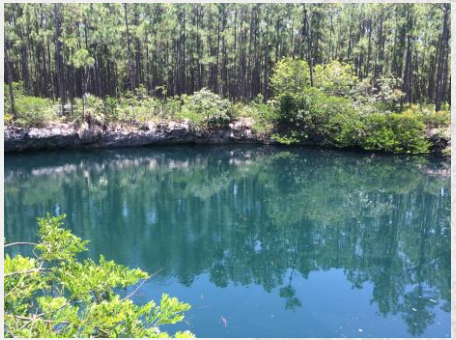
ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN BAHAMIAN MARINE PROTECTED AREAS

Katie Arkema, Dave Fisher, Katherine Wyatt
Stanford University

people

environment



ECOSYSTEM SERVICES

benefits nature provides to people

people

environment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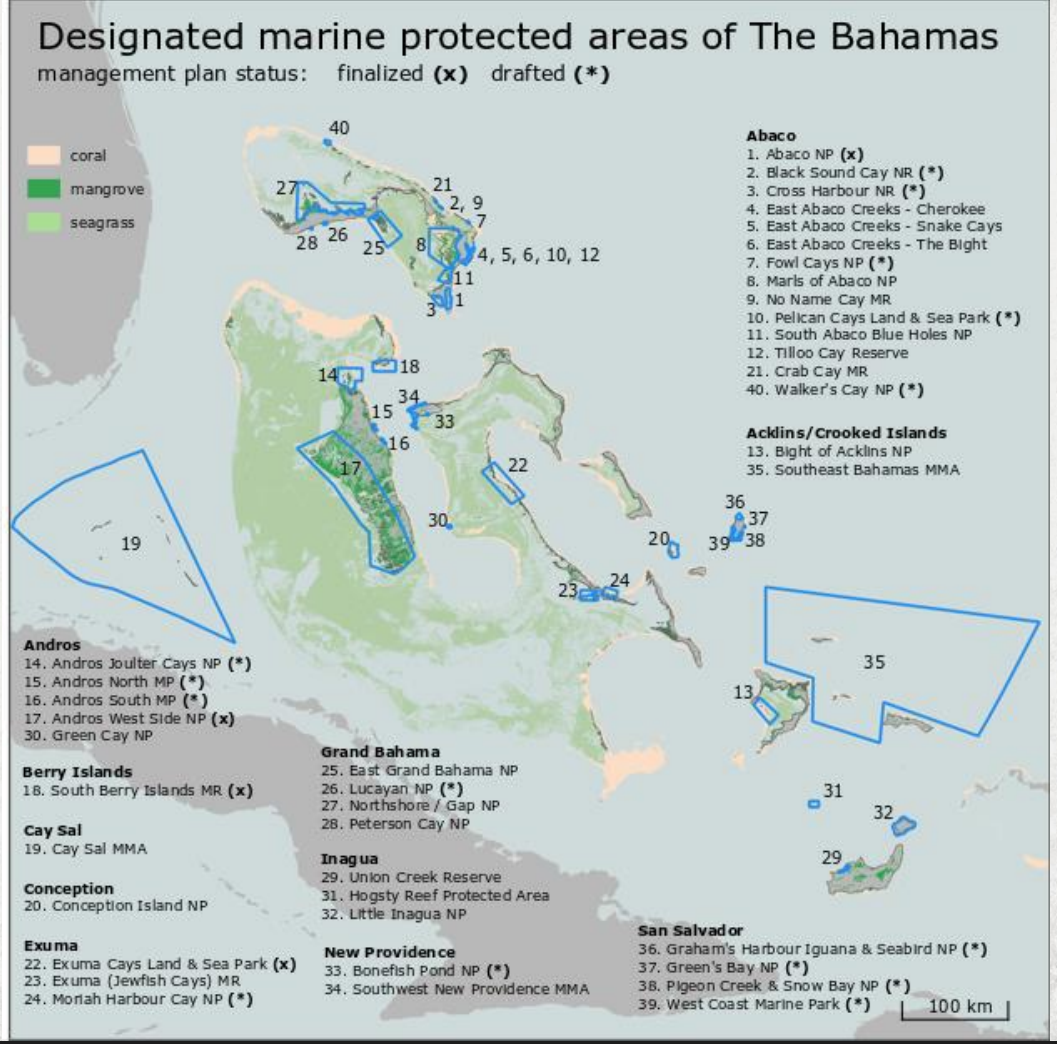
Designated marine protected areas of The Bahamas
management plan status: finalized (x) drafted (*)
coral
mangrove
seagrass
Abaco
1. Abaco NP (x)
2. Black Sound Cay NR (*)
3. Cross Harbour NR (*)
4. East Abaco Creeks - Cherokee
5. East Abaco Creeks - Snake Cays
6. East Abaco Creeks - The Bight
7. Fowl Cays NP (*)
8. Marls of Abaco NP
9. No Name Cay MR
10. Pelican Cays Land & Sea Park (*)
11. South Abaco Blue Holes NP
12. Tilloo Cay Reserve
21. Crab Cay MR
40. Walker's Cay NP (*)
Acklins/Crooked Islands
13. Bight of Acklins NP
35. Southeast Bahamas MMA
Andros
14. Andros Joulter Cays NP (*)
15. Andros North MP (*)
16. Andros South MP (*)
17. Andros West Side NP (x)
30. Green Cay NP
Berry Islands
18. South Berry Islands MR (x)
Cay Sal
19. Cay Sal MMA
Conception
20. Conception Island NP
Exuma
22. Exuma Cays Land & Sea Park (x)
23. Exuma (Jewfish Cays) MR
24. Moriah Harbour Cay NP (*)
Grand Bahama
25. East Grand Bahama NP
26. Lucayan NP (*)
27. Northshore / Gap NP
28. Peterson Cay NP
Inagua
29. Union Creek Reserve
31. Hogsty Reef Protected Area
32. Little Inagua NP
New Providence
33. Bonefish Pond NP (*)
34. Southwest New Providence MMA
San Salvador
36. Graham's Harbour Iguana & Seabird NP (*)
37. Green's Bay NP (*)
38. Pigeon Creek & Snow Bay NP (*)
39. West Coast Marine Park (*)
100 km

ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN BAHAMIAN MPAs

This work

1. Reviews past studies of economic value of marine ecosystems, species, and MPAs
2. Makes the economic case and build awareness and support for MPA declaration by quantifying the economic value of ecosystem services within the existing MPA network
3. Explores management issues and quantifies ecosystem services at the island-scale for 5 regions with MPAs with varying management regimes

SUMMARY OF ECONOMIC HABITAT VALUES IN EXISTING STUDIES

- Coral reefs: $44,500–$1.35 million km^2/yr

(fisheries, coastal protection, tourism, non-use etc.)

- Mangroves & wetlands: $850,000–$1.2 million km^2/yr

(fisheries, coastal protection, tourism, water quality etc.)

- Tidal Creeks: $35,000-$1.75 million km^2/yr

(coastal protection, fisheries, carbon sequestration)

- Seagrass: $500–$150,000 km^2/yr

(fisheries, coastal protection, tourism)

13 studies include Hargreaves-Allen 2010, 2011, 2016; SFG 2014; Micheletti et al. 2016

VALUE OF ECOSYSTEM SERVICES EXPLORED IN PREVIOUS STUDIES

- Fisheries: $124.5 million an. in lobster and reef fish export value
  - 33,100 tons/yr in subsistence catch, 4,000 fishing vessels, 9,300 directly employed
- Tourism: $402 million from stop-over visitor (2007)
  - $150 million in aggregated econ. impact from rec fishing; $115 shark-related
  - 300 fishing guides nationally, 500 nature-based tourism employees on Andros
- Coastal Protection: $3.9 billion km^2/yr in coastal protection by habitats
  - > 50% of Andros coastline protected by habitats
  - > $33,000 in avoided cost to government from erosion control on Great Abaco

22 studies including Hargreaves-Allen 2010, 2011, 2016; Hargreaves-Allen and Pendleton 2010; Smith and Zeller 2016; DMR; FAO 2009; Gittens and Braynen; Sullivan Sealey 2011; Fedler 2010; Ministry of Tourism; Micheletti et al. 2016

Production function models

changes in ecosystems →
changes in ecosystem services →
changes in benefits to people

Free & open source

ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN BAHAMIAN MPAs

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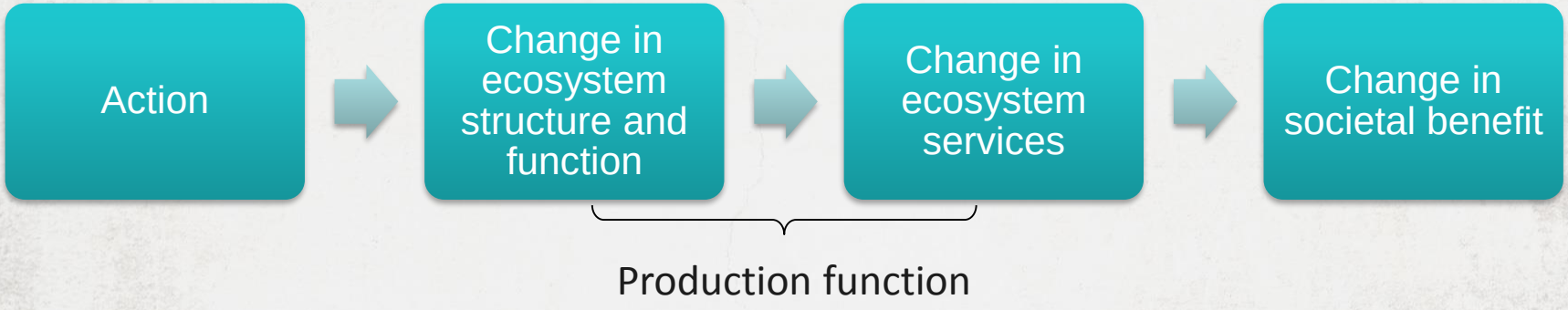
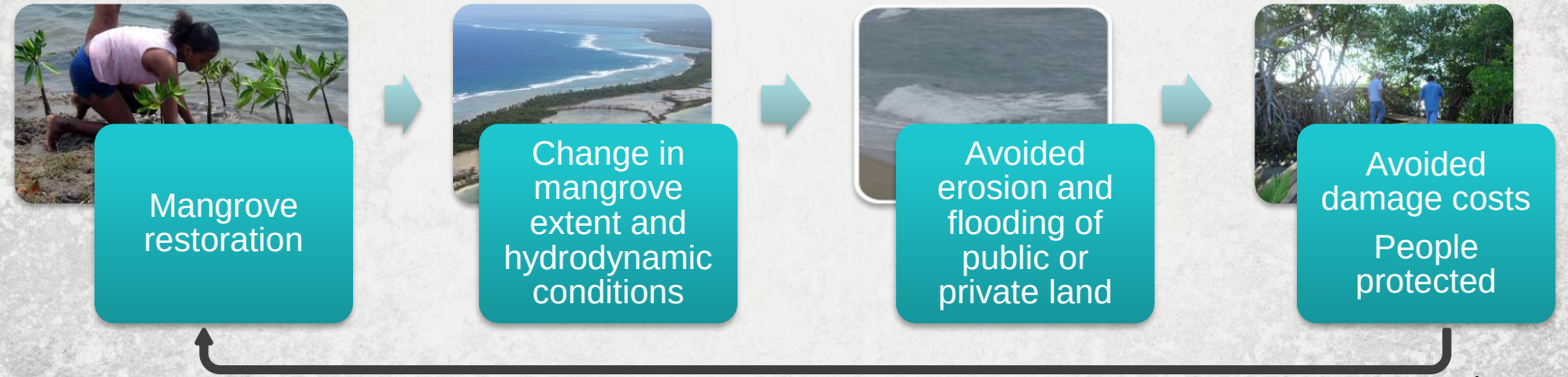
A. General framework for an ecosystem services assessment



B. Ecosystem services assessment for coastal protection services provided by habitats



Arkema et al. 2017

2. QUANTIFY THE ECONOMIC VALUE OF FOUR ECOSYSTEM SERVICES IN THE EXISTING NETWORK OF MPAS

Nursery habitat for spiny lobster fishery

Tourism

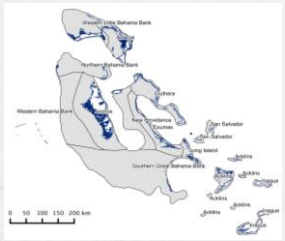
Coastal protection

Carbon storage & sequestration

VALUING NURSERY HABITAT FOR LOBSTER

Inputs

- Mangrove distribution
- Seagrass distribution
- Shelf
- Stock assessment parameters



Outputs

- Catch of spiny lobster

- Revenue from catch

- Value of habitats for contribution to catch and revenue

Amount of nursery habitats in MPAs for lobster fishery

Bank region	MPA	Proportion of region's nursery mangrove within MPA	Proportion of region's nursery seagrass within MPA
Abaco	Marls of Abaco NP	0.54	0.21
	South Abaco Blue Holes NP	0.04	0.01
	Cross Harbour NP	0.02	0.01
	Pelican Cays Land And Sea Park	0.00	0.01
	East Abaco Creeks - Snake Cays	0.00	0.01
	East Abaco Creeks - The Bight	0.01	0.01
	East Abaco Creeks - Cherokee	0.01	0.00
Acklins	Southeast Bahamas MMA	0.00	0.09
	Bight of Acklins NP	0.01	0.06
	Hogsty Reef Protected Area	0.00	0.01
Andros	Westside NP	0.69	0.53
	Joulter Cays NP	0.02	0.04
	Southern MP	0.00	0.02
Caysal	Cay Sal MMA	NA	1.00
Exuma	Exuma Cays Land & Sea Park	0.05	0.18
	Jewfish Cay MR	0.09	0.04
	Moriah Harbour Cay NP	0.02	0.03
Inagua	Little Inagua NP	0.17	0.05
New Providence	Southwest New Providence MMA	0.00	0.10
	Green Cay MP	0.00	0.02
	Bonefish Pond NP	0.16	0.01
Northern Bahama Bank	South Berry Islands MR	0.16	0.15
San Salvador	Graham's Harbour	0.00	0.17
	West Coast Dive Site	0.05	0.15
	Conception Island NP	0.00	0.10
	Pigeon Creek & Snow Bay NP	0.73	0.09
	Greens Bay NP	0.00	0.02
Western Little Bahama Bank	Northshore / The Gap NP	0.47	0.44
	East Grand Bahama NP	0.17	0.10

*MPAs with less than 0.3% of their region's mangrove and seagrass are left out of this table.

Value of nursery habitats in MPAs for lobster fishery

Nursery habitats in MPA's contribute **6.01 million pounds** to the annual lobster catch,

Generating **$22.52 million** in revenue per year.

Bank region	Annual contribution of nursery habitat in MPAs to lobster catch (millions of pounds)	Annual contribution of nursery habitat in MPAs to lobster revenue ($ millions)
Abaco	1.13	4.42
Acklins	0.10	0.37
Andros	0.58	2.28
Cay Sal	0.21	0.84
Eleuthera	0.22	0.87
Exuma	0.23	0.90
Inagua	0.03	0.10
Long Island	0.06	0.25
New Providence	0.22	0.86
Northern Bahama Bank	0.22	0.87
San Salvador	0.10	0.38
Southern Great Bahama Bank	0.96	3.77
Western Bahama Bank	0.43	1.68
Western Little Bahama Bank	1.52	5.93
totals	*6.01*	*23.52*

2. QUANTIFY THE ECONOMIC VALUE OF FOUR ECOSYSTEM SERVICES WITHIN THE EXISTING NETWORK OF MPAS

Nursery habitat for spiny lobster fishery

Tourism

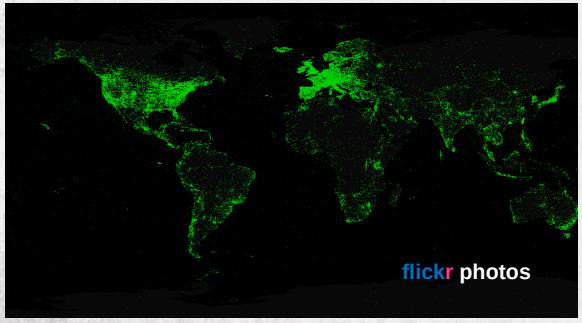
Coastal protection

Carbon storage & sequestration

TOURISM

Inputs

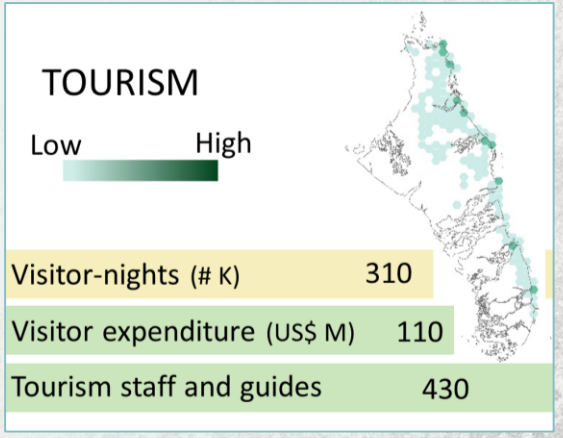
- Ministry of Tourism visitor surveys (# visitors—cruise and stopover, length of stay, $/stay)
- Industry job surveys
- Spatial distribution of visitors



