The Coastal Protection Services of Mangroves in the Philippines: Preliminary Workshop, July 2016: Day 2

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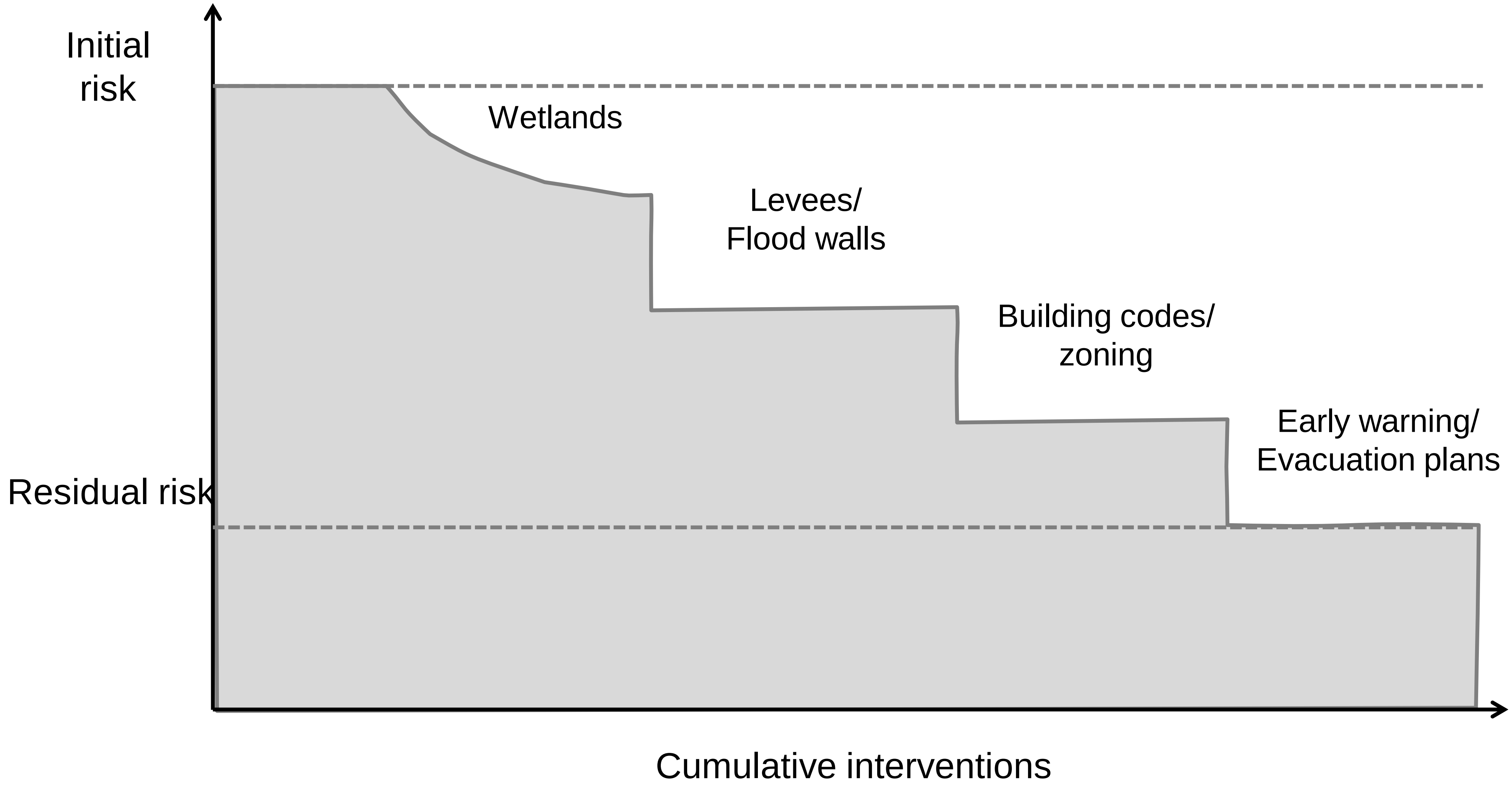
The Coastal Protection Services of Mangroves in the Philippines: Preliminary Workshop – Agenda

1. Risk and Hazard Assessment - How do engineers approach coastal risk assessment (30 min)

2. Assessing Coastal Protection Value of coastal habitats – Methods and Models – Part 1 (45 min)
    1. Methods for physical (engineering) assessments of natural coastal protection values
    2. Methods for Cost-Effectiveness Analyses
    3. Special considerations when dealing with coastal habitats – bio-physical, economic, etc.

Risk reduction cascade



Spalding et al. 2014

Combinations of structural and non-structural measures

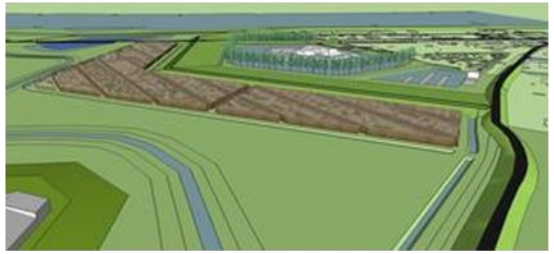
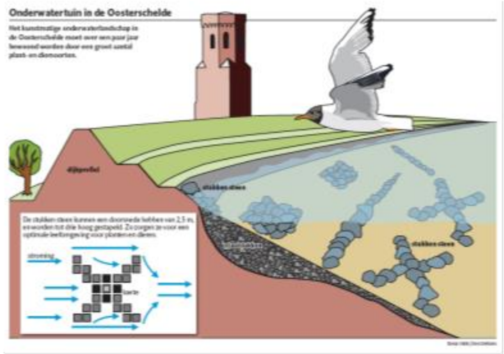
Soft solutions → **Hybrid solutions** → **Hard solutions**

more space, no dike → ***less space, dike***

flexible and cost-effective → ***less flexible, extra investment***





Van Wesenbeeck, 2015. *IAHR 2015 Keynote*

Typhoon Haiyan (2013)

Typhoon Haiyan: Philippines to plant more mangroves

Published on
Nov 24, 2013
6:37 PM

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Mangrove swamps along the the Poyuy Poyuy River in Sabang, on the island pr
Palawan in the Philippines. The Philippines said it will plant more mangrove ar
prevent a repeat of the deadly storm surges that claimed hundreds of lives duri
Typhoon Haiyan earlier this month. -- ST FILE PHOTO: LEE SIEW HUA

MANILA (AFP) - The

mes.com/fi

4 December 2013, 5.31pm AEST

Mangroves, nature's shield against typhoons and tsunami

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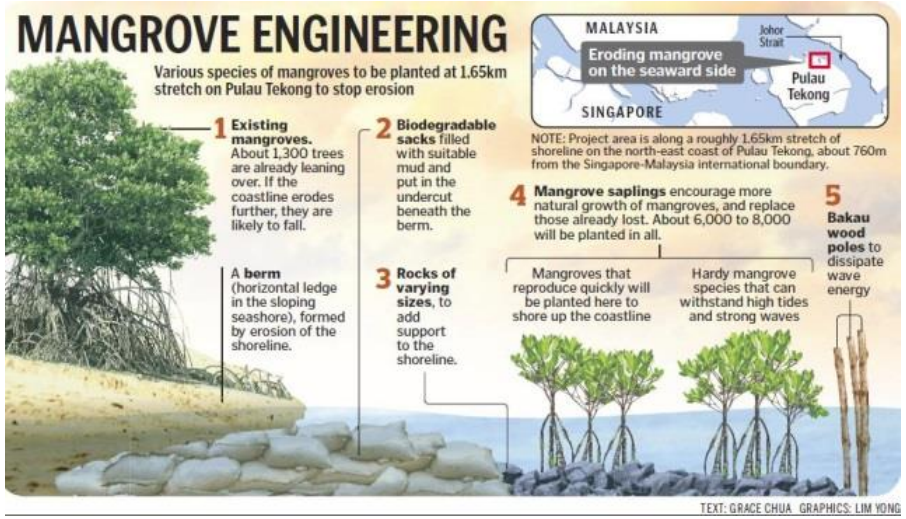
Saved by the Mangroves? A Philippine town dodges Haiyan's storm surge

PRI's The World

Van Wesenbeeck, 2015. *IAHR 2015 Keynote*

Engineering Ecosystems for Coastal Protection

ECOLOGY



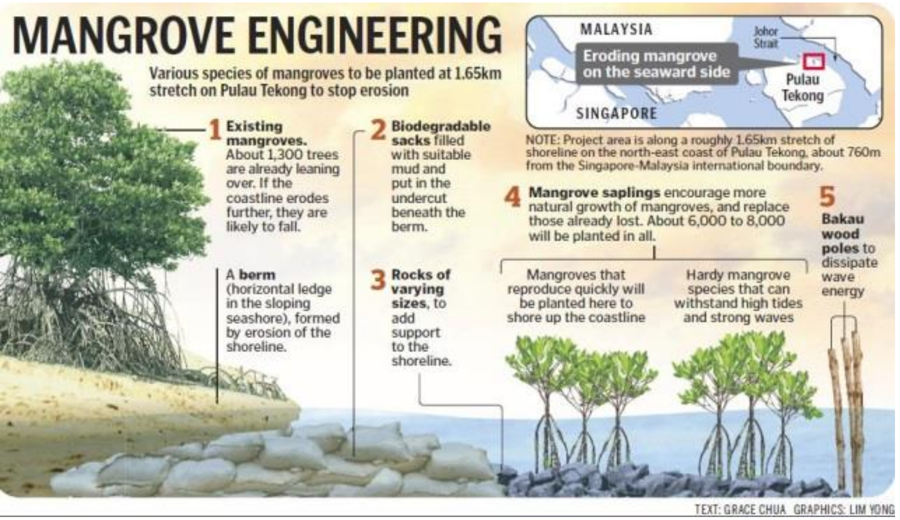
ENGINEERING (CEM)

Problem
↓
Status quo
↓
Alternatives
↓
Evaluation of effectiveness
↓
Comparison of alternatives
↓
Selection of best alternative

Reguero, et al. in prep.

Valuing Ecosystems for Coastal Protection

ECOLOGY



ENGINEERING (CEM)

Problem
↓
Status quo
↓
Alternatives
↓
Evaluation of effectiveness
↓
Comparison of alternatives
↓
Selection of best alternative

ECONOMICS (SEEA – EEA)

1. Land Cover Accounting
2. Land Use Accounting
3. Framing the Measurement of Ecosystem Conditions
4. Carbon Stock Accounting
5. Biodiversity Stock Accounting
6. Water Stock Accounting
7. Accounting for Ecosystem Services
8. Integrating Ecosystem Accounting with National Accounts

Adapted from Reguero, et al. in prep. and Fulleros, 2016.

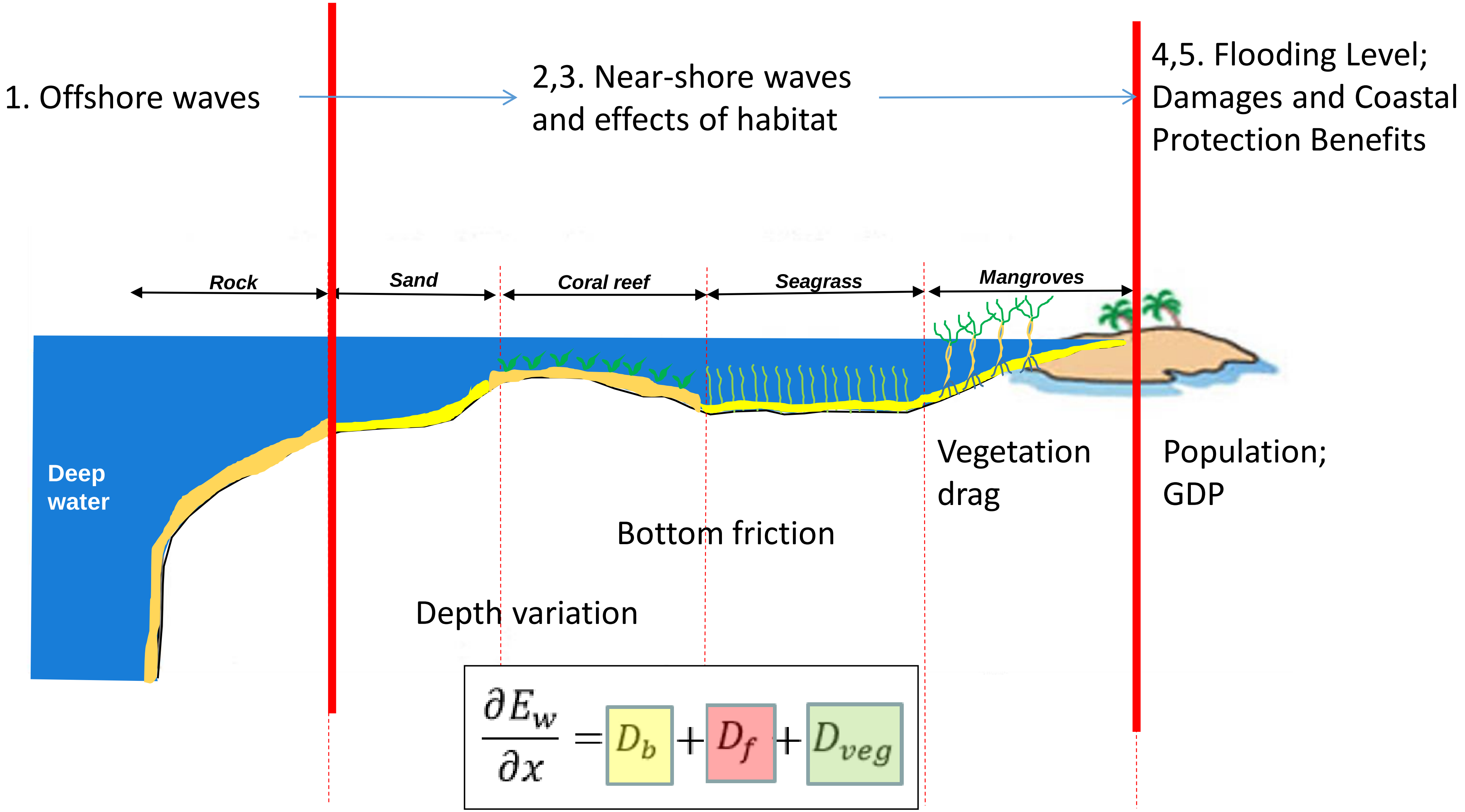
Engineering Requirements for Different Coastal Defense Options

	Artificial Reefs	Mangroves and Marshes	Beach & Dunes	Low-crested and submerged structures	Floodwalls	Levees	Storm Surge Barriers
Space requirement	*	***	**	*	*	*	*
Hazard intensity	**	**	**	**	**	**	***
Probability of functional failure	**	***	**	**	**	***	***
Probability of structural failure							
Number of additional services	***	**	**	*	-	*	-
Restriction by development	*	***	*	*	-	-	-
Influence in development	*	***	***	*	*	*	**
Construction cost	*	*	*	*	*	**	***
Maintenance costs	-	-/*	*	*	*	**	**
Sustainability / Adaptation to SLR	***	***	***	-	-	-	-
Sustainability / other threats from CC							
Fragility / reliability / Design threshold	*	*	*	**	**	***	***
Wave Attenuation/Protection	***	**	***	***	**	***	*
Surge Attenuation/Protection	*	**	**	*	**	**	***

Table 1. Qualitative ranking of importance of different design factors for several green and gray coastal defenses. *** = High; *= Low.

Reguero, et al. in prep.

