Appendix 3. Summary of Literature Review and Expert Elicitation

4.1 Sediment

4.1.1 Background

Modelled estimates indicate that 8500 kilo-tonnes/year of suspended sediment are delivered to the Reef annually (Waters et al., 2014) , a 3.2 to 5.5 fold increase from pre-European conditions for total suspended solids (Brodie et al., 2013b). Inshore areas, especially those close to river mouths continue to be exposed to increased sediment, and modelling from 2007 to 2011 show increased areas of sediment impact (Commonwealth of Australia, 2014c). Both Australian and State governments have recognised the need for water quality improvements, and the modelled annual average load reduction for sediment within the Reef was 12% from 2009 to 2014 (Brodie & Pearson, 2016) well below the 2018 target of 20% reductions. Current management strategies are largely associated with improvement in agricultural practices which in isolation are unlikely to maintain or restore the health of the Reef (Waterhouse, Brodie, Lewis, & Audas, 2016).

Much government funding has been allocated to reduce the amount of total suspended sediment entering the Reef region since the first iteration of the Reef Water Quality Improvement Plan in 2003, mostly focusing on improved catchment management practices. However, the overall water quality in all of the Reef catchment areas remains in poor condition (Queensland 2015).

4.1.2 Priority Actions

Expert Elicitation Round 1 Summary

The most common action suggested was “erosion control” which included revegetating or restoring riparian areas, restoring agricultural land with highly erodible soils, reducing terrestrial run-off, reduced cultivation, farm contour planning, treatment trains, wetlands (includes sediment detention basins) on farm, gully remediation (including alluvial), streambank remediation, fencing, weed control, feral pig control. Other actions included maintenance and restoration of coastal ecosystems (e.g. salt-marshes, mangroves, riparian forests, sea grass). Specific spatial actions included, reducing range-land grazing in Burdekin, Fitzroy and Burnett Mary regions. There was a suggested action for education and training for farmers. It was recommended that offset implementation should be integrated with public erosion control program.

Expert Elicitation Round 2 Summary

Five experts responded that actions should be defined by the underfunded actions contained within the Water Quality Improvement Plans for each Natural Resources Management Region. Three of these experts provided additional comments and questions:

“How success of these strategies will be measured will be difficult to quantify and prove which is essential for offsets”
“I don't understand what 'reducing range-land grazing' means practically. Possibly it means reducing stocking rates of livestock to reduce grazing pressure. Possibly it means buying back grazing properties.”
“Cape York WQIP also provides cost estimates and we can seek additional information from CY NRM if useful to help with cost estimates below.”

4.1.3 Costs

Literature Review

The cost and effectiveness of changing management practices to improve water quality vary significantly between different land-use categories and catchment regions on a per-hectare basis (Beher, Possingham, Hoobin, Dougall, & Klein, 2016). Alluvium (2016) recently estimated the costs to achieve water quality targets in the Reef region. A summary of the results (relevant to fine sediment) are provided below. These costs are based on some available data, modelling, and assumptions about catchment restoration.

<u>Mackay Whitsunday Region:</u>
- Grazing Practice Change C to B: $67/tonne

<u>Wet Tropics Region:</u>
- Streambank Repair Herbert 5% of Stream Length: $26/tonne
- Streambank repair Herbert 6-10% of stream length: $53/tonne
- Grazing Practice Change C to B: $155/tonne
- Grazing Practice Change B to A: $26/tonne
- Streambank Repair - Tully River 5% of stream length: $358/tonne
- Streambank Repair - Tully River 6-10% of stream length: $569/tonne
- Urban stormwater new development-Wet Tropics-Cairns: $125,000/tonne

<u>Burdekin Region:</u>
- Grazing Practice Change C to B: $158/tonne
- Gully-Burdekin 10% of gullies full repair (pro-rata): $140/tonne

<u>Fitzroy Region:</u>
- Grazing Practice Change C to B: $31/tonne
- Grazing Practice Change B to A: $28/tonne
- Gully- Fitzroy 10% of gullies full repair: $98/tonne
- Gully- Fitzroy 11% of gullies full repair: $169/tonne
- Gully- Fitzroy 26% of gullies full repair: $233/tonne

Rolfe and Windle (2016) lead a NESP-funded project to investigate “benchmarking costs of agricultural water management in GBR catchments.” Within this project, Rolfe and Windle (2016) analysed cost data from Australian-government funded Reef Rescue grant projects and developed a “guide to the cost-effectiveness of various schemes by NRM group,” included next as Table 4-1.

Table 4-1. Costs of Water Quality Improvements by NRM region (Rolfe and Windle 2016)

Region	Sediment $/tonne	Nitrogen $/kg	Nitrogen (DIN) $/kg	Pesticide (PSII) $/kg
		End of catchment loads		
Whole GBR				
Achieved: Aust Govt 2014	130		63	3,500
Predicted: Reef Regions 2015	*61*	*21*	*34*	*3,945*
Cape York				
Achieved: Aust Govt 2014	297	192		
Wet tropics				
Achieved: Aust Govt 2014	375	47	142	16,343
Achieved: Bass et al. 2013	255		438	22,886
Predicted: WQIP(70:30 funding split)			*239*	*3,076*
Burdekin				
Achieved: Aust Govt 2014	106	62	124	120,770
Mackay Whitsunday				
Achieved: Aust Govt 2014	987	164	157	19,315
Predicted: WQIP	263		68	10,178
Fitzroy				
Achieved: Aust Govt 2014	513	1,494		1,060,650
Predicted: Star et al. 2015b WQIP	277			
Burnett Mary				
Achieved: Aust Govt 2014	1,343	192		38,153
Predicted: WQIP (50:35:15 funding split)	237		142	11,918
Whole GBR				
Recommended Benchmark	$259/t		$150/kg	$8,351/kg

Expert Elicitation Round 1 Summary

Six participants provided cost information. The units are $AUD per tonne of suspended fine sediment.

Highest reasonable cost: range of $400-$1000, average of $700 per tonne
Lowest reasonable cost: range of $50-$250, average of $150 per tonne
Best estimate: range of $150-$500, average of $300 per tonne
Confidence that highest to lowest interval contains a reasonable estimate: range 10-95, average 61 (out of 100)

Participant justifications and comments:

Lowest cost ($100) came from cost benefit analysis from reef investments over a 6 year period
Highest cost ($600) from remote region estimates in Cape York
Based on pilot-scale experimental work
Best estimate includes a 50% premium on the plot scale estimates to account for additional factors in up-scaling to full gullies

The reasonable highest cost can be determined by the economic gain from the development that is being offset.
My best estimate relates to recent programs.
The cost will increase as the easy and rapidly eroding areas are treated and activities move to more difficult areas.
The cost is largely determined by the location of the works and the historical sediment loads from that catchment.
[Name withheld] has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value. However, the following information may assist experts involved in estimating costs for the surrogate: GBR Water Science Taskforce Final Report, Costs of achieving the water quality targets for the GBR (Alluvium, 2016) and external peer review, and Abbot Point T0, T2, T3 Capital Dredging PER Offset Strategy. When considering cost, it is essential that experts define the fraction of sediment relevant to 'suspended fine sediment'. The NESP Project adopts a <16µ fraction for suspended fine sediment, which [we] challenged as being too high in the context of industry activities, such as dredging.

Expert Elicitation Round 2 Summary

When asked about preference for estimating costs, two experts selected the option "There is sufficient published cost data. Use published cost estimates (including but not limited to Alluvium 2016 report, other recent peer-reviewed papers, industry data, and other relevant and quality-tested data). If this option is selected, the project team will make estimates based on the literature and provide the estimates (with references and justifications) for stakeholder comment during the draft plan review."

Two experts provided cost estimates. One of these experts suggested a range of $300-$1200 AUD per tonne, with a best estimate of $600 and a confidence of 80%, based on "Reef Trust phase II Gully Erosion Control Programme preliminary progress report. These are costs averaged over reef catchments. Some catchments will give a lower cost than others." The second expert provided the lowest reasonable estimate of $150, with a confidence of 60%, justified by "Adjustment of lowest reasonable cost based on the lifetime in which an offset will likely need to be delivered in. Estimates outlined above indicate this cost for more active remediation activities."

Four experts selected "other" and provided the following comments:

"Given only 6 responses were received that indicates that current data is insufficient" *(note that the survey did not provide an option to use the Round 1 responses and agrees that 6 responses are insufficient)*.

"I suspect the Alluvium costs are poorly informed and are over-estimates. The round 1 estimates are low by ~30% in my view. But As I said in round 1, a multiple (>2) should then be applied to estimate offset payment rates considering the uncertainty in current erosion rates and erosion control responses, and that there is an opportunity cost for doing erosion control for offsets in terms of reduced opportunity for publicly funded erosion control actions. Current catchment modelling estimates loads and erosion control responses (as represented in the Report Cards and the above costs per tonne) are for <63 um particle sediment. Detailed particle size monitoring would be required to determine the proportion of that which is <16 um. Costs to reduce <16 um fraction would increase by dividing above values by that proportion. The analysis of past 'cost benefit analysis from reef investments over a 6 year period' is likely to be a significant under-estimate and is not validated against on-ground changes. My understanding is that the available data does not indicate that the expected ground cover changes from land type fencing and extension in the Burdekin are materialising."

"Option 1 but I would like to note that consideration also needs to be given to the timeframe for achieving outcomes as an offset and choosing activities that align with those timeframes. For instance, rapid achievement of outcomes tend to be the more expensive options outlined above and the cheaper options tend to have longer timeframes for achievement of outcomes. This should be considered when providing estimates rather than choosing the cheaper option or an average of high and lower costs. This will also depend on the area where an offset should be undertaken." (*note: Option 1 was to use published cost estimates*)

"[Name withheld] is unable to provide comment on the cost estimates provided by experts for the following reasons: 1) Insufficient underlying evidence or (where not available) assumptions. 2) The cost estimates provided are informed from different sources and are arguably not comparable. The published cost data is insufficient or inappropriate."

An additional comment was included "References and justifications for cost estimates should have been mandatory as part of the Round 1 survey to allow for to allow for transparency and expert critique to ensure the cost selected is scientifically robust."

4.1.4 Spatial Priorities

Literature Review

The Fitzroy and Burdekin regions contribute at least 70% of modelled total suspended solids to the region, with grazing lands contributing to three quarters of this load, dominantly from gully and stream bank erosion (Commonwealth of Australia, 2014c). On a regional basis the Burdekin and Fitzroy sub-catchments are rated as very high and high priority for investment in improving grazing management because of their large area, very high total and anthropogenic loads and large capacity improvement (Commonwealth of Australia, 2014b).

The Queensland Water Quality Task Force Final Report identifies the Burdekin and Fitzroy regions for reducing sediment run-off (2016).

Expert Elicitation Round 1 Summary

There were twelve responses to this question, three responded that offsets should be as close as possible to the impact site, four in the same catchment, three in the same NRM region, two within the same GBR zone. Responses were mixed with some believing that offsets should occur as close as possible, but most allowing some flexibility. However, the degree of flexibility was unclear with some focusing on the same catchment, but others allowing offsets to be anywhere it was most beneficial, either within the same GBR zone or NRM region.

The high priority areas listed for implementation of offsets for this surrogate were:

- Retirement of agricultural land (references Kroon et al. 2016,2012, Bartley et al. 2014; Thorburn & Wilkinson 2013 – believe all referenced in lit review).
- Stream bank erosion for all higher order streams (Alluvium report)
- Bowen Bogie, East Burdekin, Pioneer, Mary, Lower Burdekin, Fitzroy, Don River, OConnell, Herbert, Normanby. This is a ranking of units in descending order of contribution to TSS export from gully and streambank erosion (t/ha/y).
- A good case can be made for each scenario. Offset should produce the greatest bang for the buck in achieving the largest sediment reduction to the GBR lagoon . This may or may not occur near to the development - but it should be from a site that has high connectivity to the GBR Lagoon.
- The GBR Water Science Taskforce Final Report focuses on the priority areas for sediment.

Expert Elicitation Round 2 Summary

When asked about spatial priorities for implementation of sediment offsets, two experts selected “away from the impact site, but within the same catchment,” one expert selected “As close to the site of impact (development or project site) as possible,” and two experts provided comments:

“As close to the impact site as possible but only where there is likely to be a linked benefit, eg. no point spending loads of money on remediating an area of low TSS generating land if there are areas nearby or further upstream that are going to generate higher overall benefits. The Taskforce report doesn't really identify priority areas - I would suggest you closely to refer to WQIPs. We are also in the process of updating the relative risk assessment and management prioritisation for 2017 Reef Plan Update.”

“There is significant public expectation that offsets will be realised in the area of impact, if this is not able to deliver this it will be difficult for proponents to discharge through this process”

“Suggest using the WQIP for each region. They highlight the high priority areas for the region in relation to this surrogate and the types of activities. They also provide references and justifications.”

4.2 Nitrogen (DIN)

4.2.1 Background

Modelled estimates indicate a 2 to 5.7 fold increase in the amount of nitrogen entering the Reef region since European settlement (Commonwealth of Australia, 2013), to a mean annual total nitrogen load of 37,000 tonnes/year (Waters et al., 2014). Most of the southern two-thirds of the Reef system are now exposed to elevated nutrient concentrations, though there is almost no change in nutrient loads in the northern Cape York rivers (Brodie et al., 2013b). Improvements in land management practices between 2009-2013 have led to a modelled 16 percent decrease in the average annual dissolved inorganic nitrogen in the catchment (Queensland Department of Premier and Cabinet, 2014a). However, recent analysis suggests that even with full adoption of best practice ('B' class) management throughout the region in both cane farming and grazing industries, would only result in a 27% reduction of dissolved inorganic nitrogen, while cutting edge ('A' class) practices would achieve only 34% reductions (Waters et al., 2014). Without transformational improvements, the 50% reduction target for dissolved inorganic nitrogen are unlikely to be met (State of Queensland, 2016a; Thorburn et al., 2013; Waters et al., 2014).

Improvements in land management practices between 2009-2013 have led to a modelled 16 percent decrease in the average annual dissolved inorganic nitrogen in the catchment (Queensland 2015). The overall water quality in all of the Reef catchment areas remains in poor condition (Queensland 2015), especially for monitored loads of nitrogen in the wet tropics region (Queensland 2015). However, recent analysis suggests that even with full adoption of best practice ('B' class) management throughout the region in both cane farming and grazing industries, will only result in a 27% reduction of dissolved inorganic nitrogen, while cutting edge ('A' class) practices will achieve only 34% reductions (Waters et al., 2014). Without transformational improvements, the 50% reduction target for dissolved inorganic nitrogen are unlikely to be met (State of Queensland, 2016a; Thorburn et al., 2013; Waters et al., 2014).

The Fitzroy, Burdekin and Wet Tropics regions contribute over 75% of modelled total nitrogen load to the Reef region (Commonwealth of Australia, 2014b). Recent studies have recommended 50-90% reductions in DIN in the Burdekin and Wet tropics to meet water quality guidelines, and at least a 50% reduction in fine sediment in the Wet tropics region was needed to maintain the health of the Reef (Brodie, Waterhouse, & Maynard, 2013a).

4.2.2 Priority Actions

Literature Review

Increased irrigation efficiency in furrow irrigated sugarcane would reduce nutrient losses (Brodie et al., 2013b), either by better management or through systems with higher efficiency (ie furrow to trickle) (Commonwealth of Australia, 2014c). In addition, techniques for managing gully and streambank erosion, which are a significant source of sediments in grazing lands,will require further investigation as to their viability and effectiveness. Wetland restoration or creation in riparian areas could improve nutrient retention, especially in drier regions and from irrigation tailwater but are ineffective in wet conditions (Waterhouse et al., 2016).

Expert Elicitation Round 1 Summary

The suggested actions focussed on buying up agricultural land that require high fertilizer input in environmentally sensitive areas. Several actions focussed on removing cane farming in high risk areas or degraded land or purchasing and renovating underperforming cane farms. The suggested action involved waterway, wetlands and treatment trains establishment on farm or at key locations in sub-catchments or floating wetland systems. There were links between actions for nitrogen and sediment such as Gully and streambank erosion control.

Expert Elicitation Round 2 Summary

Two experts responded that actions should be defined by the underfunded actions contained within the Water Quality Improvement Plans for each Natural Resources Management Region.

One expert selected "Underfunded actions defined within an existing strategy / plan / initiative other than the WQIP (if this option is selected, please provide details below)" and provided the following comment:

"The anthropogenic loads of DIN quoted appear to ignore that from elevated erosion rates (recently identified by DSITI project). Anthropogenic PN also contributes a similar or larger amount of N to GBR coastal waters as DIN and so erosion control should be included in the N-reduction activities."