Wood et al 2013 *Scientific Reports*

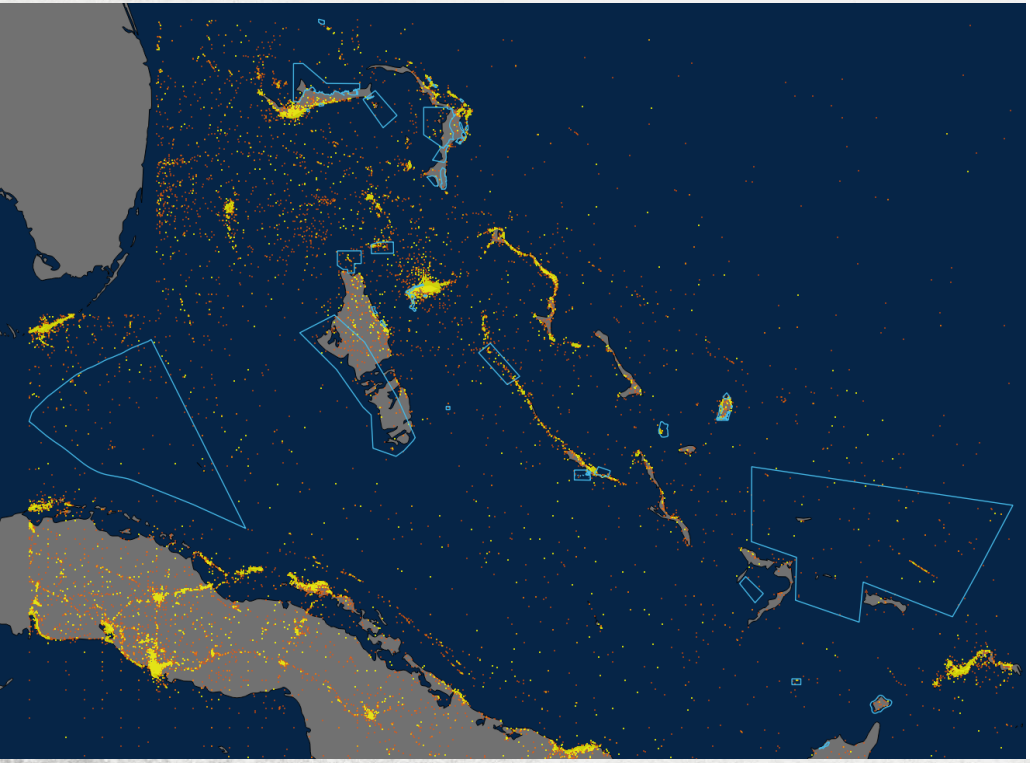
Outputs

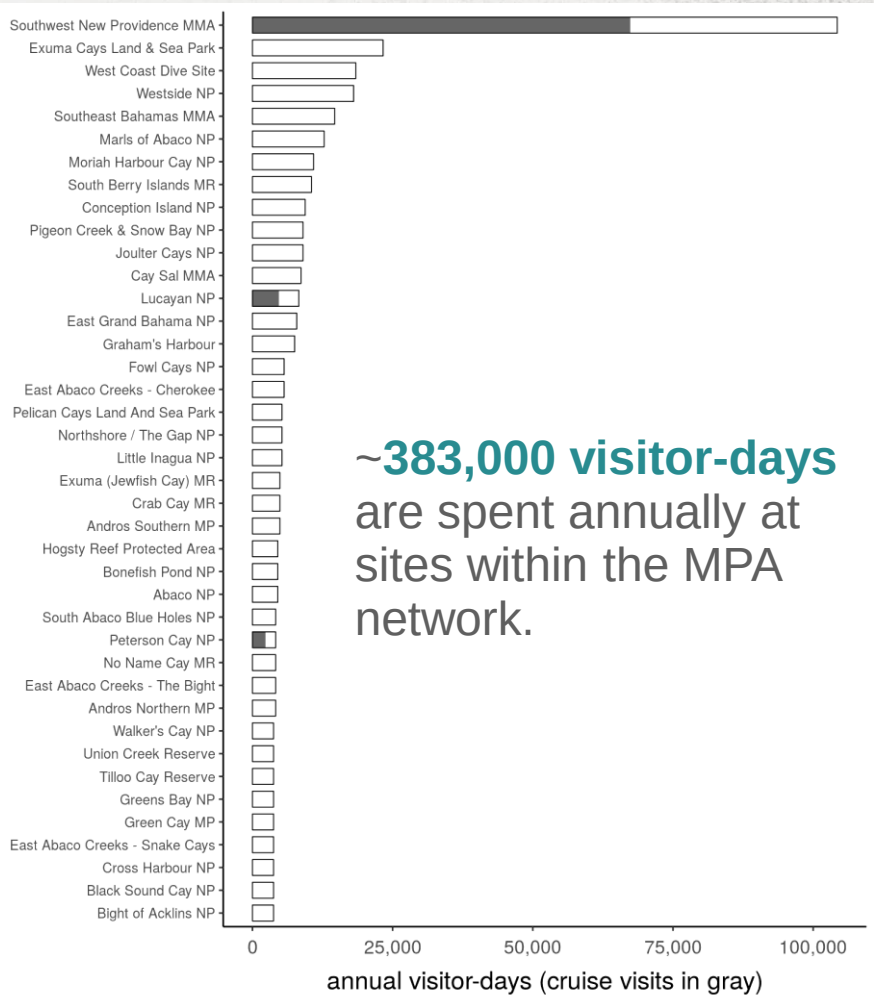
- Visitor nights per area
- Visitor expenditure
- Number of jobs



TOURISM

Approach to valuation

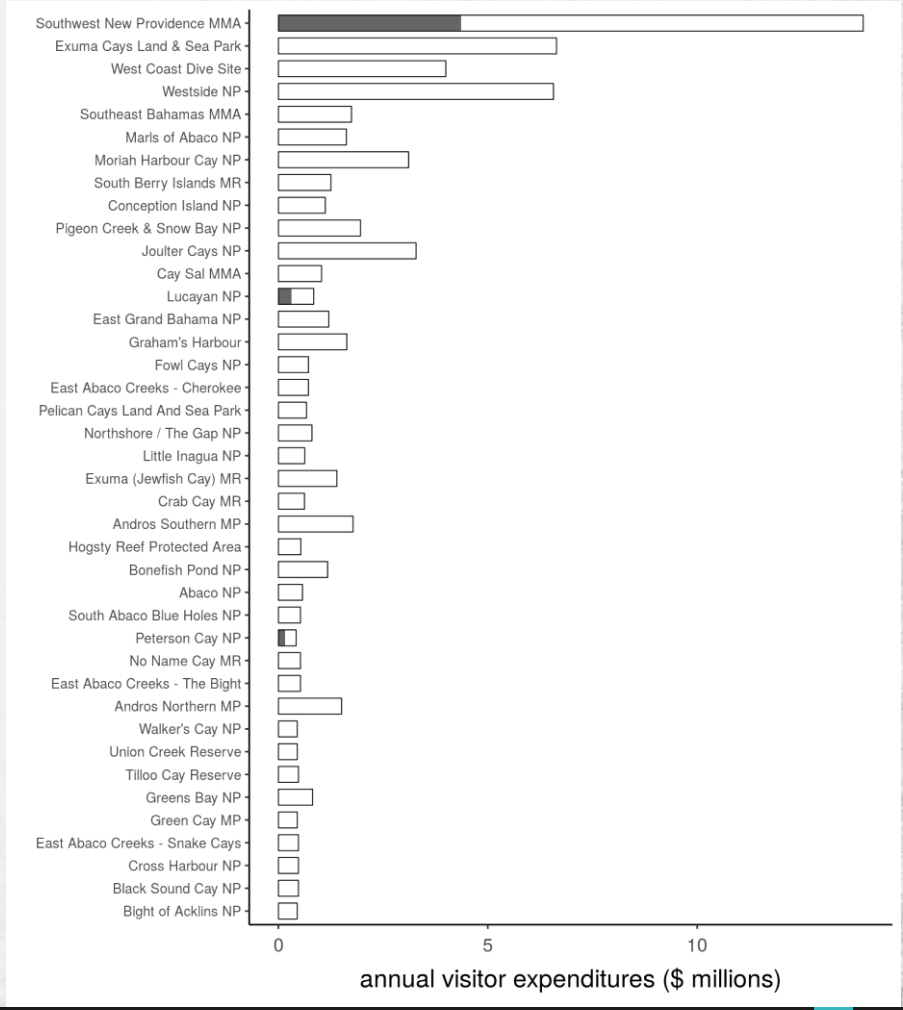




~383,000 visitor-days are spent annually at sites within the MPA network.

ECONOMIC VALUE of TOURISM IN MPAS

~$67.6 million in expenditures are associated with annual visits to sites within MPAs



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Nursery habitat for spiny lobster fishery

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Coastal protection

Carbon storage & sequestration

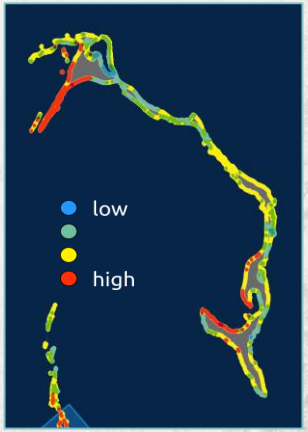
COASTAL PROTECTION

Inputs

- Geomorphology
- Habitats
- Wind exposure
- Wave exposure
- Storm surge (continental shelf)
- Relief
- Sea level rise
- Census data (population, income)

Outputs

- Exposure
- Reduction in exposure attributable to habitat
- People protected
- Income protected



COASTAL PROTECTION

Coastal habitats in MPAs reduce exposure to **39,000 people** and **$806 million** in annual income

Island group	Current MPAs	Reduction in exposure ($ millions annual income)	Reduction in exposure (# of people)
Abaco	Abaco NP – Black Sound Cay NP – No Name Cay MR – Fowl Cays NP – Tilloo Cay Reserve – Pelican Cays Land And Sea Park – Cross Harbour NP – Marls of Abaco NP – East Abaco Creeks (The Bight) – East Abaco Creeks (Snake Cays) – East Abaco Creeks (Cherokee) – South Abaco Blue Holes NP	$32.32	3,630
Acklins/Crooked	Bight of Acklins NP	$0.00	0
Andros	Northern Marine Park – Southern Marine Park – Westside NP – Joulter Cays NP	$6.40	782
Berry Islands	South Berry Islands MR	$1.92	238
Exuma	Exuma Cays Land & Sea Park – Exuma (Jewfish Cay) MR – Moriah Harbour Cay NP	$15.89	1,482
Grand Bahama	Northshore/The Gap NP – East Grand Bahama NP – Peterson Cay NP – Lucayan NP	$16.63	1,027
Inagua	Union Creek Reserve – Little Inagua NP	$0.00	0
New Providence	Bonefish Pond NP – Southwest New Providence MMA	$717.53	30,416
San Salvador	West Coast Dive Site – Greens Bay NP – Graham's Harbour – Pigeon Creek & Snow Bay NP	$15.76	1,403
totals		$806.45	38,978

2. QUANTIFY THE ECONOMIC VALUE OF FOUR ECOSYSTEM SERVICES WITHIN THE EXISTING NETWORK OF MPAS

Nursery habitat for spiny lobster fishery

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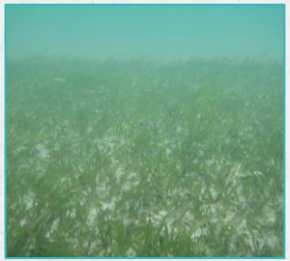
Carbon storage & sequestration

BLUE CARBON MODEL

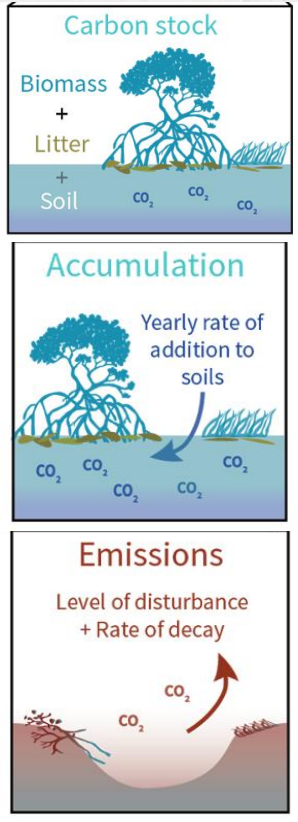
Inputs

- Mangrove distribution
- Seagrass distribution
- Biomass
- Litter
- Soil
- Rates of decay
- Social value

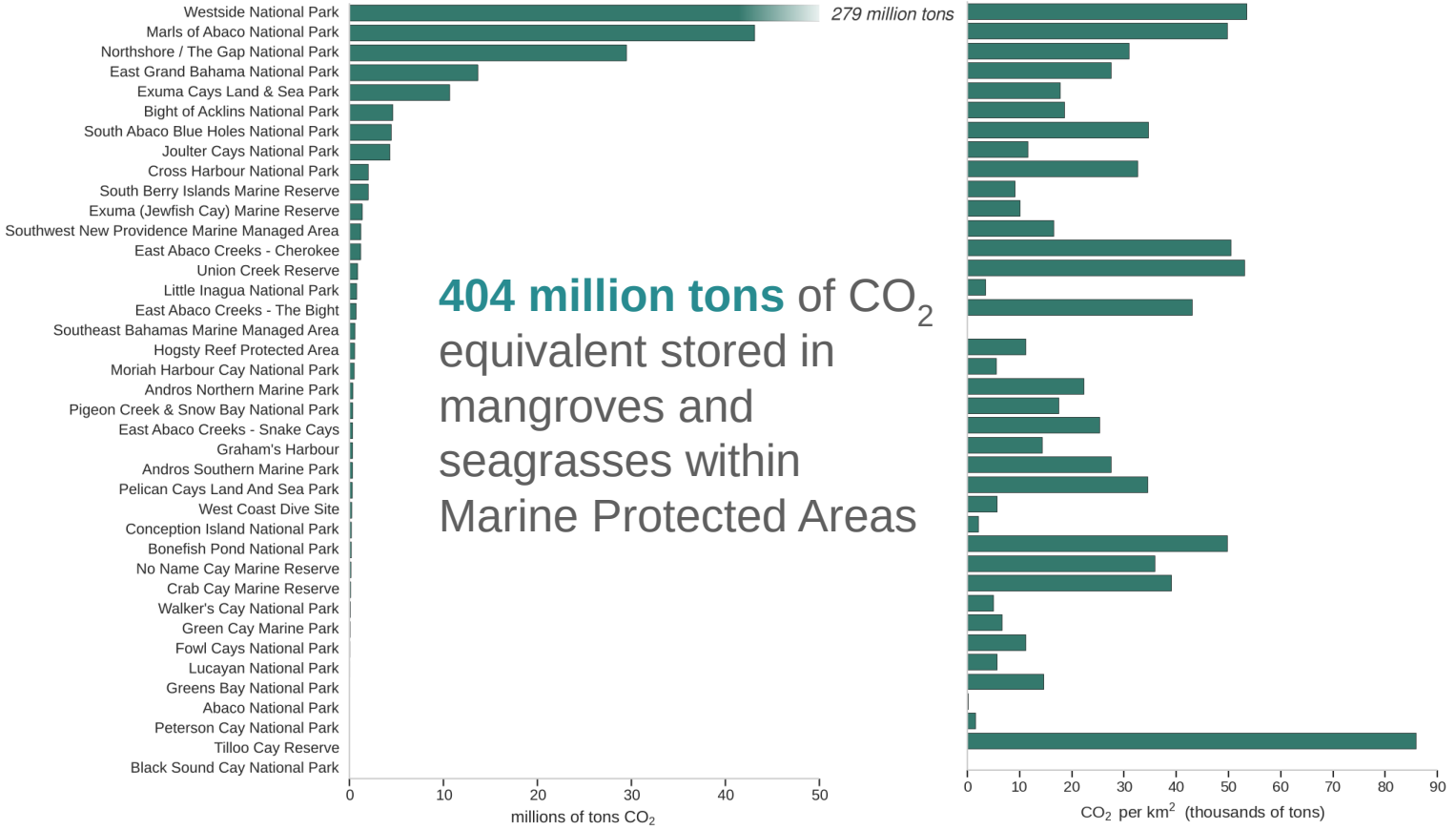


Outputs

- Carbon storage
- Carbon accumulation
- Carbon emissions
- Net sequestration
- Net present value

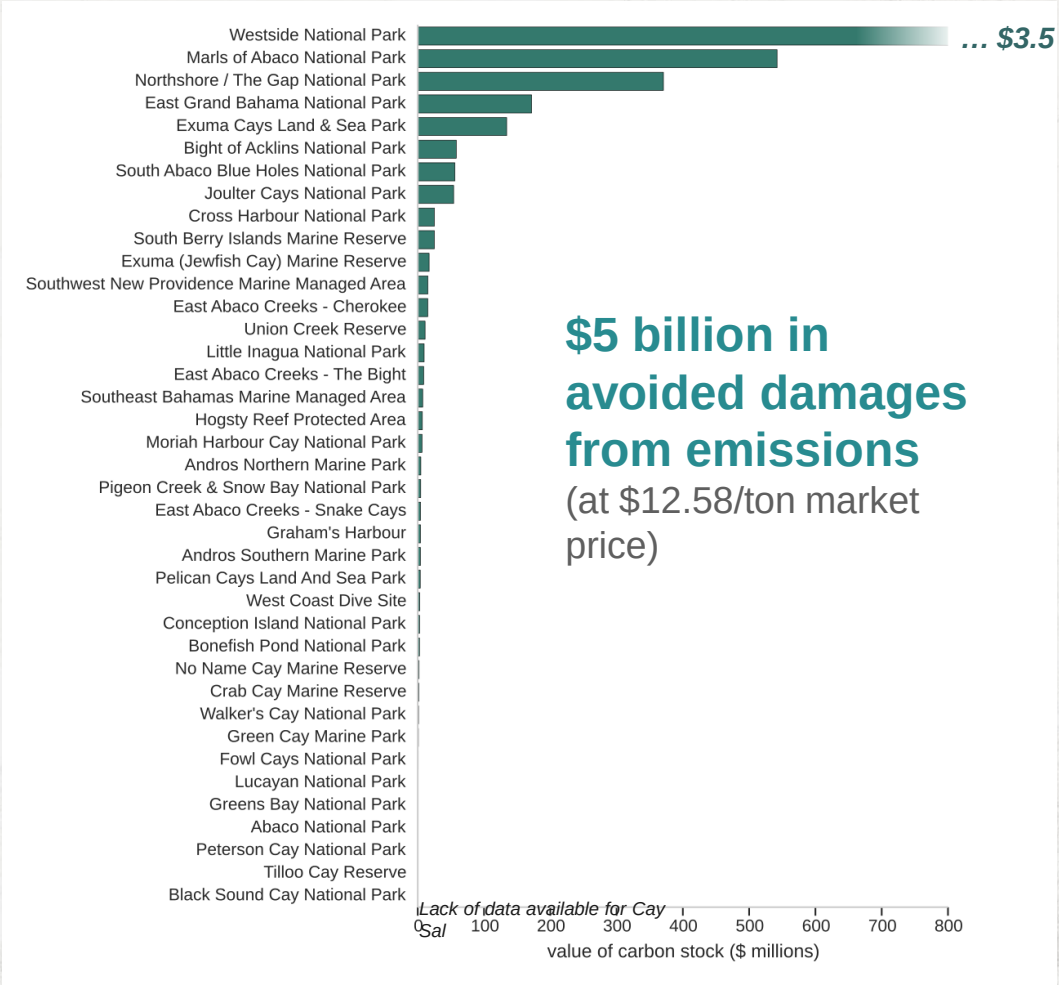


CARBON STORAGE BY MPA



404 million tons of CO_2 equivalent stored in mangroves and seagrasses within Marine Protected Areas

Value of avoided emissions by MPA



$5 billion in avoided damages from emissions
(at $12.58/ton market price)

Ecosystem Service	Values provided ecosystems within the existing MPA network	Factors that influence spatial variation in ecosystem service (not comprehensive)
Tourism	383,000 visitor-days and $67.6 million in expenditures annually	Island differences in visitation, expenditure, habitat extent, access, infrastructure
Coastal protection	Reduced exposure to 39,000 people and $806 million in income annually	Habitat type and quality, coastal elevation, shoreline type, surge potential, wave characteristics, sea-level rise, proximity of habitats in MPA to coastal population
Nursery habitat for spiny lobster	6 million lbs. and $23.5 million in revenue from the lobster fishery is attributable to nursery habitat annually	Habitat type and extent, larval recruitment to nursery habitat, proximity of nursery habitat to shallow shelf habitat for adults
Carbon storage for climate mitigation	400 million tons of CO_2 stored and $5 billion in avoided damages from emissions globally	Relative abundance of mangroves and seagrass, carbon stored in soil and aboveground biomass (based on climate).