Framework for Estimating Coastal Protection Values



From WB WAVES 2016, Chapter 4

Ocean Waves→Reef front

(Snell's law)

$$\frac{c_1}{sin\alpha_1} = \frac{c_2}{sin\alpha_2}$$

$$\frac{\partial E_w}{\partial x} = \boxed{D_b} + \boxed{D_f} + \boxed{D_{veg}}$$

$$D_b = \frac{3\sqrt{\pi}}{16}\rho g \frac{B^3 f_p}{\gamma h^5} H^7$$

Thornton and Guza 1983

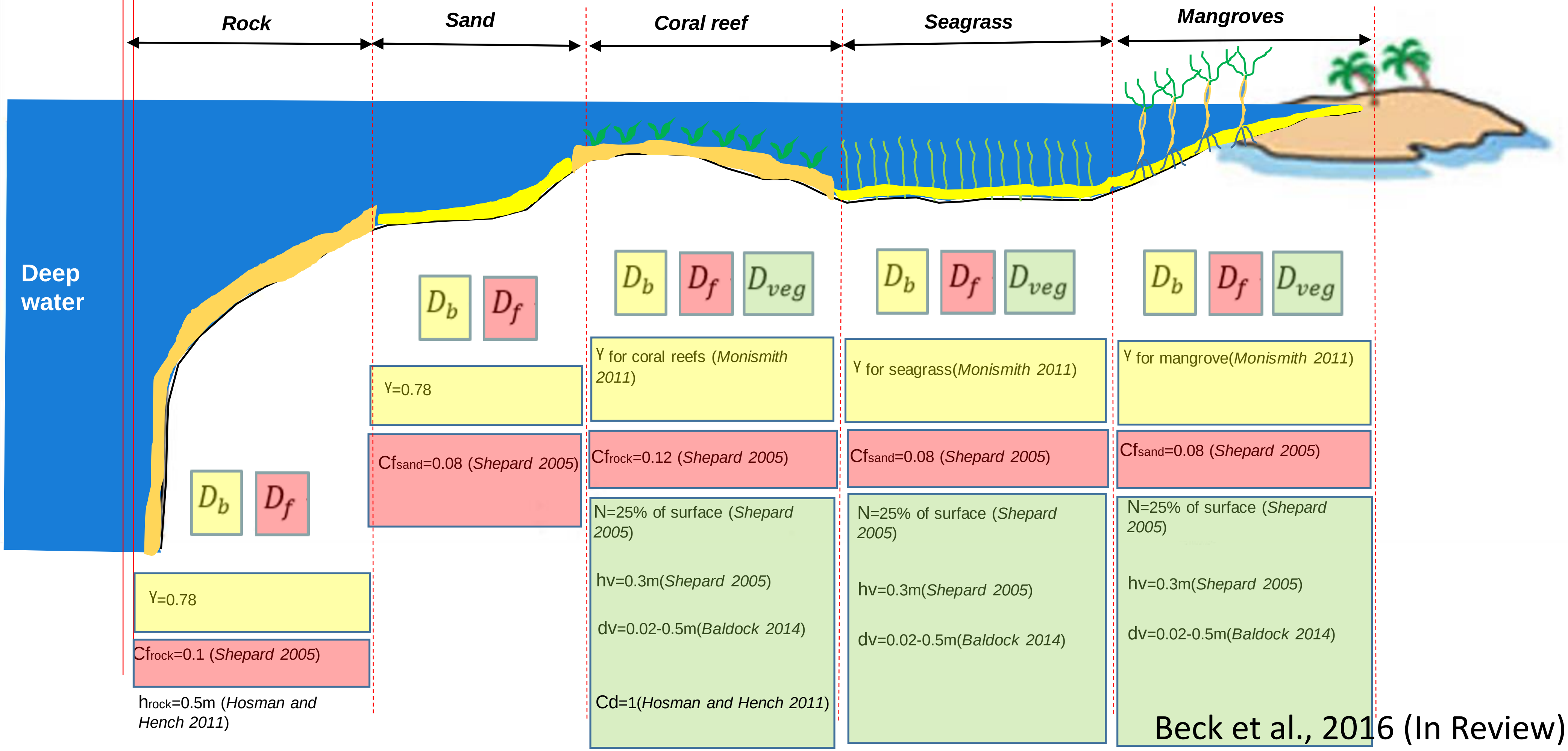
$$D_f = \frac{C_f}{16\sqrt{\pi}}\left(\frac{\sigma}{\sinh kh}\right)^3 H^3$$

Thornton and Guza 1983

$$D_{veg} = \frac{1}{2\sqrt{\pi}}\rho C_d \left(\frac{kg}{2\sigma}\right)^3 \frac{[D_r + D_t + D_c]}{3k\cosh^3 kh} H^3$$

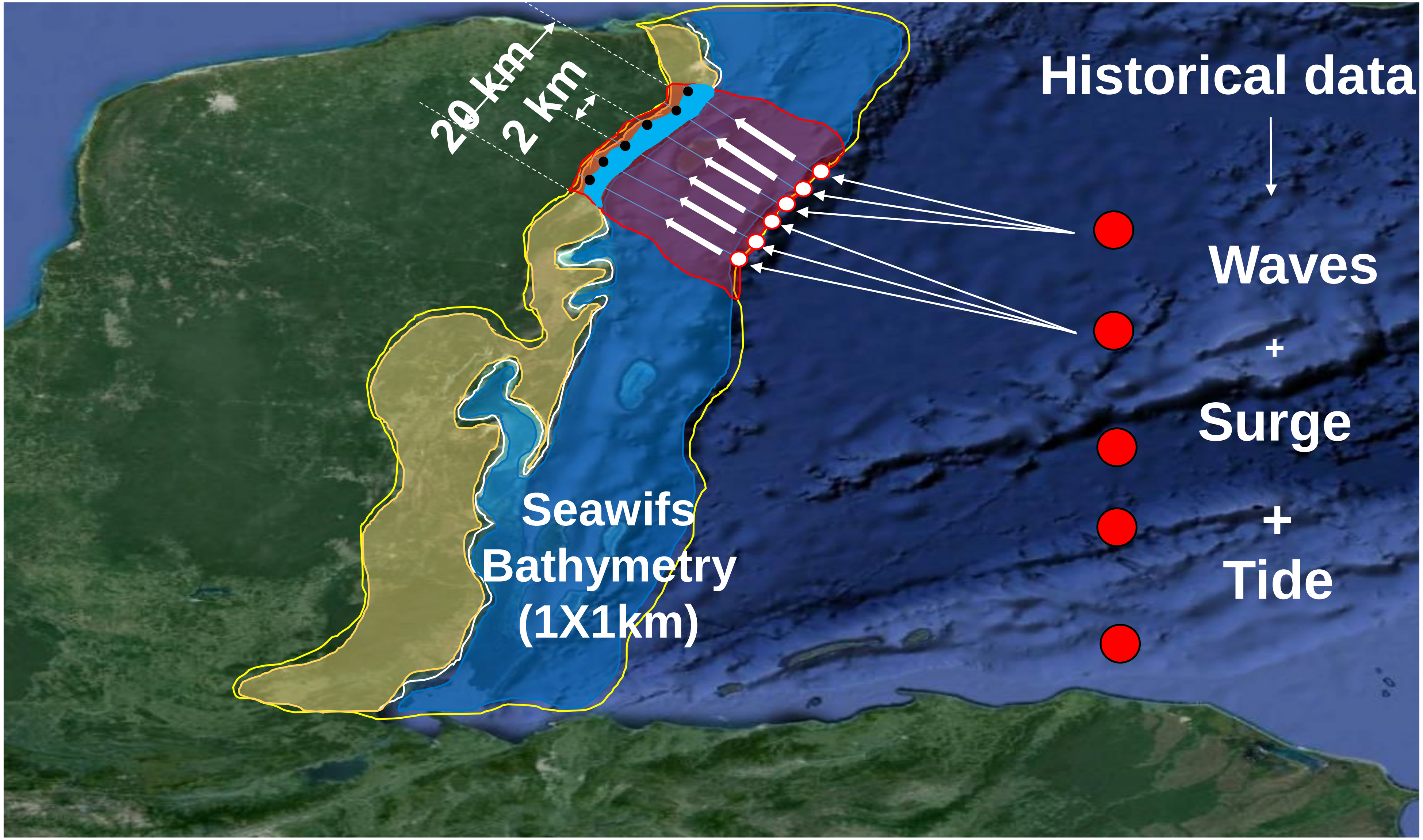
$$\boxed{N_v b_v(\sinh^3 k\alpha_v h + 3\sinh k\alpha_v h)}$$

Dalrymple et al. 1984, Mendez and Losada 2004



Beck et al., 2016 (In Review)

Coastal Protection Model – Setup for Global Model



Adapted from Beck et al. 2016 (In Review)

Global Coastal Protection Model – Expected Benefits from Reefs

Reef benefits for flood protection from 100-year event in terms of exposure of built capital to flooding with reef loss ($US billions) and relative to total national built capital.

	Built capital flooded (100-yr)		% of the national built capital	
1	Indonesia	36.48	Cayman Islands	6.81
2	Philippines	31.14	Belize	4.28
3	Malaysia	27.07	Grenada	3.76
4	Cuba	19.04	Bahamas	3.70
5	Mexico	18.87	Jamaica	2.67
6	United Arab Emirates	7.84	Cuba	2.61
7	Saudi Arabia	7.29	Philippines	2.37
8	United States	6.55	Dominican Republic	2.19
9	Dominican Republic	4.43	Malaysia	1.54
10	Thailand	2.86	Antigua and Barbuda	1.50
11	Jamaica	2.43	Seychelles	1.14
12	Vietnam	2.26	Turks and Caicos Islands	0.88
13	Taiwan	1.83	New Caledonia	0.83
14	Myanmar	1.04	Pitcairn Islands	0.74
15	Bahamas	0.77	Indonesia	0.72

Beck et al. 2016
(In Review)

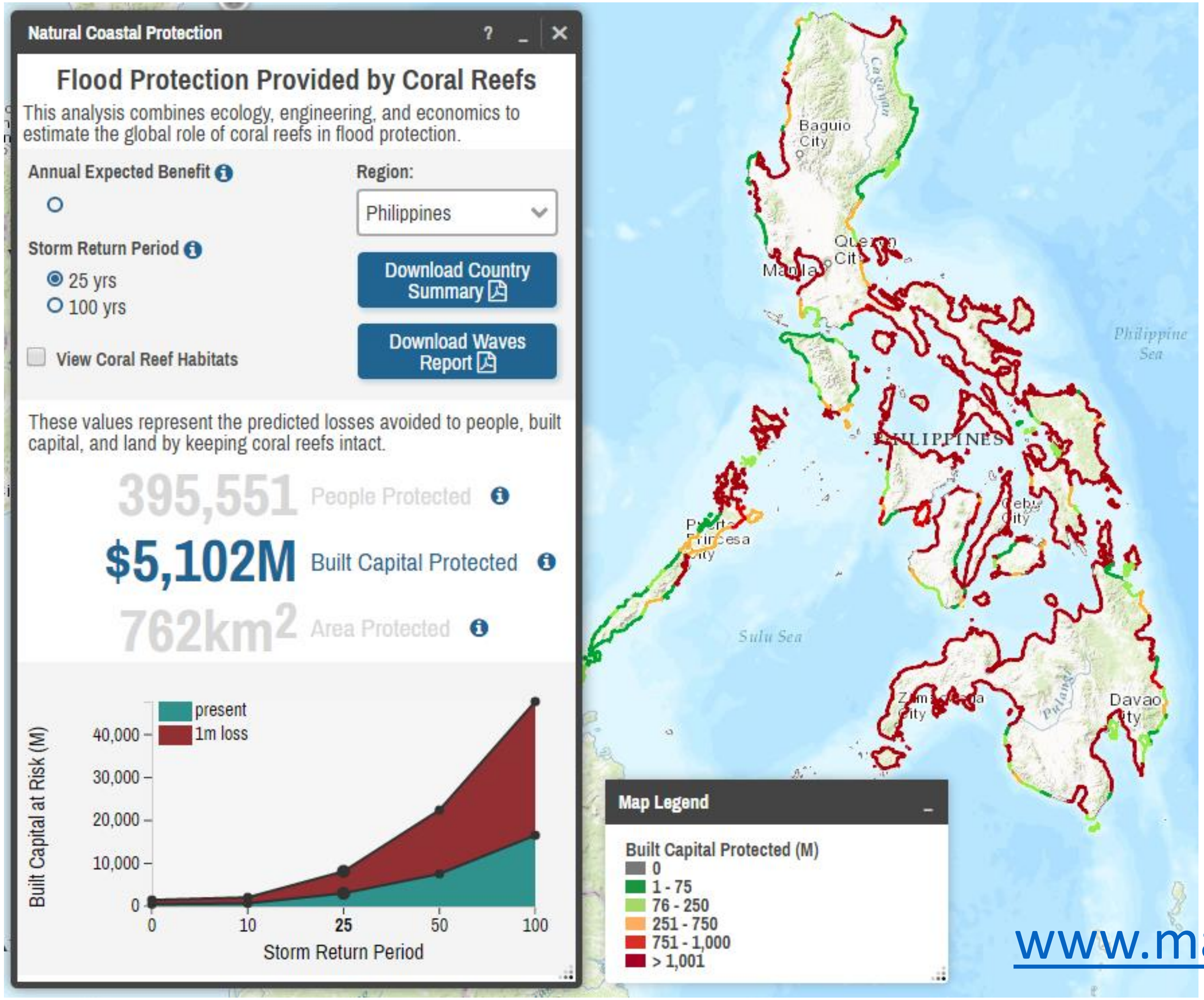
Global Coastal Protection Model – Expected Benefits from Reefs

Annual expected benefit of reefs for flood protection in terms of annual averted damages to built capital ($ millions per year) and relative to Gross Domestic Product (GDP).

