE 420)[2]	Preen & Marsh (1995)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

Nov-92	Exclude area from Baffle Creek to Burnett Heads	sGBR	SAS-OOS	1,109 (±SE 383)[2]	Marsh et al. (1994)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-93	Exclude area from Baffle Creek to Burnett Heads	-	SAS-OOS	579-679 (±SE 126)[2]	Preen & Marsh (1995)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-94	Exclude area from Baffle Creek to Burnett Heads	sGBR	SAS-OOS	807 (±SE 151)[2]	Marsh et al. (1996)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-99	-	sGBR and sections of Moreton Bay	SAS-OOS	1,654 (±SE 248)[2]	Marsh & Lawler (2001)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Apr-2001	-	Moreton Bay	SAS-OOS	919 (±SE 146)[2]	Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-2001	-		SAS-OOS	1708 (±SE 392)[2]	Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-2005	-	sGBR, Moreton Bay and a section Torres Strait	SAS-OOS	1,388 (±SE 323)[2,3,4]	Marsh et al. (2006)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-06	Section of the Bay	nGBR, and Torres Strait	SAS-OOS	1044 (±SE 399)[2,3]	Marsh et al. (2007)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-2011	-	sGBR and Moreton Bay	SAS-OOS	1,438 (±SE 438)[3,4]	Sobtzick et al. (2012)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-2016	-	sGBR and Moreton Bay	SAS-OOS	2,055 (±SE 382)[3,4]	Sobtzick et al. (2017)	Digitised and available	Yes[b]	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Moreton Bay										

Cross seasons 1976-1977	Na	-	SRS-OOS	Na	Heinsohn et al. (1978)	Not digitised, hard copy only	No	Na	Na	Na
May-77	Na	-	SRS-OOS	Na	Heinsohn (1977)	Unavailable	Na	Na	Na	Na
May-76 & Jan-77	Na	-	SRS-OOS	Na	Lear (1977)	Unavailable	Na	Na	Na	Na
XX-79	Na	-	SRS-OOS	Na	Heinsohn & Marsh (1980)	Unavailable	Na	Na	Na	Na
Jul-88 & Feb-90 (28)	Section of the bay	-	SAS-OOS	Minimum uncorrected dugong counts	Preen (1993)	Not digitised, hard copy only	No	Na	Na	Na
XX-88	-	Hervey Bay	SAS-OOS	458 (±SE 78)	Marsh et al. (1990)	Unavailable	Na	Na	Na	Na
Apr-93	Section of the bay (same as Preen 1993)	-	SAS-OOS	664	Preen & Marsh (1995)	Not digitised, hard copy only	No	Na	Na	Na
Jan-Dec 1995 (6)	-	Hervey Bay	SAS-OOS	503 (±SE 64) - 1,019 (±SE 166)[2]	Lanyon & Morrice (1997), Lanyon (2003)	Unknown. Needs checking with project investigator (Lanyon)	Unknown	Unknown	Unknown	Unknown
Nov-99	-	sGBR and Hervey Bay	SAS-OOS	171 (±SE 76)[2]	Marsh & Lawler (2001)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Dec-2000	-	Hervey Bay	SAS-OOS	344 (±SE 88)[2]	Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Apr-2001	-		SAS-OOS	366 (±SE 41)[2]	Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-2001	-		SAS-OOS	493 (±SE 45)[2]	Lawler (2002)	Digitised and available	No	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-05	-	sGBR, Hervey Bay and a section Torres Strait	SAS-OOS	453 (±SE 97)[2,3,4]	Marsh et al. (2006)	Digitised and available	Yes	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

Nov-11	-	sGBR and Hervey Bay	SAS-OOS	696 (±SE 106)[2,3,4]	Sobtzick et al. (2012)	Digitised and available	Yes	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>
Nov-16	-	sGBR and Hervey Bay	SAS-OOS	601 (±SE 80)[3,4]	Sobtzick et al. (2017)	Digitised and available	Yes	JCU Dugong Aerial Survey Database	Request can be made to JCU representatives. A data sharing agreement will be required before data can be provided.	Helene Marsh <helene.marsh@jcu.edu.au>; Christophe Cleguer <christophe.cleguer@jcu.edu.au>

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