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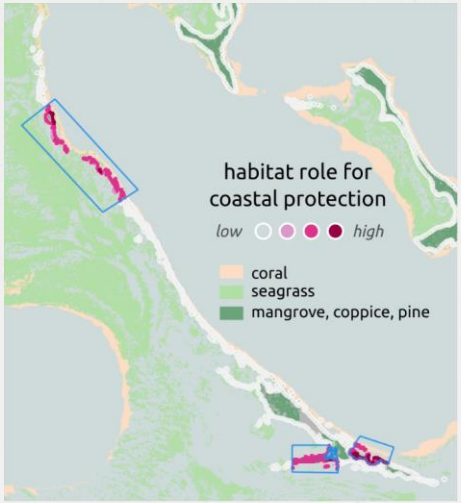
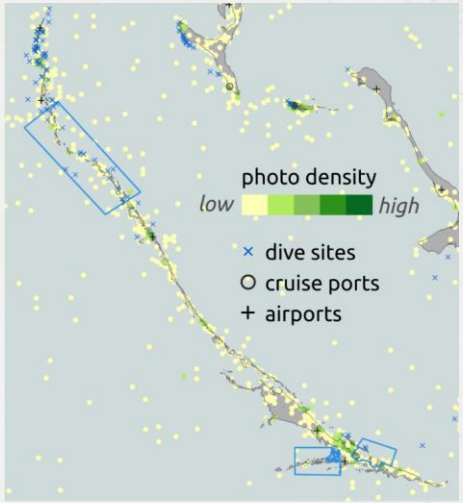
EXUMA

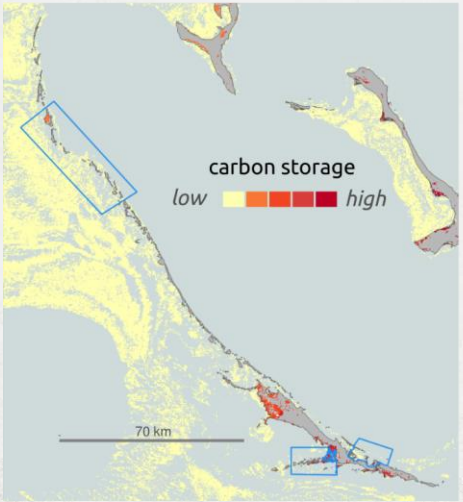
Entire coastline protected

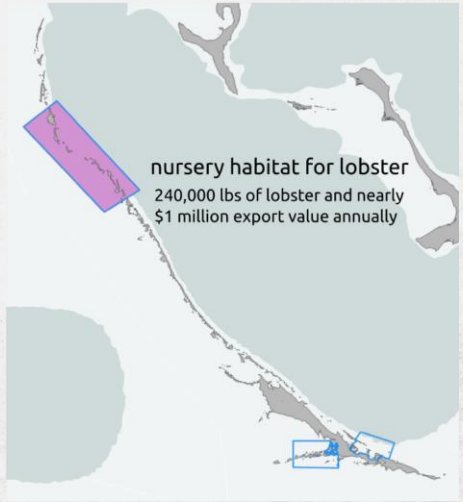




$6.6 million in visitor expenditure from 23,000 visitor-days (annually)

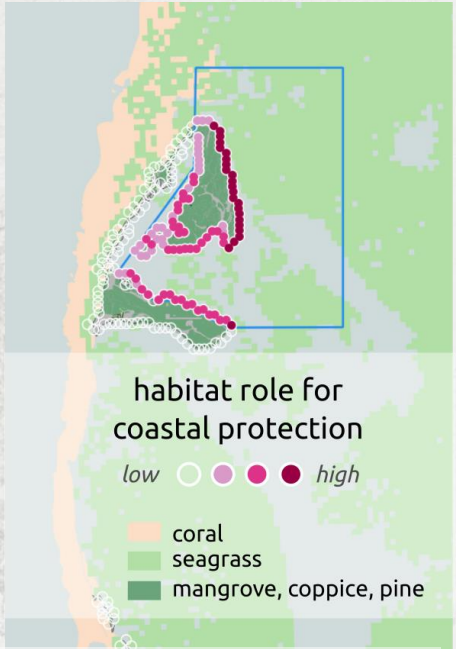
$130 million in avoided damages due to emissions by storing 10.7 million tons of carbon



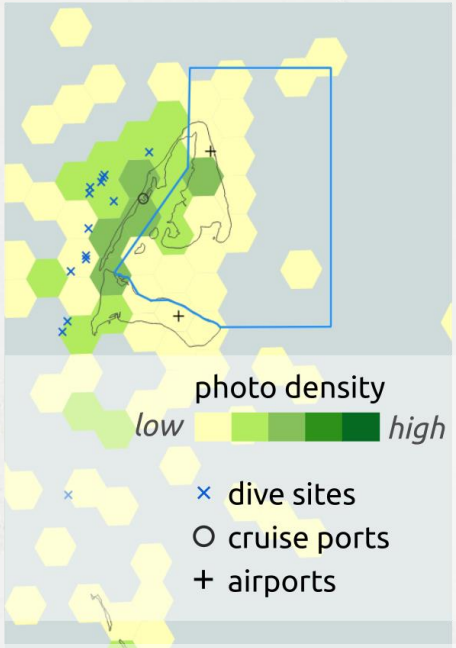


$1 million in export value from 240,000 lbs of catch (annually)

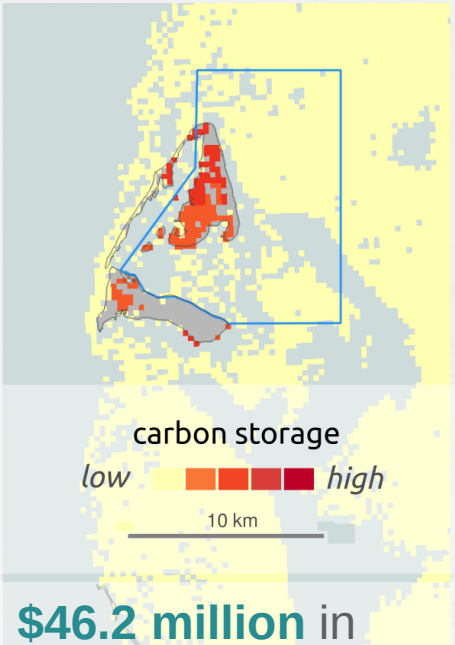
BIMINI



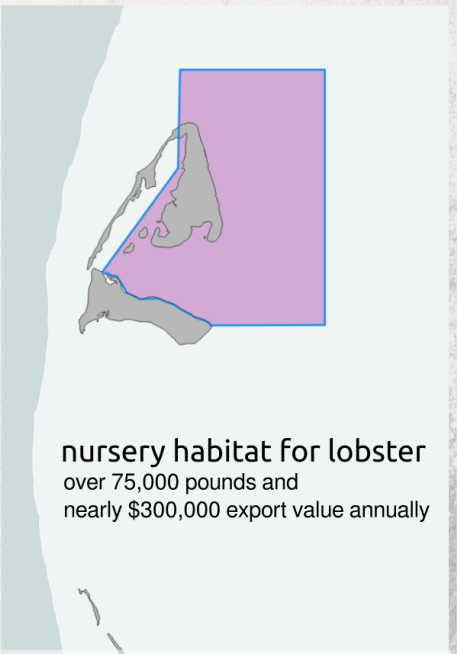
3,000 people and $31.2 million in annual income protected



$3.3 million in visitor expenditure from 19,500 visitor-days (annually)

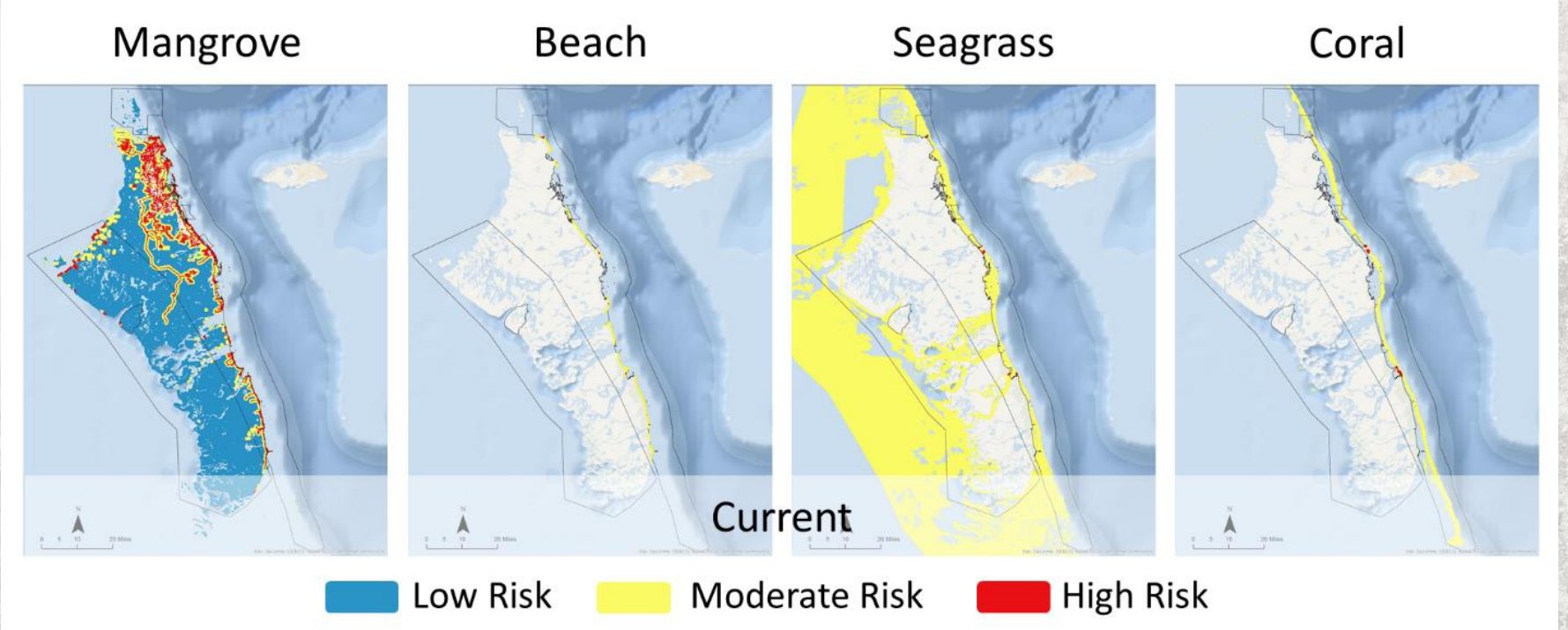


$46.2 million in avoided damages due to emissions, 3.5 million tons of carbon stored



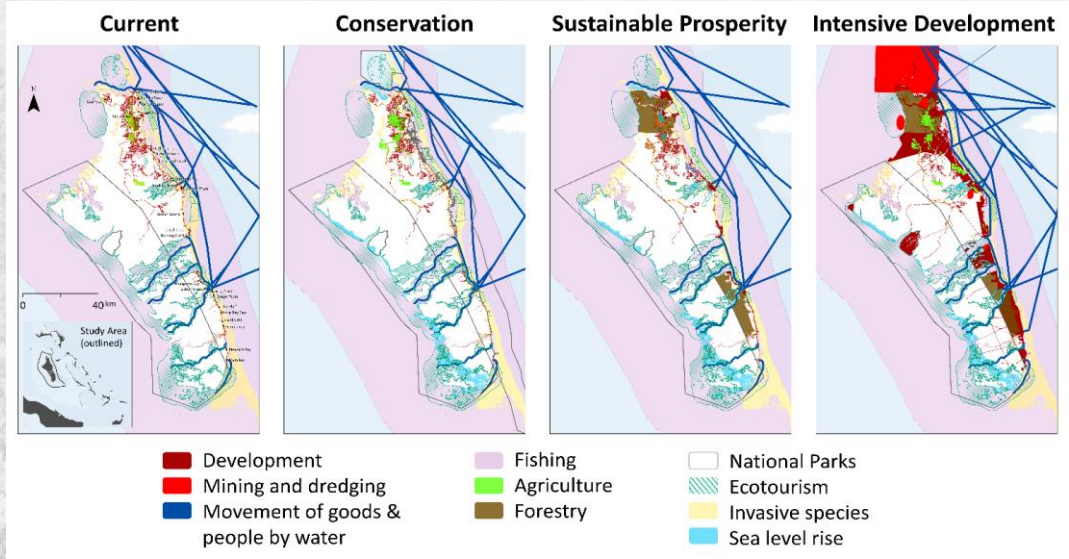
$300,000 in export value from 76,505 lbs. of catch (annually)

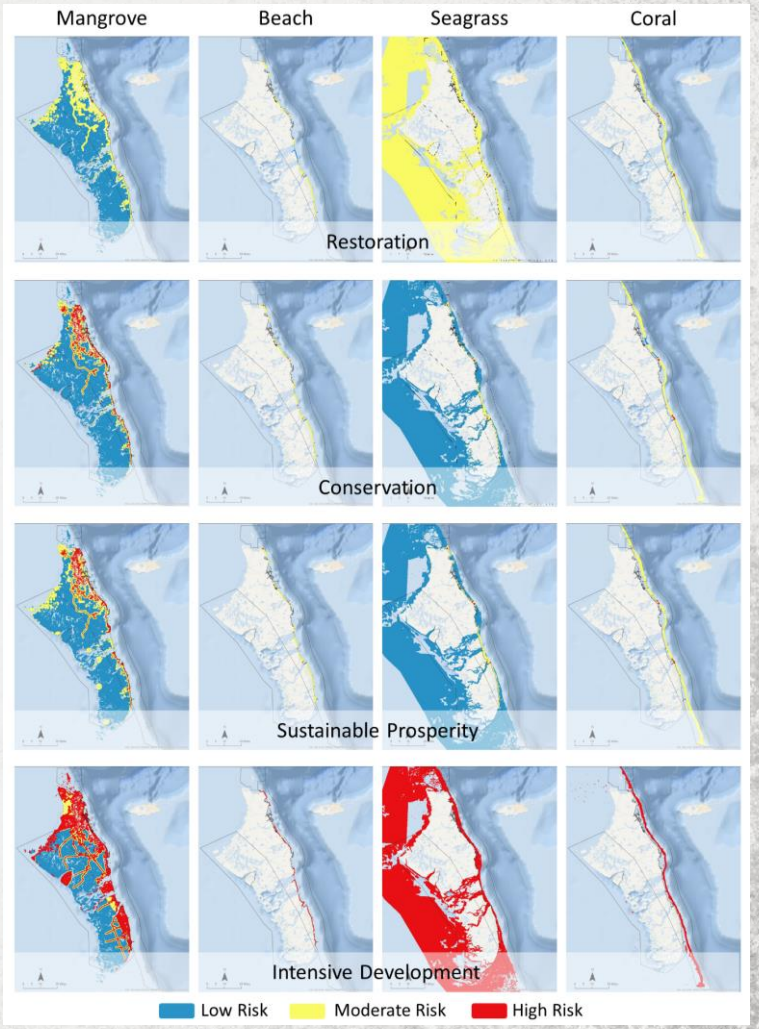
ANDROS
CURRENT RISK ASSESSMENT



ANDROS

ALTERNATIVE FUTURE SCENARIOS & ASSOCIATED RISK



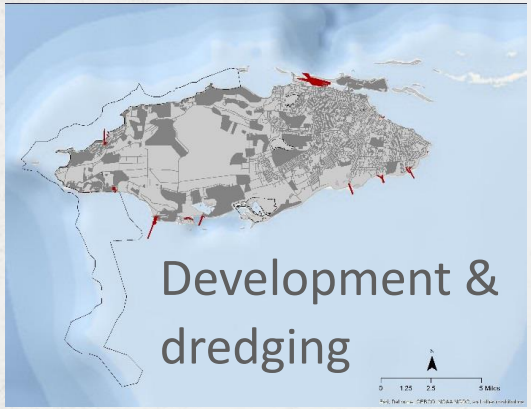


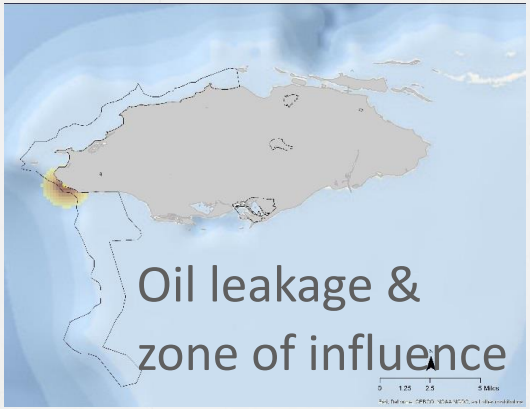
ANDROS RESULTS

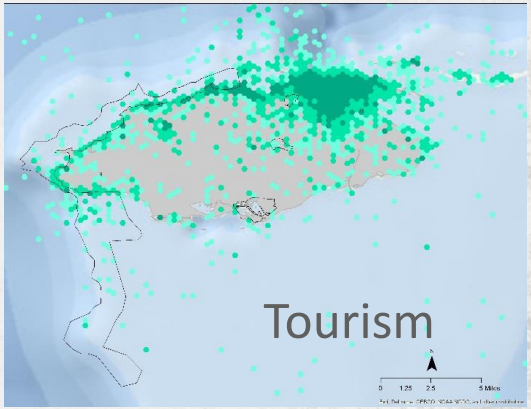
- Nursery habitats within Andros's MPAs contribute **3.5 million lbs**. in lobster catch and **$14.5 million in export value**
  - The Master Plan (sustainable prosperity scenario) could increase export value to $21. million
- Andros' MPAs support **$113 million in visitor expenditure**
  - The Master Plan would increase expenditure to $170 million
- **Coastal habitats** such as mangrove and coppice forests, coral reefs and seagrass **reduce the risk to 50% of the islands' population, protecting $2.4 million in income**
  - The Master Plan would protect 60% of the islands' population
- **Carbon storing** mangrove and seagrass in Andros West Side National Park are worth **$6 billion in avoided damages** from emissions.
  - These assets could increase by 3% under the Master Plan