Annual Averted Damages ($ millions)			Annual Averted Damages/GDP	
1	Indonesia	639	Cayman Islands	0.98
2	Philippines	590	Belize	0.37
3	Malaysia	452	Grenada	0.30
4	Mexico	452	Cuba	0.25
5	Cuba	401	Bahamas	0.16
6	Saudi Arabia	138	Jamaica	0.14
7	Dominican Republic	96	Philippines	0.13
8	United States	94	Antigua and Barbuda	0.13
9	Taiwan	61	Dominican Republic	0.11
10	Jamaica	46	Malaysia	0.09
11	Vietnam	42	Seychelles	0.06
12	Myanmar	33	Turks and Caicos	0.06
13	Thailand	32	Guadeloupe	0.05
14	Bahamas	14	Indonesia	0.04
15	Belize	9	Solomon Islands	0.04

Beck et al. 2016 (In Review)

Mapping Ocean Wealth – Country Snapshot



www.maps.oceanwealth.org

MODELLING EXAMPLE – KANIKA SANDS MANGROVE ISLAND, INDIA

Wave Reduction by Mangroves Case-Study: Study Site

- Mangrove inhabited island
- Cyclone – affected region
- In front of upcoming Dhamra Port

Narayan, 2009

Case-Study: Numerical Model Setup

- Offshore wave parameters from cyclones
- Transformation of offshore waves to near-shore
- Near-shore water levels

Step 1: Offshore Hydrodynamics

- Near-shore bathymetries
- Grid setup

Step 2: Nearshore Hydrodynamics

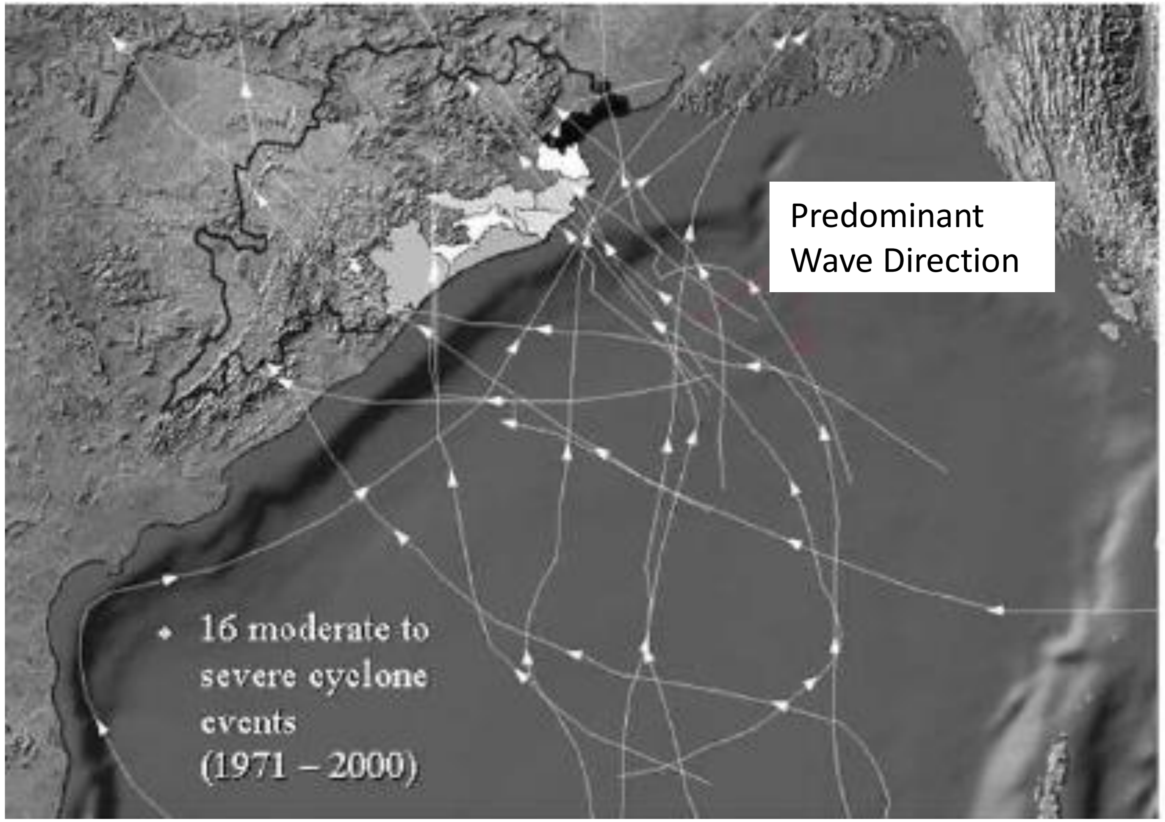
- Vegetation parameters
- Shape of mangrove vegetation patch
- Spatial vegetation density

Step 3: Vegetation Parameters

Narayan, 2009

Step 1: Offshore Hydrodynamics *Data* – Waves and Water Levels

- Offshore wave heights and time periods – from cyclones
- Used as input in SWAN 1-D with simplified offshore bathymetry
- Near-shore surge levels from previous studies

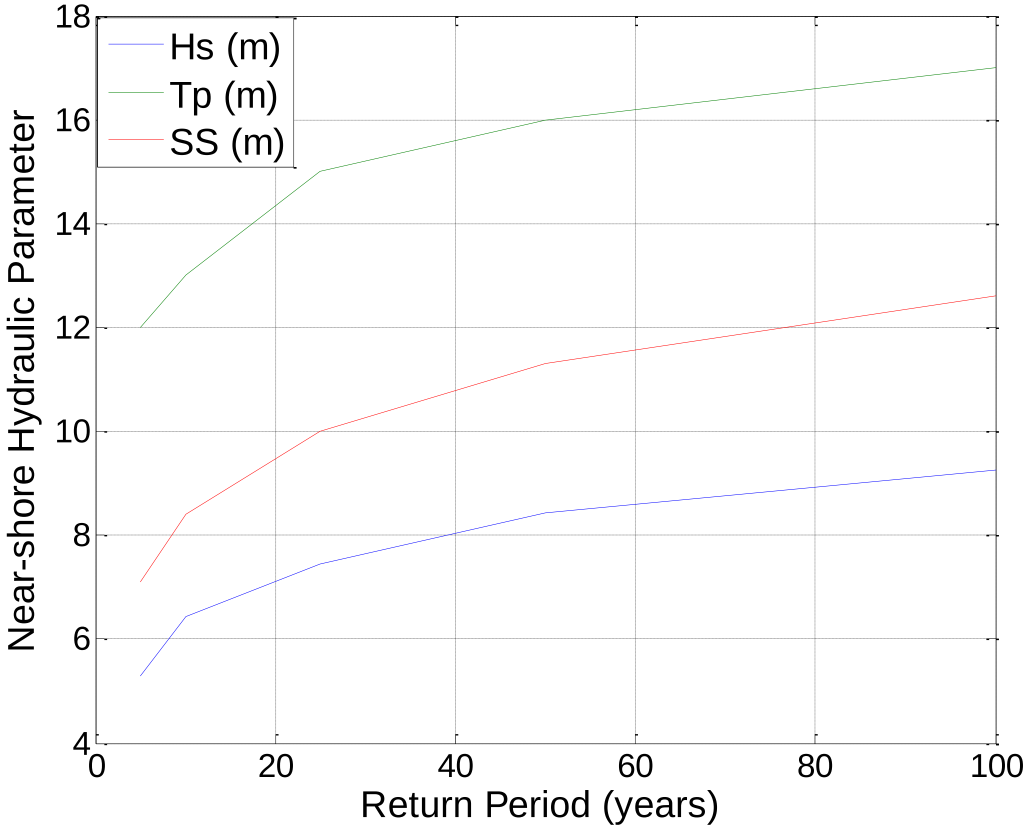


Narayan, 2009

Step 1: Offshore Hydrodynamics *Results* – Waves and Water Levels

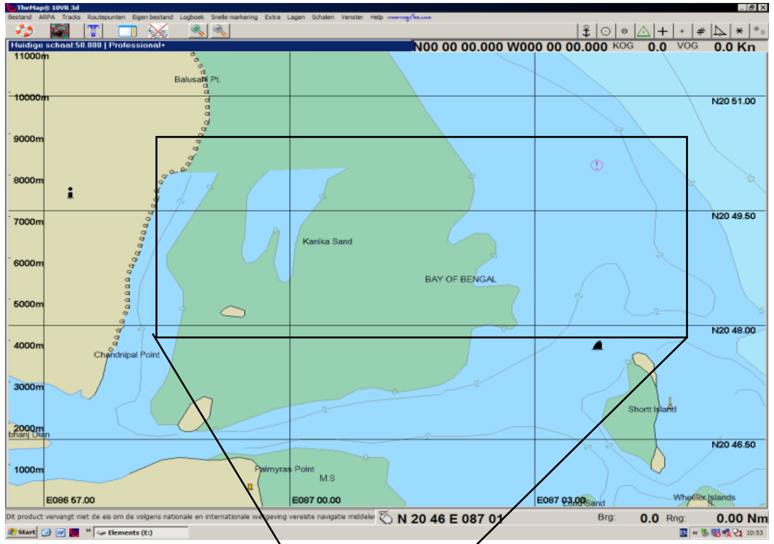
- Wave heights at -11 m and +3 m depths obtained using SWAN 1-D

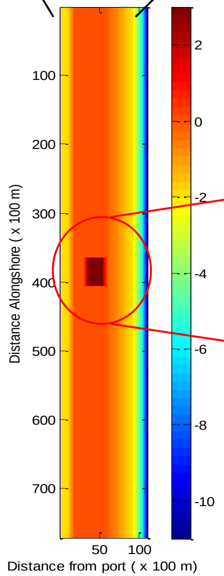
- Extreme Water Levels (EWLs) as sum of surge, tide, SLR