4.2.3 Costs

Literature Review

Abatement of DIN is highly dependent on the region, costing between $44 and $320/ha depending on farm size (State of Queensland, 2016c). Alluvium (2016) recently estimated costs to achieve water quality targets in the Reef region, summarised below.

<u>Wet Tropics</u>
- Cane Practice change C to B: $4,890/tonne

<u>Burdekin Region</u>
- Irrigation – Burdekin 20%: $12,300/tonne
- Irrigation – Burdekin 21-50%: $32,700/tonne
- Irrigation – Burdekin 51-70%: $62,500/tonne
- Irrigation – Burdekin 71-1000%: $41,700/tonne

<u>Mackay Whitsunday Region</u>
- Cane Practice change C to B: $24,700/tonne

Rolfe and Windle (2016) lead a NESP-funded project to investigate "benchmarking costs of agricultural water management in GBR catchments." Within this project, Rolfe and Windle (2016) analysed cost data from Australian-government funded Reef Rescue grant projects and developed a "guide to the cost-effectiveness of various schemes by NRM group," included as Table 4-1 *(repeated below for ease of review).*

Table 4-1. Costs of Water Quality Improvements by NRM region (Rolfe and Windle 2016)

Region	Sediment	Nitrogen	Nitrogen (DIN)	Pesticide (PSII)
	$/tonne	$/kg	$/kg	$/kg
			End of catchment loads	
Whole GBR				
Achieved: Aust Govt 2014	130		63	3,500
Predicted: Reef Regions 2015	*61*	*21*	*34*	*3,945*
Cape York				
Achieved: Aust Govt 2014	297	192		
Wet tropics				
Achieved: Aust Govt 2014	375	47	142	16,343
Achieved: Bass et al. 2013	255		438	22,886
Predicted: WQIP(70:30 funding split)			*239*	*3,076*
Burdekin				
Achieved: Aust Govt 2014	106	62	124	120,770
Mackay Whitsunday				
Achieved: Aust Govt 2014	987	164	157	19,315
Predicted: WQIP	263		68	10,178
Fitzroy				
Achieved: Aust Govt 2014	513	1,494		1,060,650
Predicted: Star et al. 2015b WQIP	277			
Burnett Mary				
Achieved: Aust Govt 2014	1,343	192		38,153
Predicted: WQIP (50:35:15 funding split)	237		142	11,918
Whole GBR				
Recommended Benchmark	$259/t		$150/kg	$8,351/kg

Expert Elicitation Round 1 Summary

Four participants provided cost information:
Highest reasonable cost: range of $1500-2000, average of $1750
Lowest reasonable cost: range of $1-100, average of $51
Best estimate: range of $150-800, average of $475
Confidence that highest to lowest interval contains a reasonable estimate: range 60-80, average 70 (out of 100).

<u>Participant justifications and comments:</u>

I am not able to estimate costs at this time.

These are preliminary numbers based on the Burdekin river basin ($800) and Bowen Bogie catchment management unit ($100). I used the Source PN contributions, attributed 70% to gully and streambank, divided by the area of mapped gully erosion, assumed $10,000 per ha treatment cost to reduce gully PN losses by 30%.

[Name withheld] has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value. However, the following information may assist experts involved in estimating costs for the surrogate: GBR Water Science Taskforce Final Report, Costs of achieving the water quality targets for the GBR (Alluvium, 2016) and external peer review, and Abbot Point T0, T2, T3 Capital Dredging PER Offset Strategy. When considering cost, it is essential that experts define the fraction of sediment relevant to 'suspended fine sediment'. The NESP Project adopts a <16μ fraction for suspended fine sediment, which [we] challenged as being too high in the context of industry activities, such as dredging.

Expert Elicitation Round 2 Summary

When asked about preference for estimating costs, one expert selected the option "There is sufficient published cost data. Use published cost estimates (including but not limited to Alluvium 2016 report, other recent peer-reviewed papers, industry data, and other relevant and quality-tested data). If this option is selected, the project team will make estimates based on the literature and provide the estimates (with references and justifications) for stakeholder comment during the draft plan review."

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question)" but did not provide a cost estimate.

Two experts selected "other" and provided the following comment:

"[Name withheld] is unable to provide comment on the cost estimates provided by experts for the following reasons: 1) Insufficient underlying evidence or (where not available) assumptions. 2) The cost estimates provided are informed from different sources and are arguably not comparable. The published cost data is insufficient or inappropriate."

"Note that Megan Star is currently collating basin-specific cost estimates for the relative risk assessment in the Scientific Consensus Statement 2017 update. There is also a NESP project that Jim Smart is involved in on land retirement of cane areas in the Wet Tropics - worth following up (led by Nathan Waltham)."

4.2.4 Spatial Priorities

Literature Review

The Fitzroy, Burdekin and Wet Tropics regions contribute over 75% of modelled total nitrogen load to the Reef region (Commonwealth of Australia, 2014b). Recent studies have recommended 50-90% reductions in DIN in the Burdekin and Wet tropics to meet water quality guidelines, and at least a 50% reduction in fine sediment in the Wet tropics region was needed to maintain the health of the Reef (Brodie, Waterhouse, & Maynard, 2013a;

Terrain NRM, 2014). The Queensland Water Quality Task Force Final Report identifies the Burdekin and Wet Tropics regions for reducing nitrogen run-off (2016).

Over eighty-five per cent of sugarcane production in Queensland occurs in three catchment areas, the Wet Tropics, Burdekin Dry Tropics and Mackay Whitsunday regions, which are often referred to as the 'priority catchment areas' (State of Queensland, 2016a). In addition, a 2012 study found that use of nitrogen fertiliser in these three areas was a top priority with approximately 80% of the total anthropocentric load of DIN being derived from sugarcane fertiliser losses in the Wet Tropics (84%); the Lower Burdekin (80%); and Mackay Whitsundays (88%) (Queensland University of Technology, 2015).

Expert Elicitation Round 1 Summary

There were seven responses to this question, with three respondents stating that offsets should be implemented in the same catchment, three within the same NRM region, and one as close to the impact site as possible. Again, most respondents agree that some flexibility in offset location should be allowed for this surrogate.

The high priority areas listed for implementation of offsets for this surrogate were:

- Retirement of agricultural land has been used as a tool for reducing diffuse pollution, for example by discontinuing production on land areas with highly erodible soils or requiring high fertilizer input in environmentally sensitive (i.e. high risk) areas. For additional references, please also see: Kroon et al. 2012 for river pollutant loads estimates (incl nitrogen) Kroon et al. 2016 for a review of GBR water quality management, and proposed ways forward Thorburn and Wilkinson 2013 for a conceptual understanding of nitrogen impacts and management
- Farm N use practice improvement - options across total farm area exist to improve NUE Wetlands waterways /treatment trains - able to be established in most sub catchments - align with water quality objectives and priorities in MW WQIP
- As for my response to TSS - The following catchment management units (WQIPs recommend priority subcatchments within these): Bowen Bogie, East Burdekin, Pioneer, Mary, Lower Burdekin, Fitzroy, Don River, OConnell, Herbert, Normanby. This is a ranking of units in descending order of contribution to TSS export from gully and streambank erosion (t/ha/y). I also considered the ability to target within management units.
- The GBR Water Science Taskforce Final Report focuses on the priority areas for nitrogen.

Expert Elicitation Round 2 Summary

One expert selected “As close to the site of impact (development or project site) as possible” and provided the comment “Total nitrogen is not relevant for the Reef and should not be discussed as a target for mitigation - please correct. DIN is the most bioavailable form of N, and therefore the greatest risk to GBR ecosystems. There are some interactions between PN, fine TSS and the formation of organic flocs but that is more about increasing turbidity than nutrient effects per se. The issue with land retirement is that it is expensive, and there are still large natural loads of DIN from rainforests and other natural landscapes. So even if we retired all the cane land in the Wet Tropics, it is not possible to achieve the load reductions required to meet the WQ Guidelines! Careful consideration is also required of how wetlands and other coastal ecosystems can function as 'filters' for nutrients as the literature shows that with the high degree of hydrological modification in the GBR catchments there is very little treatment benefits from 'natural' wetlands etc. Artificial wetlands and treatment systems are most likely the way to go in that regard, but we are really only starting down that part. Talk to Mike Ronan at DEHP about this - they recently ran a workshop on treatment systems. The WQIPs have comprehensive discussion of priorities and should be used in preference to the references identified above. We are also updating relative risk assessment at the moment as noted before." *(note: the surrogate is DIN)*

One expert selected "Away from the impact site, but within the same catchment" and commented: "The anthropogenic loads of DIN quoted above appear to ignore that from elevated erosion rates. Anthropogenic PN contributes a similar or larger amount of N to GBR coastal waters as DIN and so spatial priorities for erosion control should be considered for N-reduction activities."

One expert selected "Away from the impact site, but within the same natural resources management region" and commented "Suggest using the WQIP for each region. They highlight the high priority areas for the region in relation to this surrogate and the types of activities. They also provide references and justifications. The priority would be within the same catchment. However, if this isn't possible due to the specifics of the project and offset (i.e. if dredging were to occur in Townsville port and implementing an offset in that catchment is not possible then it could be implemented in a neighbouring catchment but within the same natural resources management region)."

4.3 Intertidal

4.3.1 Background

The current condition and trend of intertidal mudflats are not specifically mentioned within the Strategic Assessment; however they have been included with beaches and coastlines within the assessment. Currents can be modified locally as a result of coastal infrastructure, such as marinas, beach re-nourishment or dredging, leading to negative impacts on beaches and mudflats (GBRMPA 2014). In the remote north, beaches remain relatively undisturbed, except for marine debris and are considered stable. Southern inshore areas are still considered in good condition, but are deteriorating as ports and other development near urban areas have extensively modified coastal habitats and processes. Sediment supply to beaches has changed as a result of artificial barriers to the flow freshwater, leading to an increase in fine sediment and mangrove establishment in 'beach' areas (Commonwealth of Australia, 2014a).

Intertidal beaches also support a range of species, including shorebirds, seabirds and marine turtles that are impacted by changes or loss of habitat due to altered hydrological regimes, chronic and acute pollution from bioaccumulation and pesticide use, as well as the impacts of climate change, such as rising sea levels, drying and more frequent and intense climate events (Commonwealth of Australia, 2015c) that is likely to result in habitat degradation and loss of species (Iwamura et al., 2013). The condition and trend of intertidal beach species was not specifically mentioned as part of the Outlook Report, however additional information on each species is available in the species surrogate section below.

Rates of change for mudflat habitat in the Reef are not currently available, though some estimates for Australia and the entire East Asian Australasian Flyway should be available within the year (N. Murray pers. comm.). However, overall intertidal beaches and coastline habitat are thought to be stable in the northern inshore regions but deteriorating in the southern inshore regions (Commonwealth of Australia, 2014a).

Associated intertidal species such as shorebirds are thought to be in deteriorating condition, likely because of threats outside of the region (e.g., habitat loss in east Asia; Clemens et al., 2016; Iwamura et al., 2013), but also because declines in inland wetlands (Finlayson, Davis, Gell, Kingsford, & Parton, 2013) have led to losses in both resident and migratory shorebird species (Clemens et al., 2016). A recent plan for the conservation of migratory shorebirds was released identifying actions for the improved conservation of the species, one of which is to improve protection of sites and their management at both the state, national and international scales (Commonwealth of Australia, 2015c).

No specific data were available on priority unfunded actions for intertidal beach or mudflat habitat. Creation of new intertidal habitat has been trailed in a variety of locations (ECRR, n.d.) and may be appropriate it some circumstances, however does not always deliver ecological function (Morris & Gibson, 2007). No data was available for the cost of engineering intertidal habitat. Associated intertidal species are discussed in the species surrogate sections below.

4.3.2 Priority Actions

Literature Review

Creation of new intertidal habitat has been trailed in a variety of locations (ECRR, n.d.) and may be appropriate it some circumstances, however does not always deliver ecological function (Morris & Gibson, 2007).

Expert Elicitation Expert Elicitation Round 1 Summary

There were no experts responses for Intertidal actions.

Expert Elicitation Expert Elicitation Round 2 Summary

There were no experts responses for Intertidal actions.

4.3.3 Costs

Literature Review

A recent peer-reviewed global meta-analysis of the costs of marine restoration (Bayraktarov et al 2016) found the following costs for saltmarsh restoration for "developed countries": restoration cost in 2010 US$ per ha = $1,804,779 (sample size 73 projects).

Expert Elicitation Round 1 Summary

- 1 respondent suggested that this surrogate has many overlaps with the mangrove surrogate and we could consider combining these surrogates
- 1 respondent declined to estimate costs due to "insufficient information and concerns with the overarching approach"
- 1 respondent noted that "costs will depend on nature of remediation and maintenance of site, i.e., sand pumping
- 1 respondent noted an example of the Rain Island partnership project which cost $5 million over $5 years

Expert Elicitation Round 2 Summary

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question)" but did not provide a cost estimate.

4.3.4 Spatial Priorities

Literature Review

No priority areas for intertidal beach or mudflat habitat were identified in the literature review, aside from specific species priorities, for example nesting habitat for marine turtles or key areas for migratory shorebird species. Only one respondent answered this question, suggesting that offsets for this surrogate should be placed where there is the greatest opportunity for maximized return, and that efforts would be counterproductive if extensive remediation was done in areas if other pressures would exclude species use.

Expert Elicitation Round 1 Summary

There were four expert responses to this question, with 2 stating that as close to the site of impact as possible was best, while 2 thought away from the impact site but within the same NRM region or within the same GBR Zone.

Expert Elicitation Round 2 Summary

No responses.

4.4 Mangroves

4.4.1 Background

The Reef region has an estimated 2070 km2 of highly dynamic mangrove forest habitat with some localised declines and expansions (Great Barrier Reef Marine Park Authority, 2014). The overall abundance of mangroves is being maintained and they are in very good and stable condition in the northern inshore regions and good and stable condition in southern inshore regions (Commonwealth of Australia, 2014a). However, this is based on limited evidence or consensus. Climate change is likely to have implications for mangrove forest habitat, though some mangroves are able to avoid inundation by vertical accretion of sediment (Lovelock et al., 2015). The Reef Plan 2050 commits to no net loss of extent and a net improvement in the condition of wetlands and riparian vegetation in the region (Commonwealth of Australia, 2015a; Terrain NRM, 2014).

Mangrove forests in the region are diverse with over 39 species and this diversity is being maintained, especially in the north where diversity is highest (Commonwealth of Australia, 2014a). The condition of mangrove species in northern inshore areas is considered very good and stable condition, while the southern inshore species are in good condition with a stable trend. However, this is based on limited evidence of consensus (Commonwealth of Australia, 2014a). In addition, while the spatial extent of mangrove habitat is well mapped, changes in species composition is not well known (Commonwealth of Australia, 2014a).

4.4.2 Priority Actions

Literature Review

Mangrove habitat restoration and mangrove creation has been fairly successful in both hydrological restoration and planting of mangroves (Bayraktarov et al., 2016). In addition, animal assemblages such as aquatic invertebrates, birds and fish recover quickly after restoration or creation, though plant assemblage did not recover as quickly (Bosire et al., 2008; Moreno-Mateos, Meli, Vara-Rodríguez, & Aronson, 2015).

Expert Elicitation Round 1 Summary

The experts suggested several actions for mangroves including planning, partnership, process, works and replanting. The planning actions included identification of priority areas for both passive (restoring the hydrological connectivity, tidal flow regime of an already existing mangrove forest) and active restoration (planting of mangrove propagules. The partnership actions included working with traditional owners and local managers to develop regional mangrove management plans. In field actions included contouring the site to intertidal elevations favourable for mangroves, clearing invasive plants, and planting of smooth cordgrass to trap mangrove seeds at high tide from adjacent forests.

Expert Elicitation Round 2 Summary

One expert selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” and commented “Restoration of hydrological connectivity of ponded pastures - there are a range of GBRMPA and DPI documents which recommend increasing connectivity.   Planning for mangrove expansion under sea level rise - (prior QLD coastal plan) - acquiring or rezoning lands Feral pig control on indigenous lands - Carbon emissions are associated with feral pig damage of mangrove forest soils (CSIRO has done some work in this space)   Smooth cord-grass is a non native - omit this - using some saltmarsh nurse plants might be appropriate when restoring mangroves, but Spartina alternaflora is a dangerous weed."