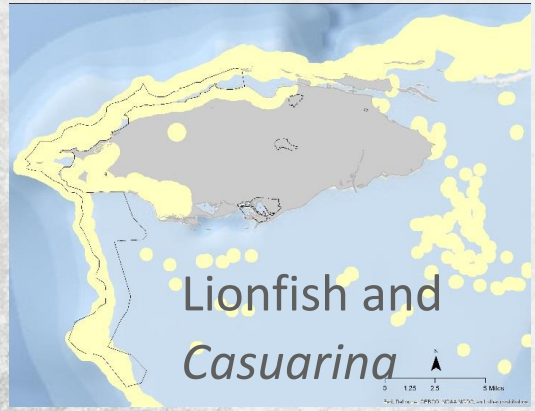
SOUTHWEST MARINE MANAGED AREA

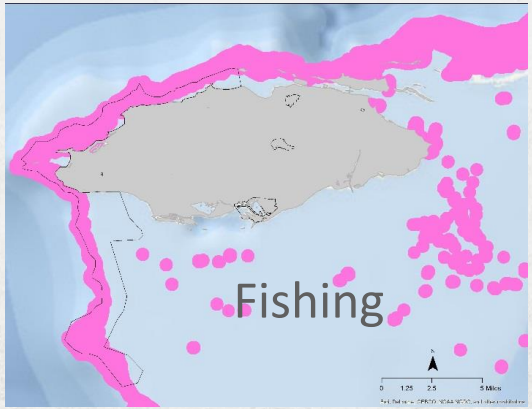
MAPPING HUMAN USES

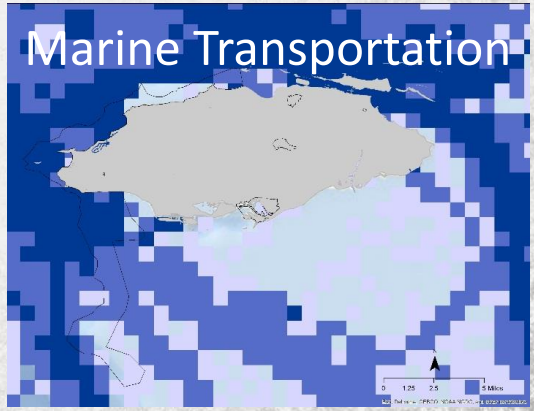






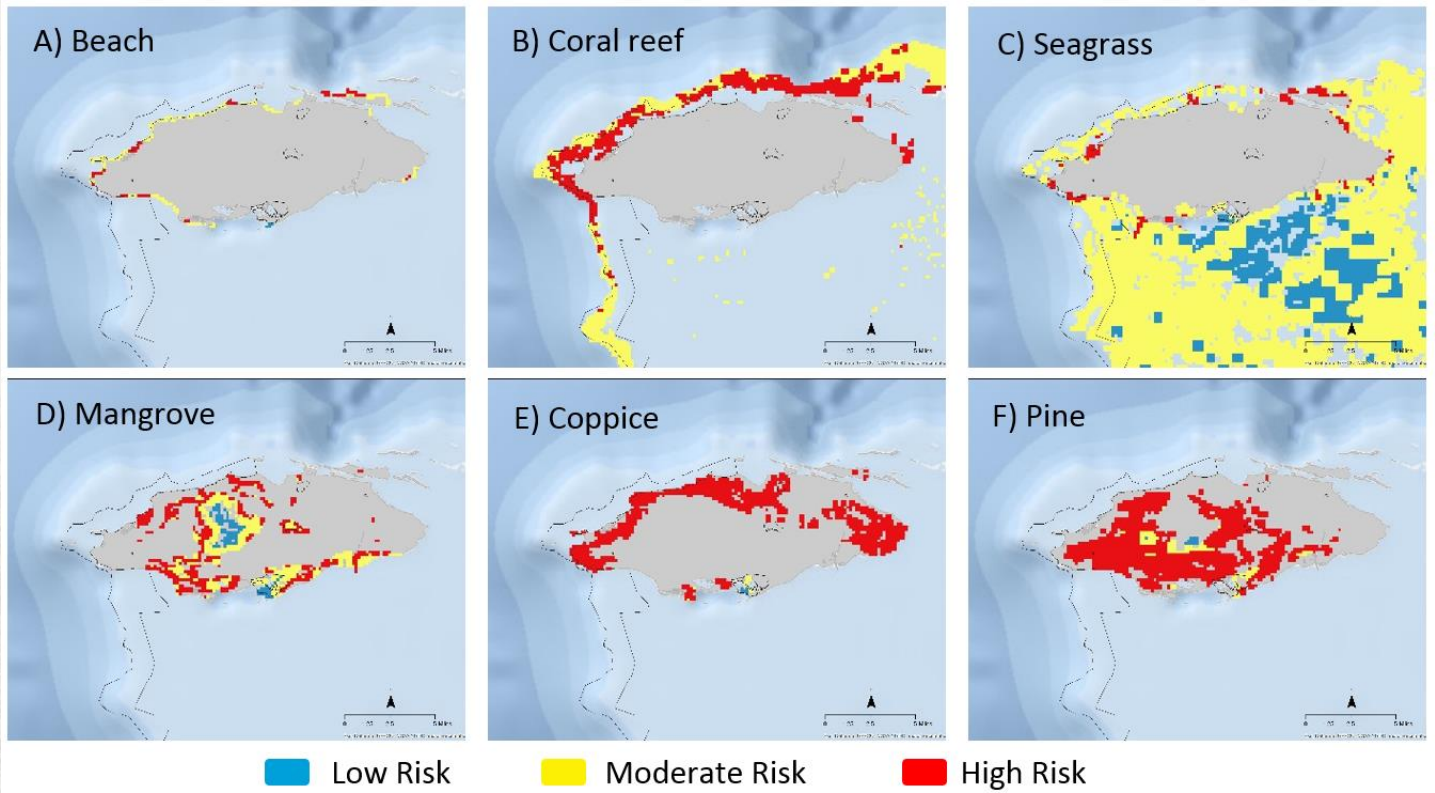




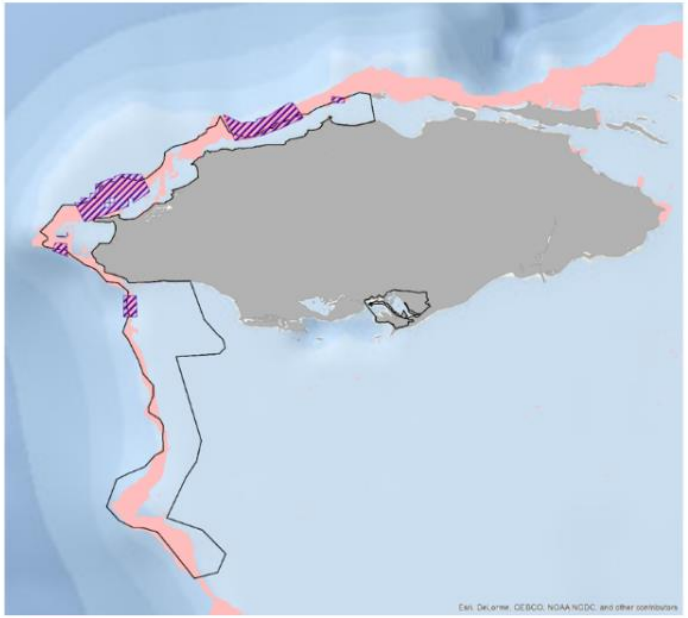


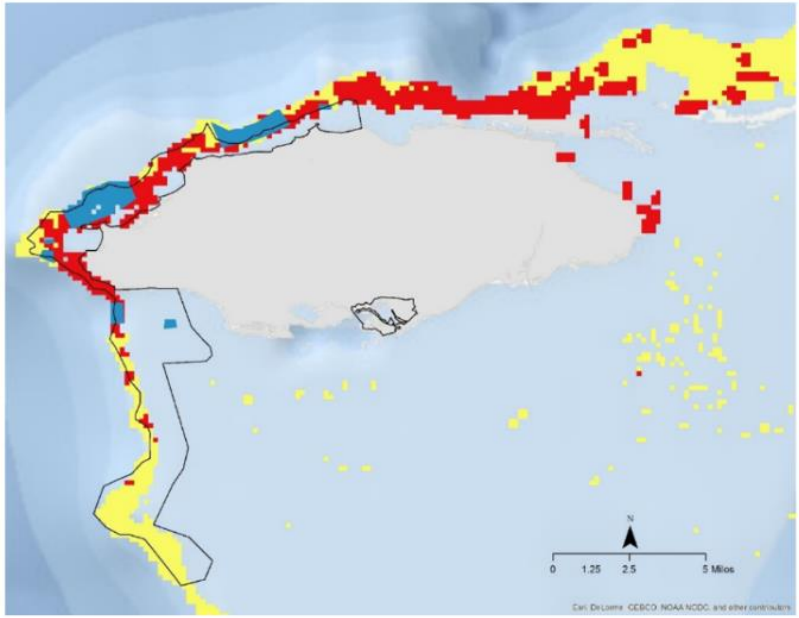
SOUTHWEST MARINE MANAGED AREA

RISK ASSESSMENT APPROACH



SOUTHWEST MARINE MANAGED AREA
PROPOSED CORAL RESTORATION





Coral

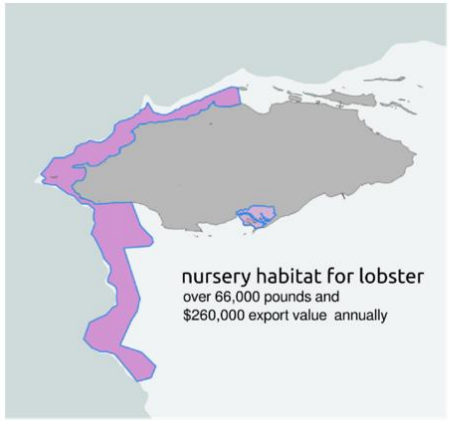
Areas of proposed restoration

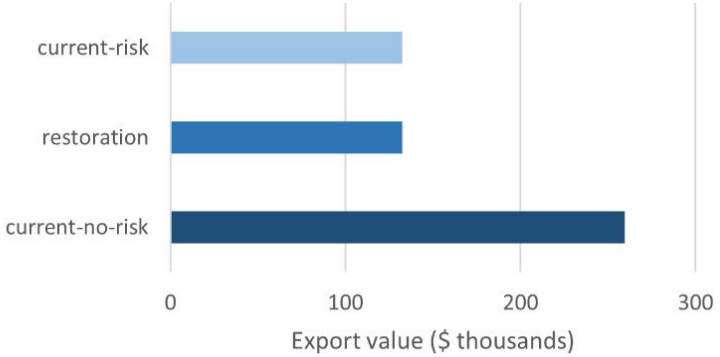
Low

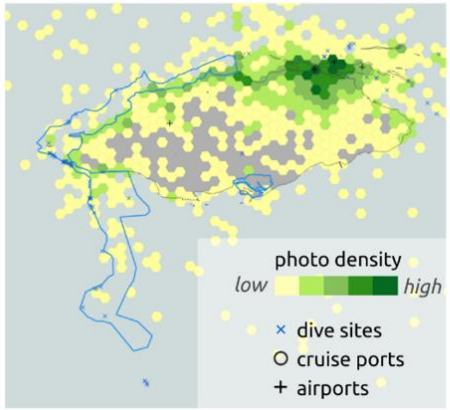
Moderate

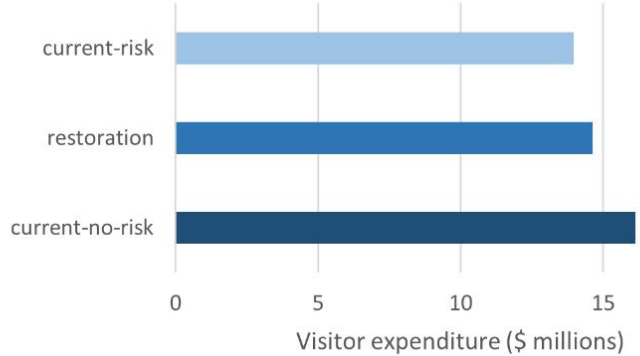
High Risk

SOUTHWEST MARINE MANAGED AREA





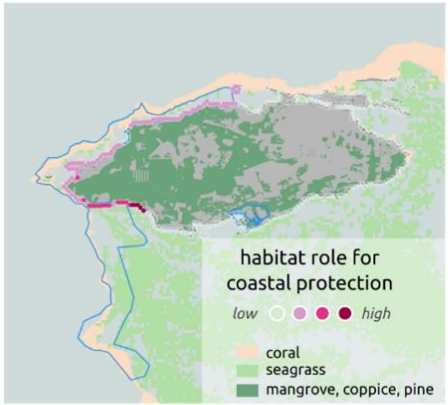


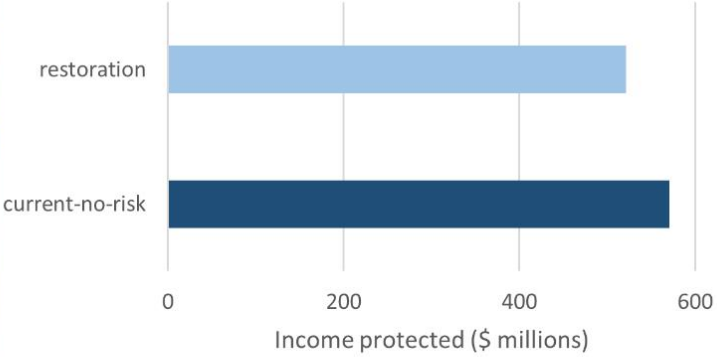


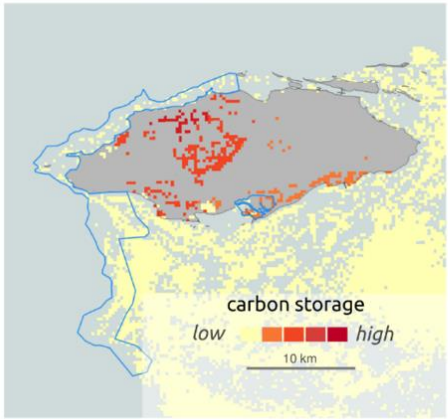
Risk from current activities reduce the export value attributable to nursery habitat by **50%, $127,000**

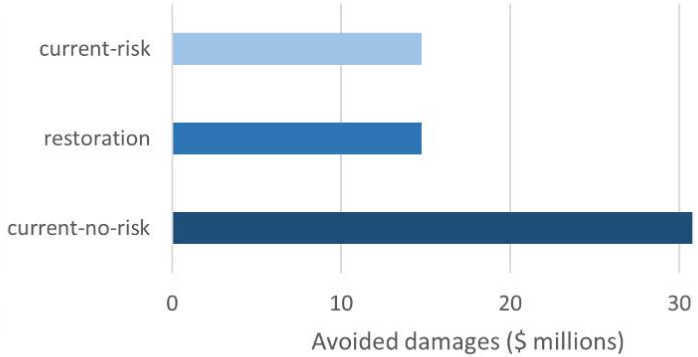
$14 million in visitor expenditure from currently, could increase by 14% with lower risk

SOUTHWEST MARINE MANAGED AREA







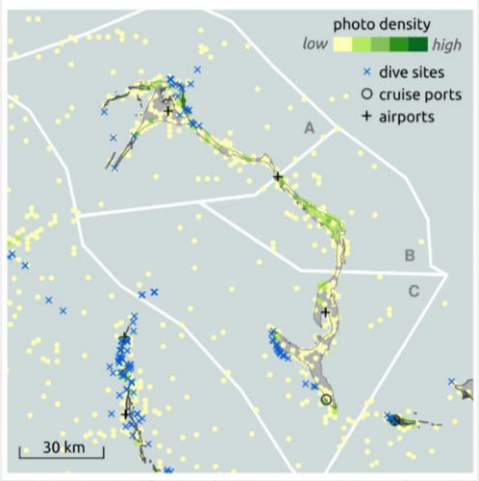


6% of people at greater risk from storms as a result of risk to habitats. Habitats could protect **30,000 people**

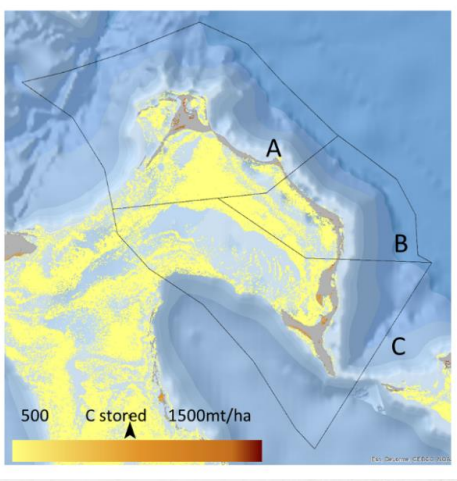
Under current risk, habitats store ½ as much carbon, worth **$16 million**

ELEUTHERA

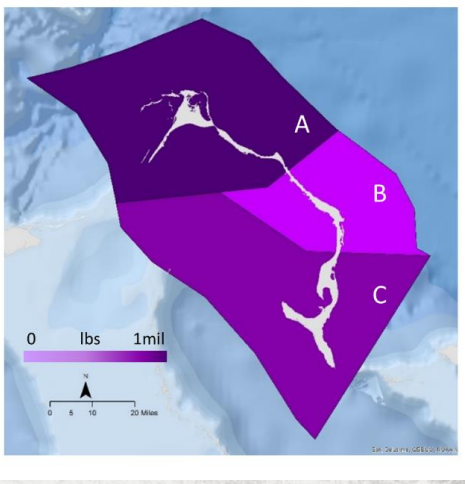
All 11,000 people protected by coastal habitats, **$130 million** in protected income



$58.5 million in visitor expenditure (annually)



$1.5 billion in avoided damages due to emissions, 120 million tons of carbon stored



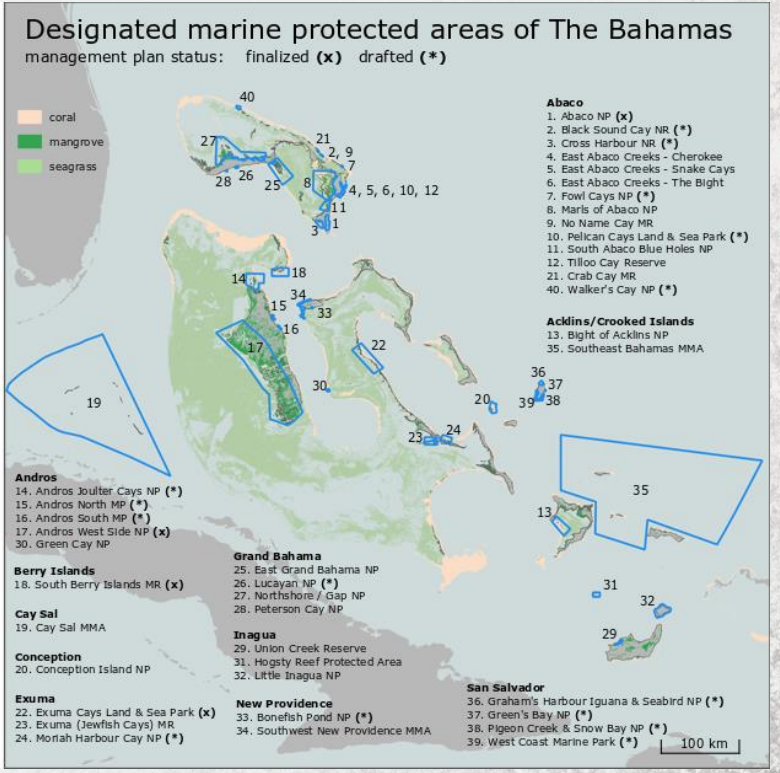
$5.7 million in export value from 1.5 million lbs. of catch (annually)

ISLAND-SCALE EVALUATION

- In-depth analysis of specific MPAs shows value of ecosystem services in these areas
  - E.g. Bimini and Exuma Cays Land and Sea Park
- Including human activities in a risk assessment highlights the potential gains of effective management
  - E.g. Andros and Southwest Marine Managed Area
- An ecosystem services approach can be used to explore locations for future MPAs
  - E.g. Eleuthera

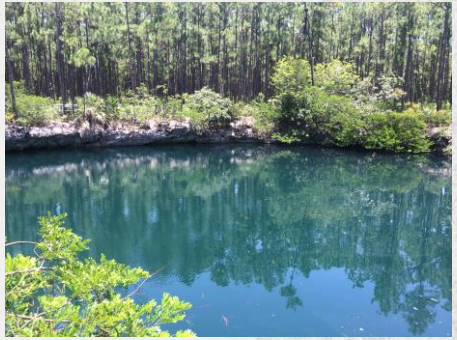
IMPLICATIONS OF FINDINGS FOR MPA POLICY, PLANNING, AND MANAGEMENT

- The economic benefits are large, and vary between locations
- Effective management is needed to maintain and grow the economic value
  - 4 of 40 MPAs have finalized management plans (as of Nov, 2017) and 15 have draft plans



IMPLICATIONS OF FINDINGS FOR MPA POLICY, PLANNING, AND MANAGEMENT

- MPA planning and management should be part of comprehensive efforts
  - E.g. National Development Planning (Vision 20140) & Integrated Coastal Zone Management
- MPA contribute to the Sustainable Development Goals (and other international commitments)
- An ecosystem services approach can help evaluation possible sites for future protection under the 20-by-20 challenge
- Iteration between ecosystem service valuation and stakeholder engagement can ensure local support and the future sustainability of MPAs



QUESTIONS?