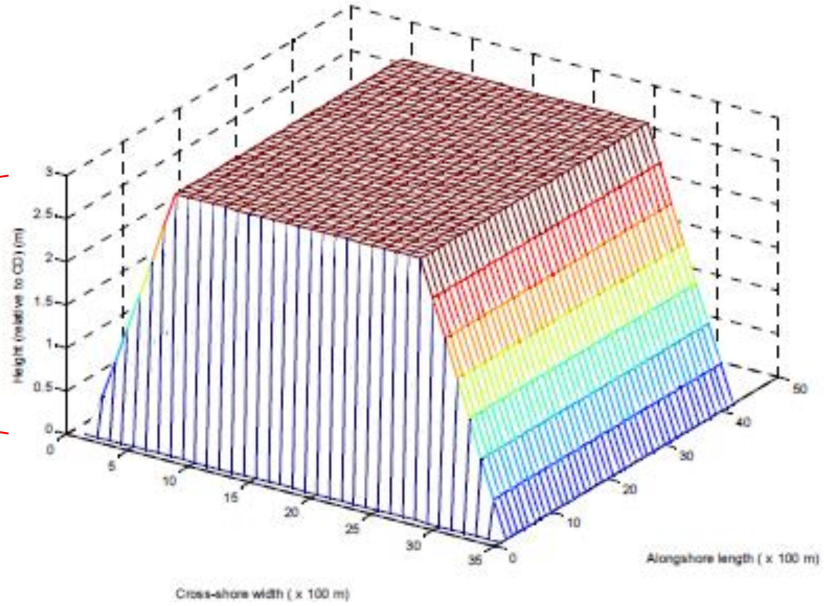


Narayan, 2009

Step 2: Nearshore Hydrodynamics *Data* – Bathymetry

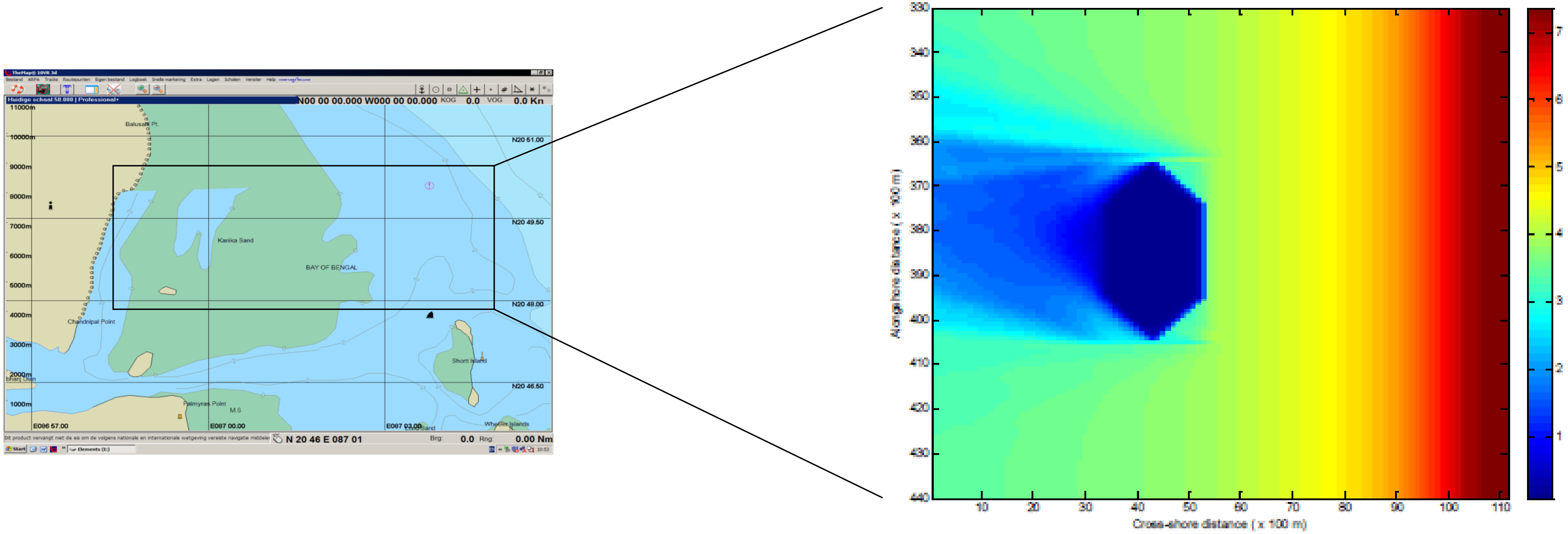






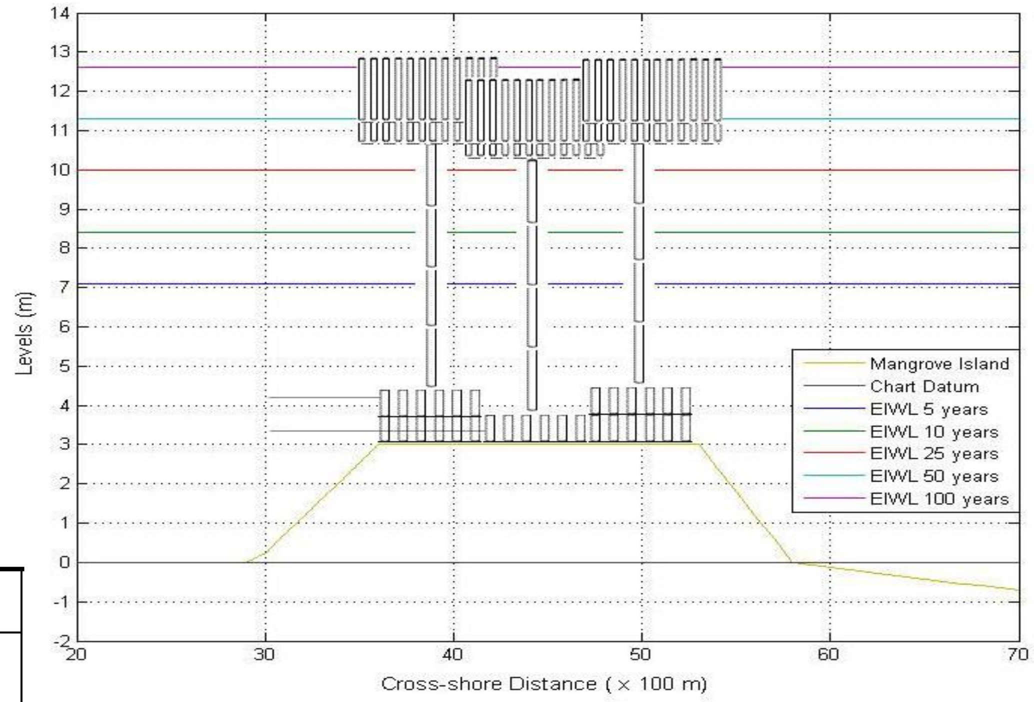
Narayan, 2009

Step 2: Nearshore Hydrodynamics *Results* – Wave Propagation



Narayan, 2009

Step 3: Mangrove Vegetation *Data* – Vegetation Characteristics

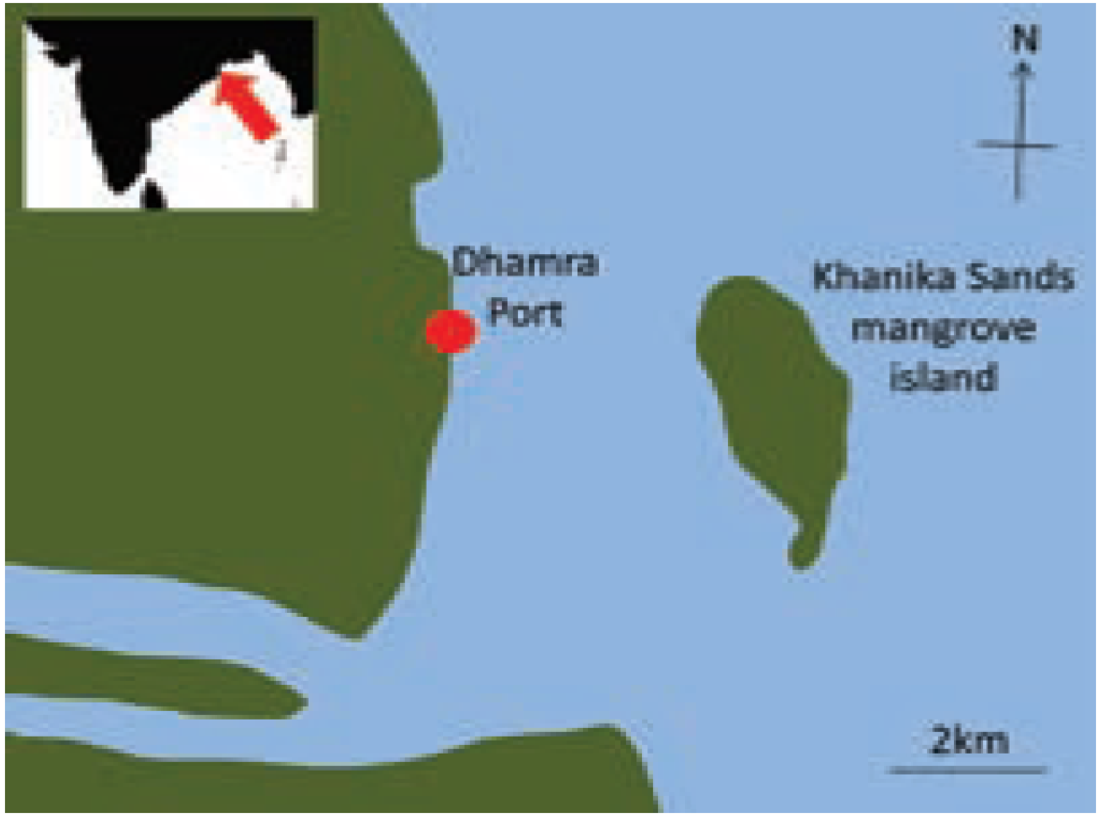


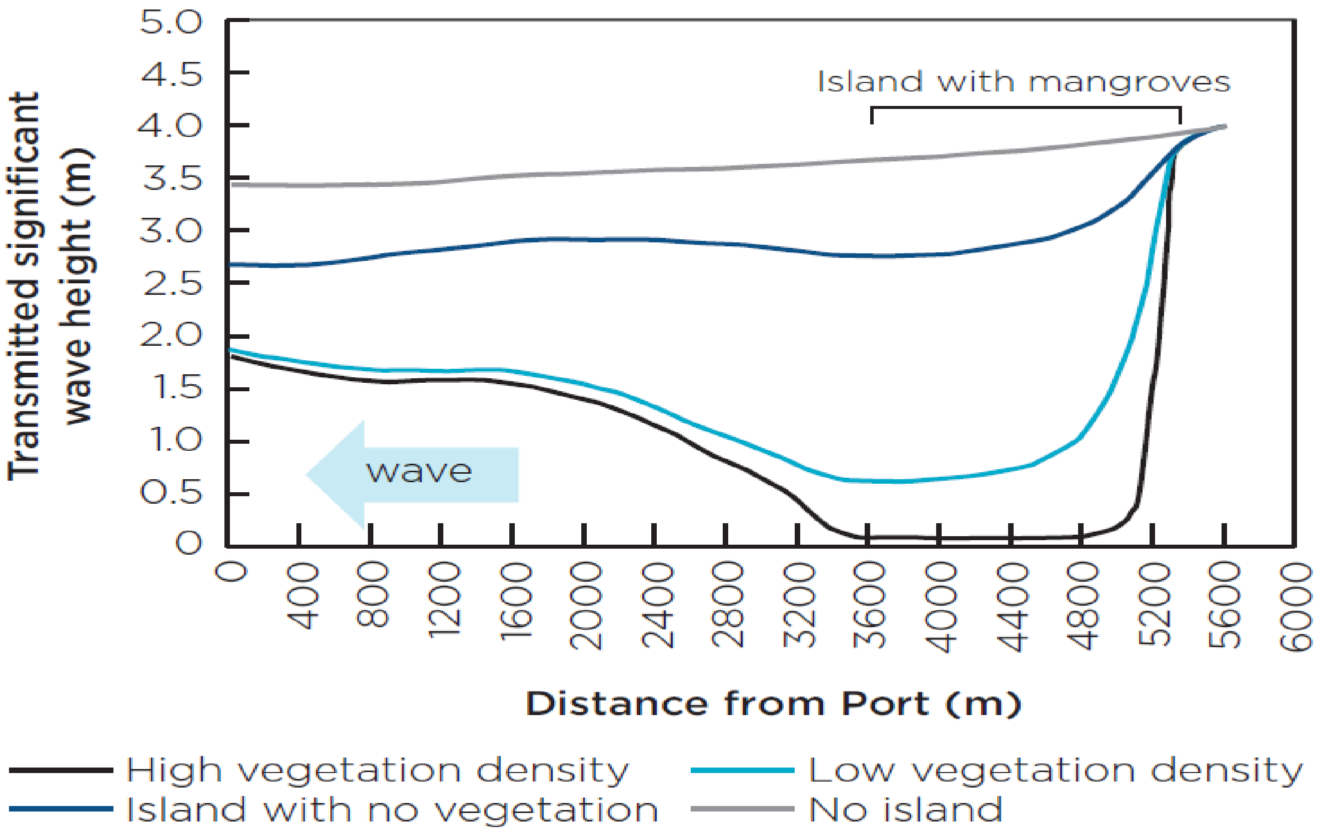
Parameter	Value Range	Control Value
1. Stem Diameter (DBH)	0.2 – 0.5 m	0.3 m
2. Pneumatophore Diameter	0 – 0.04 m	0.02 m
3. Canopy Diameter	0.02 – 1 m	0.5 m
4. Stem Density	0.5 – 1.7 m^{-2} *	0.7 m^{-2}
5. Pneumatophore Density	4 – 100 m^{-2}	50 m^{-2}
6. Canopy Density	1 – 100 m^{-2}	100 m^{-2}
7. Stem Height	3 – 15 m	6 m^{+}
8. Pneumatophore Height	0.3 – 0.8 m	0.5 m
9. Canopy Height	0.2 – 3 m	2 m

Narayan, 2009

Case-Study Step 3: Mangrove – Wave Interaction *Results* – Wave Reduction

- 60% wave reduction by mangroves
- Vegetation Removal
  - 60 year event → 20 year event
  - 7 year event → 1 year event
- Optimum width cross-shore – 300 to 800 m