Two experts selected "other" and commented:

"The focus needs to be on rehabilitation of natural living shoreline habitats in estuaries of coastal catchments. This means there needs to be an integrated focus on riparian vegetation, mangrove & saltmarsh, and shellfish reefs. Working on any part of this is unlikely to succeed. Where these habitats are damaged they need to be repaired.   This requires a multiple layered strategy framed within a monitoring program that helps identify areas at risk, prioritises rehab works, and gives on-going evaluations of shoreline status and health. So, where interventions are made then we can evaluate what worked and didn't work. This means we will be less likely to repeat mistakes and to make progress with shoreline rehab.   It is essential that a national rehab project database be compiled asap to build the foundations for future trials and mitigation works."

"Prioritizing restoration actions for coral reefs under taking into account connectivity and interdependencies with other ecosystems (e.g. seagrass, mangroves) and the factor of risk and uncertainty of the restoration site being destroyed by e.g. stochastic catastrophic events (e.g. flood plumes due to sea level rise, storms, cyclones, seawater temperature anomalies), changes in feature distribution through succession after disturbance, or anthropogenic impact (e.g. area compromised for coastal development, damaging of restoration site by local communities (trampling) or fishing (bottom trawling))"

4.4.3 Costs

Literature Review

A recent peer-reviewed global meta-analysis of the costs of marine restoration (Bayraktarov et al 2016) found the following costs for mangrove restoration for "developed countries": restoration cost in 2010 US$ per ha = $108,828 (sample size 59 projects). Outdated estimates put the cost of restoring existing areas of damaged mangrove at between $3000 and $510,000/ha (Spurgeon, 1999), while another reports costs at a range from $225-216,000/ha (Lewis, 2001).

Expert Elicitation Round 1 Summary

Four respondents provided cost information on mangroves:

Highest reasonable cost: range of $156,000-175,000, average of $165,500
Lowest reasonable cost: range of $1000-78,000, average of $39,500
Best estimate: range of $15,000-117,000, average of $66,000
Confidence that highest to lowest interval contains a reasonable estimate: range 50-80, average 65 (out of 100)

Justifications and comments included:

Costs are involved in supporting two key groups - the various community volunteer and traditional owner ranger teams acquiring images and field data; and the partner specialist scientists who provide the training, coordination and assessment expertise. The cost each group per year per riverine system amounts to around $35,000 with allowances for equipment used, vessel support and data evaluations.

Qld ports have recently examined the opportunities for mangrove restoration as part of maintenance dredging activities with a cost of approx $175,000 however this cost included the dredging component. Without the dredging component the restoration works are valued at approximately $45000/ha. A small scale restoration of mangrove habitat was undertaken in Sandringham Bay in 2009 at a cost of $10000/ha as part of a port development offset.

The majority of restoration projects published did not provide cost data in a comprehensive manner and it was often not possible to split the available cost information into capital and operating costs (= total restoration cost), or to account for the different components of restoration (planning, purchasing, land acquisition, construction, financing, maintenance, monitoring, and equipment repair/replacement). We estimated that the real total cost of restoration (including capital and operating costs) would be 2 - 4 times higher than the restoration cost reported. A conservative estimate for total mangrove restoration cost would be between 2x US$ 39,000 and 4x US$ 39,000, i.e. would lie between US$ 78000 and 156000. Note: all numbers provided here need to be converted from US$ at base year 2010 to AU$ in 2016.

The activities undertaken as part of the BMA Marine Plants Restoration Project should be considered when estimating cost given this is a demonstrated offset for this surrogate within the GBR. This is particularly the case given the extraordinary costing range provided in the literature review. Link to plan.

Expert Elicitation Round 2 Summary

Three experts selected “other” and commented:

“Costs could vary with technique used to restore or repair; e.g. hydrological restoration if removing bunds could be relatively inexpensive compared to recontouring land or planting. Adaptive management requires some potential for mid-course corrections. Costs should include monitoring post activity which was often not included in studies compiled by Bayraktarov et al. Costs should be estimated on a project by project basis”

“Trying to identify costs in this way is rather a waste of time. Surely the better approach would be to work out the methodology with trials in different circumstances in the first instance. This may take a few years with new works, but the interim strategy would be to compile a database of the relevant data and costs for intervention works that have both worked and not worked. The database needs to have measures of success well defined and quantified. Any costs I give here are all speculative and really quite misleading. Some areas may need much at all while some shoreline sections will need extra help. That's one problem. A second problem is that the methods for doing shoreline rehabilitation are yet inadequate and flawed. That is why we need to take the above approach instead of guessing. so, no answers for me for the below estimates. we have recently bid on works in central Queensland but this was for a specific section of estuarine shoreline. And, the bid was for a trial to test out methods that MIGHT work only!"

"Bayraktarov et al 2016 provide a synthesis of restoration literature including 235 studies with 954 observations from worldwide restoration projects of coral reefs, seagrass, mangroves, saltmarshes and oyster reefs to evaluate the cost-effectiveness of restoring different coastal habitats. The study has however identified significant gaps and inconsistencies within cost data reported by the literature impeding total restoration cost estimates (including capital and operational cost). Median restoration cost provided in this study are to be handled carefully and only considered as a first attempt to provide cost estimate for global restoration projects yet the real total cost are expected to be realistically at least 2 - 4 higher. I propose developing a survey for restoration practitioners (specifically The Nature Conservancy and consultancies) in order to recover information that has been lost by not-publishing critical cost data and especially the lessons learnt from failing projects."

One expert provided cost estimates:

Highest Reasonable Cost $205,000
Lowest Reasonable Cost $102,000
Best Estimate $153,000
Confidence 80%
Justification "Same justification and numbers as in Round 1 of the Expert elicitation but values converted to AUD 2016 and rounded"

4.4.4 Spatial Priorities

Literature Review

No priority areas for mangrove habitat or species were identified, though freshwater wetlands and estuaries are identified as being high priorities by Brodie and Pearson (2016). In addition, attention should be focused on salt marsh and flat locations to accommodate the inshore migration of wetland habitats in the face of climate change (Lovelock & Ellison, 2007). The identification of priority areas for mangrove conservation is ongoing in areas within the region (Cath Lovelock pers.comm.).

Expert Elicitation Round 1 Summary

There were seven expert responses to this surrogate, with two choosing offset locations as close to the impact site as possible, but the other five agreeing that away from the impact site would be preferable, 4 within the same catchment and 1 in the same GBR zone.

While no specific priority areas were mentioned for mangroves, experts stated that offsets should be within the same catchment in order to maximize connectivity between existing mangroves and other marine ecosystems such as seagrass and corals, and that arbitrary boundaries should not be applied as they may reduce effectiveness and provide less overall benefit to the surrogate.

Expert Elicitation Round 2 Summary

One expert selected “As close to the site of impact (development or project site) as possible” and commented “Where depends on ecosystem services and biodiversity that is being offset - needs assessment Where - could be where there is greatest need for extensive restoration (e.g. Fitzroy; Styx where conversion of coastal wetlands to pasture has been greatest - depends on goals/above) Where - restoration of cane land in wet tropics”

Two experts selected “Away from the impact site, but within the same catchment” and commented:

“When looking at mangroves please do take NOTE! Mangroves are important, but so too are saltmarsh habitats and high intertidal saltpans. Where do these co-inhabitors of tidal wetlands niche fit in this survey?” *(note: intertidal surrogate)*

“As state in Round 1, a thorough spatial prioritization of restoration actions for suitable habitat for this surrogate is yet urgently needed”

4.5 Seagrasses

4.5.1 Background

Seagrass extent is currently estimated at 5700 km2 of shallow intertidal and subtidal areas, and 40,000km2 of sparser (<5% cover) of deep water areas. There is strong evidence that seagrass extent is declining within the Reef (Coles et al., 2015). The 2009 Outlook Report stated that the overall area of seagrass meadows had remained relatively stable over the preceding 20 years, however monitoring of inshore meadows in the central and southern coast of the Reef indicate overall declines in abundance, especially in the Townsville, Abbot Point, Cairns, Gladstone and southern Cape York regions (Commonwealth of Australia, 2014a; McKenzie et al., 2012), as well as other locations susceptible to cyclones and flooding events (Coles et al. 2015). Regularly monitored meadow areas have shrunk by 38% since the 1980s, and have reduced abundance with some sites showing minimal or no sexual reproduction (Waycott and McKenzie 2010). Other indicators of seagrass condition such as reproductive effort and nutrient status have also deteriorated, and are highly vulnerable to additional impacts because of reduction to small remnant patches with limited seed banks (Coppo, McKenzie, & Brodie, 2016; Great Barrier Reef Marine Park Authority, 2014). Conditions of both northern inshore and offshore regions are still considered to be in very good condition with stable trends, however southern inshore populations are in very poor and deteriorating condition, and southern offshore habitats are in poor condition, though the trend data for offshore seagrasses in the south is unknown because of unreliable data (Commonwealth of Australia, 2014a).

Seagrass diversity in the Reef is being maintained, though there have been severe declines in abundance and species composition in southern inshore seagrass areas (Great Barrier Reef Marine Park Authority, 2014). Seagrass species in the northern inshore and offshore meadows are considered to be in very good condition with stable trends, however southern inshore species are in very poor condition with deteriorating trends and southern offshore species are in poor condition. However there is very little data available for the trend and condition of offshore species or habitats in the northern or southern regions and assessments are based on very limited evidence or anecdotal information (Commonwealth of Australia, 2014a).

While the 2014 Outlook Report and Strategic Assessment report seagrass in the northern region as very good stable, and the southern region, especially inshore as very poor and deteriorating (Commonwealth of Australia, 2014a; Great Barrier Reef Marine Park Authority, 2014), there is strong evidence that seagrass is now declining in all parts of the Reef (McKenzie et al., 2015). The Reef Plan 2050 target for seagrass is for improved condition and resilience indicators at a Reef-wide scale. While little can be done to counteract the impacts of extreme weather events (outside of major policy changes), passive restoration such as water quality and catchment management improvements will help aid in the condition and resilience of seagrass habitat (Paling, Fonseca, van Katwijk, & van Keulen, 2009). However, preliminary model results suggest active restoration of seagrass is important, especially in areas where the ability for seagrass to recolonise is limited (Saunders et al., in review). This could occur, for instance, in areas with reduced seagrass abundance, limited seed production, or where environmental conditions hinder the establishment of seagrass plants.

4.5.2 Priority Actions

Literature Review

A variety of transplanting mechanisms are available, some more successful than others (Bayraktarov et al. 2016). However, seagrass planting and restoration is by itself only moderately successful and a review of current seagrass restoration in NSW found that it could not be counted on to achieve 2:1 habitat compensation (Ganassin & Gibbs, 2008). No specific information is available on restoration of seagrass species.

Expert Elicitation Round 1 Summary

The seagrass actions focussed on the need for research including basic biology for all species - seed production, seed viability, seedling survival, seedling growth rate, recovery/replenishment rates, recolonization by animals –thresholds of tolerance for the different seagrass species to the range of stressors (turbidity, temperature, nutrients). The suggested action of spatial mapping was recommended. The extensive set of information that is available on seagrass values at each of the GBR Ports should be considered when identifying conservation actions.

Expert Elicitation Round 2 Summary

Three experts selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” and commented:

“Not sure though that there are many strategies that actually do this - that would be a good start!”

“- Basic biology for all species - reproductive rates and strategies - Thresholds of tolerance for the different seagrass species to the range of stressors (turbidity, temperature, nutrients).   - A better understanding of important feedback loops required such as links between water quality, sediment microbiomes and seagrass systems.   - Understanding the most effective methods and techniques for restoration of different seagrass species and habitats.   - Spatial mapping of seagrass extent in areas outside of Ports. The development of a decision-making framework based on the best available information to inform management. - Understanding the adaptive capacity of seagrasses to future predictions of climate change”

“The existing QLD DAF guidelines for habitat research identify the gaps in seagrass research. Particular attention should be paid to improving estimations of the ecosystem services provided by seagrass, including deeper-water meadows. The problem is that these knowledge gaps are not being closed, that is, the science remains unresolved even as seagrass continues to be dredged for port developments, or at least is adversely affected indirectly by port dredging.”

One expert selected “other” and commented “Prioritizing restoration actions for coral reefs under taking into account connectivity and interdependencies with other ecosystems (e.g. seagrass, mangroves) and the factor of risk and uncertainty of the restoration site being destroyed by e.g. stochastic catastrophic events (e.g. flood plumes due to sea level rise, storms, cyclones, seawater temperature anomalies), changes in feature distribution through succession after disturbance, or anthropogenic impact (e.g. area compromised for coastal development, damaging of restoration site by local communities (trampling) or fishing (bottom trawling))"

4.5.3 Costs

Literature Review

Seagrass restoration is expensive, and in Australia mechanical seagrass transplantation was costed out at about $1,000/ha, and though manual planting was far cheaper, may not include ongoing monitoring costs (Paling et al., 2009). In many instances, protection of seagrass is far more efficient than restoration, especially depending on the scale of disturbance(Paling et al., 2009). For example, aquaculture and transplanting costs an estimated $84,779 - 565,208/ha, while passive restoration through seagrass protection was only $2,193 - 472,309 (Bayraktarov et al., 2016).

Expert Elicitation Round 1 Summary

Six respondents provided cost information on seagrasses:

Highest reasonable cost: range of $50-$3,000,000, average of $1,017,103
Lowest reasonable cost: range of $50-214,000, average of $68,513
Best estimate: range of $50-321,000, average of $180,263
Confidence that highest to lowest interval contains a reasonable estimate: range 50-80, average 65 (out of 100) plus two respondents who entered "low" instead of a number

Justifications and comments included:

> You need the research first - if you had a restoration method you could afford name a place in the GBR where it would be necessary/desirable - I can think of one for one species - this is totally the wrong approach

> The costs are not really directly related to a physical re-establishment of seagrass but are more focused on reasonable cost for the research and management projects listed [in previous answer] that would facilitate better protection and management of the seagrass resource

> I would estimate these costs from Bayraktarov et al 2016. Note that cost for seagrass restoration (min $6,654/ha, median $106,782/ha, max $4,106,047/ha for developed countries reported by the literature) are in US$ at base year 2010 and would need appropriate conversion to AU$. The majority of restoration projects published did not provide cost data in a comprehensive manner and it was often not possible to split the available cost information into capital and operating costs, or to account for the different components of restoration (planning, purchasing, land acquisition, construction, financing, maintenance, monitoring, and equipment

repair/replacement). We estimated that the real total cost of restoration (including capital & operating cost) would be 2 - 4 times higher than the cost reported. A conservative estimate for total seagrass restoration cost would be between 2x US$ 107,000 and 4x US$ 107,000, i.e. would lie between US$ 214,000 and 428,000. Note: all numbers provided here need to be converted from US$ at base year 2010 to AU$ in 2016.

[Name withheld] has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value. This is particularly the case given the extraordinary costing range provided in the literature review.

Preliminary model results suggest active restoration of seagrass is important, especially in areas where the ability for seagrass to recolonise is limited (Saunders et al., in review). This could occur, for instance, in areas with reduced seagrass abundance, limited seed production, or where environmental conditions hinder the establishment of seagrass plants.

Here is the citation: Saunders MI, Bode M, Atkinson S, Klein C, Metaxas A, Beher J, Beger M, Mills M, Giakoumi S, Tulloch V, Possingham H (In review) Simple rules can guide whether land or ocean based conservation will best benefit marine ecosystems.

Expert Elicitation Round 2 Summary

Two experts selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).” but neither provided cost estimates.

One expert selected “Develop an estimate based on the global meta-analysis cost data (Bayraktarov et al 2016).”

Two experts selected “other” and commented:

“Data from Bayraktarov is the best available at present. There are limitations to the database used in that study, which as indicated above, should be factored in when using those numbers. E.g. cost should be multiplied to factor in unknown costs. Offset projects should be closely monitored, and the real costs quantified, such that later projects can utilize updated cost and feasibility information.”

“Bayraktarov et al 2016 provide a synthesis of restoration literature including 235 studies with 954 observations from worldwide restoration projects of coral reefs, seagrass, mangroves, saltmarshes and oyster reefs to evaluate the cost-effectiveness of restoring different coastal habitats. The study has however identified significant gaps and inconsistencies within cost data reported by the literature impeding total restoration cost estimates (including capital and operational cost). Median restoration cost provided in this study are to be handled carefully and only considered as a first attempt to provide cost estimate for global restoration projects yet the real total cost are expected to be realistically at least 2 - 4 higher. I propose developing a survey for restoration practitioners (specifically The Nature Conservancy and consultancies) in order to recover information that has been lost by not-publishing critical cost data and especially the lessons learnt from failing projects.”