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EXTRA SLIDES

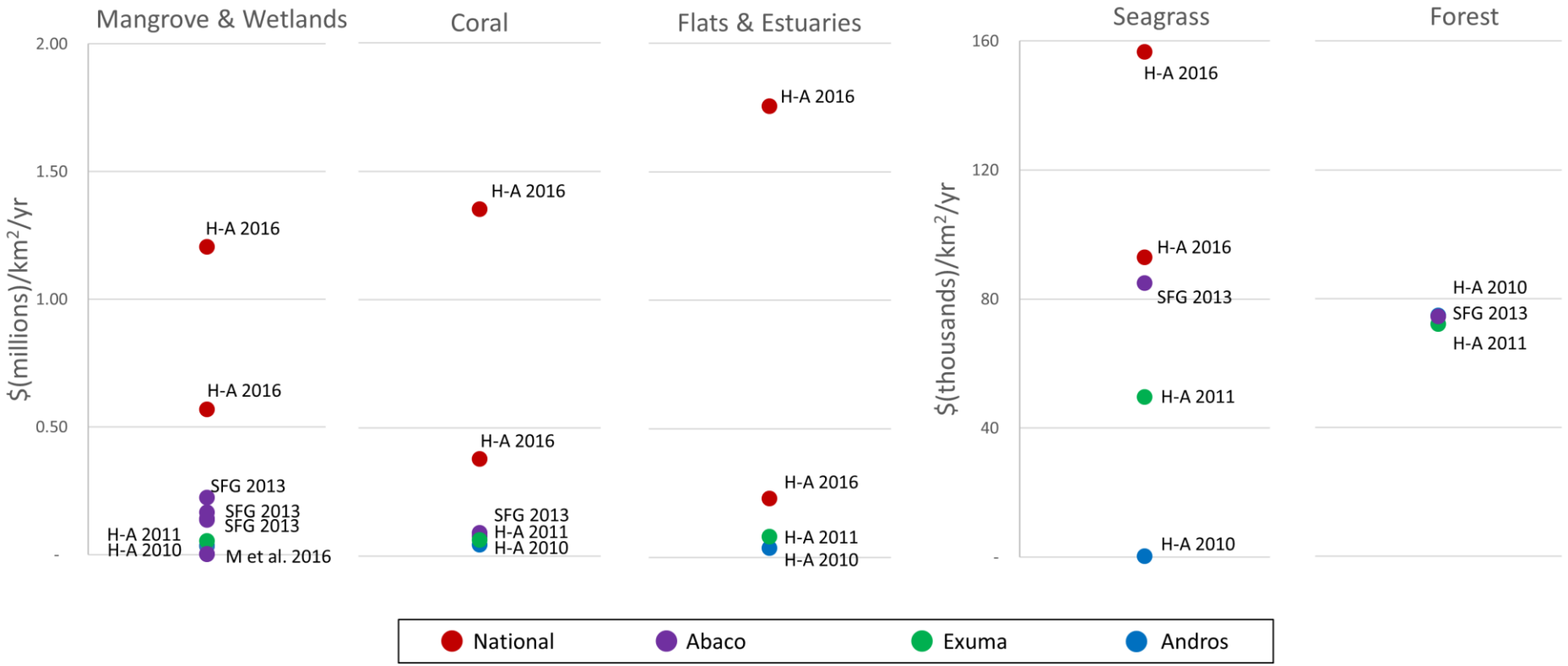
ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN BAHAMIAN MARINE PROTECTED AREAS

We reviewed the existing literature to glean useful information and to give context for our analysis

Approach:

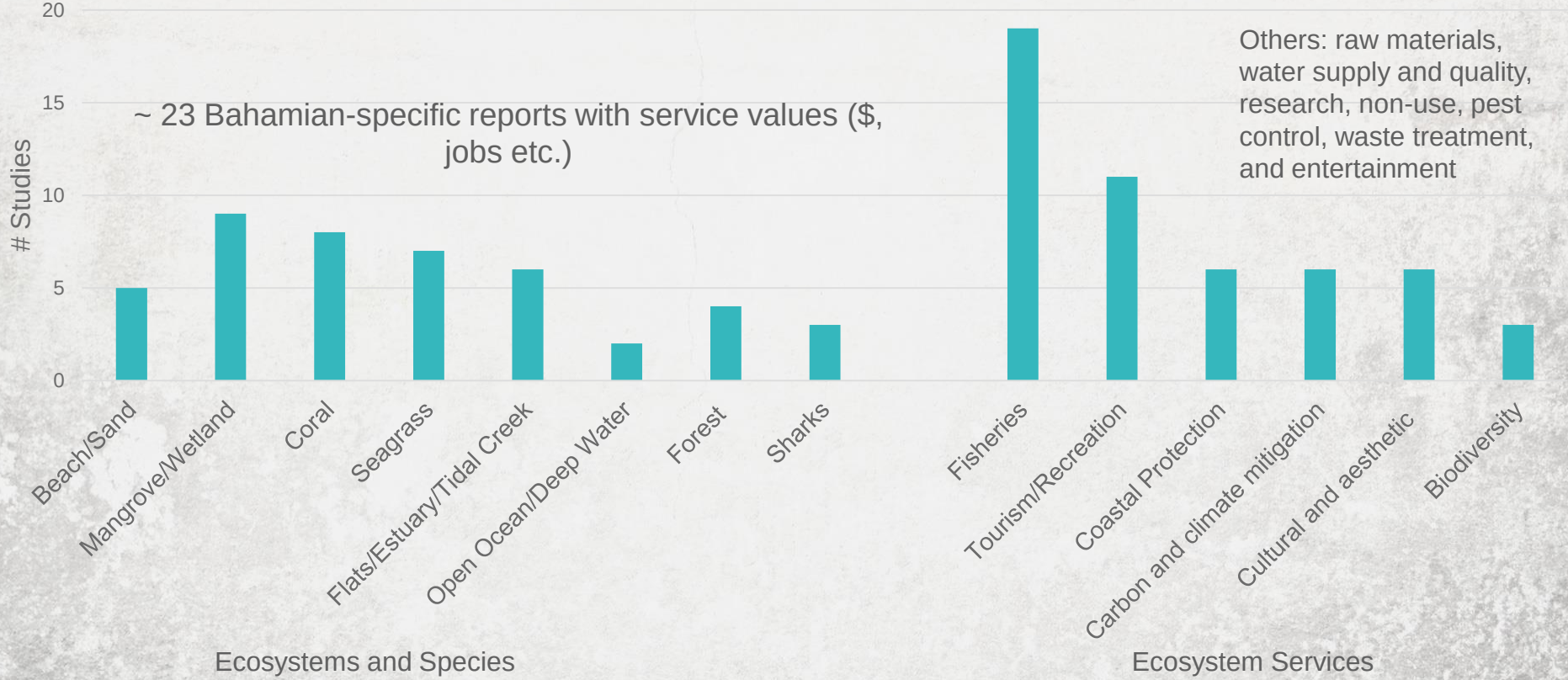
- We focused on existing studies of economic value (variety of metrics) of species, habitats, and marine protected areas in The Bahamas
- We searched the peer-reviewed literature, reports and citations within, and studies by local experts
- Values did not need to be monetary, but they did need to include demand from people for the services

ECONOMIC VALUE OF HABITATS (PER UNIT AREA)



Sources: Hargreaves-Allen (H-A) 2010, 2011, 2016; Clavelle and Jylkka (SFG) 2014, Micheletti et al. (M et al.) 2016

NUMBER OF VALUATION STUDIES BY ECOSYSTEMS AND SERVICES



PREVIOUS ECONOMIC VALUATION STUDIES

- 23 Bahamas-specific valuation studies
- Mangroves, coral, seagrass, and tidal flats the most commonly valued
  - Benefits-transfer approaches are the most common
  - Up to $1.2 – $1.75 million per km^2, depending on the habitat
- Fisheries and tourism the most commonly studied
  - $125 million in export value for fisheries, > $400 million in visitor expenditure
- Opportunities for new work
  - Focus on coastal protection benefits of habitats from storms
  - Spatially-explicit approaches
  - Specific contribution of MPAs

ECONOMIC VALUE OF FISHERIES

- Lobster
  - $64.5 million annually in export value from 2,301 tons/yr (2000-2009)
  - Reconstructed catch was 4.5x greater, 10,500 tons/yr
- Reef fish
  - $60 million annually in export value
- Subsistence fishery
  - 33,100 tons/yr supporting food security for thousands of Bahamians
- Employment
  - 4,000 Bahamian fishing vessels
  - 9,300 directly employed in the fishing industry
  - 1,300 active lobster fisherman

Sources: Hargreaves-Allen and Pendleton 2010, Smith and Zeller 2016, DMR, FAO 2009, Gittens and Braynen, Sullivan Sealey 2011

ECONOMIC VALUE OF TOURISM

- $402 million annually from stopover visitors (2007)
  - 4.5 million visitors annually contributing 60% to the national economy (2007)
- $50 million in annual expenditure related to sharks with aggregated economic impact of $115 million
- $75 million in annual expenditure from guided and non-guided fishing with aggregated economic impact more than $150 million
- Employment figures are limited
  - > 500 employees in nature-based tourism on Andros (2010)
  - > 300 fishing guides nationally (2010)

Sources: Hargreaves-Allen 2010, Hargreaves-Allen and Pendleton 2010, Fedler 2010, Ministry of Tourism

ECONOMIC VALUE OF COASTAL PROTECTION

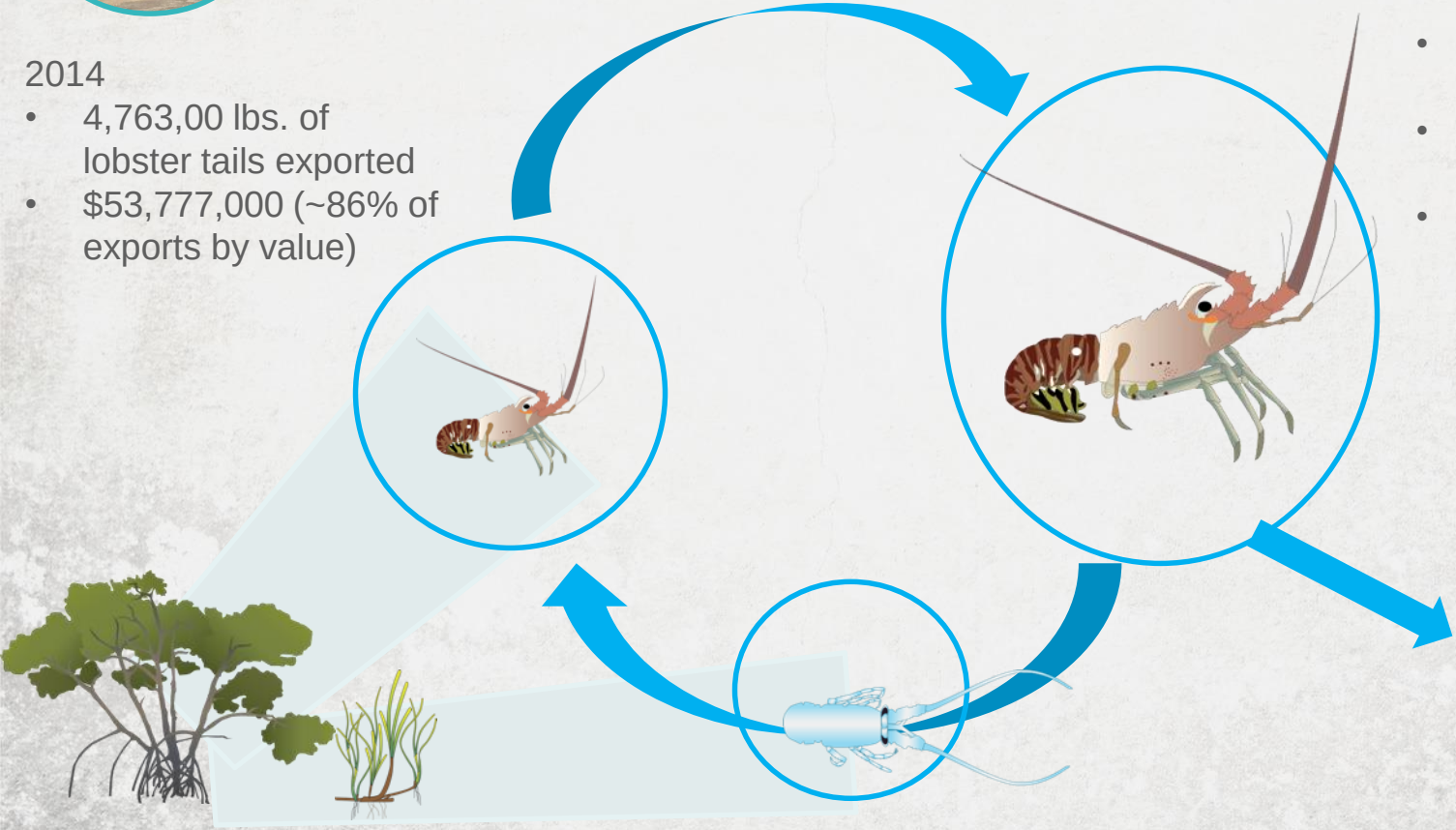
- Habitats in The Bahamas provide an estimated $3.9 billion km^2/yr in coastal protection and $120 million in erosion control
- Exuma
  - $8.5 million km^2/yr in disturbance regulation
- Andros
  - $6.8 million km^2/yr in disturbance regulation
  - 95 km of shoreline and 50% of the coastal population protected by natural habitats
- Great Abaco
  - $1,137 in avoided costs for communities from disturbance protection
  - $1,348 in avoided costs for government from disturbance protection
  - $33,423 in avoided costs for government from erosion protection

Sources: Hargreaves-Allen 2010, 2011, 2016; Micheletti et al. 2016

VALUE OF LOBSTER CATCH ATTRIBUTABLE TO MANGROVES AND SEAGRASS IN MPAs

2014

- 4,763,00 lbs. of lobster tails exported
- $53,777,000 (~86% of exports by value)