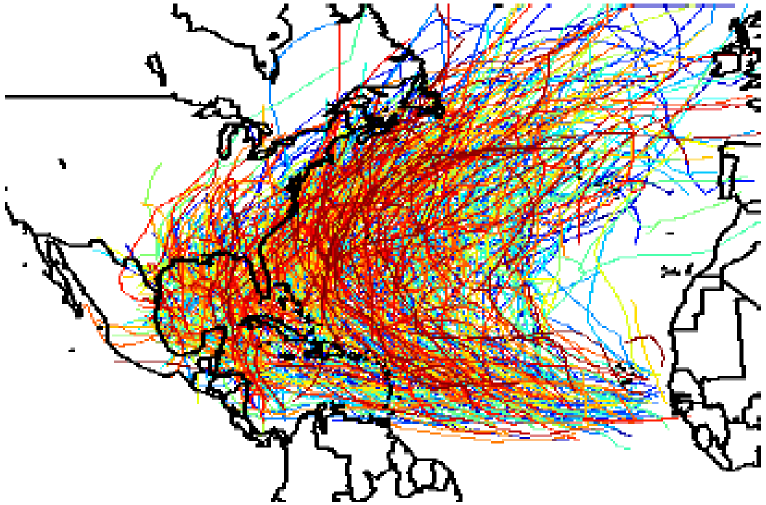




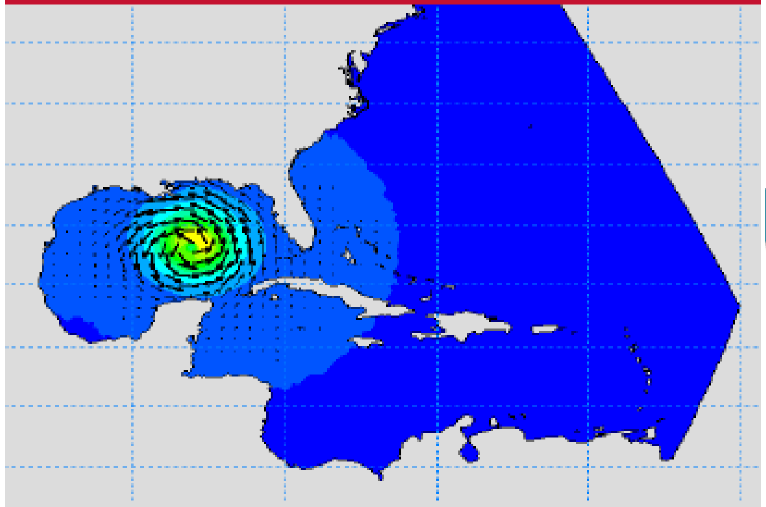
MODELLING EXAMPLE – HURRICANE SANDY AND COASTAL WETLANDS, U.S.A

RMS Case-Study Step 1: Offshore Hydrodynamics

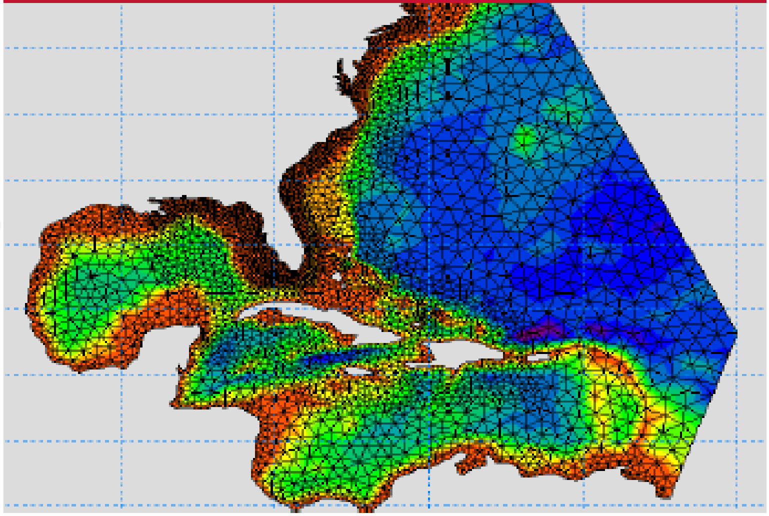
TRACK SET



WIND FIELD

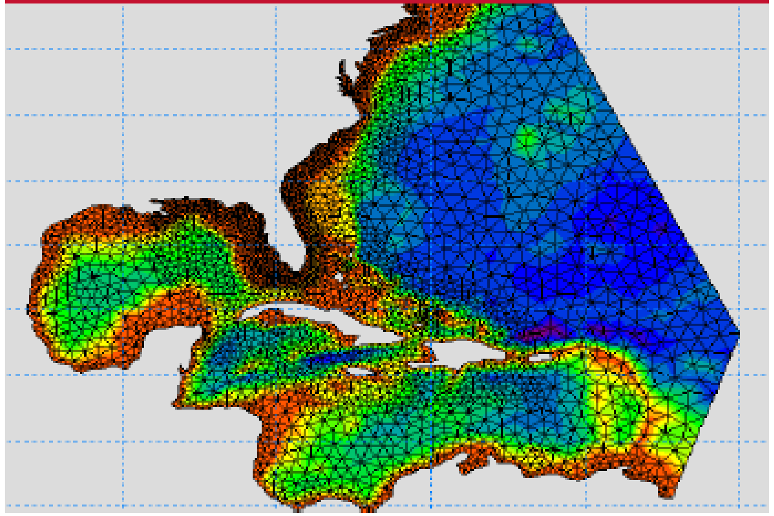


REGIONAL MESH

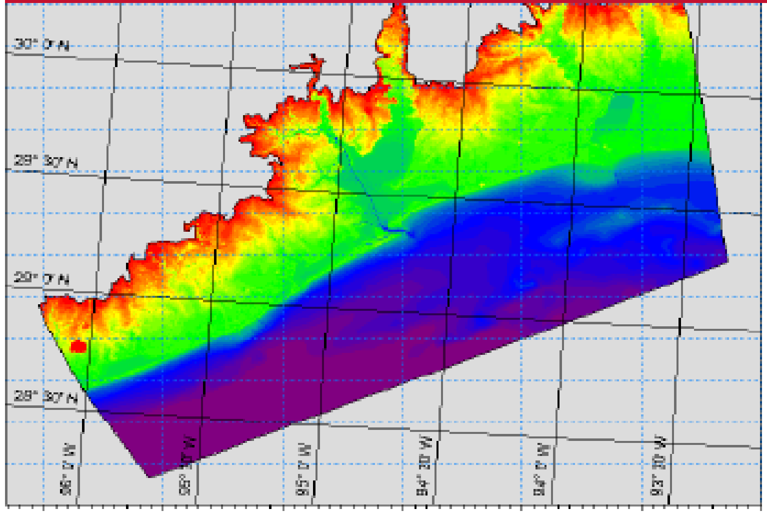


RMS Case-Study Step 2: Nearshore Hydrodynamics

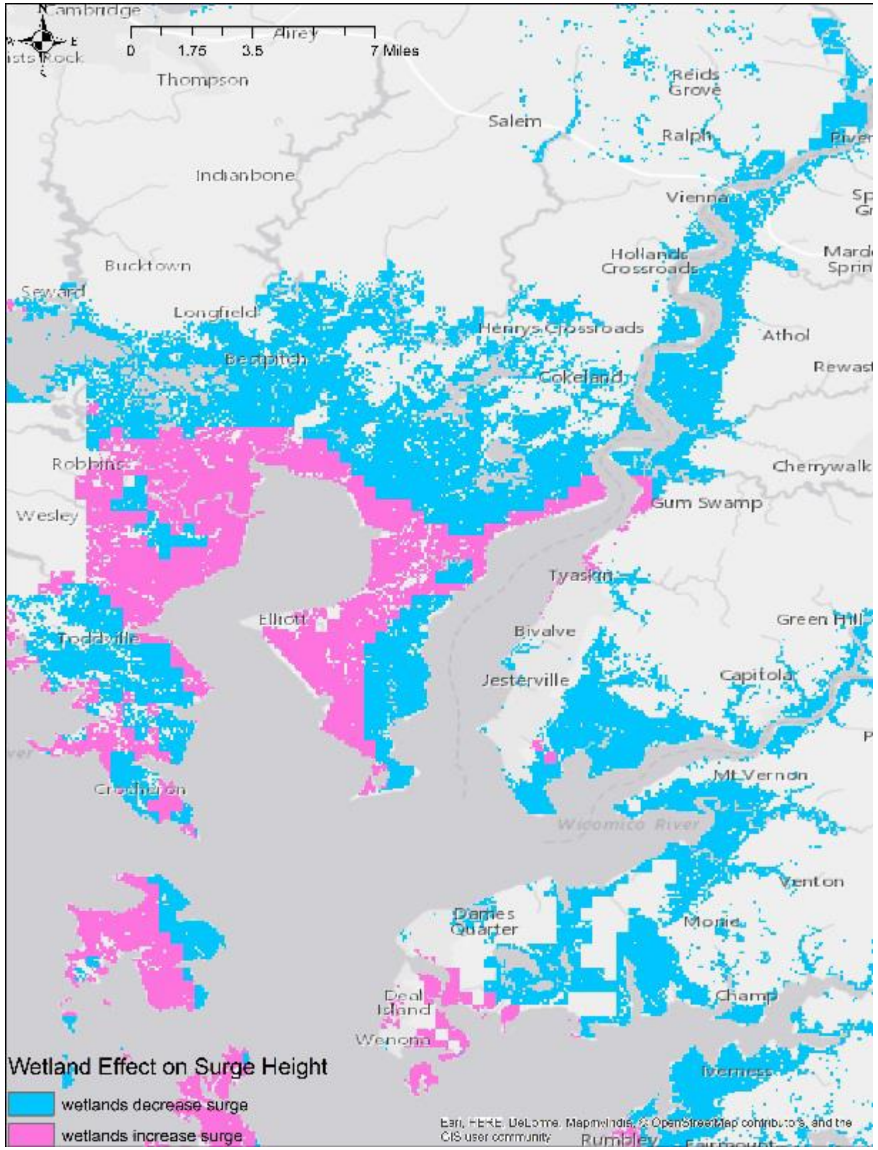
REGIONAL MESH

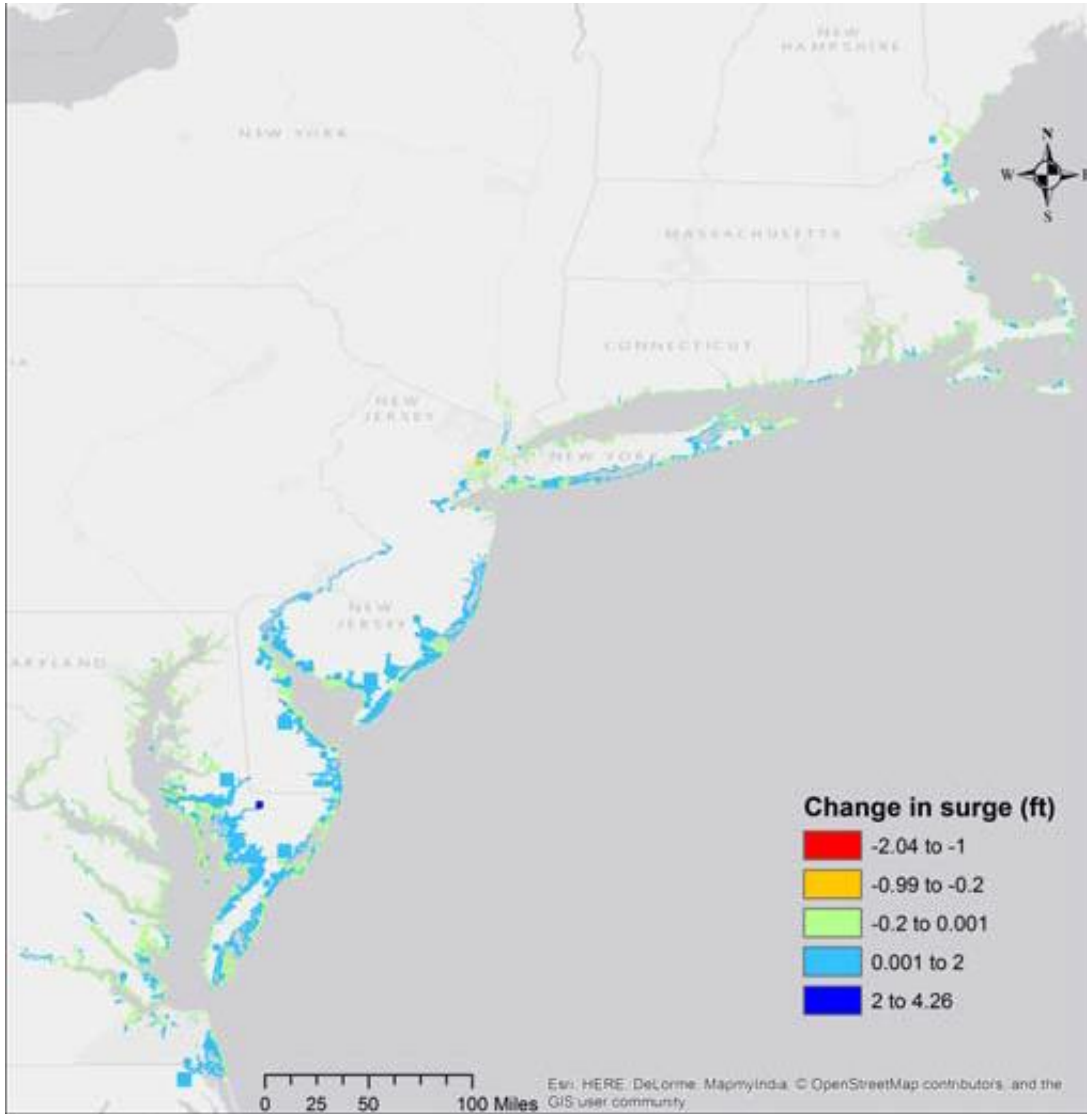


LOCAL MESH



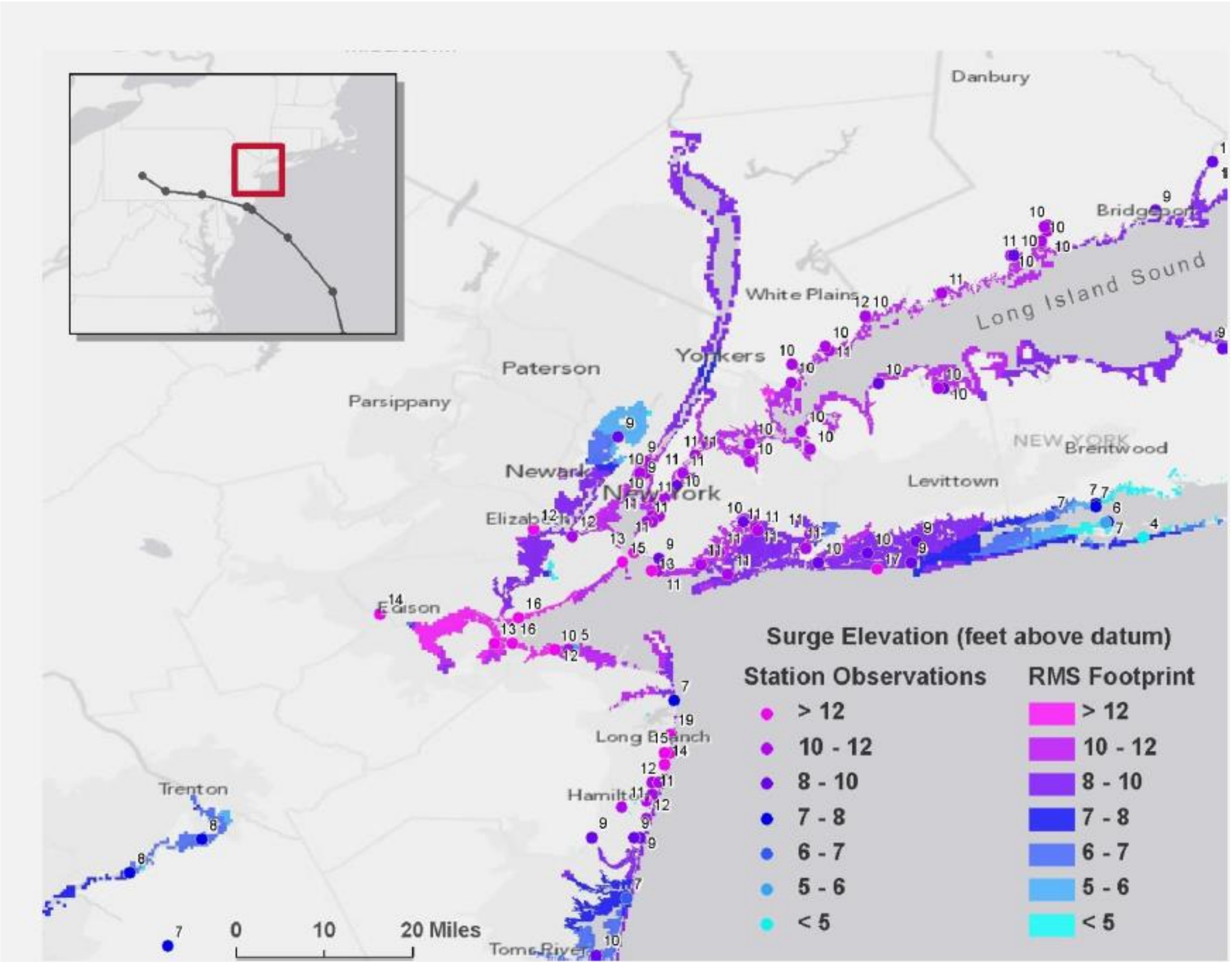
RMS Case-Study Step 3/4: Surge Interaction with Ecosystems



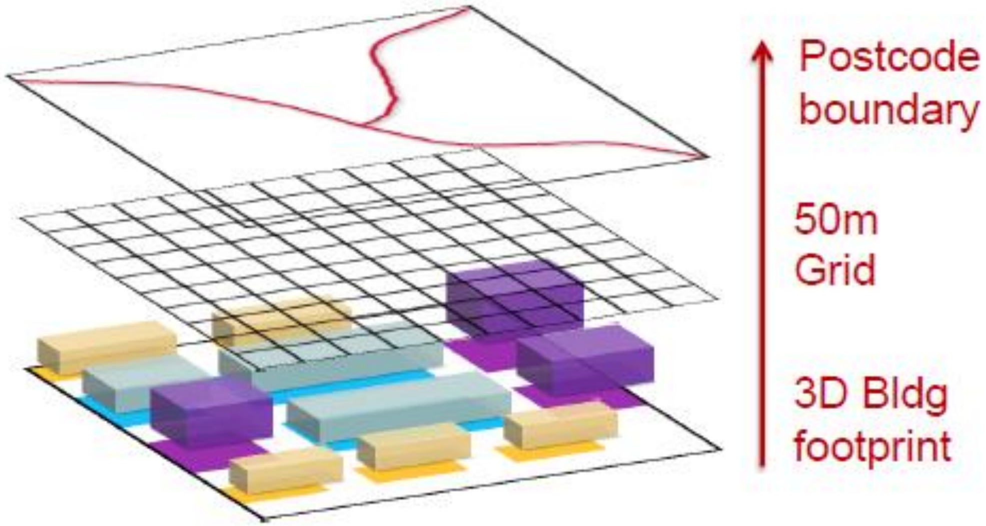


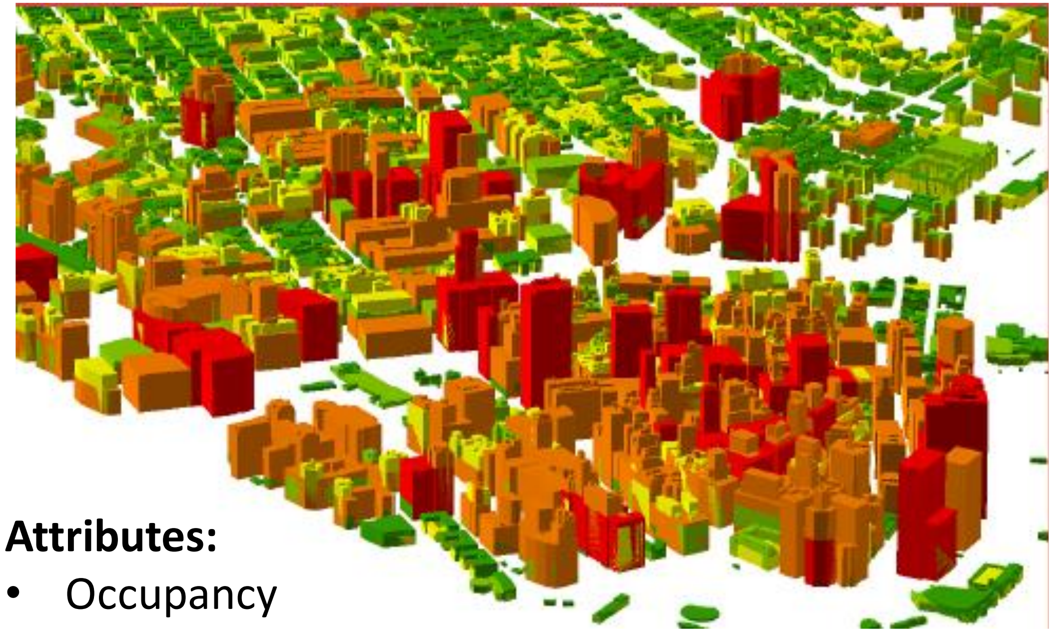
Narayan et al. 2016. White Paper (In Review): Coastal Wetlands and Flood Damage Reduction