One expert provided cost estimates:

Highest Reasonable Cost $562,000
Lowest Reasonable Cost $281,000
Best Estimate $421,000
Confidence 80%
Justification “Same justification and numbers as in Round 1 of the Expert Elicitation but values converted to AUD 2016 and rounded”
Offsets should be located as close to the impact site as possible. However there is a need to ensure that rules regarding the siting of offsets does not prevent delivery of offsets in other areas if a better conservation outcome can be achieved. In addition, another respondent stated “Current and draft GBR policies are heavily focused on ensuring outcomes which consider the current condition and trend of the value in a particular “region”. However there is lack of consistency between regional boundary definitions making the delivery of regional outcomes complex and confusing - we have a plethora of regional boundaries in use at present.”

No specific priority areas for offset implementation were mentioned by respondents, but one respondent noted that basic research on tropical seagrass is needed before even attempting restoration. Water quality was also noted as a significant issue for seagrass especially for active seagrass restoration and that specific offset areas for this surrogate should be guided by models of habitat suitability, prioritization of costs, feasibility and other benefits.

Standard Metric

- See GHHP seagrass reports for developing report cards https://dims.ghhp.org.au/repo/data/public/d3be7a
- And Queensland offset policy https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/68601/Marine-Fish-Habitat-Offset-Policy-12.pdf
- The seagrass surveys from JCU / trop water consider area and quality
- Most seagrass restoration studies report on 'item-based' metrics such as survival of restored organisms and increase in biomass. A good composite metric would be ecosystem services provided by restored seagrass (e.g. carbon storage capacity and mitigation of climate change, habitat for marine invertebrates, nursery habitat for fish, water filtration) in comparison to those provided by pristine seagrass meadows.

Expert Elicitation Round 2 Summary

Two experts selected “Away from the impact site, but within the same natural resources management region” and commented:

“Areas of seagrass habitat that are supporting the most valuable ecosystem services and ecological function should be prioritized for offsets”

“We now have a good handle on the causes of seagrass loss, but the consequences for ecosystem services are only vaguely known. Two specific types of research can solve this dilemma: 1) determine rigorously what fisheries species actually RELY on seagrass habitat at some stage in their life history, 2) properly quantify carbon sequestration rates for different types of seagrass meadows across the GBR (currently only done for a couple of seagrass species in very few places, needs a broad-scale assessment).”

Two experts selected “As close to the site of impact (development or project site) as possible” and commented:

“The priorities you identify above for the Wet Tropics basins need to be properly cited and put in context! These sorts of priorities are only specific to WQ impacts and within a certain context of relative risk and area. While these assessments are available for every region to support the WQIPs, I would hesitate to use it for this purpose.   I would imagine that seagrass will respond to local improvements, but I am no expert!”

“I believe that where feasible offsets should occur as close to the impact site as possible. However, there may be instances where better outcomes can be achieved elsewhere. In those instances there should be flexibility to implement offsets in the same catchment or same NRM region.”

Two experts selected “Away from the impact site, but within the same zone of the GBRWHA (Northern, Central, or Southern zones)” and one of these experts commented “As state in Round 1, a thorough spatial prioritization of restoration actions for suitable habitat for this surrogate is yet urgently needed”

4.6 Shallow Reefs

4.6.1 Background

Coral Reef habitat

Coral cover is an indicator of coral Reef status and has declined rapidly since the 1960s when coral cover was 45-55% on mid and outer Reefs (Hughes et al. 2011), and to 28% in 1980s (Sweatman & Syms, 2011), down to about 14% by 2011 with the rate of decline increasing recently (De'ath, Fabricius, Sweatman, & Puotinen, 2012). Coral cover in the entire Reef has declined by about 50% since 1985, while inshore coral Reef cover has decline by 34% since 2005 (Brodie et al., 2013b). The average rate of coral cover decline is about 1.45% per year since 2006 and is more severe in the southern regions (Commonwealth of Australia, 2014a), while crown of thorns starfish (COTS) outbreaks have affected nearly 1/3 of Reefs in the Reef over the last 60 years (Brodie et al., 2013b).

The most recent report of the AIMS long term monitoring program shows that from 2012 to 2015 hard coral cover in the central and southern sections has increased, however the northern section shows a decline in coral cover because of an intense cyclone and renewed activity of crown-of-thorns starfish in the region (AIMS 2016). Northern inshore and offshore coral reef habitats are considered to be in good condition with stable trends and have not shown similar declines as the southern regions, with coral cover staying in the 40-50% rate in Torres Straight region, and 30% in northern Cape York.

Across the region coral cover has declined by 50 percent since 1985 (Brodie et al., 2013b), the rate of coral decline is likely increasing through time especially in the southern Reef. While northern populations were listed in good and stable condition in 2014 (Commonwealth of Australia, 2014a), mass bleaching events in the Reef resulted in the severe bleaching of 81% of corals surveyed in the Northern GBR and 33% in the central GBR (ARC, 2016) with overall coral mortality of 22% (as of June 2016) (AIMS, 2016). As a result, northern and central reefs will likely have deteriorated since the last condition assessment. Investment in water quality initiatives and COTS removal will likely alleviate some pressure on Reef systems, and the Reef 2050 Plan commits to improving the condition and resilience of coral Reefs, but commitments are processes rather than targeted actions to improve Reef outcomes.

Coral Reef species

Trends for coral reef species are the same as for coral reef habitats (see above; AIMS 2016). There is limited monitoring of coral species composition, however there is consensus that diversity and abundance has declined dramatically for the Reefs south of Cooktown (Commonwealth of Australia, 2014a). Core samples from Pelorus Island indicate that historically Reefs in the region were dominated by Acropora corals, characteristic of clearer waters, however from 1920 -1955 Acropora assemblages collapsed and were replaced by more turbid water corals or species with limited live coral and it is believed that many inshore Reefs in the southern two-thirds of the Reef are likely to have undergone a similar shift in composition (Commonwealth of Australia, 2014a).

Coral diversity and abundance has also declined, especially in the Reefs south of Cooktown (Commonwealth of Australia, 2014a). Coral species were on a stable trajectory in the northern inshore and offshore Reefs prior to 2016 mass bleaching events, however long-term impacts of the bleaching event is still unknown (AIMS, 2016). Coral species in the southern inshore and offshore regions of the Reef are in deteriorating condition, though should improve with Reef 2050 targets, the extent of which has not been determined. Little is known about the trend of invertebrate species in the region, but are thought to be deteriorating in southern inshore regions but stable elsewhere throughout the Reef (Commonwealth of Australia, 2014a).

Associated benthic species (other invertebrates, macroalgae, benthic microalgae)

There are thousands of invertebrate species in the region, many are important fisheries such as prawns and crabs and none are currently assessed as over-fished (Commonwealth of Australia, 2014a). However, there is little data on the status of non-commercial species and declines coral cover (Commonwealth of Australia, 2014a) and in water quality are likely to impact species and those that rely on them (e.g marine turtles; C. Limpus pers. comm.). Current condition for invertebrate species is reported as very good and stable condition in all regions, except for southern inshore populations which are in good condition but deteriorating (Commonwealth of Australia, 2014a). However these estimates are based on very limited evidence or anecdotal information, especially for offshore areas of the southern Reef.

It is thought that the diversity of macroalgae is being maintained, though this could be impacted by changes to coral-algae relations such as changes in ocean chemistry and herbivore abundance. Microalgae is little studied, but is assumed to be undisturbed for most of the GBR (Commonwealth of Australia, 2014a). Details of condition and trend data are based on very limited evidence or anecdotal information, in all regions but southern inshore where data is limited rather (Commonwealth of Australia, 2014a). Both macroalgae and benthic microalgae are understudied and have very limited data availability but are believed to be in very good condition in the north and good condition in the south, with stable trends (Commonwealth of Australia, 2014a).

4.6.2 Priority Actions

Literature Review

Coral restoration and habitat enhancement are feasible and in some cases successful in improving coral spawning stock on degraded Reefs (Spadaro, 2014). In addition, coral larval rearing and transplant and the installation of artificial Reefs have been identified as plausible offset options for coral restoration and enhancement (Jones et al., 2015) and provide an array of services including enhancing habitat for fish and other species (State of Western Australia, 2012). Other restoration techniques include ex situ coral cultivation, growing corals, and transplantation of coral (Bayraktarov et al., 2016).

No additional priority actions were found for associated benthic species, or benthic microalgae, though macroalgae restoration of a species of fucoid alga has been shown to be successful in Sydney (Campbell, Marzinelli, Vergés, Coleman, & Steinberg, 2014) though areas with continued human pressure had difficulty with establishment (Borja, Fontán, & Muxika, 2013).

Expert Elicitation Round 1 Summary

The experts suggested that shallow reefs offset actions include research (water quality), reef restoration which takes into account connectivity of coral reefs with other marine and coastal, and techniques for scaling up restoration efforts.

Expert Elicitation Round 2 Summary

Three experts selected "Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)" and commented:

"Funding of actions that have a direct link to improved management, with a focus on reducing the threats to the system, such as assessing a range of management actions that could be implemented to improve the health of the Great Barrier Reef. GBRMPA has a list of projects they would want funded- that list should be a starting point. Coral restoration is a risky venture and if the main threats the system is facing (such as a reduced water quality) are not first mitigated, coral restoration is unlikely to succeed."

"Removal of marine debris increased compliance to prevent illegal take removal of COTs and Drupella."

"Prioritizing restoration actions for coral reefs under taking into account connectivity and interdependencies with other ecosystems (e.g. seagrass, mangroves) and the factor of risk and uncertainty of the restoration site being destroyed by e.g. stochastic catastrophic events (e.g. flood plumes due to sea level rise, storms, cyclones, seawater temperature anomalies), changes in feature distribution through succession after disturbance, or anthropogenic impact (e.g. area compromised for coastal development, damaging of restoration site by local communities (trampling) or fishing (bottom trawling))"

One expert selected "other" and commented "whilst recognizing this is not an action - restoration is unlikely to be a feasible option in large areas of the GBR due to impact in the Marine park, whilst this may change (and is slowly changing) there are significant approval barriers to this as an option (most of which could trigger offsets in their own right)"

4.6.3 Costs

Literature Review

The cost of coral restoration from 18 observations in developed countries was found to be a minimum $7,647/ha and a maximum of $143,000,000/ha, for a median cost of around $1,826,651 (Bayraktarov et al., 2016). Another study found that major Reef restoration costs about US$100,000 –1,000,000's per hectare, while lower cost transplantations costs S$2000 –13,000 per hectare (Edwards & Gomez, 2007). However in Australia revegetation of subtidal Reef was about 38,000 AUD/ha (Edwards & Gomez, 2007).

Expert Elicitation Round 1 Summary

Two respondents provided cost information for shallow reefs. One person said “I think the most appropriate way to estimate the cost of rehabilitation would be to estimate how much it would cost to obtain an ecosystem level benefit equivalent to the ecosystem level damage through local management (water quality). However, the relationships discussed in my previous comments, and in the sections about sedimentation and nitrogen concentration are a requirement for this approach to be applicable.” The second person said “COTs removal in Cairns section ~$10 million over 3 years (doesn't include in-kind contributions).”

Expert Elicitation Round 2 Summary

One expert selected “I do not feel qualified to answer this question.”

One expert selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).” but did not provide any estimates.

Four experts selected “other” and commented:

“I think you can only go with published literature in your timeframes.”

“I think that an explicit calculation of the costs of implementing coral restoration should be undertaken for the region. This would require developing a project plan and coming up with a budget. The global meta-analysis could help guide the development of a project plan by indicating the types of costs that occur in coral reef restoration, but trying to use numbers developed for another region could lead to a large mis-estimation of costs, which could reduce the ability to operationalize a coral reef restoration project.”

“With such limited responses I am struggling to see that there is currently enough information in this area (the workshop was cancelled due to this level of engagement) “

“Bayraktarov et al. is the best available resource at present for costing data for coral restoration. The limitations of that data analysis do need to be factored in though.”

“Bayraktarov et al 2016 provide a synthesis of restoration literature including 235 studies with 954 observations from worldwide restoration projects of coral reefs, seagrass, mangroves, saltmarshes and oyster reefs to evaluate the cost-effectiveness of restoring different coastal habitats. The study has however identified significant gaps and inconsistencies within cost data reported by the literature impeding total restoration cost estimates (including capital and operational cost). Median restoration cost provided in this study are to be handled carefully and only considered as a first attempt to provide cost estimate for global restoration projects yet the real total cost are expected to be realistically at least 2 - 4 higher. I propose developing a survey for restoration practitioners (specifically The Nature Conservancy and consultancies) in order to recover information that has been lost by not-publishing critical cost data and especially the lessons learnt from failing projects."

One expert provided cost estimates:

Highest Reasonable Cost $871,000
Lowest Reasonable Cost $436,000
Best Estimate $653,000
Confidence 80%
Justification "Same justification and numbers as in Round 1 of the Expert elicitation but values converted to AUD 2016 and rounded"

4.6.4 Spatial Priorities

Literature Review

The regions of the Reef where coral species and populations are still in good condition (at least until the most recent bleaching events) include the Torres Straight and the Northern Cape York (Brodie & Pearson, 2016; Coppo et al., 2016). Coral Reefs in the southern two-thirds of the Reef, especially inshore Reefs, are being continually damaged by disturbance and water quality declines, such that they lose resilience and cannot recover adequately (Commonwealth of Australia, 2014a). Research has found that protection of live coral cover and Reef habitat in the Keppel islands is a high priority, as well as the restoration of riparian vegetation and minimisation of the impacts of cattle in key catchment areas such at the Fitzroy (Williamson, Ceccarelli, Rossetti, Russ, & Jones, 2016). For the Wet Tropics region, relative risk based on water quality parameters is greatest for coral in the Tully Murray basins, and areas highly valued for tourism and recreation including Hinchinbrook Island, Goold Island, the Brooks Islands, and the Family Island group including Bedarra Island and Dunk Island (Waterhouse et al., 2014).The Daintree region was rated as moderate; it has a very high risk to the Reef due to its COTS influence but is rated as very low for all other inputs (Brodie et al., 2013b).

Expert Elicitation Round 1 Summary

There were five expert responses to this question, with most (3) stating that offsets for shallow coral reefs should be as close to the site of impact as possible, and two stating that offsets should be away from the impact site but within the same GBR zone.

While no specific priority offset locations were mentioned by respondents, one noted that reefs are heavily affected by water quality such as sedimentation and total nitrogen, while another stated that offset location would depend on where the value/process has the greatest opportunity to maximise outcomes, they stated "There is no point putting in extensive effort at the site of the impact if the viability of the coral communities at that location in the long-term is poor. You would be better off choosing an adjacent source reef with good conditions where larvae recruits could disperse to adjacent areas. Should also consider clades of zooxanthellae in the corals to maximise coral resilience to future pressures. Water quality should be improved at and adjacent to the impact site."

Standard metric:

- Not to my knowledge
- Most coral reef restoration studies report on 'item-based' metrics such as survival of restored organisms and increase in biomass. A good composite metric would be ecosystem services provided by restored coral reefs (e.g. habitat for marine invertebrates and fish, recycling of inorganic nutrients in nutrient-poor regions, coastal protection, provision of food) in comparison to those provided by pristine coral reefs.
- No

Expert Elicitation Round 2 Summary

Two experts selected “Away from the impact site, but within the same zone of the GBRWHA (Northern, Central, or Southern zones)” and commented:

“I agree with the respondent above that coral reef restoration projects should occur in places where they are most likely to succeed. Investing in restoration of a degraded reef without removing the initial threat is a poor investment.”

“As state in Round 1, a thorough spatial prioritization of restoration actions for suitable habitat for this surrogate is yet urgently needed”

Three experts selected “As close to the site of impact (development or project site) as possible” and commented:

“”As described public which to see offsets in their backyard which has significant political pressure affiliated with this. Bottom line with corals particularly is if the baseline conditions for why they were impacted are still the same, reestablished or new stock will have the same impacting processes “

“source areas for other reefs”

“Ideally the offset site is close to the impact site. However, where the long term prospects of the reef are poor nearby to the impact site, then there should be opportunity to offset further afield.”

One expert commented “As per seagrass comments, please revise the discussion of priority areas above - these assessments are relative risk, based on WQ parameters. The citations are also incorrect - all Waterhouse et al. 2014-106. Other supporting studies for the WQIPs cover this discussion to some extent aswell including Lewis et al sediment synthesis.”

