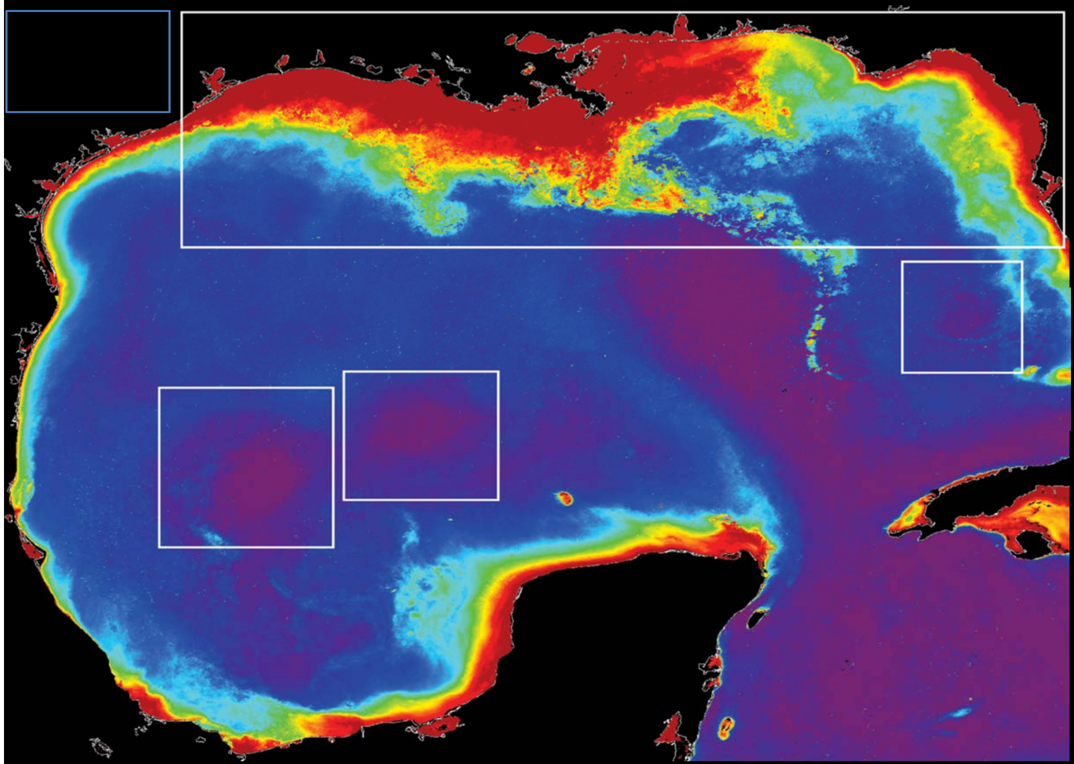
Monitoring and Ecosystem Indicators in the Gulf of Mexico and Mexican portion of the Caribbean Sea



Technical Workshop on selecting indicators for the state of regional seas

30 June -2 July 2014, Geneva, Switzerland

Dr. Norma Patricia Muñoz Sevilla

Secretary of Research and Postgraduate Studies

National Polytechnic Institute

CIIMAR GOMC

Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe

Oceans and Coasts Ecosystem Health: Priority Issues in the Gulf of Mexico and Mexico´s Caribbean Sea

1) POLLUTION
   a. Hypoxia
   b. Nutrients
   c. Eutrophication & algal blooms
   d. Oil spills
   e. Microplastics
2) LIVING MARINE RESOURCES
   a. Illegal fishing, Ghost fishing, IUU
   b. Invasive species, noise pollution
3) CLIMATE CHANGE (Hydrometeorological extreme events, hurricanes, flooding, sea leverl rise, erosion, storm surge)