RMS Case-Study Step 3/4: Flooding by Sandy Surge



RMS Case-Study Step 5: Damage Estimation

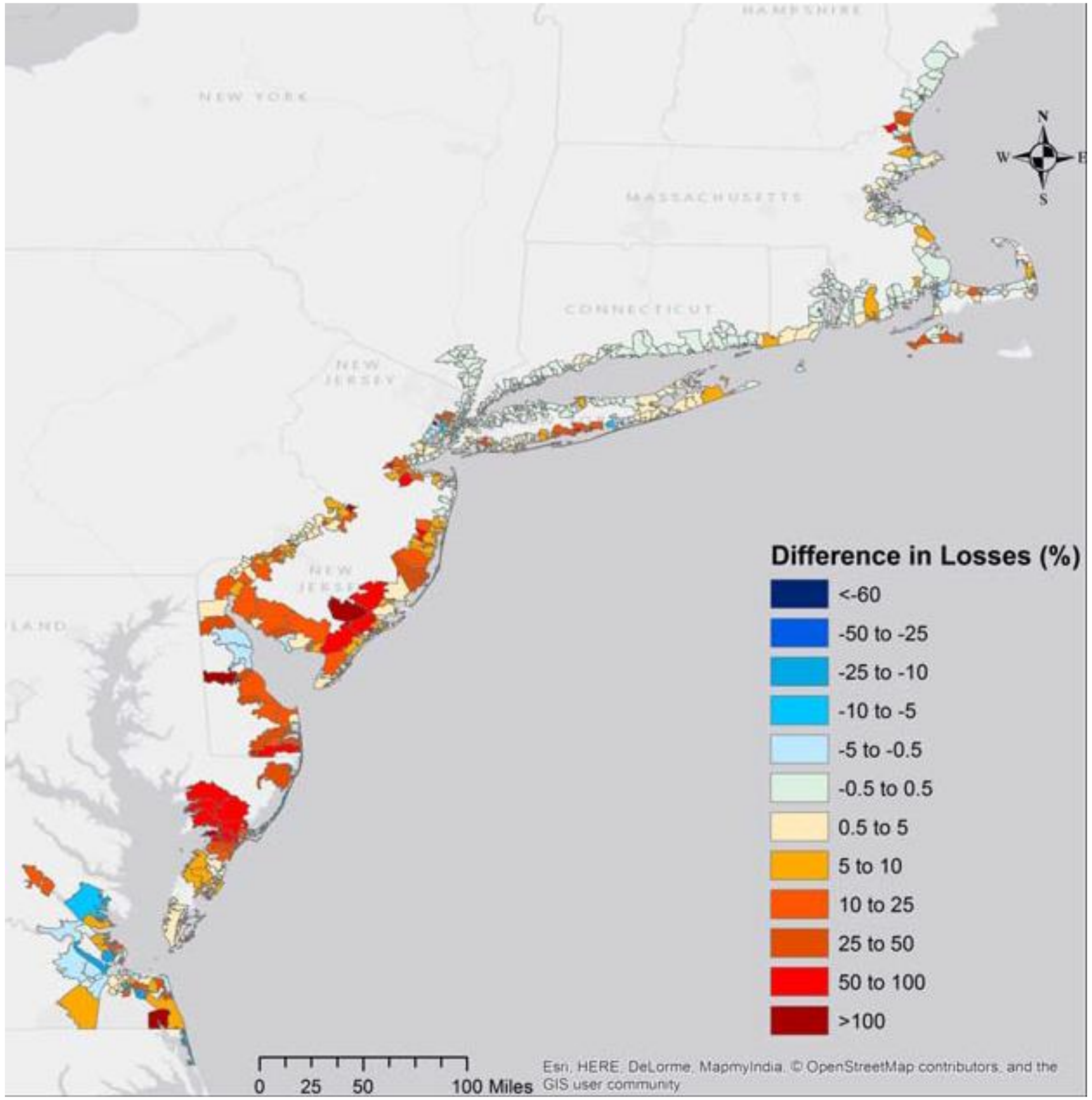


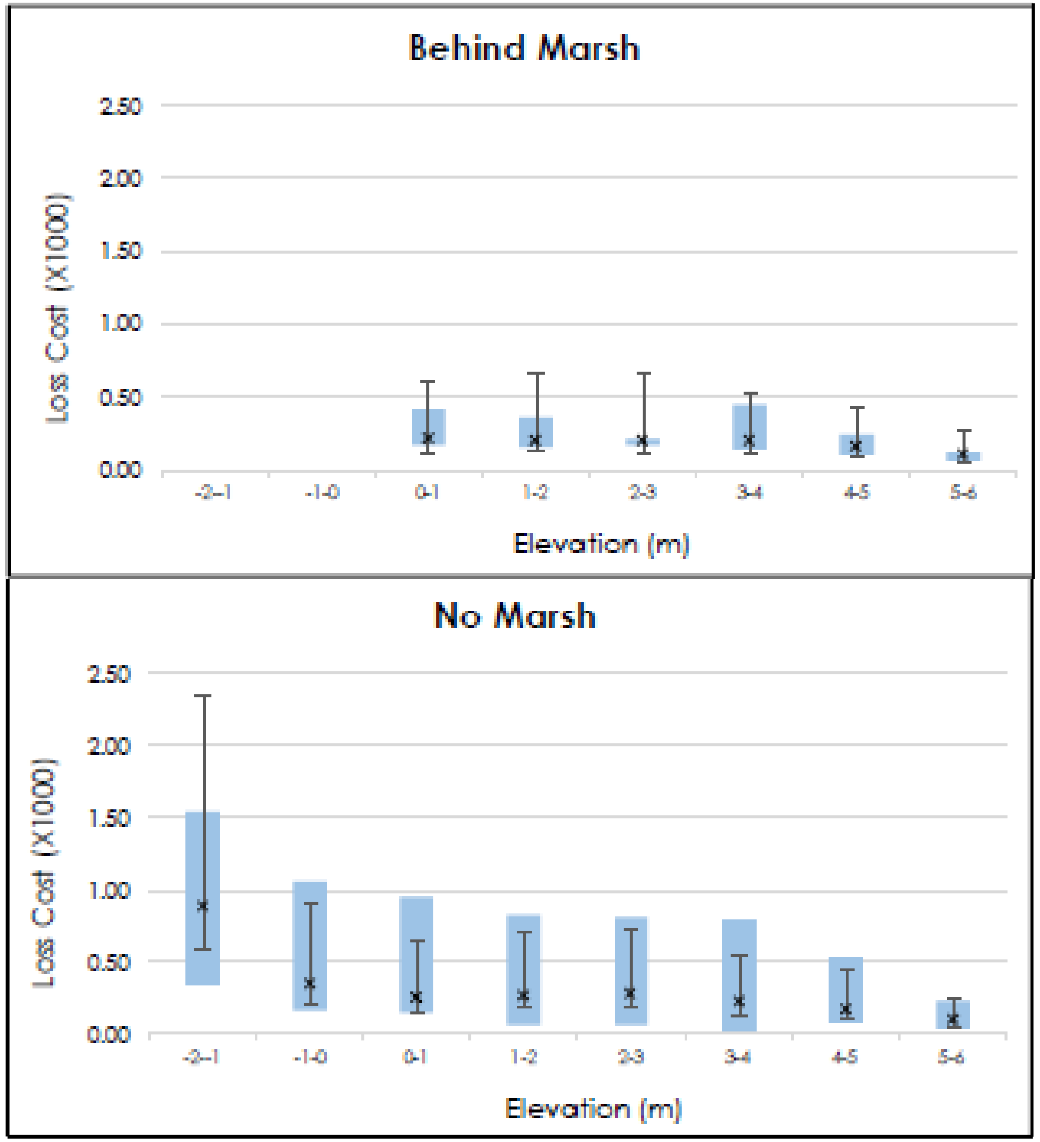


Attributes:

- Occupancy
- Number of Floors
- Square Footage
- Valuation
- Basement
- Year of Built
- Construction

RMS Case-Study Step 6: Coastal Protection Value of Ecosystems





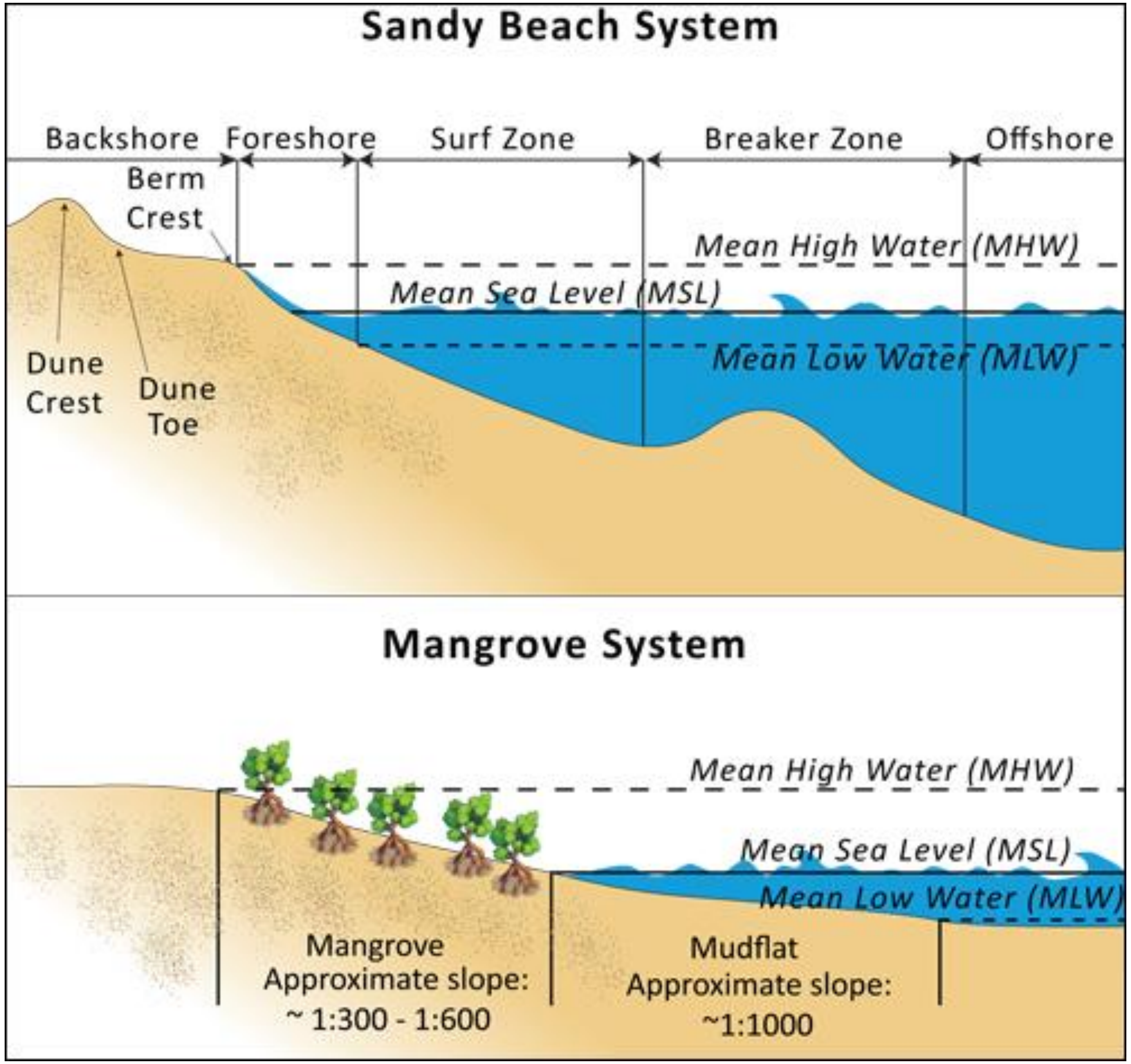
Narayan et al. 2016. White Paper (In Review): Coastal Wetlands and Flood Damage Reduction

MODELLING EXAMPLE – INVEST COASTAL PROTECTION TOOLBOX

INVEST Step 1: Profile Generator Model

Options to generate a cross-shore profile:

1. Use a bathymetric DEM
2. Manually enter cross-shore profile
3. Assume a profile using INVEST empirical guidance



http://www.naturalcapitalproject.org/invest/

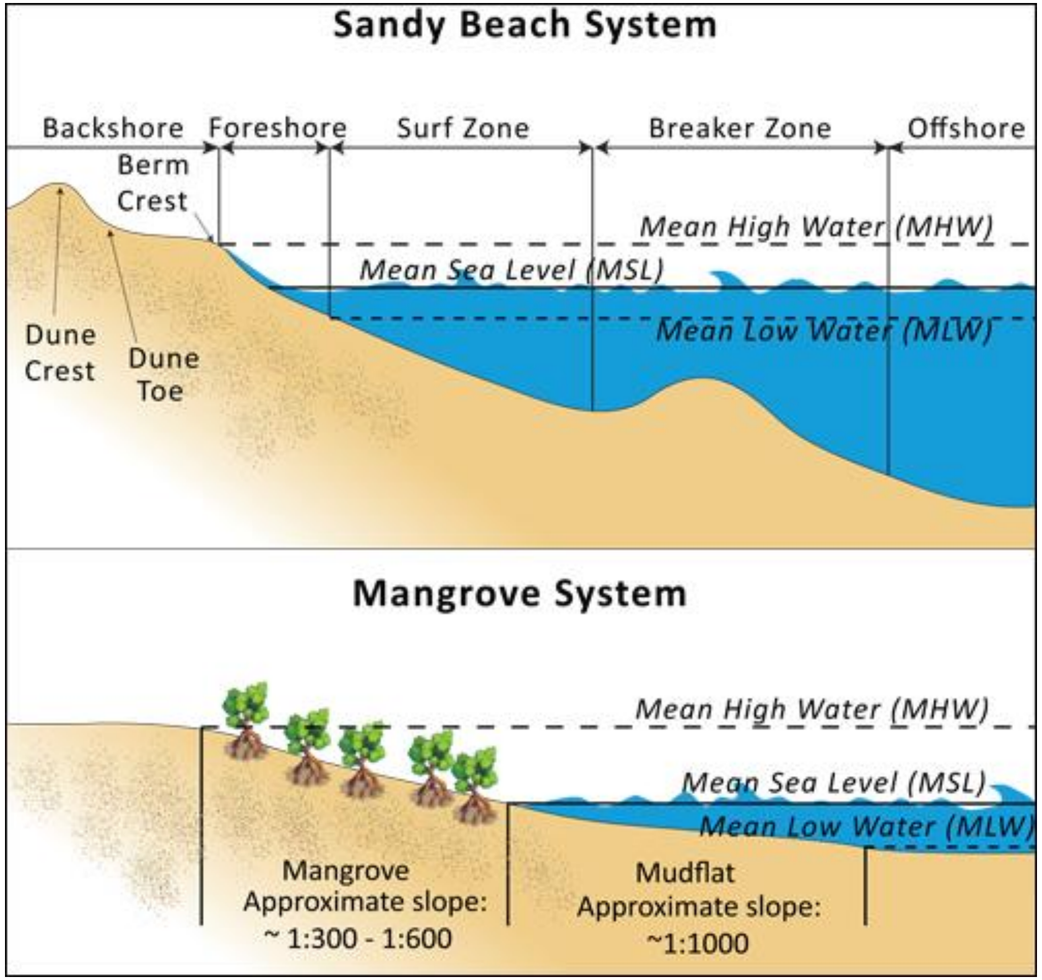
http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/coastal_protection.html#profile-generator-model

INVEST Step 2: Nearshore Waves and Erosion

- Wave Propagation Estimated Using:

$$\frac{1}{8}\rho g \frac{dC_g H^2}{dx} = -D$$

- $D = D_{break} + D_{veg} + D_{bot}$
- D_{break} is depth-induced wave breaking (e.g. wave breaking at shallow depths)
- D_{veg} is vegetation induced wave-drag ((e.g. drag through mangrove trees) - after Mendez and Losada 2004
- D_{bot} is bed friction (or roughness) (e.g. reef cover)



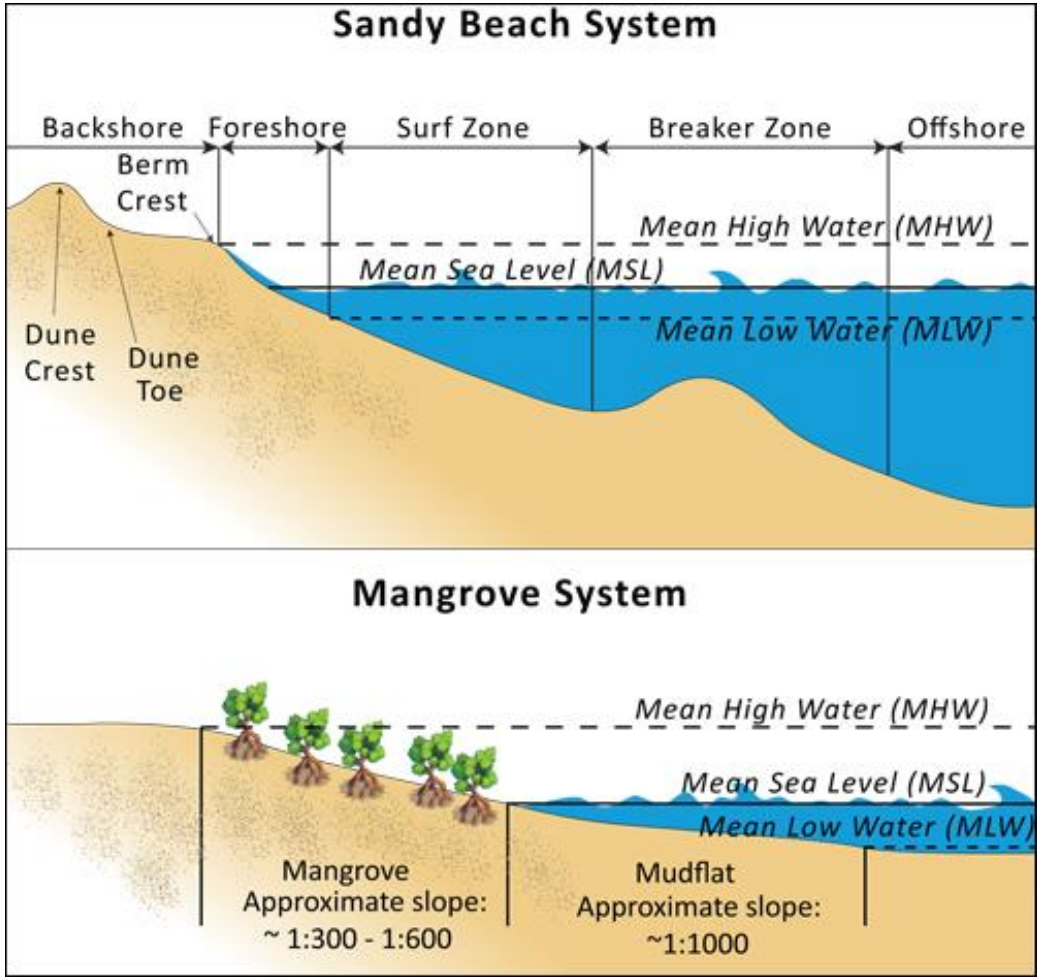
http://www.naturalcapitalproject.org/invest/

http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/coastal_protection.html#profile-generator-model