4.7 Deep Reefs

4.7.1 Background

Deep Reefs in the Reef are understudied and there no long term monitoring data (Commonwealth of Australia, 2014a). Modelled studies indicate mesophotic Reefs are widespread in the Reef, and are unlikely to have recent physical damage, though records from Myrmidon Reef offshore from Townsville show significant damage from cyclone Yasi in 2011. In addition, little is known about recently discovered cold water corals in areas greater than 1000m (Commonwealth of Australia, 2014a). Northern offshore coral Reefs are considered to be in very good and stable condition, and southern offshore coral Reefs are in good and stable condition, however this is based on limited evidence or consensus. No species-specific information is available for deep-water coral Reef species or coral composition. In addition, no specific information is available for other invertebrates, macroalgae or benthic microalgae of deep Reefs and the condition and trend is assumed to be the same as for shallow coral Reefs.

Little is known about the trajectory of deep coral Reef habitat in the region, but they are thought to be in stable condition throughout the region (Commonwealth of Australia, 2014a). There is a critical lack of information on the current extent or condition of deep Reef ecosystems, and seabed habitat and species in the region that is deeper than 200m. No data is available on specific deep water coral species. The Reef 2050 Plan commits to achieving good condition for coral Reefs, however no specific deep Reef targets or actions are discussed.

There is a lack of data regarding the trend of invertebrate species in the region, but are thought to be deteriorating in southern inshore regions but stable elsewhere throughout the Reef (Commonwealth of Australia, 2014a). Both macroalgae and benthic microalgae are understudied and have very limited data availability but are believed to be in very good condition in the north and good condition in the, with stable trends (Commonwealth of Australia, 2014a). This data is based on 'coral species' indicators and is likely more accurate for shallow reefs than for deep reef systems.

4.7.2 Priority Actions

Literature Review

One theoretical study suggests restoration of deep reefs is feasible but almost exorbitantly expensive (Van Dover et al., 2014), however there is little empirical evidence either way (UNEP-WCMC, 2015).

Expert Elicitation Round 1 Summary

There were no expert suggestions for offset actions for deep reefs.

Expert Elicitation Round 2 Summary

One expert selected "Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)" but did not provide any comments.

4.7.3 Costs

Literature Review

No data on cost was identified through the literature review.

Expert Elicitation Round 1 Summary

No responses on cost information for deep reefs.

Expert Elicitation Round 2 Summary

No responses.

4.7.4 Spatial Priorities

Literature Review

No spatial priorities for Deep Reefs or associated benthic species were identified through the literature review.

Expert Elicitation Round 1 Summary

Only two respondents answered this question with one stating that offsets for this surrogate should be implemented away from the impact site but within the same GBR zone and the other that the offset should be as close as possible to the impact site.

No specific priority areas for offset implementation were described for this value with one respondent stating that deep reefs were highly unlikely to be an offsettable surrogate.

Expert Elicitation Round 2 Summary

No responses.

4.8 Lagoon Floor

4.8.1 Background

The lagoon floor generally consists of sand and mud and supports a wide range of species. The habitat is likely to be in good condition in all parts of the Reef with a stable trend, though no long-term monitoring data is available. Areas with trawling impacts are likely in poor but recovering condition, with extreme weather events possibly leading to damage of the lagoon floor (Commonwealth of Australia, 2014a). Data of the condition of this habitat is based on limited information, while trend data is based on very limited or anecdotal evidence.

There are thousands of invertebrate species in the region, many are important fisheries such as prawns and crabs and none are currently assessed as over-fished (Commonwealth of Australia, 2014a). However, there is little data on the status of non-commercial species and declines coral cover (Commonwealth of Australia, 2014a) and in water quality are likely to impact species and those that rely on them (e.g marine turtles)(C. Limpus pers. comm.). Current condition for invertebrate species is reported as very good and stable condition in all regions, except for southern inshore populations which are in good condition but deteriorating (Commonwealth of Australia, 2014a). However these estimates are based on very limited evidence or anecdotal information, especially for offshore areas of the southern Reef and there is little or no information on the basic biology and ecology of most marine invertebrates (Ponder, Hutchings, & Chapman, 2002).

Lagoon floors are generally thought to be in good condition and on stable trajectory throughout the region, the Reef 2050 Plan commits to keeping inter-reef habitat in this condition (EHT5) at a reef-wide scale (Commonwealth of Australia, 2015a). There is limited data on invertebrate species in the region, even those commercially harvested are understudied. Invertebrates are thought to be in stable condition throughout the region, except in the southern inshore areas that are deteriorating (Commonwealth of Australia, 2014a). This assessment is based on very limited or anecdotal evidence, and there is no information on planned actions to improve benthic species in areas where they are declining.

4.8.2 Priority Actions

Literature Review

Restoration for subtidal muddy habitat has proved successful in short time periods (Veríssimo et al., 2012). Acute and persistent disturbance could take 10-25 years for recovery, while restoration after physical impacts without ongoing legacy impacts might take only 1.5-10 years to recover (Borja, Dauer, Elliott, & Simenstad, 2010).

For benthic species, changes in sedimentation loads and farming practices would improve conditions, or minimisation of dredging and benthic trawling (Ponder et al., 2002). For example, trawling is extremely damaging to epifaunal communities, and restrictions in areas the areas trawled or modified gear could minimise impacts (Ponder et al., 2002).

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

No responses.

4.8.3 Costs

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

No responses.

4.8.4 Spatial Priorities

Literature Review

No spatial priority areas for lagoon floor habitat or associated benthic species were identified in the literature review.

Expert Elicitation Round 1 Summary

Three respondents answered this question with two stating that offsets for this surrogate should be away from the impact site, either within the same GBR zone or within the same catchment, with another stating that the offset for this surrogate should be as close to the site of impact as possible.

No specific priority areas for offset implementation were described for this value with one respondent stating that lagoon floors were highly unlikely to be an offsettable surrogate.

Expert Elicitation Round 2 Summary

No responses.

4.9 Shoals

4.9.1 Background

There is little data and no ongoing monitoring of shoal habitats in the Reef. Shoals are likely to be impacted by physical damage as a result of fishing, anchoring, groundings and storms. Based on limited evidence or consensus, they are thought to be in good and stable condition throughout the region.

There are thousands of invertebrate species in the region, many are important fisheries such as prawns and crabs and none are currently assessed as over-fished (Commonwealth of Australia, 2014a). However, there is little data on the status of non-commercial species and declines coral cover and in water quality are likely to impact species and those that rely on them (e.g marine turtles; C. Limpus pers. comm.). Current condition for invertebrate species is reported as very good and stable condition in all regions, except for southern inshore populations which are in good condition but deteriorating (Commonwealth of Australia, 2014a). However these estimates are based on very limited evidence or anecdotal information, especially for offshore areas of the southern Reef and there is little or no information on the basic biology and ecology of most marine invertebrates (Ponder et al. 2002).

There is no ongoing monitoring of shoals in the Reef but shoal habitats are thought to be in good stable condition throughout the region (Commonwealth of Australia, 2014a). The Reef 2050 Plan commits to maintaining this trajectory for shoals in the entire region. There is limited data on invertebrate species in the region, even those commercially harvested are understudied. Invertebrates are thought to be in stable condition throughout the region, except in the southern inshore areas that are deteriorating (Commonwealth of Australia, 2014a). This assessment is based on very limited or anecdotal evidence, and there is no information on planned actions to improve benthic species in areas where they are declining.

4.9.2 Priority Actions

Literature Review

No priority actions are available for shoals or associated benthic species.

Expert Elicitation Round 1 Summary

There was one expert response for shoals, which focussed on the need for definition and did not suggest an offset action . “The literature review (as provided above) references shipping activities and implies that this is 'likely' to impact the surrogate. [Name withheld] is of the opinion that a more balanced view in relation to the way in which the surrogate condition and trend is defined needs to be provided. Without this there is a risk that the identified conservation actions will not effectively deliver no net loss for this surrogate”.

Expert Elicitation Round 2 Summary

No responses.

4.9.3 Costs

Literature Review

No costs data were identified in the literature review.

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

No responses.

4.9.4 Spatial Priorities

Literature Review

No spatial priority areas were identified for shoal habitat or associated benthic species within the Reef.

Expert Elicitation Round 1 Summary

Only two respondents answered this question with one stating that offsets for this surrogate should be implemented away from the impact site but within the same GBR zone and the other that the offset should be as close as possible to the impact site.

No specific priority areas for offset implementation were described for this value with one respondent stating that shoals were highly unlikely to be an offsettable surrogate.

Expert Elicitation Round 2 Summary

No responses.

4.10 Island Vegetation

4.10.1 Background

While there are about 1050 islands in the Reef region, there is limited monitoring of island conditions. All inshore and offshore islands in the northern and southern regions are purported to be in good condition with stable trends. However this is based on limited evidence or consensus, and there is increasing pressure from the impacts of coastal development, recreation and climate change, especially in the southern regions (Commonwealth of Australia, 2014a).

There is limited evidence or consensus on the trend of islands within the Reef, however they support a wide range of species and are thought to be in stable condition (Commonwealth of Australia, 2014a). The Australian and Queensland governments have an integrative management agreement to maintain the ecological and biological diversity of island environments (State of Queensland, 2014), and targets under the Reef 2050 Plan to maintain good condition of islands in the region (Commonwealth of Australia, 2015a).

4.10.2 Priority Actions

Literature Review

Feral pest and invasive species eradication on islands not already funded, for example aerial baiting and or shooting of cats, ants, foxes, dogs, goats, horses and deer could all be prioritised for management in islands where it is not already occurring (Commonwealth of Australia, 2014a; Pressey & Wenger, 2015). A small percentage of islands are annually monitored for pest species but information is lacking on the status and trends of island habitats, including about 700 islands in the WHA that are not part of protected areas (many have important values such as seabird rookeries; Commonwealth of Australia, 2014a).

Expert Elicitation Round 1 Summary

The action recommended was island shoreline circumferences be monitored using the Shoreline Video Assessment Method.

Expert Elicitation Round 2 Summary

No responses.

4.10.3 Costs

Literature Review

Costs of pest eradication vary considerably based on island location and type of pest, for example the Macquarie island pest eradication project costs approximately $24.7 million over 8 years, due to remote locations, number of pests and complexity of intervention (Parks and Wildlife Service, 2014). Pressey and Wenger (2015), include a table of costs for pest eradication, including costs for specific islands.

Expert Elicitation Round 1 Summary

"Costs outlined for estuarine systems could be applied - or even less since islands might often be quite small. This means that around $25,000 per year per island group."

[Name withheld] "has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value. This is particularly the case given the extraordinary costing range provided in the literature review."

"$10,000 to $1 million per ha"

Expert Elicitation Round 2 Summary

No responses.

4.10.4 Spatial Priorities

Literature Review

Within the Reef there are 38 islands that act as important nesting sites for marine turtles, of which Raine Island is very significant due to the large aggregation of nesting green turtles. In addition, Milman island, Wild duck island, peak island and the cays of the Capricorn bunker are all important areas for the survival of marine turtles in the Reef (Great Barrier Reef Marine Park Authority, 2014). At least 20 species of seabirds breed on islands in the Reef, and there are also significant nesting sites throughout the region (Commonwealth of Australia, 2014a).

Expert Elicitation Round 1 Summary

Two respondents agreed that offsets for Island terrestrial vegetation should occur as close to the site of impact as possible, however there were no responses as to priority areas for offset implementation for island surrogates.

Expert Elicitation Round 2 Summary

No responses.

4.11 Halimeda

4.11.1 Background

Halimeda is a genus of green macroaglae. Large tracts of the northern Reef are dominated by Halimeda bank habitat. The habitat is poorly studied but thought to be in very good and stable condition, given its isolation, however calcification rates are likely to be impacted by ocean chemistry changes as a result of climate change (Commonwealth of Australia, 2014a), and due to changes in nutrient upwelling and ocean circulation (Great Barrier Reef Marine Park Authority, 2014). This assessment of condition and trend data is based on very limited evidence or consensus. In addition, there is no data available on the condition or trends of specific Halimeda species, and they remain unmentioned in the Strategic Assessment and Outlook Reports (Great Barrier Reef Marine Park Authority, 2014).

There is limited information on the condition or trajectory of Halimeda habitat or species, but they are thought to be in stable condition. Halimeda is not mentioned as a target in the Reef 2050 Plan (Commonwealth of Australia, 2015a).

4.11.2 Priority Actions

Literature Review

No priority actions were available for Halimeda habitat or Halimeda species.

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

No responses.

4.11.3 Costs

Literature Review

No costs data were identified through the literature review.

Expert Elicitation Round 1 Summary

[Name withheld] “has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value.”

Expert Elicitation Round 2 Summary

No responses.

4.11.4 Spatial Priorities

Literature Review

No spatial priority areas were identified for Halimeda habitat or Halimeda species within the Reef.

Expert Elicitation Round 1 Summary

Only two respondents answered this question with one stating that offsets for this surrogate should be implemented away from the impact site but within the same GBR zone and the other that the offset should be as close as possible to the impact site. There were no suggestions for high priority areas for offset implementation of this surrogate

Expert Elicitation Round 2 Summary

No responses.

4.12 Bony Fish

4.12.1 Background

Commercially relevant fish species are monitored for sustainable harvest by the Department of Fisheries (DAF), however there is no long-term analysis of trends in coral reef fishes, which are likely to have been highly impacted by habitat declines. Both target and nontarget fish populations that interact with the fisheries are under significantly more pressure in the southern two-thirds of the Reef, but conditions of northern populations are still relatively unknown. Severe weather events and declines in water quality are likely to exacerbate fisheries declines (Commonwealth of Australia, 2014a). In addition, fishing pressure has likely reduced the size of fish and fish populations, and reduced abundance, especially in Spanish mackerel that are approaching 'overfished' stock status, and coral trout whose populations have declined from 'sustainably fished' stock status to 'uncertain.'

Northern inshore and offshore populations are reported to be in good condition, with stable offshore population but deteriorating inshore populations. Southern inshore and offshore populations are thought to be in good condition, and stable in offshore populations but deteriorating in inshore populations (Commonwealth of Australia, 2014a). This is especially true from two species of threadfin salmon that have been assessed to have high vulnerability, grey mackerel with medium vulnerability, snapper which has been assessed as overfished (Great Barrier Reef Marine Park Authority, 2014).

Trajectories for bony fish will vary based on the species, but overall trends are deteriorating for inshore populations in the north and south, while offshore populations are more stable. Reef 2050 Plan sets out actions to improve the sustainability of fisheries in the Reef (Commonwealth of Australia, 2015a), including species plans to keep coral trout stocks at 60% unfished populations. A new fisheries green paper sets this 60% target for all fisheries in the state (State of Queensland, 2016b).

4.12.2 Priority Actions

Literature Review

While a net buyback program for the inshore net fishery is ongoing (State of Queensland, 2015), there are still concerns about the number of licenses for this fishery (Darren Cameron, pers comm). In addition, while some commercial fisheries are outfitted with Vessel monitoring systems (VMS) such as trawlers in the region, additional VMS for all fisheries would improve management practices in the Reef (Darren Cameron, pers comm). Impacts to fish populations can also be improved by re-instating connectivity between coastal habitats and river and estuary systems (Creighton, Boon, Brookes, & Sheaves, 2015), and restoration of fish habitat spawning and nursery grounds.

Expert Elicitation Round 1 Summary

There were two suggested offset action categories involving research and habitat. The research actions suggested knowledge and data about the links between habitat and fishes and fishers need to be encouraged to keep more detailed catch records and catch locations. The habitat action suggested improve connectivity in coastal habitats (e.g. remove barriers to fish passage).

Expert Elicitation Round 2 Summary

One expert selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” and commented “Critical gap in our understanding of how fishing pressure including from Charter Industry is affecting the functional roles fish have on coral reefs and in seagrass meadows.”

4.12.3 Costs

Literature Review

No costs data were identified through the literature review.

Expert Elicitation Round 1 Summary

“It will depend as not all bony fish are equal. For example, one IUCN listed Maori Wrasse has far greater value than 1 bream or the same kilogram equivalent of bream.”

[Name withheld] “has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value.”

Expert Elicitation Round 2 Summary

One expert selected “other” and commented “Approximate guide. Calculate the total monetary value of fishing in GBR waters (direct commercial harvest, recreational fishing value, charter fishing value, indigenous fishing value; for each of these, include the flow-on economic consequences of jobs and related businesses). Add the total estimated tourism monetary value of having fish to look at on the GBR (only able to be estimated at this stage).”