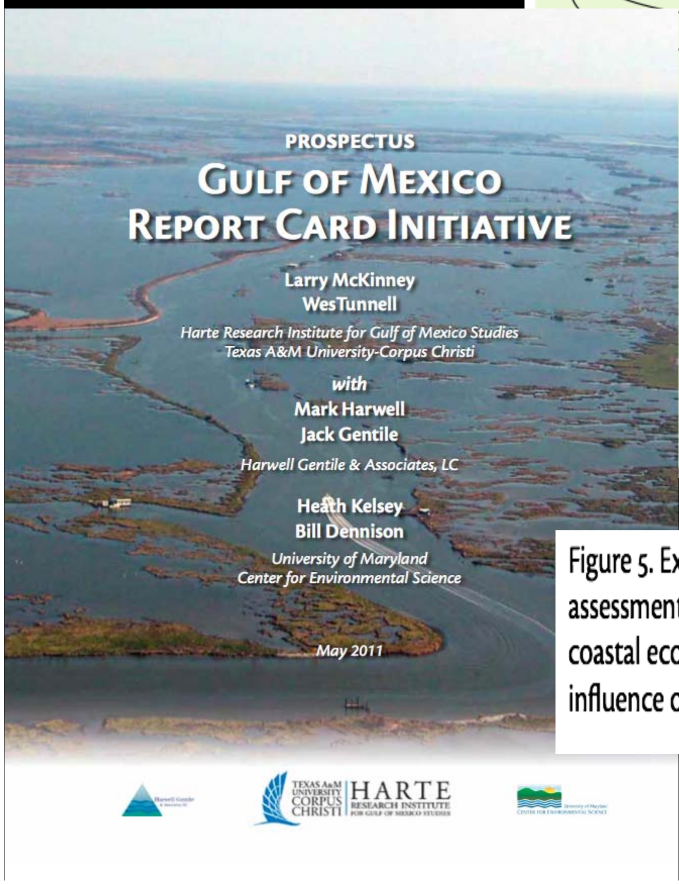
Pollution is not just hazardous chemicals--

Pollution -"the introduction by man, directly or indirectly, of substances or energy into the marine environment, resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fisheries, impairment of quality for use of seawater, and reduction of amenities."

(GESAMP, Joint Group of Experts on the Scientific Aspects of Marine Pollution, a United Nations sponsored advisory group)

The list of pollutants grows, many are persistent, and they influence social and natural ecosystems, especially in populated, coastal urban areas.

- Organic loading, waste products
- Greenhouse gasses
- Pathogens
- Petroleum hydrocarbons
- Polycyclic aromatic hydrocarbons
- Halogenated hydrocarbons
- Heavy metals
- Nutrients
- Radionuclides
- Endocrine disruptors
- Litter
- Light
- Noise