INVEST Steps 3/4: Erosion Reduction and Avoided Damages

- Erosion reduction estimated using wave height profiles and wave run-up value sets, calculated for with and without vegetation

- Avoided erosion damages using market values; tax estimates; replacement cost values



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MANGROVE COASTAL PROTECTION MODEL: REQUIREMENTS, CONSIDERATIONS AND KEY OUTPUTS

Coastal Protection Model: Critical Data Requirements

- Study Domain/Extent
- Bathymetry
  - Offshore
  - Nearshore
- Hydrodynamics
  - Offshore wave heights and water levels – *may be computed using global metocean datasets*
  - Storm tracks, intensities – *available from global datasets*
  - Wind speeds, fetch distance – *for every-day waves, e.g. INVEST*
  - Nearshore wave heights and water levels – *may be computed using offshore and bathy data*
- Ecosystem Characteristics
  - Extent
  - Width
  - Density and Fragmentation
  - Species (Primary or Distribution)
  - Age
- Inland Floodplain
  - Topography (i.e. for elevation, slope, distance to coast)
  - Land-use/Land-cover
  - Known coastal defenses – *may be assumed as captured in Topo*
- Flood Damages
  - Population
  - Built Capital (Assets)

Coastal Protection Model: Special Considerations for Ecosystems

- Study Domain/Extent
  - Ecosystem extent may be difficult to define/relate to modelling or accounting unit
- Bathymetry
  - Crucial for all ecosystems; may be difficult to measure within inter-tidal habitats
- Hydrodynamics
  - Storm properties (duration, forward speed,…) will influence variations in ecosystem impacts
- Ecosystem Characteristics
  - Should assess/ measure parameters like relative height, relative width, standing biomass, etc.
  - Should assess uncertainties in ecosystem health (relevant to coastal protection)
- Inland Floodplain
  - Ecosystem presence (esp inter-tidal) can help reduce overall exposure to flood risk
- Flood Damages
  - Ecosystems can occasionally increase flood damages depending on relative location of hazard and assets

Coastal Protection Model: Key Outputs

1. Storm Surge Inundation Heights and Extents
    a) With mangroves
    b) Without mangroves
    c) For multiple sea-level scenarios

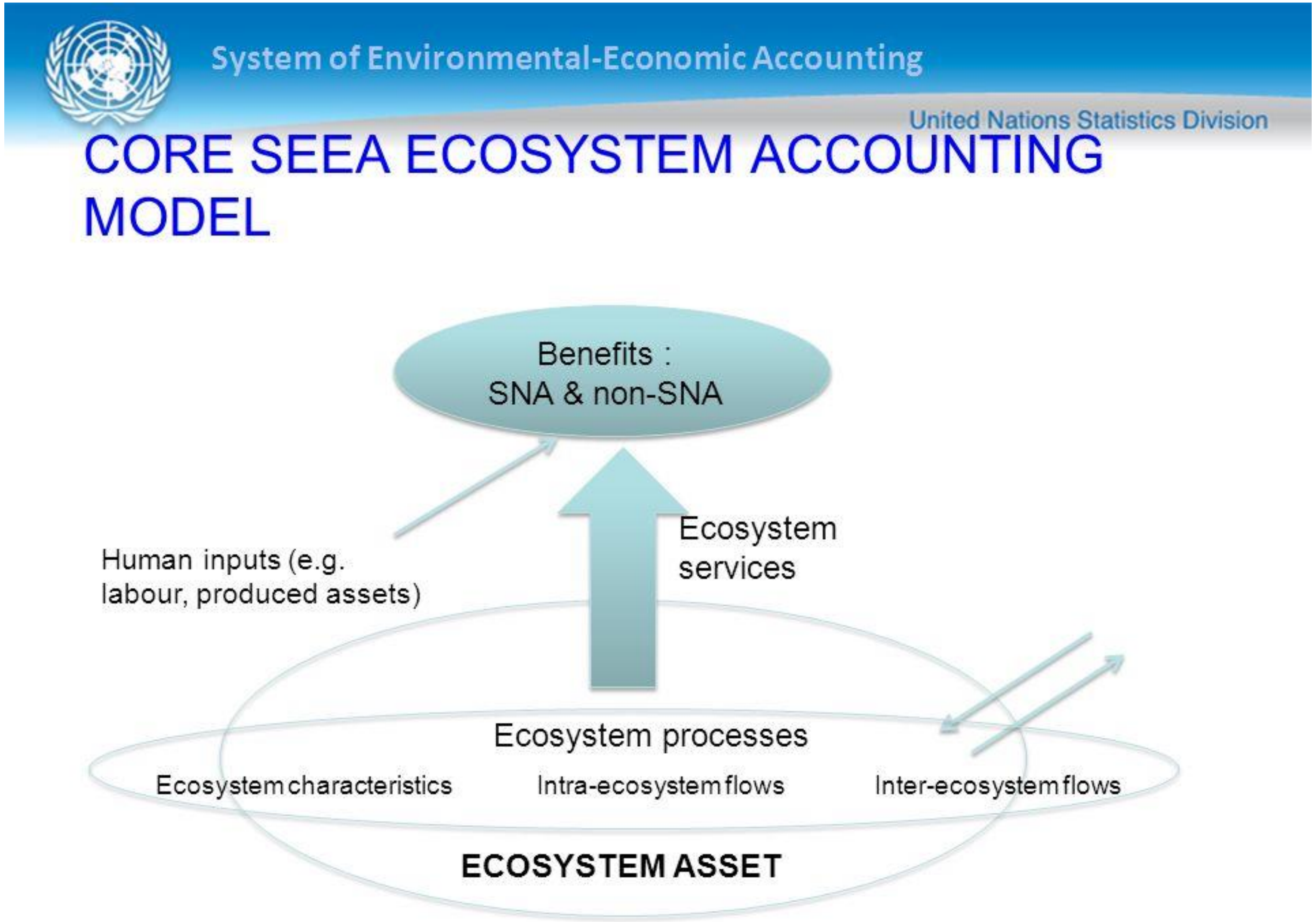
2. Storm – surge Induced Damages
    a) With mangroves
    b) Without mangroves
    c) For multiple sea-level scenarios

3. National Map of Spatial Variation
    a) In mangrove effect on flooding extents
    b) In mangrove effect on flood damages
    c) For multiple sea-level scenarios

4. Case-Study Results
    a) High resolution estimates of mangrove effects
    b) Sensitivity analyses for different sea-level and mangrove scenarios

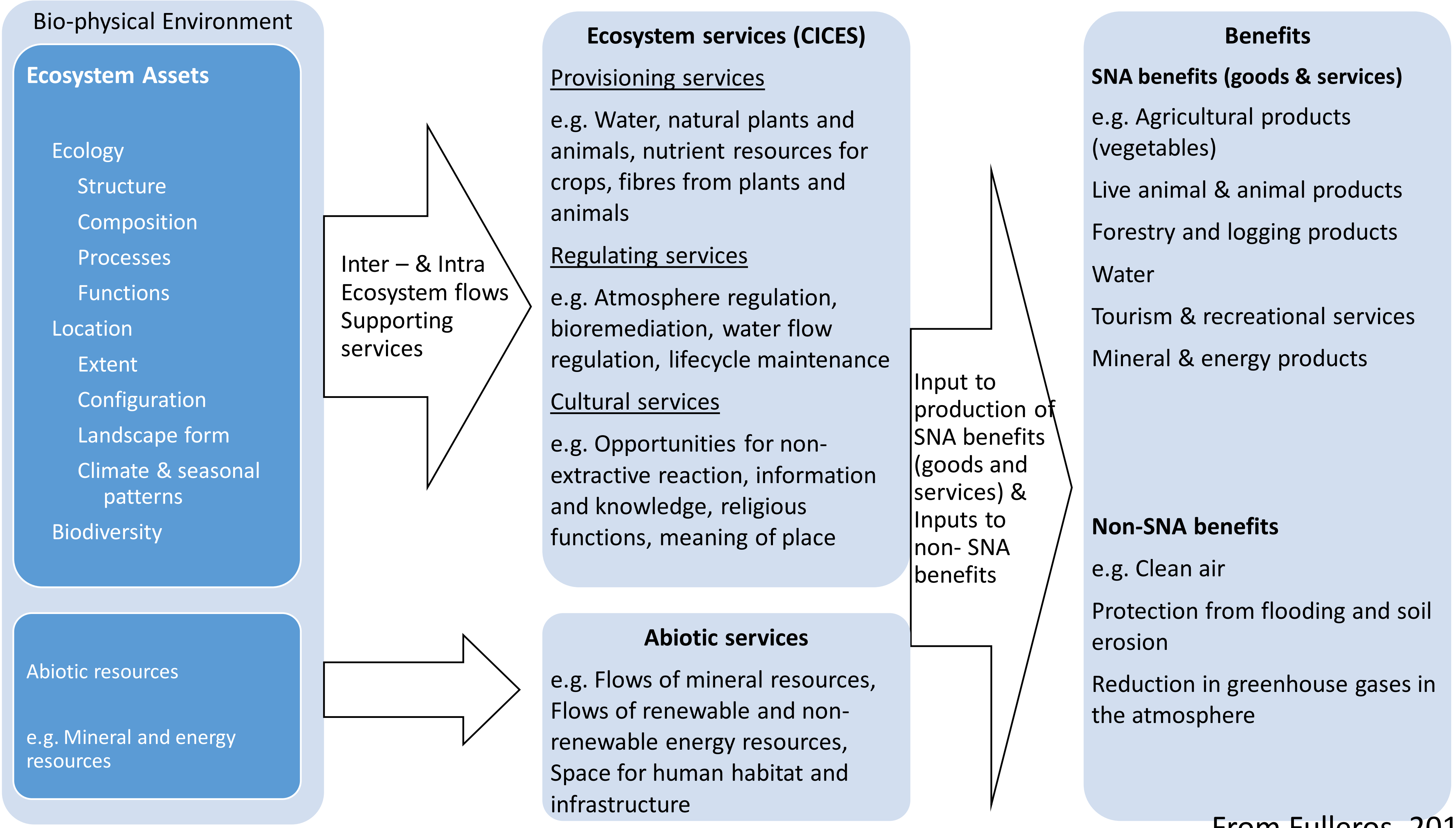
THOUGHTS ON INTEGRATION OF CP MODEL OUTPUTS INTO SEEA – EEA FRAMEWORK

Model of flows related to ecosystem services



From Fulleros, 2016 (PSA).

Broader model of flows in ecosystem accounting



From Fulleros, 2016 (PSA).

Example Accounting for Ecosystem Condition Characteristics

	Ecosystem extent	Characteristics of ecosystem condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
	Area (proportion of EAU)	Indicators (e.g. Leaf area index, biomass index)	Indicators (e.g. species richness, relative abundance)	Indicators (e.g. soil fertility, soil carbon, soil moisture)	Indicators (e.g. river flow, water quality, fish species)	Indicators (e.g. net carbon balance, primary productivity)
Type of LCEU						
Forests						
Agricultural land						
Urban areas						
Inland water bodies						

Note: key interest with these tables is particularly with evaluating the trends over time.

From Fulleros, 2016 (PSA).

Example Accounting for Ecosystem Condition Characteristics

	Ecosystem extent	Characteristics of ecosystem condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
	Area (proportion of EAU)	Indicators (e.g. Leaf area index, biomass index)	Indicators (e.g. species richness, relative abundance)	Indicators (e.g. soil fertility, soil carbon, soil moisture)	Indicators (e.g. river flow, water quality, fish species)	Indicators (e.g. net carbon balance, primary productivity)
Type of LCEU						
Forests						
Agricultural land						
Urban areas						
Inland water bodies						

For Coastal Protection, additional indicators can include soil retention rates, land elevation, age, etc.

Note: key interest with these tables is particularly with evaluating the trends over time.

From Fulleros, 2016 (PSA).

Definition of Terms

- ***Mangrove Ecosystem Extent / Mangrove Area Asset Account***

Mangrove Ecosystem Extent Account

- Refers to the size of the mangrove ecosystem asset.
- Generally measured in terms of surface area, e.g. hectares of land cover type.
- It can be reflected in the proportion of different types of mangrove forest

Mangrove Area Asset Account

- A unique environmental asset that delineates the "**space**" covered by a mangrove forest.
- It can be reflected in the proportion of different classifications of mangrove forest e.g. land cover (fringe, riverine, basin, overwash, scrub and hammock) and land use (e.g. recreational, strictly protected area, fishpond – production mangrove forest). – "coastal protection/buffer mangrove forest"?

From Fulleros, 2016 (PSA).

	Parameter / Data	Disaggregation	Period	Source (Agency / Publication / Admin Data)
C.	**Protective Services Account**			
1	Detailed mangrove extent map and map interpretation (in hectares)			
	1.1 By political subdivision	Municipal and Barangay	2010, 2014 and previous years	PSA / NAMRIA / LGU Pagbilao
	1.2 By Type of Mangrove Forest	Overwash, Fringe, Riverine, Basin, Scrub and Hammock	2016	Mangrove Characterization Inventory
	1.3 By Mangrove Forest Zonation	Seaward, Middle, Landward and Riverine (River mouth and upstream forebank / backbank)	2016	Mangrove Characterization Inventory
2	Thematic Map of Pagbilao Land Cover, Elevation Map and Storm Surge Inundation (without mangrove) including map interpretation			
	2.1 Land Cover	Municipal and Barangay	Historical, 2010 and 2014	NAMRIA
	2.2 Elevation Map	Municipal and Barangay	Historical, 2010 and 2014	NAMRIA
	2.3 Storm Surge Inundation			
	- without mangrove (simulated)	Municipal and Barangay	One-shot study	PhilVocs
	- with mangrove (simulated)	Municipal and Barangay	One-shot study	PhilVocs
	2.4 Tsunami Inundation			
	- without mangrove (simulated)	Municipal and Barangay	One-shot study	PhilVocs
	- with mangrove (simulated)	Municipal and Barangay	One-shot study	PhilVocs

From Fulleros, 2016 (PSA).

	Parameter / Data	Disaggregation	Period	Source (Agency / Publication / Admin Data)
C.	**Protective Services Account**			
	2.5 Bathymetry	Municipal and Barangay	Latest	NAMRIA
	2.6 Coral Area Extent	Municipal and Barangay	Latest	NAMRIA
	2.7 Land Use	Municipal and Barangay , By Type of Use	Every after 10 years	NAMRIA
3	Inventory Data (Vegetation characteristics)	Municipal	One-shot study	PhilVocs
4	Residential and non-residential structures (within extent of simulated inundation - on a with or without mangrove scenario)			
	4.1 Location / thematic map (mangrove, built-up and inundation maps)	Municipal, by type of residential units	One-shot study	PhilVocs, NAMRIA, PSA
	4.2 Map interpretation	Municipal, by type of residential units	One-shot study	PhilVocs, NAMRIA, PSA
5	Agricultural Area and Estimated Production (within extent of simulated inundation - on a with or without mangrove scenario)			
	5.1 Location / thematic map (mangrove, agriculture area and inundation maps)	Municipal	One-shot study	PhilVocs, NAMRIA, PSA
	5.2 Map interpretation	Municipal	One-shot study	PhilVocs, NAMRIA, PSA

From Fulleros, 2016 (PSA).