4.12.4 Spatial Priorities

Literature Review

The only high priority area for offset implementation listed was fishing license buyback with a priority on inshore areas, but that offset location should depend on the value of the surrogate and where the greatest opportunity for maximum benefit can be derived, most likely through the entire home range of the impacted species.

Expert Elicitation Round 1 Summary

Three respondents replied to this questions with one stating that offsets should be as close to the site of impact as possible, but the other two agreeing that offsets should be away from the impacts site, either in the same GBR zone or within the same catchment.

Expert Elicitation Round 2 Summary

One expert selected “Away from the impact site, but within the same natural resources management region.”

4.13 Sharks and Rays

4.13.1 Background

Overall, shark and ray populations are considered to be in good condition, though there are concerns over several shark species including the grey and whitetip Reef sharks, and the Speartooth shark which was critically endangered but is now thought to be extinct in the Reef region (Commonwealth of Australia, 2014a). An additional thirty species are under high risk from changing climate and eleven species are under high risk from otter trawl operations (Great Barrier Reef Marine Park Authority, 2014), while coastal and estuarine species have been identified as the most vulnerable groups within the Reef and adjacent waters (eg blacktip sharks, hammerheads) (Commonwealth of Australia, 2012c). In addition, the largetooth, dwarf and green sawfish have had substantial range contractions and population declines (Great Barrier Reef Marine Park Authority, 2013), and there are increasing concerns about the threat of the deep-water line fishery to deep-water shark species, that are particularly susceptible to extinction because of habitat specifications and life history traits (shark vulnerability assessment). There are also concerns for species that interact with the trawl fishery, while shark-like batoids (ie sawfish, guitarfish) are particularly vulnerable to inshore net fisheries (Great Barrier Reef Marine Park Authority, 2014). Whale sharks, shortfin and longfin makos, and porbeagle sharks are pelagic and elusive species within the GBR with limited information of status and trends for populations.

Though many shark and ray species are data-deficient, the overall trend for shark and ray populations in the region is deteriorating (Commonwealth of Australia, 2014a). The action plan for sharks delivers guidance on improved conservation and management of sustainable shark fisheries (Commonwealth of Australia, 2012b), and while the Reef 2050 Plan commits to increases in ‘key indicator species’, shark and rays are not specifically mentioned (Commonwealth of Australia, 2015a).

4.13.2 Priority Actions

Literature Review

Shark and ray conservation is difficult to assess as some species are commercially harvested and others are protected. No specific priority actions were found for sharks and rays, though there are recovery plans in place for several protected shark species including the Grey nurse shark, white shark, and a multi-species recovery plans for sawfish and other river sharks (Freshwater sawfish, Green sawfish, Dwarf sawfish, Speartooth shark). Protection of any habitat where riverine sharks aggregate for breeding, foraging, resting or migrating is considered habitat critical to the survival of the species (Commonwealth of Australia, 2015b).However a coordinated program to address anthropogenic pressures on inshore sharks and rays is needed, including improvements in water quality and the identification of areas of high conservation value (Commonwealth of Australia, 2012c). In addition, some historical net fishing areas interact in speartooth shark and sawfish habitat and closures could be beneficial in these areas (Commonwealth of Australia, 2012a). In addition, license buybacks (though already listed as a management action) could be beneficial in areas with incidental catch of protected shark species (i.e. sawfish interactions in the otter trawl fishery) (Commonwealth of Australia, 2012b), as well as the removal of barriers to sawfish migration in riverine habitats (Chevron Australia, 2012).

Expert Elicitation Round 1 Summary

There were no expert suggestions for offset actions for Sharks and Rays.

Expert Elicitation Round 2 Summary

One expert selected "Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)" and commented "DOE 2015 - Sawfish and River Sharks - Multispecies Recovery Plan, actions are not being funded (to my knowledge). At least 650K is needed for a widespread public and Indigenous engagement program to identify sawfish and river shark hotspots on the east coast, for targeted research, capacity building, and a monitoring and evaluation program. These are itemised in the Recovery Plan. These hotspots need to be reflected in coastal planning, e.g. water quality improvement plans and development impact assessment processes. Maybe also consider habitat recovery for degraded hotspot sites. Regarding other sharks and rays: (1) restore the Qld fisheries observer program. Note - this should be funded as outright by the Qld gov as part of their core responsibility, NOT from offsets which would be a gross example of inappropriate cost shifting; (2) identify critical coastal habitats that could be at risk from coastal development (3) a harvest strategy for the Qld east coast inshore finfish fishery that includes monitoring and evaluation."

4.13.3 Costs

Literature Review

While the costs of most of these activities are species and location dependent, the Queensland government allocated 10 million dollars to fund license buy-backs for the inshore net fisheries, however the cost of the licenses are dependent on the catch per unit effort (CPUE) and the average number of days fished (DAF pers. comm). More detailed information on the specific costs of each license is available from the QLD Department of Fisheries (DAF). For example, WWF Australia recently agreed to purchase a single shark net license in the Reef for $100,000 (The Guardian Australia, 2015).

Expert Elicitation Round 1 Summary

No responses on cost information for this surrogate.

Expert Elicitation Round 2 Summary

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next" and provided the following estimates:

Highest Reasonable Cost $800,000
Lowest Reasonable Cost $550,000
Best Estimate $700,000
Confidence (no response)

Justification "DOE 2015 Sawfish and River Sharks - Multispecies Recovery Plan - costings for action 2 and 3, plus 20% based on my experience of working up in Cape York."

4.13.4 Spatial Priorities

Literature Review

The only high priority area for offset implementation listed was fishing license buyback with a priority on inshore areas, but that offset location should depend on the value of the surrogate and where the greatest opportunity for maximum benefit can be derived, most likely through the entire home range of the impacted species.

Expert Elicitation Round 1 Summary

Two respondents to this question stated that offsets for sharks and rays should be implemented away from the impact site but within the same GBR zone.

Expert Elicitation Round 2 Summary

One expert selected "Away from the impact site, but within the same natural resources management region" and commented "Offsets should focus on the hotspot areas where sawfish/river shark abundance is highest and where critical ecological processes (e.g. nurseries) are occurring. This MIGHT include ensuring that riverine habitat"

4.14 Sea Snakes

4.14.1 Background

There are 14 species of snakes, with declines in species richness occurring from north to south (Great Barrier Reef Marine Park Authority, 2014). An estimated 100,000 sea snakes are caught as by-catch in the trawl fishery leading to a 26% mortality rate (Great Barrier Reef Marine Park Authority, 2014). Of particular concern is the high risk of the east coast otter trawl fishery to two species of sea snake, the ornate Reef and the elegant sea snake (Great Barrier Reef Marine Park Authority, 2014). All sea snake populations throughout the Reef considered to be in poor but stable condition, however this is a data poor species and trend and condition data are based on very limited and limited evidence or consensus (Commonwealth of Australia, 2014a).

There is extremely limited information on sea snake abundance, but populations are thought to be in poor condition, with a stable trajectory (Commonwealth of Australia, 2014a). However, while the Reef 2050 Plan commits to increases in 'key indicator species', sea snakes are not specifically mentioned (Commonwealth of Australia, 2015a).

4.14.2 Priority Actions

Literature Review

Results from a recent research project estimated that over 100,000 sea snakes are caught in the East Coast Trawl Fishery each year (Commonwealth of Australia, 2011c). The implementation of by-catch reduction devices (BRDs), research on the impact of shorter trawl times and the impacts of climate change, and other measures to mitigate the impacts of trawling areas with high incidental mortality rates were all listed as important activities in the Reef Sea snake vulnerability assessment (Commonwealth of Australia, 2011c). In addition, a study found that Fisheye BRD were the most effective at excluding sea snakes, reducing catch rates by 60% (Courtney et al., 2007).

Expert Elicitation Round 1 Summary

The experts suggested two categories of offset actions: research and removing threat of activities.

The research actions included adddressing data deficiency; desktop review of species specific distributions; defining relative abundance, habitat, biodiversity and connectivity; desktop review of species specific vulnerability and threat assessments based on life history, connectivity; desk top assessment of the adequacy of existing marine reserves in protecting sea snakes in the GBR catchment; and improving monitoring of interactions with anthropogenic threatening processes (e.g. trawl fishing, dredging/coastal development, offshore mining.

The suggested actions included improving the quality of important seagrass, reef and intertidal habitats; remove trawling; reducing impact of coastal development threat and climate change threat mitigation.

Expert Elicitation Round 2 Summary

Two experts selected "other actions" and commented:

"-The development of a GBR wide conservation strategy for sea snakes -Development of a cumulative impacts assessment for sea snakes and to determine an estimate of how much habitat is available for offsetting throughout each species range (e.g. it is not infinite, so what is our best estimate of how much is available to 'take' in return for offsetting (through coastal development), with regard for the level of site fidelity in this group. -genomic connectivity assessments of the 16 GBR species (as the easiest and probably cheapest method available, which can use archival samples from Blanche D'Anastasi, Vimoksalehi Lukoschek, Tony Courtney and Queensland Museum and supplementary sampling via trawl by catch) to determine the geographic scale of over which offsets should be considered. -Removal of trawl effort -reducing the impacts of coastal development (mining/gas/oil extraction, ports, agriculture, urban, commercial, ports) -Reducing the impacts of offshore development (dredging, risk of shipping incidents, mining/oil/gas extraction"

"- Increased resources to facilitate research on data deficient species, - Developing management strategies (e.g. bycatch reduction policy, seismic mining survey policy) to reduce interaction with anthropogenic threatening processes (i.e. trawling, mining and coastal development)"

4.14.3 Costs

Literature Review

No cost data was identified in the literature review on the implementation of any of the above actions.

Expert Elicitation Round 1 Summary

Three respondents provided information on costs for this surrogate.

Highest reasonable cost: range of $500,000 - 1,000,000, average of $750,000
Lowest reasonable cost: range of $6,000-50,000, average of $28,000
Best estimate: range of $100,000-100,000, average of $100,000
Confidence that highest to lowest interval contains a reasonable estimate: one response of 40/100 (two blank)

Justifications and comments:

The values of estimated costs were based on previously mentioned values associated with seagrass habitat restoration. Since sea snakes are often highly site attached and are closely linked with these habitats, it is reasonable to find 100 individuals within a hectare of seagrass habitats in marine snake biodiversity hotspots.

Sorry! I don't know how much it would cost to remove trawl hours vs. individual sea snake. Could be calculated by dividing sea snake by-catch by trawling revenue.

[Name withheld] has declined to estimate costs for offset implementation due to insufficient information and concerns with the overarching approach being taken to arrive at the value.

Expert Elicitation Round 2 Summary

One expert selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).” and provided the following estimates:

Highest Reasonable Cost $100,000
Lowest Reasonable Cost $20,000
Best Estimate $100,000
Confidence (no response)
Comment “If you are permanently taking or damaging sea snake habitat, this is as good as taking them forever. This is unacceptable and $100000 for deleting part or all of a population that may not be able to self replenish for a long time, if at all, seems reasonable to me. I have reduced my minimum estimate as I realise that $50 000 as a minimum is almost certain to be rejected.”

One expert selected “other” and commented “Directly measuring costs of reducing threatening processes for sea snakes can be unreliable as sufficient information is not available to accurately assess the interaction between sea snakes and threatening.”

4.14.4 Spatial Priorities

Literature Review

No spatial priority data for sea snakes were identified through the literature review.

Expert Elicitation Round 1 Summary

All five respondents agreed that offsets for sea snake should occur away from the impact site, with three stating that offsets should be within the same GBR zone, and two stating offsets should occur within the same catchment. One respondent thought a missing option was “ the area that will reap the most benefit from the offset. My selection above is selected to prevent proponents from using offset funds to do works that they can advertise in order to gain social licence, or using the money for works that would benefit them.”

Very specific priority areas for implementation of offsets for sea snakes were listed:

- High priority areas for these species includes inshore areas of the Central GBR as well as the offshore southern reef habitats of the GBR
- Some known hotspots: Princess Charlotte Bay, Cleveland Bay, Townsville, Coral Sea (Mellish especially), Keppels, Swains-Pompey Reef Complex.

Expert Elicitation Round 2 Summary

Two experts selected “Away from the impact site, but within the same zone of the GBRWHA (Northern, Central, or Southern zones)”

4.15 Marine Turtles

4.15.1 Background

Northern inshore and offshore marine turtle populations are generally in poor and deteriorating condition, with southern inshore and offshore populations are in good and stable condition (Commonwealth of Australia, 2014a). Nesting green turtles in the southern region increased by 3.8% per year for the 40 years up to 2008, but mass strandings of mainly green turtles were reported for 2011, 2012 and 2013 as a result of decreases in seagrass abundance (Great Barrier Reef Marine Park Authority, 2014). Northern stocks of green turtles have increased greatly since the 1970s, but have plateaued and declined slightly in recent decades, with early indications that northern nesting females are in early stages of decline (Great Barrier Reef Marine Park Authority, 2014).

Populations of hawksbill turtles in the northern Reef have shown a 3% annual rate of decline, with some stability in population size between 2003 and 2008 (Great Barrier Reef Marine Park Authority, 2014). Loggerhead populations continue to recover after greater than 80% declines between 1970 and early 2000s, however there are concerns about juvenile recruitment from impacts outside of the Reef.

4.15.2 Priority Actions

Literature Review

The current marine turtle recovery plan is out of date, however a new draft recovery plan with specific actions will be available by the end of 2016 (Rachel Groom pers. comm). A recent study found that the actions most recommended by marine turtle scientists was to reduce the glow during nesting season, manage (trap, bait, shoot) foxes, feral pigs, and dogs in sea turtle nesting habitat, reduce suspended sediment, protect freehold and lands lease land (295 km 2) from coastal development, buyout trawling and gill net fishing licenses in Reef, any fishery with high incidental interaction with marine turtles (ie Eastern Tuna and Billfish Fishery), artificially shade nests, protect additional breeding and feeding habitat through the use of protected areas, and rubbish removal (i.e., ghost nets, large scale plastics pollution; Klein et al., 2016).

Expert Elicitation Round 1 Summary

Experts suggested a range of actions covering research, education, habitat management and works.

Research actions included monitoring in-water and nesting distribution and abundance of each species as part of Integrated monitoring program.

Monitoring actions included observers/video on vessels in inshore gill net fishery and TEDs in Trawl fishery.

Mitigation actions included predator control at nests; reducing risk of vessel strike including "Go slow zones" in high risk areas; reduction of glow from boats and land based sources of pollution near nesting sites; reduction in terrestrial runoff- sediments and herbicides to protect seagrass beds; closure of gill net fishery in BIAS and remote areas where surveillance is impossible

A spatial suggested action was restoration of Raine Island sea turtle nesting habitat.

Partnership actions included TUMRAs with remote Indigenous hunting communities; and indigenous rangers programs monitoring megafauna and assisting with strandings.

Education of fishers and support turtle hospitals to increase the likelihood of survival or animals injured through anthropological impacts.

Expert Elicitation Round 2 Summary

One expert responded “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” and commented “Many of the current and pending strategy documents include contributions from several experts. It would be worthwhile to consider these documents where appropriate. The priorities should be considered on a case-by case basis and should consider the scale and impact to species affected. Offsets that contribute to lowering direct mortality of adult age classes should be prioritised.”

Two experts commented:

“Implement the marine debris threat abatement plan Actions aimed at addressing all threats ranked as high or very high in the Marine Turtle Recovery Plan International collaboration to aid the mitigation of turtle use in the south pacific - especially for hawksbill turtles which are the GBRs only declining species International collaboration to cease the commercial use of marine turtles in PNG (the PNG take comprises a high % of turtles from the nGBR)”

“Depends on place”

4.15.3 Costs

Literature Review

The costs of these actions were also listed and prioritised based on cost versus effectiveness. The cost of reducing glow was $10.7-47.1 million, the management of ferals on Curtis Island was $0.8-2.81 million, reduce sediment was $61.6-225.7 million; protection of land from development on Curtis and facing islands was $28.4 million; Buyout 50% of trawling and gill net fishing was $100-258.4 million, and the cost of artificially shading duck island nests was $0.610 million dollars (Klein et al., 2016). More information is available in the supplementary material for that study. In addition, the marine turtle recovery plan lists actions to reduce the by-catch of marine turtles in fisheries at $1.9 million over 5 years, marine debris removal at $65,000 over 5 years and limiting egg predations at $215,000 over 5 years (Commonwealth of Australia, 2003)

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

One expert selected “Consult with additional experts (please provide contact details below)” and did not provide any contact names or details.

Two experts selected “I do not feel qualified to answer this question.”