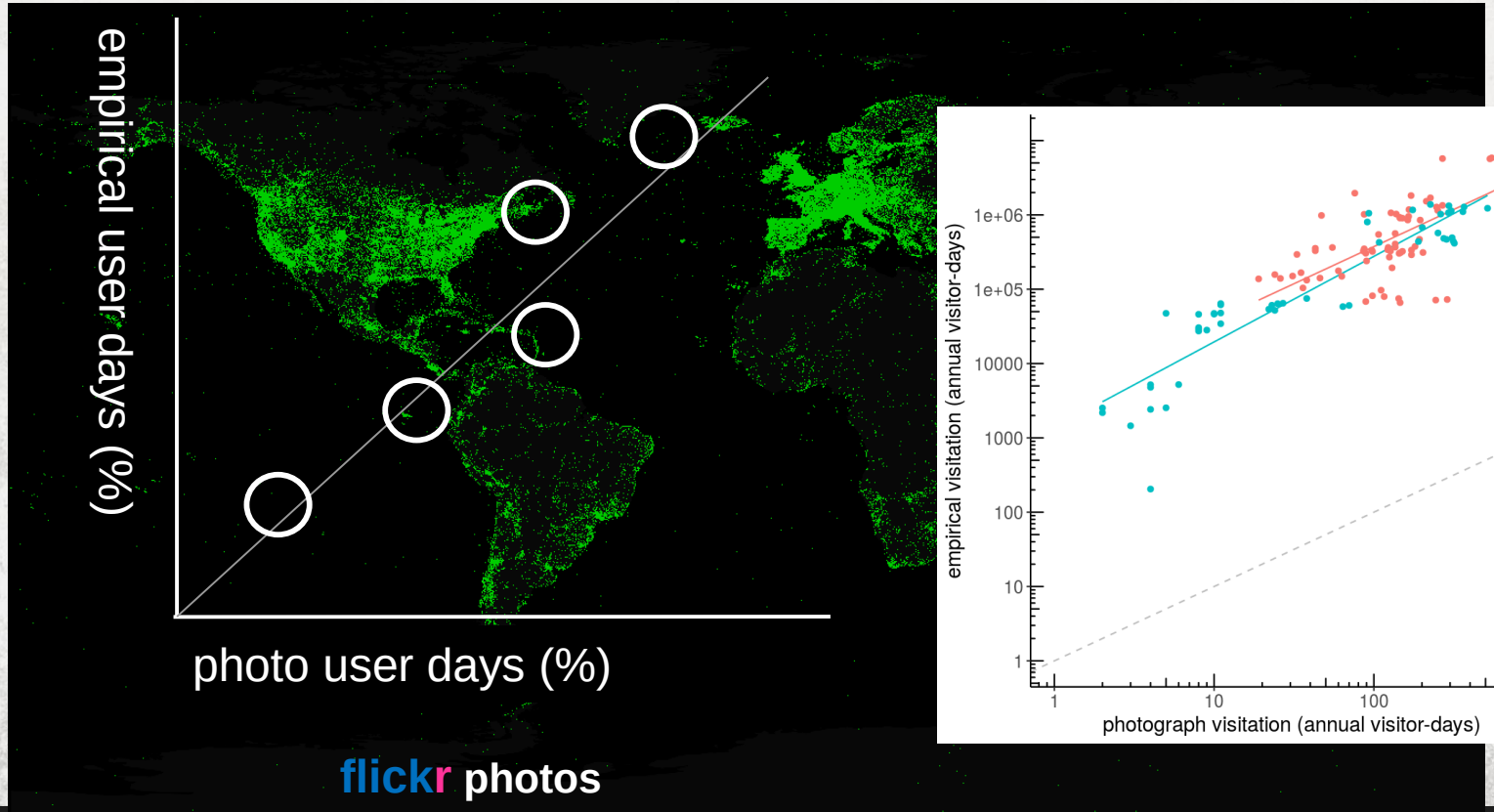


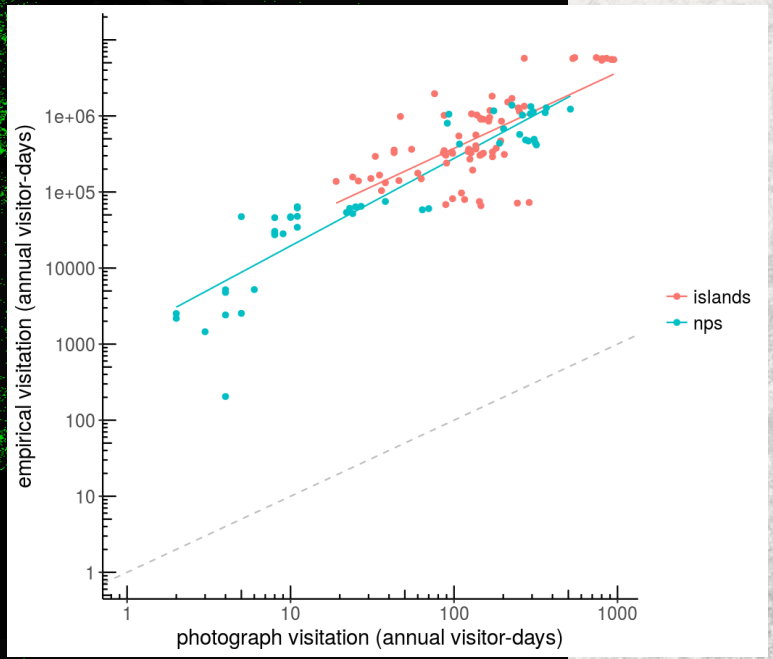
- Age-structured matrix model
- Beverton-Holt recruitment
- Habitat dependent survivorship

TOURISM

APPROACH TO TRACK PEOPLE

Wood et al 2013
Scientific Reports





TOURISM

EXTENSIVE SURVEY DATA

Ministry of Tourism 2015 Statistics:

- 9,943,549 total visitor nights

VISITOR NIGHTS IN THE BAHAMAS BY ISLAND 1977 - 2015

YEAR	Nassau/P.I.	%	Grand Bah.	%	Out Isl.	%	TOTAL	%
1977	2,558,070	44.5%	1,822,030	31.7%	1,374,330	23.9%	5,754,430	100.0%
1978	3,276,210	47.1%	2,114,100	30.4%	1,569,880	22.6%	6,960,190	100.0%
1979	3,751,550	47.4%	2,321,760	29.3%	1,847,640	23.3%	7,920,950	100.0%
1980	3,849,190	45.6%	2,613,630	31.0%	1,973,320	23.4%	8,436,140	100.0%
1981	3,353,800	44.9%	2,286,900	30.6%	1,829,930	24.5%	7,470,630	100.0%
1982	3,372,920	45.0%	2,134,080	28.5%	1,983,310	26.5%	7,490,310	100.0%
1983	3,963,350	48.7%	2,067,200	25.4%	2,110,080	25.9%	8,140,630	100.0%
1984	4,074,100	49.8%	1,964,730	24.0%	2,146,450	26.2%	8,185,280	100.0%
1985	4,251,420	50.8%	2,132,370	25.5%	1,984,565	23.7%	8,368,355	100.0%
1986	4,113,610	49.1%	2,135,300	25.5%	2,126,010	25.4%	8,374,920	100.0%
1987	4,192,850	48.3%	2,334,645	26.9%	2,157,810	24.8%	8,685,305	100.0%
1988	4,122,370	47.3%	2,459,640	28.2%	2,125,620	24.4%	8,707,630	100.0%
1989	4,395,605	49.0%	2,451,040	27.3%	2,130,980	23.7%	8,977,625	100.0%
1990	4,454,070	49.7%	2,252,920	25.1%	2,255,865	25.2%	8,962,855	100.0%
1991	4,197,680	50.0%	2,094,160	24.9%	2,110,085	25.1%	8,401,925	100.0%
1992	3,819,375	47.0%	2,125,405	26.2%	2,179,195	26.8%	8,123,975	100.0%
1993	4,040,620	47.1%	2,266,080	26.4%	2,278,330	26.5%	8,585,030	100.0%
1994	4,134,885	46.7%	2,381,250	26.9%	2,330,395	26.3%	8,846,530	100.0%
1995	4,268,675	47.3%	2,453,380	27.2%	2,309,400	25.6%	9,031,455	100.0%
1996	4,650,095	49.1%	2,322,445	24.5%	2,492,845	26.3%	9,465,385	100.0%
						4%	9,637,375	100.0%
						a	n/a	n/a
						a	n/a	n/a
						7%	9,048,361	100.0%
						5%	8,972,782	100.0%
						1%	8,703,805	100.0%
						8%	8,956,743	100.0%
						0%	9,898,181	100.0%
						3%	10,297,327	100.0%
						2%	10,272,466	100.0%
						2%	10,054,257	100.0%
						6%	9,678,609	100.0%
						5%	9,039,234	100.0%
						6%	9,128,158	100.0%
						7%	9,123,171	100.0%
						9%	9,628,832	100.0%
						8%	9,357,869	100.0%
						3%	9,567,039	100.0%
						9%	9,943,549	100.0%

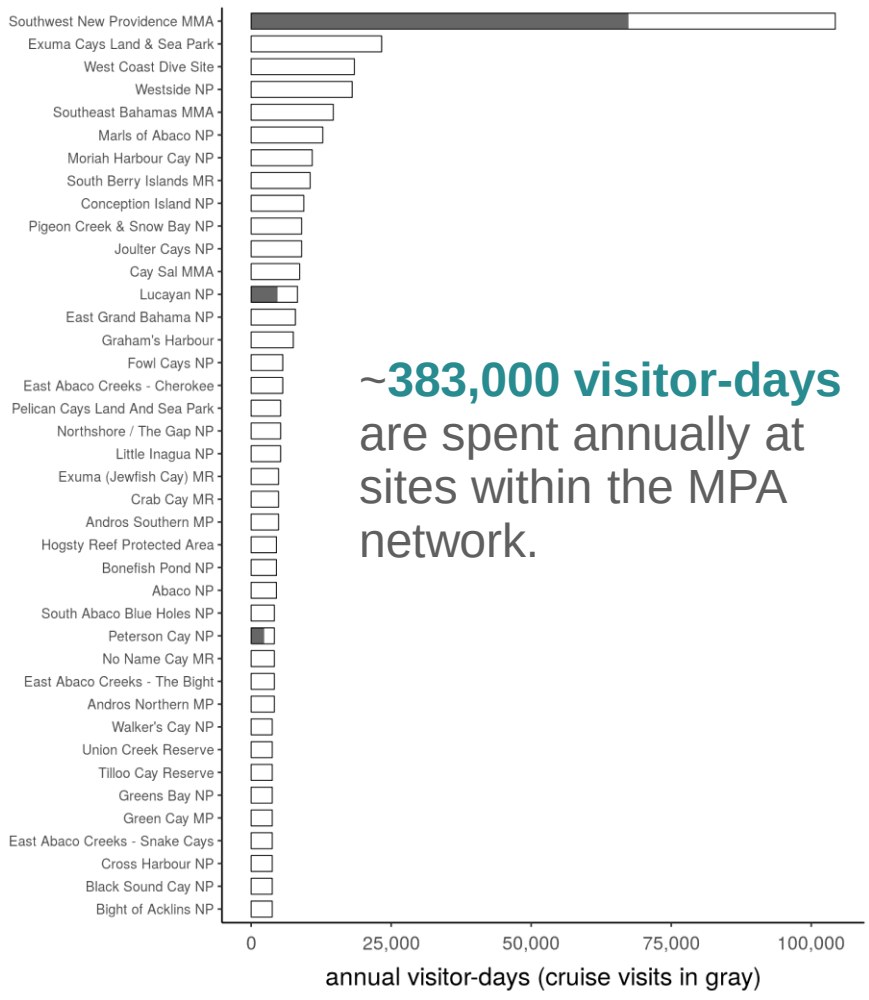
43 Source: Immigration Card and Research & Statistics Dept. Ministry of Tourism

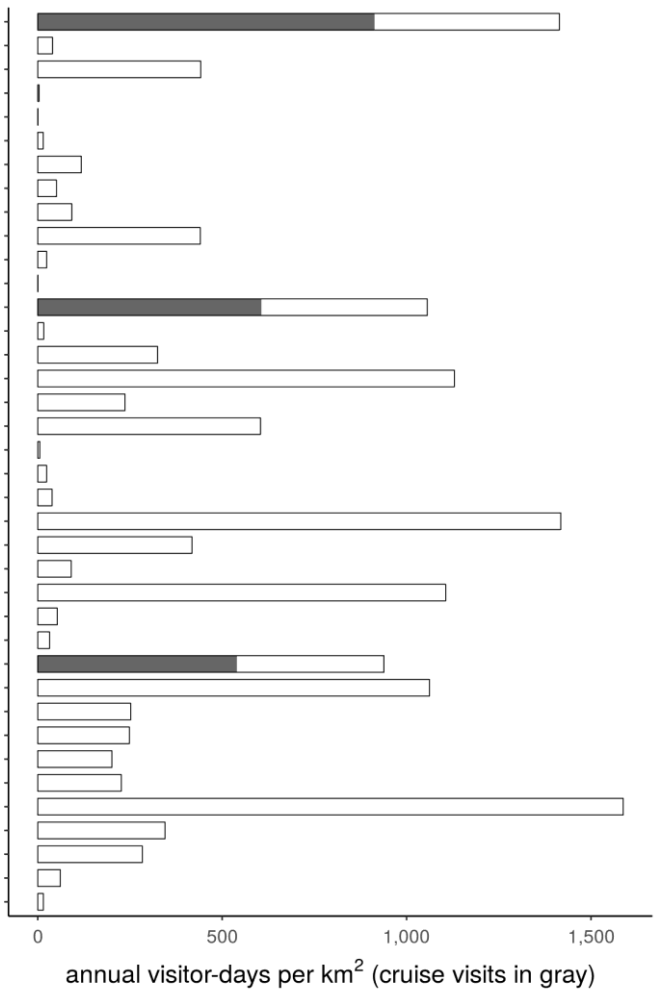
source: air_sea_landed_cruise_arrivals_1998-2015.xls http://www.tourismtoday.com/services/statistics/foreign-air-sea

island	entry_point	air	sea_landed	cruise	year
Grand Bahama	Freeport	159317	82771	698142	2015
Grand Bahama	GBI Yachts	0	2938	0	2015
Grand Bahama	West End	580	20632	0	2015
New Providence	Nassau	1007760	9961	2248632	2015
Abaco	Castaway Cay	0	0	382110	2015
Abaco	Marsh Harbour	70017	1634	0	2015

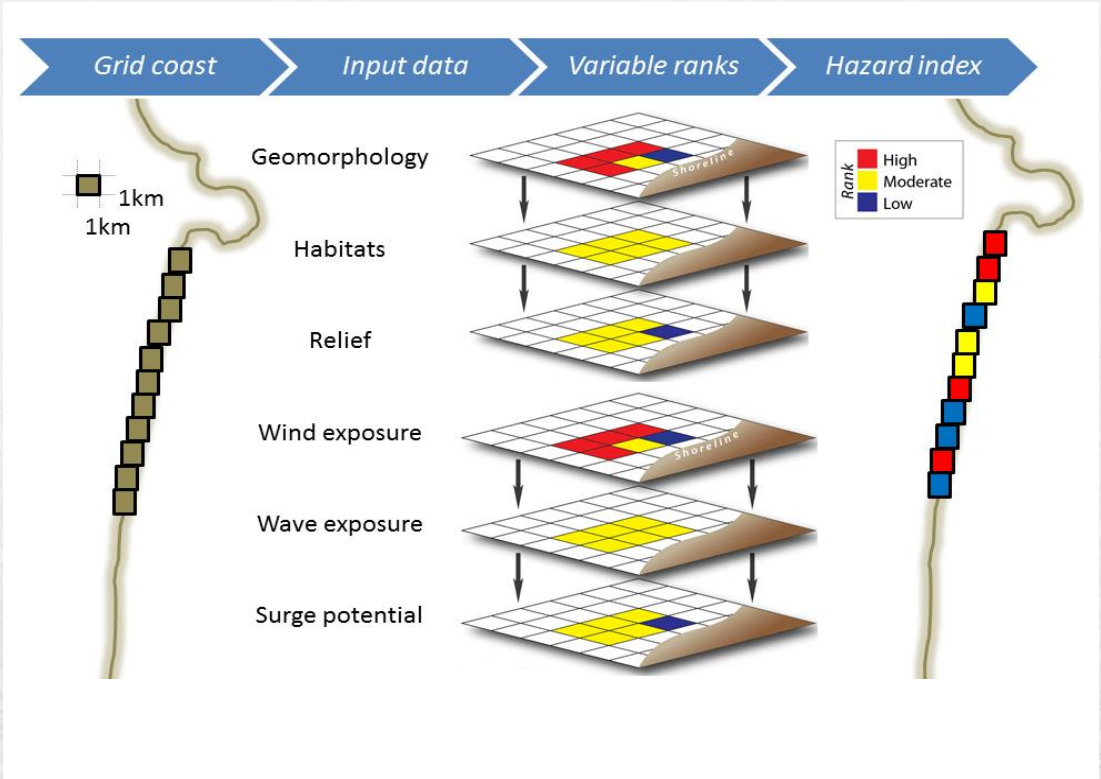
VISITORS

~383,000 visitor-days are spent annually at sites within the MPA network.