	Parameter / Data	Disaggregation	Period	Source (Agency / Publication / Admin Data)
C.	**<u>Protective Services Account</u>**			
6	Existing Infrastructures (within extent of simulated inundation - on a with or without mangrove scenario)			
	6.1 Location / thematic map (mangrove, infra within built-up and inundation maps)	Municipal	One-shot study	PhilVocs, PAGASA, NAMRIA, PSA, CBMS
	6.2 Map interpretation	Municipal	One-shot study	PhilVocs, PAGASA, NAMRIA, PSA
7	Value and type of housing units within the pilot area	Municipal	One-shot study	Valuation Study
8	Value of agricultural lands (within extent of simulated inundation - on a with or without mangrove scenario)	Municipal	One-shot study	Valuation Study, PSA (processed zonal values) and BIR (raw data on zonal values)
9	Data on replacement cost and value			
	9.1 Sea Walls	Municipal	One-shot study	Valuation Study
	9.2 Breakwaters	Municipal	One-shot study	Valuation Study
	9.3 Natural Protection Measures	Municipal	One-shot study	Valuation Study
D.	**<u>Provisioning Services (Fish Production Enhancement Services)</u>**			
1	Detailed mangrove extent map and map interpretation (in hectares)			
	1.1 By political subdivision (barangay)	Barangay	2010, 2014 and previous	PSA, NAMRIA
2	Length of coastline	Municipality, Barangay	One-shot study	PSA, NAMRIA
3	Length of mangrove	Municipality, Barangay	One-shot study	PSA, NAMRIA

From Fulleros, 2016 (PSA).

	Parameter / Data	Disaggregation	Period	Source (Agency / Publication / Admin Data)
C.	**Protective Services Account**			
6	Existing Infrastructures (within extent of simulated inundation - on a with or without mangrove scenario)			
	6.1 Location / thematic map (mangrove, infra within built-up and inundation maps)	Municipal	One-shot study	PhilVocs, PAGASA, NAMRIA, PSA, CBMS
	6.2 Map interpretation	Municipal	One-shot study	PhilVocs, PAGASA, NAMRIA, PSA
7	Value and type of housing units within the pilot area	Municipal	One-shot study	Valuation Study
8	Value of agricultural lands (within extent of simulated inundation - on a with or without mangrove scenario)	Municipal	One-shot study	Valuation Study, PSA (processed zonal values) and BIR (raw data on zonal values)
9	Data on replacement cost and value			
	9.1 Sea Walls		One-shot study	Valuation Study
	9.2 Breakwaters	Municipal	One-shot study	Valuation Study
	9.3 Natural Protection Measures	Municipal	One-shot study	Valuation Study
D.	**Provisioning Services (Fish Production Enhancement Services)**			
1	Detailed mangrove extent map and map interpretation (in hectares)			
	1.1 By political subdivision (barangay)	Barangay	2010, 2014 and previous	PSA, NAMRIA
2	Length of coastline	Municipality, Barangay	One-shot study	PSA, NAMRIA
3	Length of mangrove	Municipality, Barangay	One-shot study	PSA, NAMRIA

Addition of Expected Damage Function Approach, for national scale?

From Fulleros, 2016 (PSA).

DAY 2 PARTNER PRESENTATIONS

DAY 2 DISCUSSION

Data Sources, Types and Availability

No	Bathymetry	Mangrove Characteristics	Topography	Asset/Socio-Economic Data	Validation Data
1	Data: *Bathymetry/ Habitat Maps* Agency: *CoRVA* Extent/ Resolution: ?? Availability: ??	Agency: *PHIL-LIDAR (UP C-Eng)* Funding: *CCC* Extent: *National (**Samar, Leyte** Completed)*	Data: *LiDAR (1 m)* Agency: *PHIL_LIDAR (UP C-Eng)* Extent: ***Samar/Leyte*** Availability: ??	Data: *Household Census Info* Agency: *Gem/ PHIL-LIDAR (UP C-Eng* Funding: *CCC* Extent: ***Samar, Leyte< El Nido*** Availability: Now Resolution: Per Barangay	Data: *Storm Surge Heights from survey* Agency: *PAGASA* Extent: ***Davao Oriental*** *(**Baganga**, Cateel, Boston)* Availability: ??
2	Data: *Bathymetry/ Reef Maps* Agency: *MSI* Extent: ***El Nido*** Availability: *Now*	Data: *Habitat Maps* Agency: *CoRVA* Extent/ Resolution: ?? Availability: ??	Data: *DEM (5 m)* Agency: *NAMRIA* Extent: ***National*** Availability: *Now*	Data: *Database of fish ponds* Agency: *BFAR (FRMD)* Extent: ***Infanta, Quezon*** Availability: *Now*	Data: *Storm Surge Heights* Agency: *Project Noah* Extent: ***National*** Availability: *Now, may have to pay for processing*

Data Sources, Types and Availability

No	Bathymetry	Mangrove Characteristics	Topography	Asset/Socio-Economic Data	Validation Data
3	Data: *Bathymetry* Agency: *PAGASA* Extent: ***Davao Oriental*** Availability: *Dec 2016*	Data: *Mangrove Community Structure/Sedimentation Rates* Agency: *Dr. Samson(De LaSalle)/ Dr Rollon (UP)* Extent: ?? *(**Haiyan – Samar/Leyte**)* Availability: ??	Data: *LiDAR Imagery* Agency: *Dream Project (UP)/ Project NOAH* Extent: *Selected Areas* Availability: ??	Data: *Fish sanctuary database* Agency: *BFAR* Extent: ***National*** Availability: *Now*	Data: Storm Surge Heights Agency: MGB Availability: ??
4	Data: *Bathymetry* Agency: *NAMRIA* Extent/ Resolution: ***National,*** *Variable resolution* Availability: *Now*	Data: *National Data on Mangrove Cover as of 2010* Agency: *NAMRIA* Extent: ***National*** Availability: *NOW – Shapefiles ??*	Data: Shore/ Beach Profiles and Coastal Structure Info Agency: MGB Extent: 150+ profiles (typhoon belt) Availability: Now (??)	Data: *Survey Data on Household info, Yolanda Deaths, Damage Estimates* Agency: *EEPSEA Project Data* *Extent:* ***Yolanda*** *Track* Availability: *August 15, 2016*	*Data*: SS Heights *Agency*: USAID *Extent*: Yolanda *Available:* Now
5	Data: Bathymetry Agency: CORVA (CIMERP) Extent: Biri, El Nido, Guiuan, Siargao Availability: Now ??	Data: *Mangrove Mapping for Verde Island Passage* Agency: *BMB* Extent: ***Oriental Mindoro, Occidental Mindoro and Batangas*** Availability: *Now*	-------	Data: Socio-Economic Data Agency: ERDB Extent: 42 provinces Availability: On-going	-------

Data Sources, Types and Availability

No	Bathymetry	Mangrove Characteristics	Topography	Asset/Socio-Economic Data	Validation Data
6	Data: Shore/ Beach Profiles and Coastal Structure Info Agency: MGB Extent: 150+ profiles (typhoon belt) Availability: Now (??)	Data: *Integrated Coastal Resources Management Program (Sustaining our Own Coasts: The Ridge to Reef Approach)* Agency: *BMB* Extent: ***National*** Availability: *NOW – via GIZ*	-------	Data: Population and Household survey shapefiles (available online) Extent: Yolanda track, per Barangay Agency: EEPSEA Availability: Aug 15	-------
7	-------	Data: *ACCCoast Mangrove and FLA Mapping* Agency: *BMB* Extent: ***CALABARZON, MIMAROPA, Bicol, Eastern Visayas, CARAGA, Zamboanga Peninsula*** Availability: *NOW – via GIZ*	-------	-------	-------
8	-------	Data: *Mangrove Baseline Data* Agency: *ERDB* Extent: ?? Availability: *Not Available (On-going) – viz GIZ*	-------	-------	-------

Data Sources, Types and Availability

No	Bathymetry	Mangrove Characteristics	Topography	Asset/Socio-Economic Data	Validation Data
9	-------	Data: *Coastal Resource Assessment* Agency: *BFAR* Extent: ***National*** Availability: *Now*	-------	-------	-------
10	-------	Data: *Inventory of Mangroves* Agency: *Zoological Society of London* Extent: ***Panay Island*** Availability: ??	-------	-------	-------
11	-------	Data: 1945 Mangrove map (digitized) (from U. Texas) Agency: EEPSEA Extent: Yolanda Track Availability: August 15 Letter: to EEPSEA	-------	-------	-------
12	-------	Data: Mangrove Baseline Mapping Agency: ERDB Extent: 42 provinces Availability: On-going	-------	-------	-------

Data Sources and Types – Exercise to Identify Study Sites

Study Region	Coastal Risk	Coastal Mangroves	Data Availability: Bathymetry and Topography	Data Availability: Mangroves	Data Availability: Socio-Economic and Validation
NATIONAL	Present	Present	Bathy –Depth Soundings (NAMRIA) Topo: IFSAR DEM 5m (NAMRIA)	2010 Mangrove Cover (NAMRIA) 1945 Mangrove Cover Digitized (EEPSEA)	Household Info per Barangay (Gem) BFAR Fish Sanctuary Database (BFAR)
SAMAR • … • …			Coastal Features: Beach Profile data (MGB) PHIL_LIDAR Data (CCC – UP Ceng) ??? MSI/ CORVA data ????		EEPSEA Death/Damage Surveys Yolanda SS Heights (USAID/Uni Tokyo/ Project Noah)
LEYTE • Tacloban • ...	Present	Present	Coastal Features: Beach Profile data (MGB) – Northern Leyte (31 municipalities) PHIL_LIDAR Data (CCC – UP Ceng) ??? MSI/ CORVA data ????		EEPSEA Death/Damage Surveys Yolanda SS Heights (USAID/Uni Tokyo/ Project Noah)
PALAUAN • El Nido • Coron • …	• Absent • Present	• Present • Present	PHIL_LIDAR Data (CCC – UP Ceng) ??? MSI/ CORVA data ????		

Data Sources and Types – Exercise to Identify Study Sites

Study Region	Coastal Risk	Coastal Mangroves	Data Availability: Bathymetry and Topography	Data Availability: Mangroves	Data Availability: Socio-Economic and Validation
Mindoro Oriental • … • …			Coastal Features: Beach Profile data (MGB) PHIL_LIDAR Data (CCC – UP Ceng) ??? MSI/ CORVA data ????		EEPSEA Death/Damage Surveys Yolanda SS Heights (USAID/Uni Tokyo/ Project Noah)
Mindoro Occidental					
Visayas					

Potential Study Sites: Northern Leyte, Guiuan (mg+CORVAdata), Siargao (mg + CORVAdata), Northern Bohol (mg+MGBdata on subsidence and flooding), Busuanga (Palauan), Coron has damage data

Potential Study Sites

- Tacloban (N. Leyte) – high risk; has mangrove presence; overlap of good topography, socio-economic and shore profile data; complex coastline with channel
- Guiuan – point of first land-fall of Typhoon Haiyan (/Yolanda); has mangrove presence; open coast; overlap of mangrove data and potential CORVA data on reef bathymetry
- Siargao – popular tourist site; high risk; overlap of mangrove data and potential CORVA data on reef bathymetry
- Northern Bohol – substantial mangrove presence; overlap of mangrove data and MGB data on land subsidence and flooding
- Busuanga (Palauan) – only location in Palauan with damages data; point of last landfall of Typhoon Haiyan in Philippines
- Coron (Palauan) – data on damages

Group Discussion: Model Expectations, Outputs and Alignment with other efforts

1. Model Advantages and Disadvantages
    a) Advantages
        - Open Access
        - Can be used for DRM/Policy
        - Easy reference, input to PAGASA National Inundation maps

    b) Disadvantages
        - Data Availability/Jurisdiction
        - Technical capacity needed to use/ operate model, and maybe for interpreting some results
        - Transferability of site-specific results
        - Model not yet incorporated into a cost model (i.e. not comparing to structural alternatives for cost, avoided damages, etc.)

Group Discussion: Model Expectations, Outputs and Alignment with other efforts

2. Desired/ Expected Model Outputs

a) Identification of specific flood risk zonations or no-build zones

b) Preparation of Coastal Risk Maps

c) Data on Inundation per return period

d) Use of information for Early Warning Systems, Monetary Evaluations, Vulnerability Indices

e) Preparation of guide for deciding/ choosing appropriate coastal protection measures

f) Transformation of model outputs to environmental statistics and environmental accounts

Group Discussion: Model Expectations, Outputs and Alignment with other efforts

3. How do we align with on-going analyses in the Philippines?

   a) Adopt PSA study site

   b) Create up-datable data bank of mangrove characteristics relevant for various ecosystem services

   c) Standardise methods for data processing on ecosystem characteristics to complement with SEEA-EEA work in the Philippines

   d) Complement post-hazard analyses by EEPSEA

   e) Align with ongoing Geo-hazard Assessment program of MGB

   f) Help fill data gaps for storm surge damage extents, for PSA's impact evaluation studies

SALAMAT PO.

- Links to some natural defense databases
  - http://www.maps.coastalresilience.org/global/# - SNAPP Coastal Defenses, USA
  - http://www.naturalcapitalproject.org/ - Natural Capital Project, USA
  - http://mycopri.org/ - Living shorelines Database, USA
  - http://el.erdc.usace.army.mil/ewn/ - Engineering with Nature, USA
  - http://www.ecoshape.nl/overview-bwn.html - Building with Nature, Netherlands
  - http://www.omreg.net/ - Managed Realignment Database, UK

EXTRA SLIDES

Sources of data on offshore hydrodynamics

- A comprehensive list of global datasets on sea surface conditions can be found in: *http://www.aviso.altimetry.fr/en/data.html.*

- Sources of wave data include wave buoys: for example, *http://www.ndbc.noaa.gov/*; and satellite measurements: example, *http://www.oceanor.com/Services/wwa_info/*

- Examples of precomputed wave atlases include Global Ocean Waves (Reguero et al. 2012, 2013), NOAA's operational hindcast (*http://polar.ncep.noaa.gov/waves/index2.shtml)*; ERA-20C (*http://www.ecmwf.int/en/research/climate-reanalysis/era-20c*) and WW3 CFSRR Reanalysis (*http://polar.ncep.noaa.gov/waves/CFSR_hindcast.shtml*.).

- Information on tide levels can be found at *http://www.oco.noaa.gov/tideGauges.html*.

- Databases on storm surge include Surgedat: *http://surge.srcc.lsu.edu/data.html* and Dynamic Atmospheric Correction (DAC) – *http://www.aviso.altimetry.fr/en/data/products/auxiliary-products/atmospheric-corrections/description-atmospheric-corrections.html*.

- Data on past storm events can be found at *https://www.ncdc.noaa.gov/stormevents/* and *https://climatedataguide.ucar.edu/climate-data/ibtracs-tropical-cyclone-best-track-data*.

Info from WB WAVES Chapter 4.

Sources of wave data beyond numerical simulation include wave buoys (for example, http://www.ndbc.noaa.gov/) and satellite measurements, (for example, http://www. oceanor.com/Services/wwa_info/).

[b] Some examples of precomputed Wave Atlases: Global Ocean Waves: Reguero et al. 2012, 2013; NOAA: operational hindcast http://polar.ncep.noaa.gov/waves/index2.shtml and WW3 CFSRR Reanalysis Hindcasts http://polar.ncep.noaa.gov/waves/CFSR_hindcast.shtml.

[c] There are also some databases that provide measurements of storm surge for several locations, such as Surgedat: http://surge.srcc.lsu.edu/data.html.

Surge attenuation depends strongly on the forest width and other factors, such as vegetation density and relative submergence or the storm velocity.

[e] Main parameters: structure geometry (crest width, slopes, freeboard) and porosity, incident wave parameters (height, period), and depth.

Info from WB WAVES Chapter 4.