One expert selected “other” and commented “The Curtis Island costings provided in the literature review for marine turtles is incorrect. Total numbers in regards to feral animal control has been used i.e. $2.81M, when this is the total feral animal strategy for the Island and is certainly not all about turtles. [Name withheld] is disappointed that this commentary, which was provided in the Round 1 survey, was not presented in the results. The published cost data is insufficient or inappropriate.” *(note: costings have been confirmed as correct).*

4.15.4 Spatial Priorities

Literature Review

Raine Island is the breeding ground for one of the world’s largest populations of green turtles. Active management of Raine Island, including beach engineering and sand replenishment, is being implemented by Queensland.3

Additional priority areas for conservation for marine turtles include predator control at Curtis Island, Facing Island and Nest Island, glow reduction within 20km of Woongarra Coast, sediment reduction from the Fitzroy river by 20%, protection of land from development on Curtis and Facing Islands and artificial shading of nests at Wild Duck island (Klein et al. 2016). Coastal seagrass pastures impacted by flood run-off and cyclone damage, especially between Cooktown and Rockhampton make conditions less favourable for Green turtle populations, and impact benthic communities that are a mainstay of the loggerhead diet after 2010/11 flood events (Col Limpus pers. comm.). In addition, management of sea turtles within ports is not possible for conservation purposes, additional management may be needed in these areas (Col Limpus pers. comm.).

Expert Elicitation Round 1 Summary

Three respondents answered this questions with two stating that offsets for marine turtles should occur as close to the site of impact as possible, but another stating that offsets should be away fro the impact site but within the same GBR zone.

While no specific priority areas for offset implementation were identified, one respondent stated that the offset implementation should be dependant on the impact to nesting sites and/or important populations, and another that offset location will depend on where the value/process has the the greatest opportunity to be maximised and the nature of the impact. It was also discussed that offsets “should cover the entire home range of the species impacted” and “should take into consideration genetic stocks, not just marine turtles as a whole or individual populations, i.e. nth GBR stock and sth GBR stock.” In addition, it was noted that “the State and Commonwealth both share the rule that offsets should be located as close to the impact site as possible. However there is a need to ensure that rules regarding the siting of offsets does not prevent delivery of offsets in other areas if a better conservation outcome can be achieved. For example, higher conservation outcomes would presently be achieved for Olive Ridley turtles by allowing offsets that protect nests from predation in Western Queensland to be delivered for impacts on foraging habitat in the GBR."

Expert Elicitation Round 2 Summary

One expert selected "Away from the impact site, but within the same natural resources management region" and commented "Considerations should again consider the actual impact and scale. The impact to site is likely to be highly variable i.e. vessel traffic, habitat loss, lighting - other. The degree of impact to the site will likely determine how reasonable it is to offset within the the same site vs catchment/region or other."

One expert commented "They should be implement for the same stock if possible - especially for nesting beach strategies, but because of mixed stock foraging areas there is likely to be overlap with other stocks (within and across species). Except for nesting beach protection, Catchments, NRM and GBR zones are not relevant scales for migratory species."

One expert commented "Depends on the site - close to major netting beach or not."

4.16 Estuarine Crocodiles

4.16.1 Background

Crocodiles are considered in good and increasing condition throughout their range, and are actively recovering from declines following commercial harvesting of species. Surveys from 2010-2011 show populations in the southern two-thirds of the great barrier Reef recovery steadily, limited only by suitable nesting habitat (Great Barrier Reef Marine Park Authority, 2014).

4.16.2 Priority Actions

Literature Review

Water quality improvements and removal of nets in inshore waters would be beneficial for the species (Department of the Environment, 2016b).

Expert Elicitation Round 1 Summary

There was one suggested action "Supporting indigenous communities".

Expert Elicitation Round 2 Summary

No response.

4.16.3 Costs

Literature Review

No costs were available from literature review

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question)."

4.16.4 Spatial Priorities

No spatial priorities were identified through the literature review

Expert Elicitation Round 1 Summary

Offset implementation for crocodiles was split between two respondents, with one stating that offsets should occur as close to the site of impact as possible and the other that offsets should occur away from the impact site but within the same GBR zone, with the offset implementation zone completely dependent on the impact on nesting site or important populations for the species.

Expert Elicitation Round 2 Summary

No response

4.17 Seabirds

4.17.1 Background

It is estimated that 1.4- 1.7 million seabirds use the region for breeding, as well as about 425,000 non-birding birds, for a total seabird population in the Reef in excess of 2 million (Great Barrier Reef Marine Park Authority, 2014). Declines of up to 70 percent of nesting seabird populations have been estimated at Raine island where fourteen seabirds species habitually breed (Commonwealth of Australia, 2014a). Long term monitoring at four important seabird rookeries show significant declines in several species, likely as a result of extreme weather events, climate change and increased human activities (Turner, Green, & Chin, 2006). In addition, a survey of 16 seabirds found declines in 13 of the species, including the most common species in the area (Great Barrier Reef Marine Park Authority, 2014).

Wedge tailed Sheerwater surveys indicate an nearly 40% decline in the southern Reef, while Black Noddy populations have remained stable. Brown Booby populations have also declined near Swains Reef and breeding pairs at Ganney Cay were around 500 in 1980 and are currently less than 100 individuals (Great Barrier Reef Marine Park Authority, 2014). Lesser Frigate Birds surveys in 2013 shower the highest number of breeding pairs since surveys started in 1979, though Common Noddies, Crested and Sooty terns all show a range of annual variation in breeding numbers with no discernible trend (Great Barrier Reef Marine Park Authority, 2014).

Overall, the condition of the population is species dependent, and highly variable depending on location and exposure to threats. However northern and southern inshore populations are estimated to be in good and stable condition, while the northern and southern offshore populations are in poor and deteriorating condition (Commonwealth of Australia, 2014a). This assessment is based on limited evidence for both the condition and trend of the population, as there is limited long term data. Trajectories for seabirds will vary considerably based on the species, but overall trends are deteriorating for offshore populations, while inshore populations are more stable (Commonwealth of Australia, 2014a). There are several plans and agreements for migratory bird species, all of which require the protection of migratory birds and their habitats and the identification and removal of threats to the species (Commonwealth of Australia, 2005, 2011b, 2011d). In addition the Reef 2050 Plan (BT5) commits to improvements in population and habitats of key indicator species (Commonwealth of Australia, 2015a).

4.17.2 Priority Actions

Literature Review

Priority actions for the conservation of seabirds include the removal of marine debris (listed as a key threatening process; Wilcox, Van Sebille, & Hardesty, 2015), limiting access to sensitive areas not already under conservation land tenure and limiting the impact of long-line fisheries on seabird populations in the region, an activity that is also listed as a key threatening process for the species (Turner et al., 2006). Continuing monitoring programs and increasing management and monitoring of key breeding sites in the region could better conserve pelagic seabirds in the region (Commonwealth of Australia, 2011d).

Inshore seabirds would benefit from prioritising monitoring location where species are most vulnerable, continuing pest control at key breeding sites, and the management and protection of known important forage-fish resources, especially where they overlap with commercial and recreational fishing areas (Commonwealth of Australia, 2011b). In addition, a variety of critical research and monitoring priorities are listed in a report on seabirds and shorebirds in the face of climate change in the Reef region (Commonwealth of Australia, 2008).

Expert Elicitation Round 1 Summary

There was one suggested action summarised as “research of feeding and breeding success of the offshore species.”

Expert Elicitation Round 2 Summary

No response.

4.17.3 Costs

Literature Review

No costs data were identified through the literature review. However rat eradication on islands is ongoing in many areas, though accurate cost data is not yet publically available.

Expert Elicitation Round 1 Summary

One response:
Highest reasonable cost $325,000
Lowest reasonable cost $25,000
Best estimate $300,000
Confidence 40/100

“I have considered the need for two possible types of offsets. Offsets for on-island disturbance/removal of breeding habitat, or offsets associated with anthropogenic impacts on critical foraging resources. The first of these offsets could require the re-establishment of coastal and island breeding habitat. No costings are available for this so as a minimum surrogate I have used ~$K20-25/ha which are the cost associated with rainforest replanting in the Wet tropics. This cost would not include sand/substrate replenishment, the production and transportation of plants and other materials to breeding sites or plot maintenance costs. The second offset type could require significant changes to current pelagic fisheries practices, including modifications to fishing zones and catch limits. The highest cost provided is based on 10% decrease in annual allowable catch in the eastern tuna and billfish fishery due to foraging ground closures. This 'cost to implement' would likely be at the colony scale for pelagic foraging guilds with the appropriate surrogate metric ranging from 1000-20,000 individuals/species”

Expert Elicitation Round 2 Summary

One expert selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).”

4.17.4 Spatial Priorities

Literature Review

Spatial priority areas for conservation for seabirds include habitats critical to the survival of the species, including Raine Island for the protection of the Herald petrel, including breeding grounds that might occur within the coral sea (Commonwealth of Australia, 2005). Ensuring the maintenance of ongoing monitoring at Michaelmas Cay is valuable for longterm data on seabirds in the GBRWHA (Commonwealth of Australia, 2011b, 2011d). In addition, management of visitation on seabird breeding islands is important. However, additional research is key to identifying important areas for seabird conservation, especially in the face of climate change impacts throughout the region (Fuller & Dhanjal-Adams, 2012).

Expert Elicitation Round 1 Summary

Four respondents answered this question, with two stating that offsets for this surrogate should be implemented as close to the impact site as possible and the other two stating that it should occur away from the impact site but within the same GBR zone.

The only priority area for offset implementation discussed was at feeding sites and associated foraging locations.

Expert Elicitation Round 2 Summary

No response.

4.18 Shorebirds

4.18.1 Background

Fifteen species of shorebirds are resident in Australia and an additional thirty-four species are regular migrants (Queensland 2016). No population estimates are available for the regions shorebird population, though 70-80% declines have been recorded Australia-wide in the last 25 years. This is likely a result of changes to coastlines and population growth in coastal habitats, both in the region and throughout the migratory shorebird flyway (Commonwealth of Australia, 2014a). Overall, shorebirds are likely in poor and deteriorating condition throughout the region, though very limited evidence is available.

Trajectories for shorebirds will vary considerably based on the species, but overall trends are poor and deteriorating for all regions within the Reef (Commonwealth of Australia, 2014a). There are several plans and agreements for shorebird species, all of which require the protection of shorebirds and their habitats and the identification and removal of threats to the species (Commonwealth of Australia, 2011b, 2015c). In addition the Reef 2050 Plan (BT5) commits to improvements in population and habitats of key indicator species (Commonwealth of Australia, 2015a).

4.18.2 Priority Actions

Literature Review

Priority actions for shorebird conservation revolve around habitat protection, especially for migratory species both inside the Reef region and in other locations throughout the flyway (Clemens et al., 2016; Iwamura et al., 2013). Other actions include removal of ghost gear such as fishing nets, though mortality has not been quantified from this source, and reduction in anthropogenic disturbance at key locations (ie dogs and people at post-breeding sites), removal and/or remediation of chronic pollution in feeding areas as shorebirds bioaccumulate herbicides and pesticides, invasive species control, such as flora and fauna species that impact wetland areas, and predator removal in key areas (Commonwealth of Australia, 2015c). In addition, a variety of critical research and monitoring priorities are listed in a report on seabirds and shorebirds in the face of climate change in the Reef region (Commonwealth of Australia, 2008).

Expert Elicitation Round 1 Summary

There were no suggested actions for shorebirds.

Expert Elicitation Round 2 Summary

No response.

4.18.3 Costs

Literature Review

No cost data was available from the literature review.

Expert Elicitation Round 1 Summary

No responses

Expert Elicitation Round 2 Summary

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question)."

4.18.4 Spatial Priorities

Literature Review

A newly developed shorebird conservation plan for Australia lists priority areas for shorebird conservation, one of which is the protection of wetland habitat in Australia on which migratory shorebirds depend (Commonwealth of Australia, 2015c). However, key spatial priority areas are focused mainly on impacts elsewhere in the region, specifically habitat loss and degradation at stop-over sites throughout Asia and the Yellow Sea region. However, additional research is key to identifying important areas for shorebird conservation.

Expert Elicitation Round 1 Summary

Three respondents answered this questions, with two stating that offsets should be implemented away from the impact site but within the same GBR zone, and another stating that an offset should be as close to the impact site as possible. No high priority areas were described.

Expert Elicitation Round 2 Summary

No response

4.19 Whales

4.19.1 Background

An estimated 15 whale species visit the Reef, and while there is no information on most of the species, Humpback whales are recovering well at a pace of 10.5 to 12.3% per year and an estimated 12,000 individuals in 2012 (Great Barrier Reef Marine Park Authority, 2014). Additional information can be found on the Commonwealth Conservation Advice for Humpback Whales. Little is known of the population of Dwarf Minke whales in the region, though they are reported consistently in the north and in low numbers in the south. The major threats to cetaceans are the impacts of climate change, especially in feeding grounds in the southern ocean, as well as the impacts of coastal development, ports and shipping activities and underwater noise pollution, leading to disturbance and displacement (Commonwealth of Australia, 2014d). Overall, whale populations are considered to be in good and increasing condition throughout the region.

Whales in the region are generally in good condition, though population estimates are only available for Humpback whales in the Reef which are increasing (Commonwealth of Australia, 2014a). The condition and trend factors for all whales is based on the Humpback whale population as there is limited evidence to support population data for any other species. However, there are recovery plans in place for blue, fin, sei and southern right whales, but no actions for whales are specifically mentioned in the Reef 2050 Plan.

4.19.2 Priority Actions

Literature Review

Actions to remove threats such as reducing entanglements and interactions with fishing gear, including entanglements in rock lobster pot lines which has been increasing, water quality improvements, reduction in marine debris, reduction in noise interference and reducing boat strikes as vessel numbers and populations grow in the region (Commonwealth of Australia, 2007, 2014d; Environment, 2016) will benefit the population. In addition, Bryde's whales are under-studied and more information is needed on the ecology of feeding, nursery and calving areas in the region, surveys and research to determine distribution and abundance of the population and ongoing monitoring (Department of the Environment, 2016a).

Expert Elicitation Round 1 Summary

There was one response which did not provide any suggested actions but suggested focus on definitions "The literature review (as provided above) references ports and associated activities and states that this disturbs and displaces the surrogate despite the findings of the Underwater Noise Prediction from Port Development at Abbot Point, Qld (McCauley et al, 2012), and the GBR Shipping Review of Environmental Implications (PGM, 2012). [Name withheld] is of the opinion that a more balanced view in relation to the way in which the surrogate condition and trend is defined needs to be provided. Without this there is a risk that the identified conservation actions will not effectively deliver no net loss for this surrogate."

Expert Elicitation Round 2 Summary

One expert selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” but did not provide any details.

4.19.3 Costs

Literature Review

No cost data was identified in the literature review.

Expert Elicitation Round 1 Summary

No responses.

Expert Elicitation Round 2 Summary

One expert selected “Consult with additional experts (please provide contact details below)” but did not provide any details.

One expert selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).” but did not provide any estimates.

4.19.4 Spatial Priorities

Literature Review

The only spatial priority identified in the literature review were areas with a high level of interaction with whale watching activities (Commonwealth of Australia, 2007).

Expert Elicitation Round 1 Summary

Three respondents answered this questions, with two stating that offsets should be implemented away from the impact site but within the same GBR zone, and another stating that an offset should be as close to the impact site as possible. No specific priority areas for offset implementation were discussed, with one respondent stating “It is highly unlikely that this would be an offsetable surrogate instead potential impacts would be addressed through approval conditions.”

Expert Elicitation Round 2 Summary

One expert responded “Refer to earlier response and also consider if greater benefit to the species could be achieved in other locations for the same subpopulation.” *(note it is not clear which “earlier response” is relevant)*

4.20 Dolphins

4.20.1 Background

An estimated 18 species of dolphin are found in the region, with limited information or monitoring on the status or population of most species (Great Barrier Reef Marine Park Authority, 2014). All dolphins are protected in the region, but two inshore species, the Indo-Pacific humpback dolphin and the Australian snubfin dolphin have small localised, inshore populations, that are under threat from human development and expansions are likely declining. While there are no population estimates for the Indo-Pacific humpback dolphin in the region, estimates in Cleveland Bay are 50 or less, 64 on the Capricorn coast, 107 in Keppel bay and 85 at Port Curtis (Great Barrier Reef Marine Park Authority, 2014). However, because of the small populations, declines are unlikely to go detected (Commonwealth of Australia, 2014a). Similarly, the snubfin population is limited to less than 100 in Cleveland and Halifax bays, 70 in Keppel Bay area. For the snubfin population to remain stable most areas can only sustain 1 animal death every four years, however the viability of the population is currently at risk, and limited biological and ecological data is available on the species (Cagnazzi, Parra, Westley, & Harrison, 2013).