COASTAL PROTECTION
APPROACH

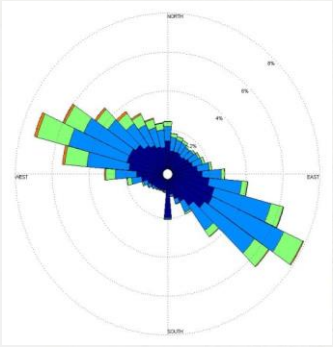


Arkema et al. Nature Climate Change 2013

COASTAL PROTECTION
DATA INPUTS

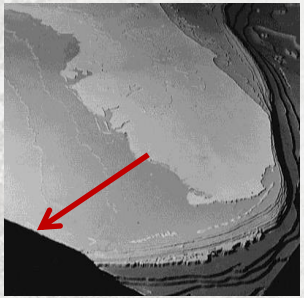
Geomorphology

Habitats



Wind exposure

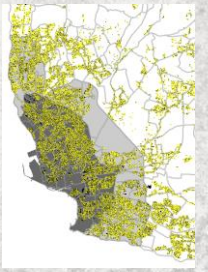
Wave exposure



Storm surge

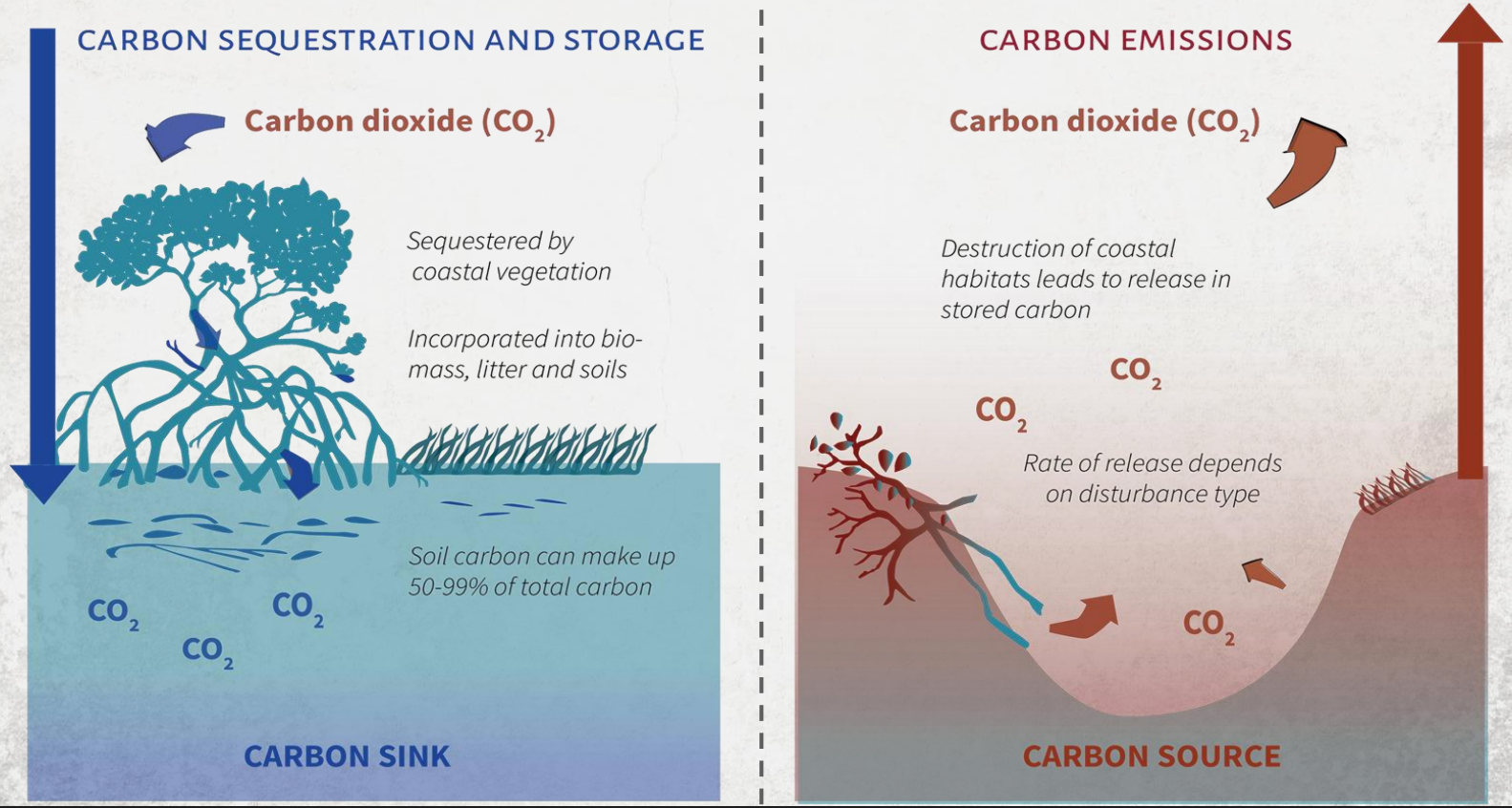
Relief

Sea level rise

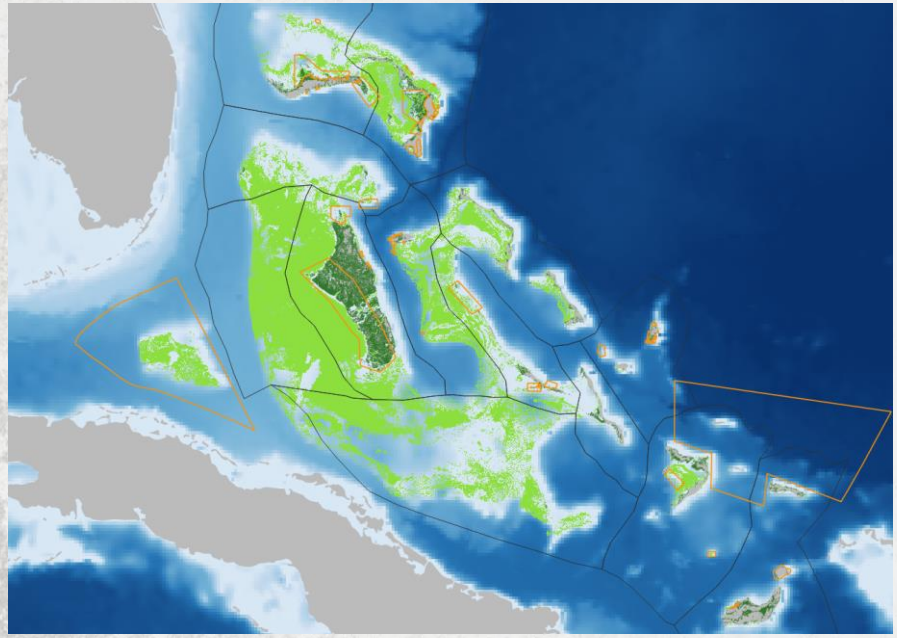


Social & Economic metrics

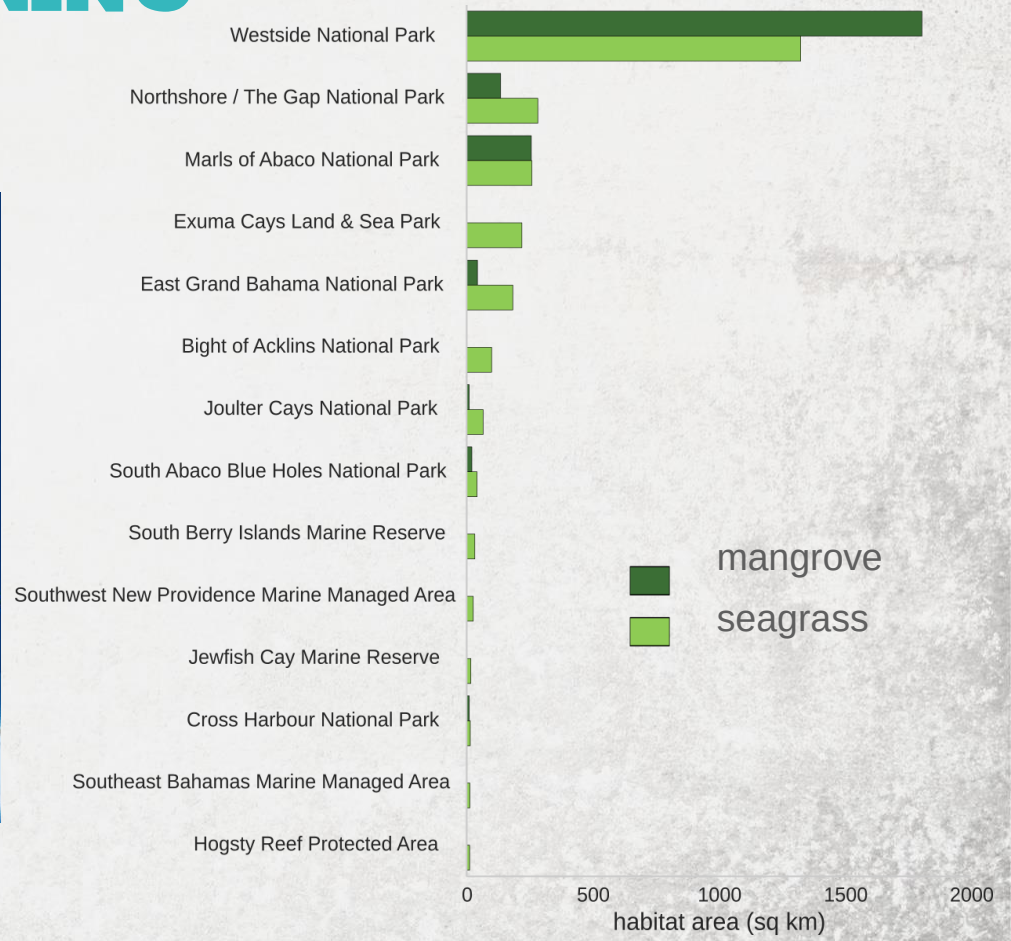
CARBON STORAGE/SEQ PROVIDED BY MANGROVES AND SEAGRASS IN MPAS



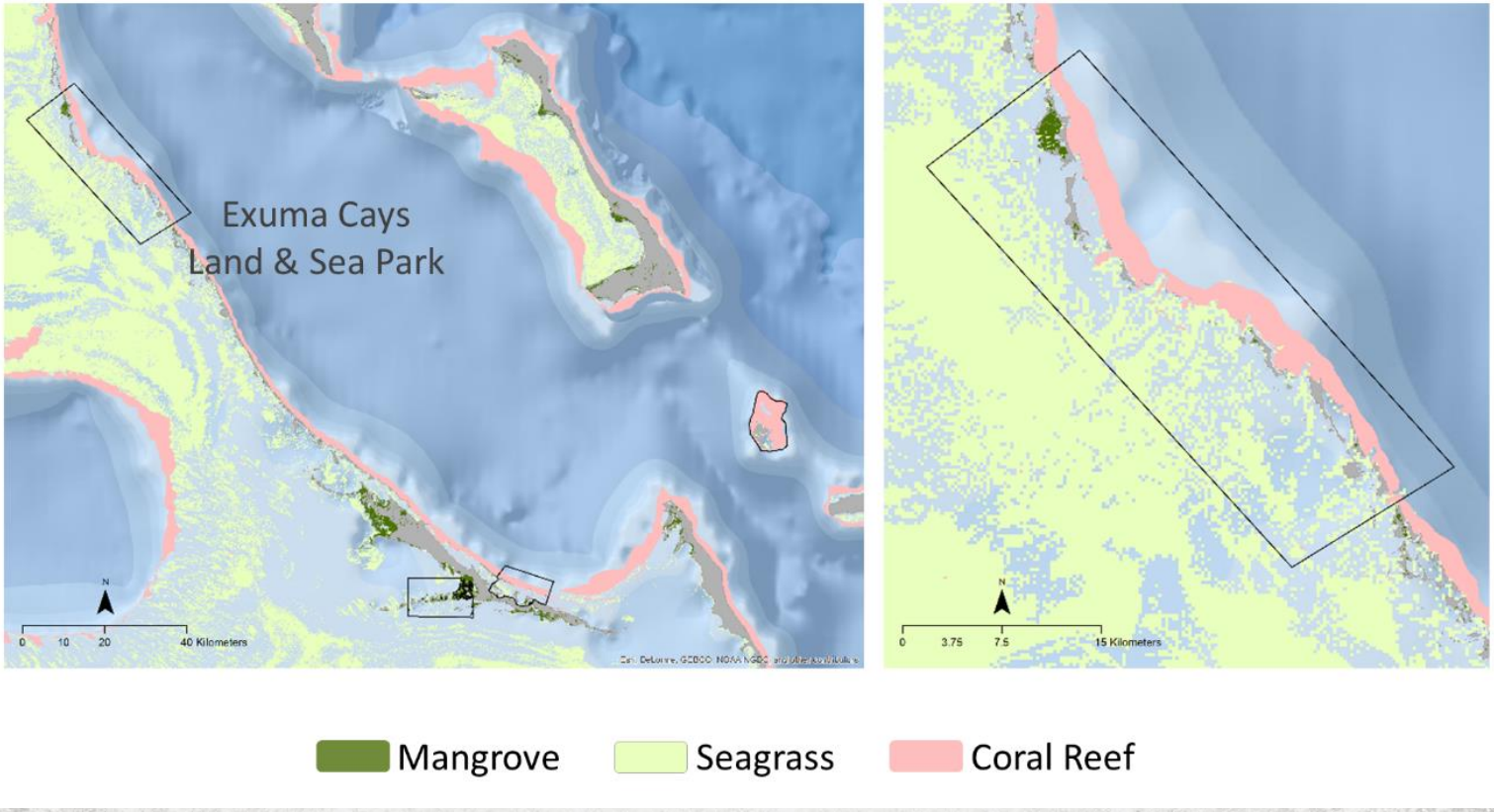
CARBON-STORING HABITATS



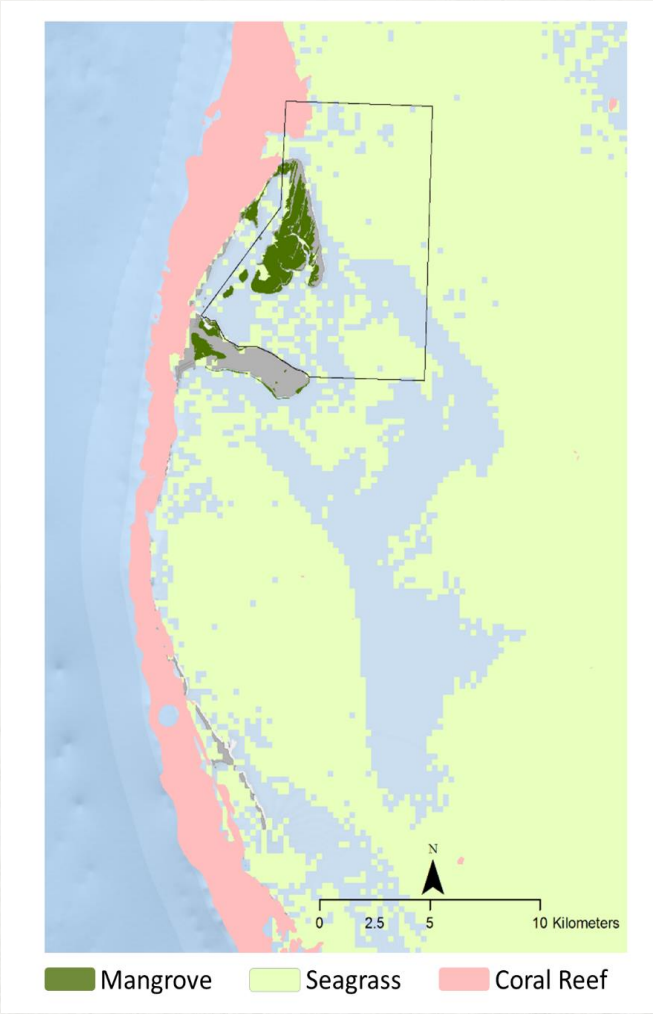
MPAs



EXUMA


Exuma Cays
Land & Sea Park
N
0 10 20 40 Kilometers
N
0 3.75 7.5 15 Kilometers
Mangrove
Seagrass
Coral Reef

BIMINI

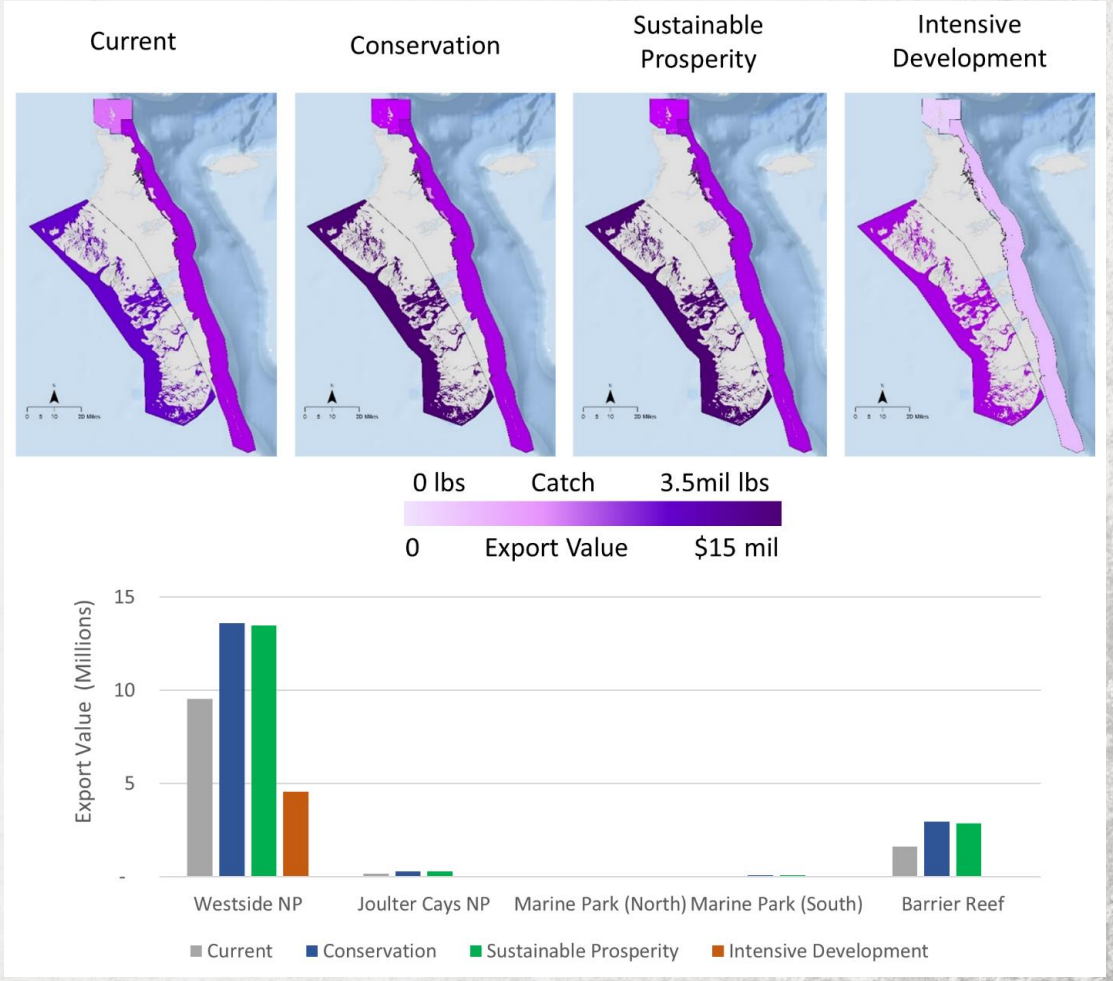


ANDROS


Joulter Cays National Park
N. Marine Park
S. Marine Park
barrier
reef area
Westside
National Park
N
0
12.5
25
50 Kilometers
Mangrove
Seagrass
Coral Reef

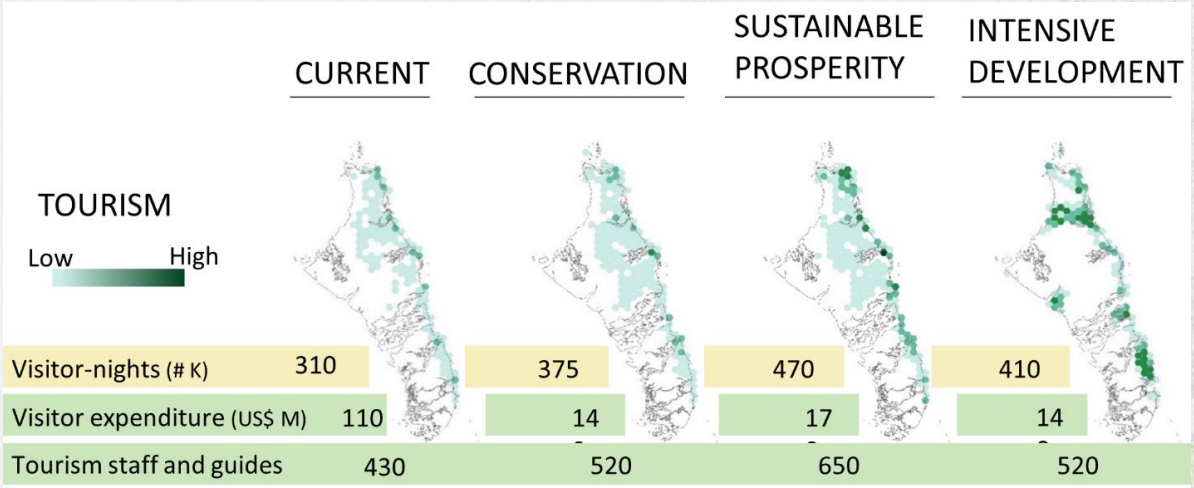
ANDROS
FISHERIES

- Nursery habitats within Andros's MPAs contribute **3.5 million lbs**. in catch and **$14.5 million in export value**
- The Master Plan (sustainable prosperity scenario) could increase this to $21. million

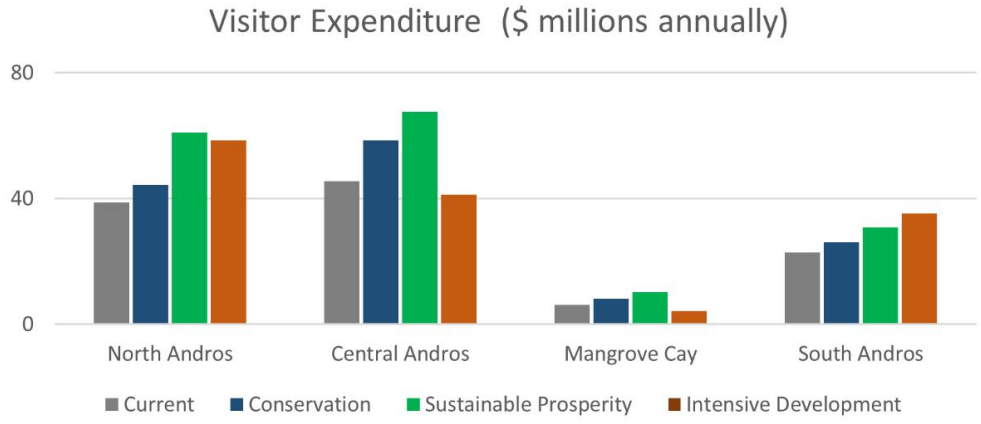


ANDROS TOURISM

- Andros' MPAs support **$113 million in visitor expenditure**
- The Master Plan (Sustainable Prosperity scenario) would expenditure to $170 million

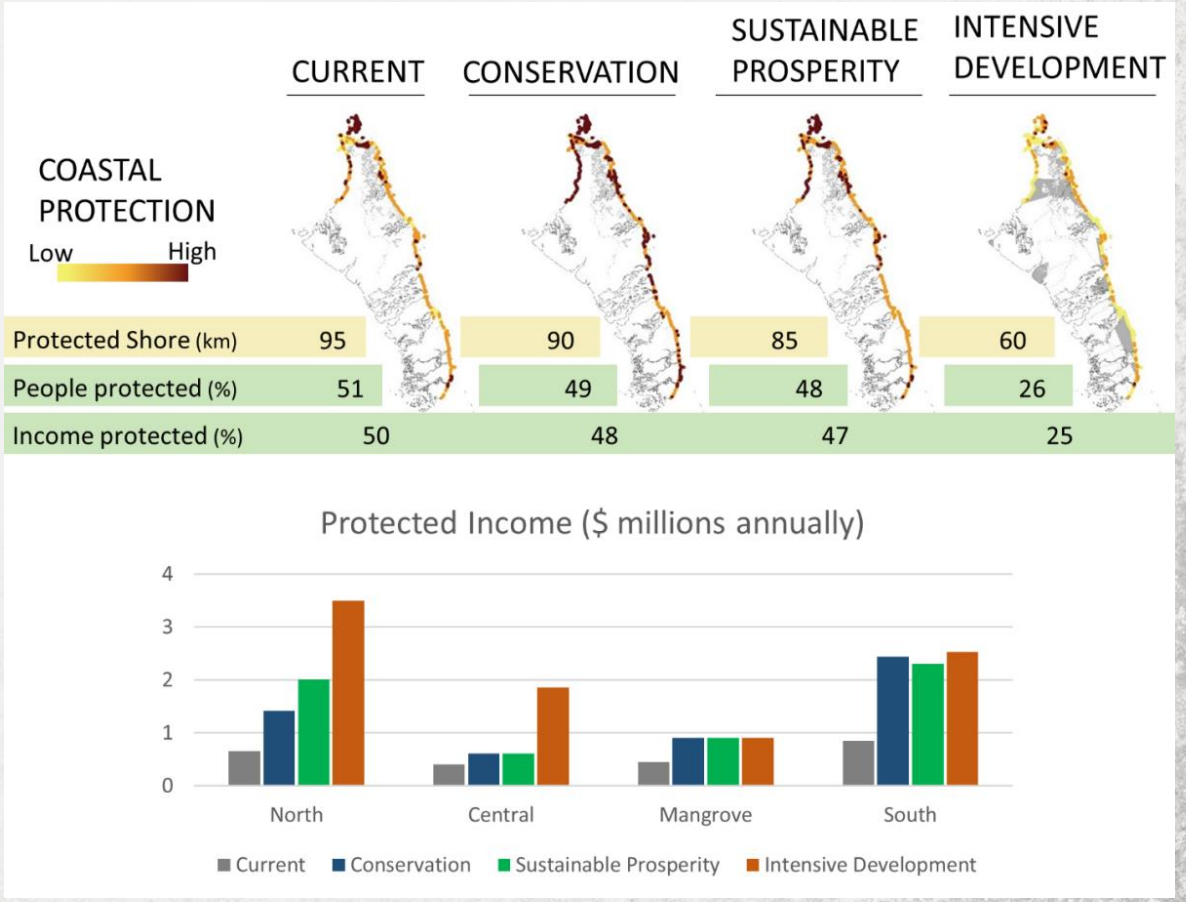


	CURRENT	CONSERVATION	SUSTAINABLE PROSPERITY	INTENSIVE DEVELOPMENT
Visitor-nights (# K)	310	375	470	410
Visitor expenditure (US$ M)	110	14	17	14
Tourism staff and guides	430	520	650	520



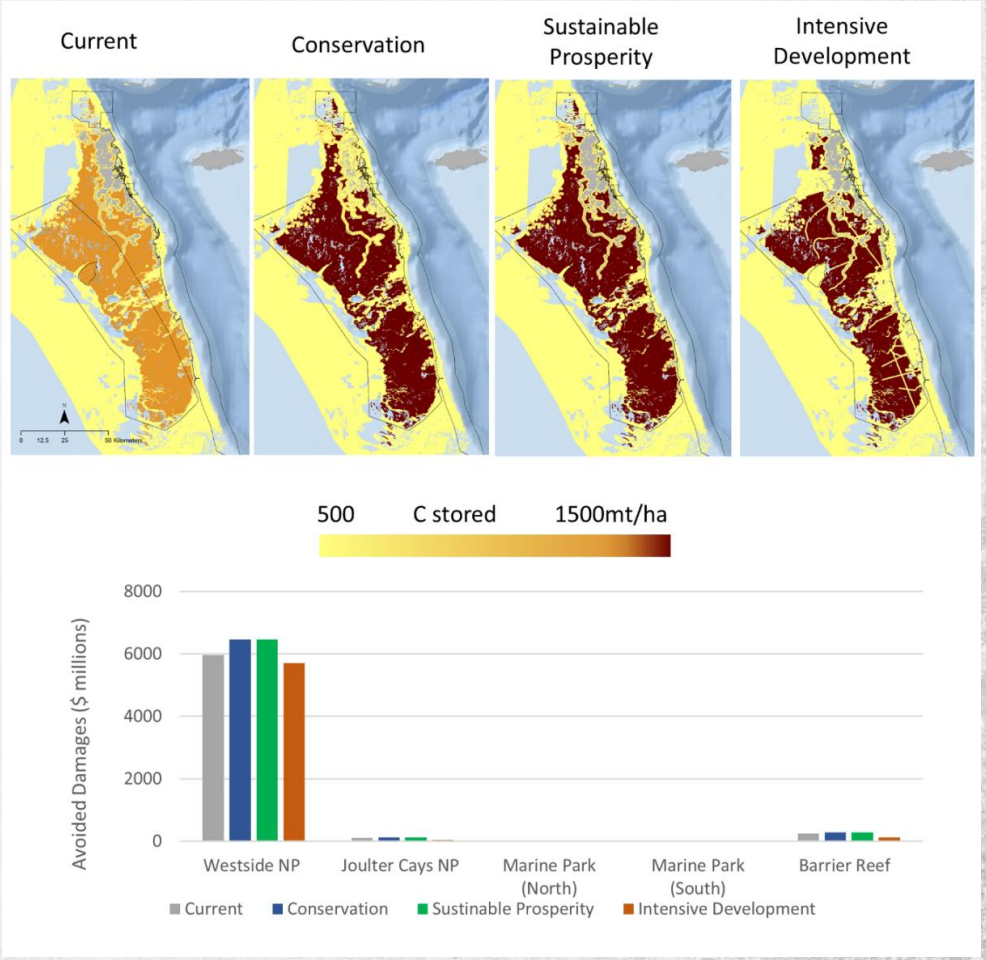
ANDROS
COASTAL PROTECTION

- **Coastal habitats** such as mangrove and coppice forests, coral reefs and seagrass **reduce the risk to 50% of the islands' population, protecting $2.4 million in income**
- The Master Plan (Sustainable Prosperity scenario) would protect 60% of the islands' population

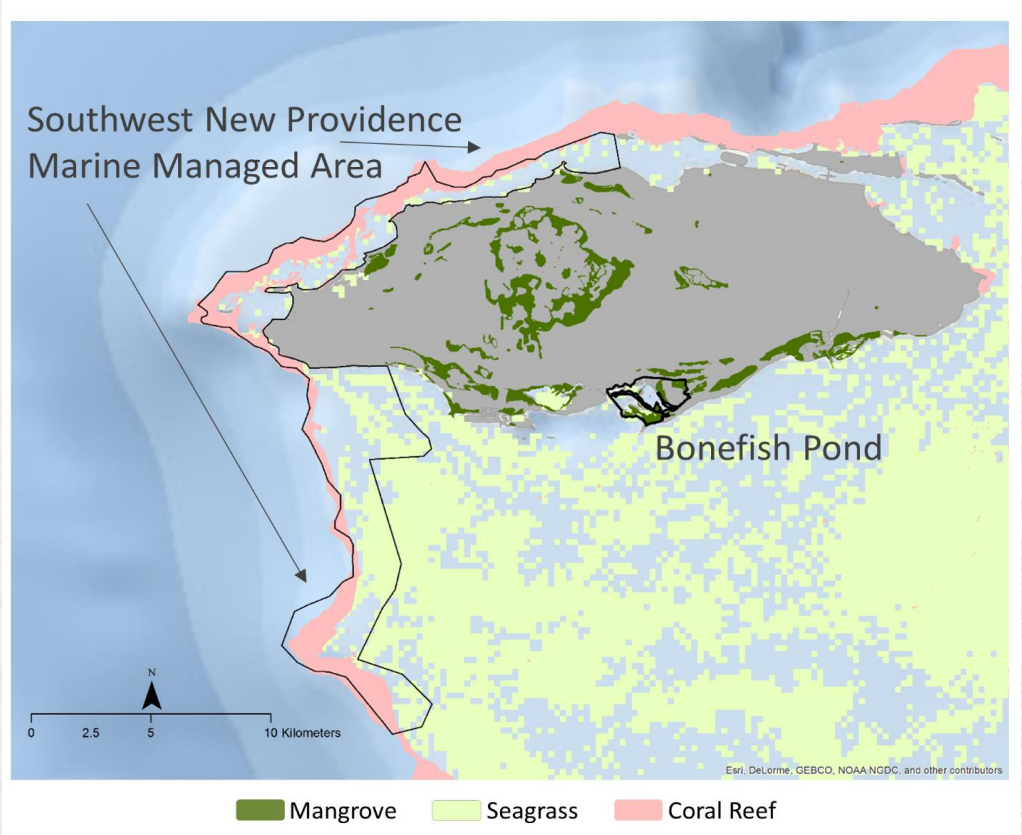


ANDROS
CARBON STORAGE

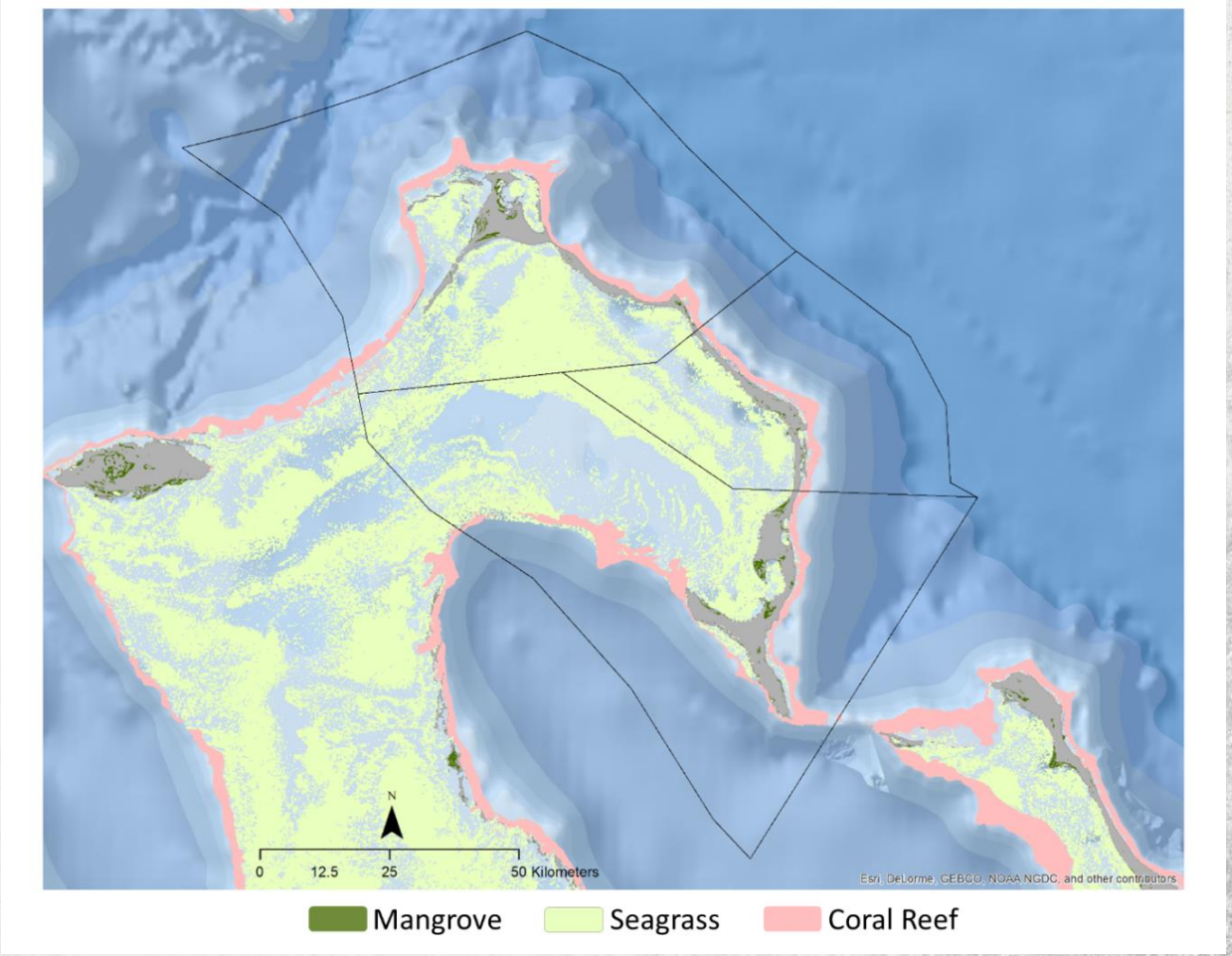
- Carbon storing mangrove and seagrass in Andros West Side National Park are worth **$6 billion in avoided damages** from emissions.
- These assets could increase by 3% under the Master Plan (Sustainable Development Plan)



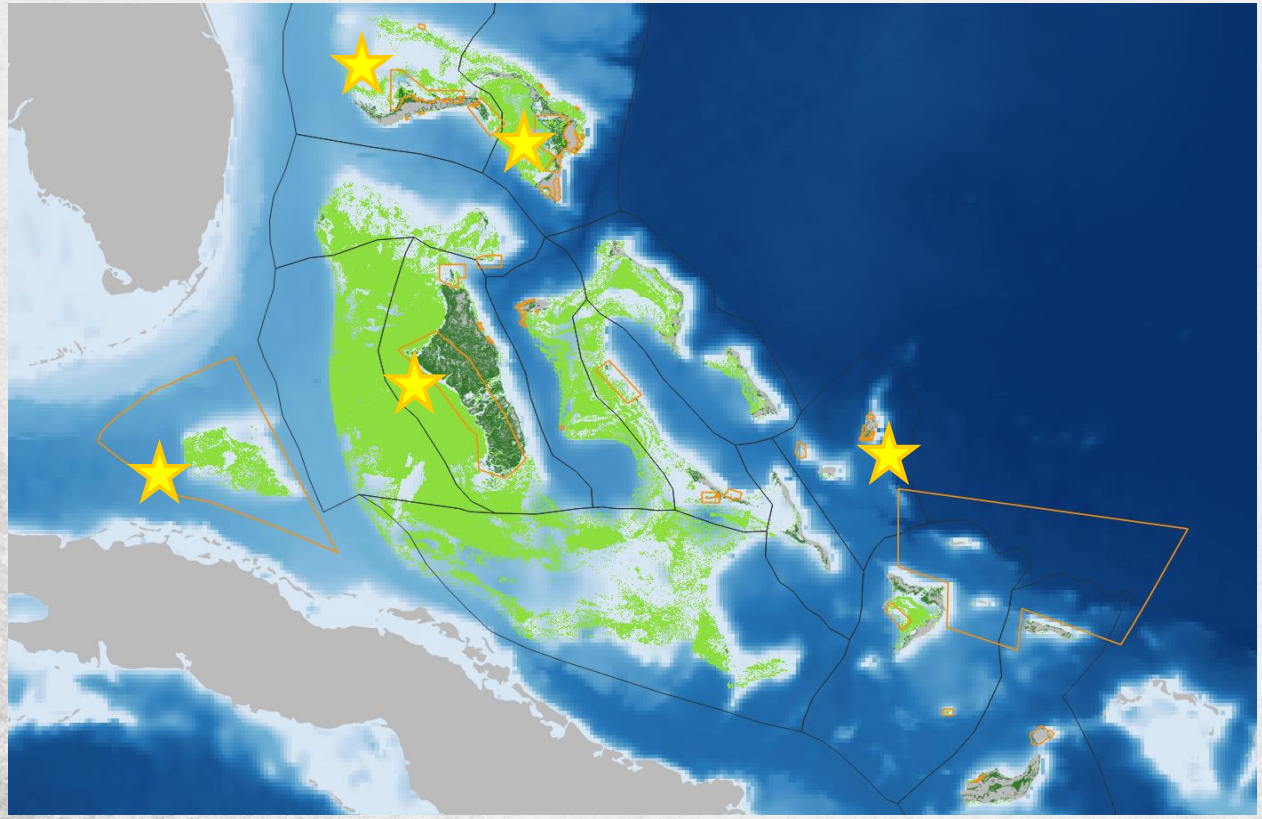
SOUTHWEST MARINE MANAGED AREA



ELEUTHERA


N
0
12.5
25
50 Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Mangrove
Seagrass
Coral Reef

Distribution of mangroves and seagrass among shelf areas



Seagrass

Mangroves

MPAs