Overall dolphin population are stable throughout the regions, except in southern inshore regions where populations are poor and deteriorating (Commonwealth of Australia, 2014a), though the Outlook report (2013) states that overall the dolphin population in the Region is good but deteriorating. This is especially true for two species: Australian snubfin and Indo-Pacific humpback dolphins, which lack population data but are likely declining throughout their range (Commonwealth of Australia, 2014a). The Reef 2050 Plan specifically commits to stabilising or increasing the population of both species throughout the region (Commonwealth of Australia, 2015a).

4.20.2 Priority Actions

Literature Review

Priority actions for dolphin conservation in the region include minimising impact of inshore net fishery and East Coast Inshore Fin Fish Fishery (ECIFFF) on dolphin populations, especially in areas that have high interactions with Indo-Pacific humpback or Australian Snubfin dolphin (Commonwealth of Australia, 2011a). Additional research is needed to examine fishing effort data, SOCI data, observer records and stranding data to assess the effectiveness of current management measures in ensuring adequate conservation of snubfin dolphins (State of Queensland, 2011). For Indo-Pacific humpback dolphins more data is needed on interactions between inshore populations and the East Coast Trawl fishery as well as the ECIFFF fishery, in particular the set mesh net operators (Department of the Environment, 2016d). In addition, improvements in habitat and water quality protection are key, as well as minimising the threat that underwater noise and activity from increased vessel traffic, surveying, construction, dredging and maritime operations pose to inshore dolphins (Commonwealth of Australia, 2011a).

Expert Elicitation Round 1 Summary

The experts suggested actions associated with research, partnership, reducing impacts and educations.

The research and monitoring actions included research on distribution and abundance of coastal dolphins; and robust definition of Biologically Important Areas (BIAS) by experts; and observers /video on vessels in relevant fisheries.

The partnership action included TUMRAs, investment in Indigenous ranger programs and education of fishers.

The actions associated with reducing impacts included buy out/closures of inshore gill net fishery and trawl fisheries in key areas; closure of gill net fishery in BIAS and remote areas where surveillance is impossible.

Expert Elicitation Round 2 Summary

Two experts selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” and one of these experts commented “National co-ordination of marine mammal research and conservation activities is imperative for successful conservation and management initiatives. The Australian Marine Mammal Centre (AMMC) based on Hobart previously co-ordinated these activities, The Australian Marine Mammal Centre of the Department of the Environment and Energy was established as the first national research centre focused on understanding, protecting and conserving the whales, dolphins, seals and dugongs in our region. Funding to AMMC was cut in 2014 with the new government, leaving marine mammal research in Australia with no co-ordination network. AMMC worked extremely well, with a grants program that was transparent and fair. It is recommended that any available funding is once again directed through AMMC, with some core funding going-towards AMMC administrative and overhead costs. The Commonwealth Government has developed 'A Coordinated National Research Framework to Inform the Conservation and Management of Australia’s Tropical Inshore Dolphins'. Note, I cannot seem to find this document on the internet, but it can be obtained by emailed Prof. Helene Marsh (Helene.Marsh@jcu.edu.au) or Dr. Mike Double (Mike.Double@aad.gov.au). This strategy has a number of high priority activites which could be considered for funding. • The prioritised Objectives are: Enabling Objective Objective 1 - Indigenous Engagement: Foster effective and informed partnerships with Australia’s Indigenous communities to enable sustainable conservation management of tropical inshore dolphins. Research Objectives High Priority Objective 2 - National Distribution Data: Provide for access to and analysis of standardised national tropical dolphin data to assess distribution and underpin management and conservation. Objective 3 - Long-term Monitoring: Gather and use information over long-term timescales to determine trends, mitigate impacts from threats, and support adaptive management and conservation of tropical inshore dolphins. Objective 4 - Threat Risk Assessment: Identify, map and assess threats to tropical inshore dolphins, understand related impacts, and mitigate risks. Research Objectives – Medium Priority Objective 5 - Dispersal and Movement: Improve understanding (at national, regional and local scales) of dispersal, movement, and genetic connectivity of tropical inshore dolphins to aid conservation and management at appropriate geographic scales. Objective 6 - Mortality and Life History: Foster collaborative and national approaches to effectively gather mortality, life history and dietary information from stranded and by-caught specimens. Objective 7 - Citizen Science: Foster community participation in data collection on tropical inshore dolphins and develop a continuous-improvement approach to methods and related programs. • The 2015 Coordinated National Research Framework also provides guidance on criteria for selecting priority key research sites, while recognising the need for flexibility in response to future major development proposals in areas where there may or may not have been previous dolphin research. • It is expected that further updates and revisions of this Coordinated National Research Framework will be needed within the next five years and so this Framework should be regarded as a 'living document'."

One expert selected "other" and commented "Depends on the site of the development."

One expert commented "Underwater noise was highlighted as a concern but no actions (or was this captured under research, partnership, reduction impacts and education)."

4.20.3 Costs

Literature Review

No specific data was identified in the literature review on the cost of implementing these management actions.

Expert Elicitation Round 1 Summary

No responses

Expert Elicitation Round 2 Summary

One expert selected "Consult with additional experts (please provide contact details below)" but did not provide details.

One expert selected "other" but did not provide a comment.

Two experts selected "I do not feel qualified to answer this question."

One expert selected "The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question)." but did not provide any cost estimates.

One expert commented "Previous cost estimates have been provided in a 2012 Inshore Dolphin Report http://www.marinemammals.gov.au/__data/assets/pdf_file/0020/115517/Inshore_Dolphin_Workshop_Report_Dec2012_final.pdf Further consultation should be undertaken with Dr. Mike Double, Australian Marine Mammal Centre, Mike.Double@aad.gov.au, who is an independant expert in this field and previously led the AMMC."

One expert commented "Inshore dolphin research and management actions are expensive because of the boat work required, poor weather than can postpone planned surveys, and remote regions inshore dolphins inhabit. The highest reasonable cost (50 million) is provided based on experience with conducting inshore dolphin research projects in remote areas, knowledge of the costs of effectively involving indigenous rangers groups and high costs of any management initiatives (i.e. observer programs, buy-back schemes etc)

Lowest reasonable cost - Previous cost estimates have been provided in a 2012 Inshore Dolphin Report http://www.marinemammals.gov.au/__data/assets/pdf_file/0020/115517/Inshore_Dolphin_Workshop_Report_Dec2012_final.pdf. However, these costs were estimated in 2012, and costs would have increased since this time. 2 million over 3 years was provided by the Whale and Dolphin Protection Plan (http://www.nrm.gov.au/national/local/whale-dolphin-protection). Some good research was undertaken under this plan, but it was insufficient to assess the national status of inshore dolphins and implement management initiatives or continue any long-term research in priority sites."

4.20.4 Spatial Priorities

Literature Review

Spatial priority areas for dolphin conservation in the Reef are focused specifically on habitat areas for inshore snubfin and Indo-Pacific humpback populations (Commonwealth of Australia, 2014a). More specifically the population within the Fitzroy river area as it is composed of less than 100 individuals (Cagnazzi et al., 2013), and the impacts of net fishing activity in the areas between Halifax Bay to Cleveland Bay (State of Queensland, 2011), and of inshore dolphins that inhabit areas within the East Coast Inshore FinFish Fishery (ECIFFF; Commonwealth of Australia, 2011a).

Expert Elicitation Round 1 Summary

Four respondents answered this questions with most stating that offsets should occur away from the impact site but within the same GBR zone, and one stating that offsets should occur as close to the site of impact as possible. Biologically important areas were mentioned as high priority areas for offset implementation, with one respondent stating "It is highly unlikely that this would be an offsetable surrogate instead potential impacts would be addressed through approval conditions."

Expert Elicitation Round 2 Summary

Two experts selected "As close to the site of impact (development or project site) as possible" and commented:

"Public expectation and population impacts are for these to be at or very near the impact site"

"Spatial priorities can be found within the 'Coordinated National Research Framework to Inform the Conservation and Management of Australia's Tropical Inshore Dolphins'. Note, I cannot seem to find this document on the internet, but it can be obtained by emailed Prof. Helene Marsh (Helene.Marsh@jcu.edu.au) or Dr. Mike Double (Mike.Double@aad.gov.au). An excellent example of an offset strategy to monitor inshore dolphins was implemented in Darwin Harbour by INPEX and NT Government. The inshore dolphin component was included within the 30 million coastal offset strategy (http://www.inpex.com.au/media/1707/coastal-offset-strategy-commonwealth-government.pdf), where monitoring information was obtained at the project site, and new information from other parts of the Territory. The Rio Tinto Alcan (RTA) Amrun project also provides a good example of where offsets for inshore dolphins could be implemented. Because dolphins are highly mobile, particularly when disturbed, offsets were implemented in three sites, one close to the site of impact, one close to a neighbouring site that had been impacted, and one in a neighbouring site that had no impact and would not be impacted in the near future. The requirement for RTA to conduct studies during pre-construction, construction and post construction was a good example of where, and how, offsets should be directed. The allowed cost of 1 million was too low for this project to be undertaken over the 5 years, which has been a problem for implementation of the RTA inshore dolphin strategy. The associated strategy and references can be found at: Attached is the link to the Rio site - http://www.riotinto.com/australia/reports-and-publications-16120.aspx This relevant documents are: Inshore Dolphin Offset Strategy - Response to Reviewer Inshore Dolphin Offset Strategy Inshore Dolphin Baseline Survey"

One expert commented "Depends on the site of development "

One expert commented "Areas of occupancy or distribution of species subpopulations impacted should be determined before implementation and inform site selection"

4.21 Dugongs

4.21.1 Background

Dugongs occur throughout the inshore regions of the Reef, with populations to the north in good and stable condition (Great Barrier Reef Marine Park Authority, 2014), but populations to the south of Cooktown declining at a rate of 78.7% per year between 1962-1999 from 72,000 to 4000 individuals (Marsh, De'Ath, Gribble, & Lane, 2005). Evidence suggested that the southern and central population stabilised around 2009, but ongoing severe weather events, loss of seagrass habitats and combined human related impacts such as incidental catch in fishing nets, boat strikes, declining water quality and marine pollution, and coastal development have led to increased dugong mortality, the effects of which are not yet known (Brodie & Pearson, 2016; Marsh et al., 2005; Marsh, Hodgson, Lawler, Grech, & Delean, 2007). Dugong populations are best in Hervey Bay (coppo et al. 2014), and in the northern Reef and the Torres Strait (Sobtzick, 2014). The northern inshore population is estimated to be in good and stable condition, while the southern inshore population of dugongs is in very poor and deteriorating condition (Commonwealth of Australia, 2014a).

While the Reef Strategic Assessment is the most up to date complete assessment of the Reef and all of its MNES, it was completed in 2014 based on earlier data and marine systems are dynamic, condition and trends included in this report are likely to have shifted in the two years since its publication and will continue change in the future. Dugong populations in the northern region of the Reef are reported as stable while southern populations are deteriorating significantly in the southern region (Commonwealth of Australia, 2014a; Marsh et al., 2007; Sobtzick, 2014). The Reef 2050 Plan commits to stabilising or increasing the population of dugongs at a Reef wide scale (Commonwealth of Australia, 2015a).

4.21.2 Priority Actions

Literature Review

Key priorities for dugong conservation are improvements in water quality and abundance of seagrass habitat throughout the region, as these are key for dugong conservation (Department of the Environment, 2016c; Marsh et al., 2007). In addition, reductions in interactions and incidental catches is shark exclusion devices and in fisheries net, sustainable management of indigenous hunts, and better management of coastal development, port expansion and vessel movements could improve threats to dugong populations (Department of the Environment, 2016c).

Expert Elicitation Round 1 Summary

The experts suggested actions for dugongs associated with research, partnerships and reducing threats.

The research and monitoring actions included development of robust monitoring dugong distribution and abundance; Robust definition of Biologically Important Areas (BIAS) by experts; and observers/video on vessels in inshore gill net fishery.

The threat mitigation actions included reduction in terrestrial runoff- sediments and herbicides to protect seagrass beds; Closure of gill net fishery in BIAS and remote areas where surveillance is impossible; and development of robust means of reducing risk of vessel strike in BIAS

The partnership actions included TUMRAs, indigenous rangers programs funded securely in long term with robust on going training on monitoring megafauna and education of fishers about bycatch.

Expert Elicitation Round 2 Summary

One expert selected “Underfunded actions defined within an existing strategy / plan / initiative (please provide details below)” but did not provide details.

Three experts selected “other” and commented:

“Depends on the site of the development. I would like to add replacing gill nets with lines in the mackerel fishery as a mitigation measure”

“Establish spatially meaningful monitoring of seagrasses in remote areas of the GBR that also support large populations of dugong such as in Princess Charlotte Bay and Shoalwater Bay to enable an understanding of likely impacts of habitat change on key dugong populations”

“Monitoring of fishing activity in the gillnet fisheries and (perhaps) subsequent closures, licence buy backs or other to reduce effort where likelihood of interaction is high.”

4.21.3 Costs

Literature Review

No cost data was identified through the literature review.

Expert Elicitation Round 1 Summary

One response:
Highest reasonable cost $30,000
Lowest reasonable cost $5,000
Best estimate $15,000
Confidence 80/100

“My estimate above then is the cost of (assisting the fisher to) buying and fitting the VMS (and camera) and of staff time to review the data. This doesn't necessarily convert to a single dugong life saved, but I hope is a reasonable unit for offsetting.”

Expert Elicitation Round 2 Summary

Two experts selected “I do not feel qualified to answer this question.”

One expert selected “Consult with additional experts (please provide contact details below)” but did not provide details.

Two experts selected “The published cost data is insufficient or inappropriate. Use the average estimates from the Round 2 expert elicitation (opportunity to revise your estimates and provide justifications/ references in the next question).” but only one expert provided estimates:

Highest Reasonable Cost $30,000
Lowest Reasonable Cost $5,000
Best Estimate $15,000
Confidence 80%
Justification “Based around having been told by fishery managers that the VMS unit itself would cost approx. $2K. Would prefer to include some inexpensive video camera to film net hauls, but then recognising that significant staff time required to view and analyse location data and footage. At the lower end, occasional (6 monthly?) spatial analysis of boat locations overlaid with dugong hotspots would be valuable and relatively cheap.”

4.21.4 Spatial Priorities

Literature Review

Spatial priorities for dugong conservation are not readily available for the Reef as the species move with seagrass abundance (Helene Marsh pers. comm). However populations in the Torres Strait and Hervey Bay are still in relatively good condition (Brodie, 2013) while southern populations of dugongs are declining rapidly as a result of water quality and seagrass abundance issues (Department of the Environment, 2016c; Sobtzick, 2014; Sobtzick, Hagihara, Grech, Jones, & Marsh, 2015)

Expert Elicitation Round 1 Summary

Six respondents answered this question, with four stating that offsets for this surrogate should occur away from the impact site but either within the same GBR zone (3) or within the same catchment (1), two thought offsets should occur as close to the site of impact as possible.

Specific high priority areas for offset implementation included Biologically Important areas of regionally significant marine species (BIAS) if “robustly defined by expert elicitation”, and any of the bays in the GBR where dugong populations are consistently estimated at greater than 100kg. Lastly, one respondent stated “special attention needs to be afforded the far northern section of the GBR where populations of species like dugong and sawfish are still considered in good condition.”

Expert Elicitation Round 2 Summary

One expert selected “Away from the impact site, but within the same zone of the GBRWHA (Northern, Central, or Southern zones).”

One expert selected “Away from the impact site, but within the same catchment.”

Three experts provided comments:

“Depends on the site of the development . What is meant by southern populations of dugongs. I mean dugongs in the GBR south of Cooktown but I think others mean SEQ. Need to be careful here.”

“Again, consideration should be given to the impact (from the project) on these species and understanding what significant threats exist within the area impacted. Ideally, if the impacted site maintains a degree of integrity it would be worthwhile investing further in the local area. If this is not the case and there are other significant mortality issues affecting the stock more regionally - these should be addressed.”

“I remain torn on this one - I'm not sure what direct offsets you can offer for seagrass loss. Some improvement of catchment management/reduction of sedimentation into the same bay would be ideal, but it would be very hard to work out, for example, how much riparian fencing in a Burdekin tributary = 1 ha seagrass.”