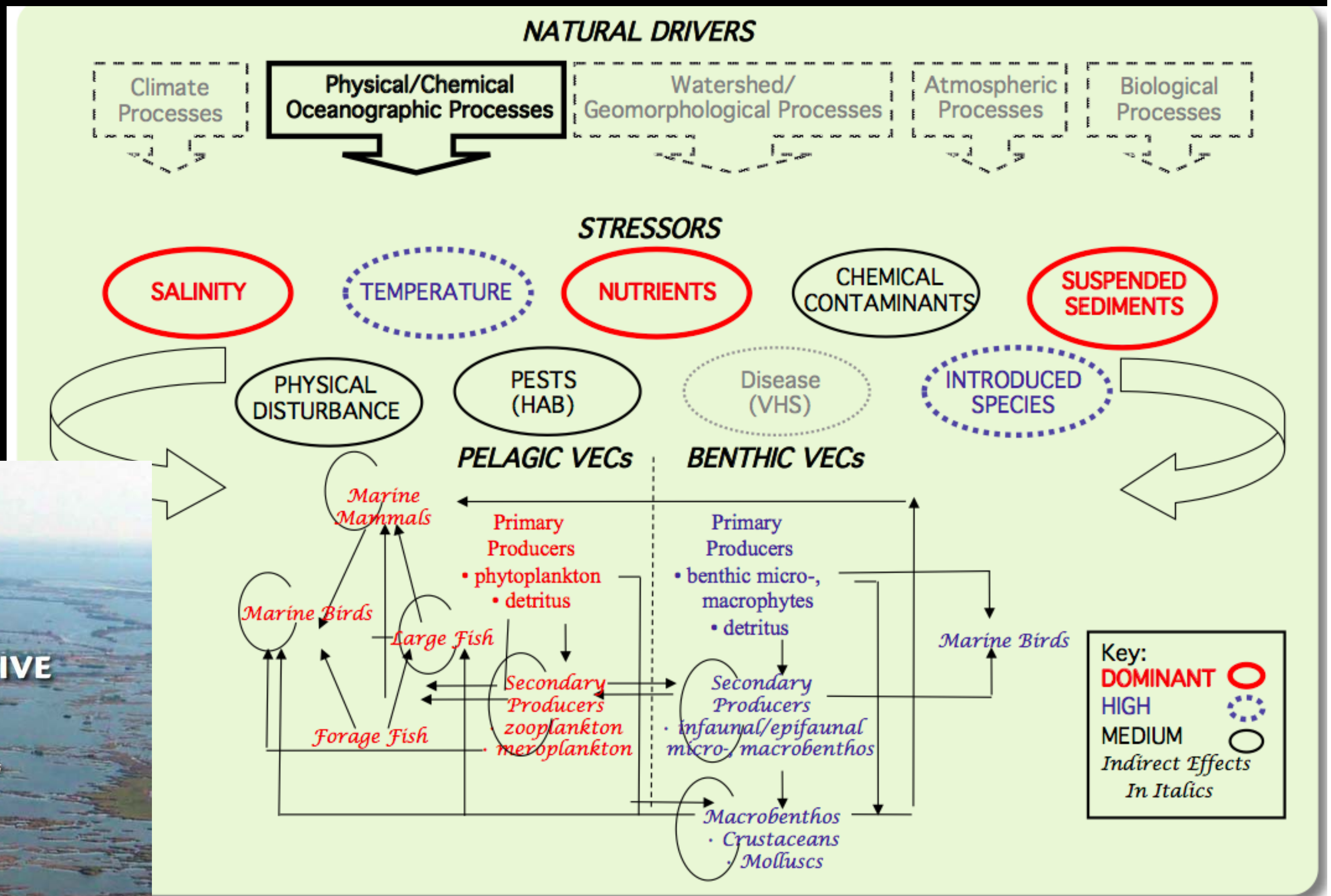
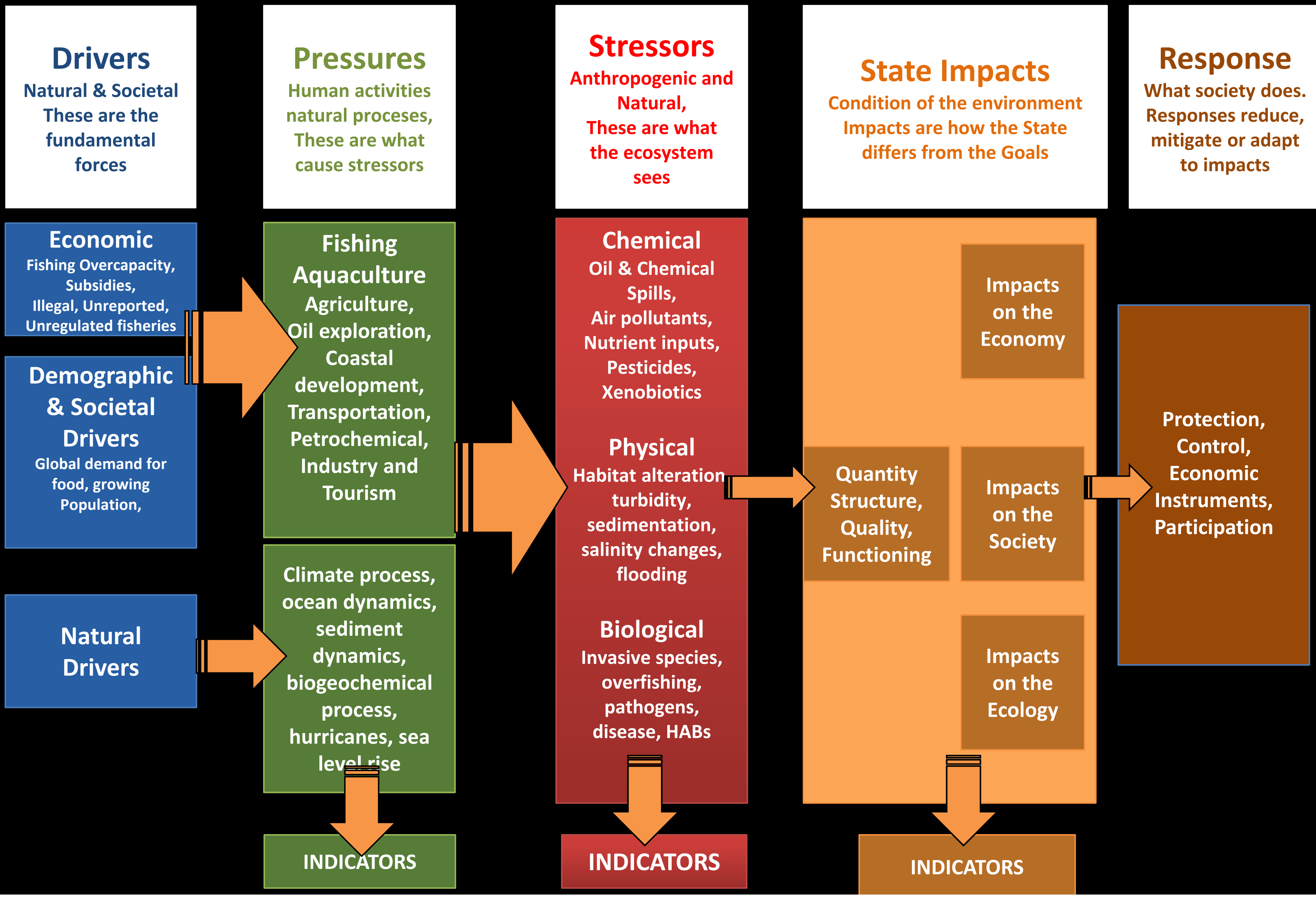


Figure 5. Example Conceptual Ecosystem Model of Prince William Sound and the Gulf of Alaska. This illustrates an ecological risk assessment-based conceptual ecosystem model, integrated with a trophodynamical conceptual model, as applied to a large-scale coastal ecosystem (from Harwell MA, Gentile JH, et al. 2010. A conceptual model of natural and anthropogenic drivers and their influence on the Prince William Sound, Alaska, ecosystem. *Human and Ecological Risk Assessment* 16(4): 672-726).

Developing indicators for the Gulf of Mexico



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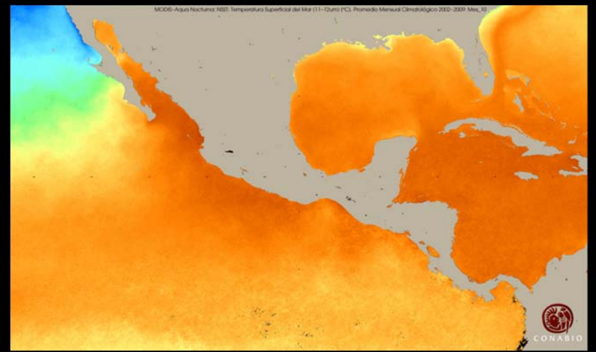
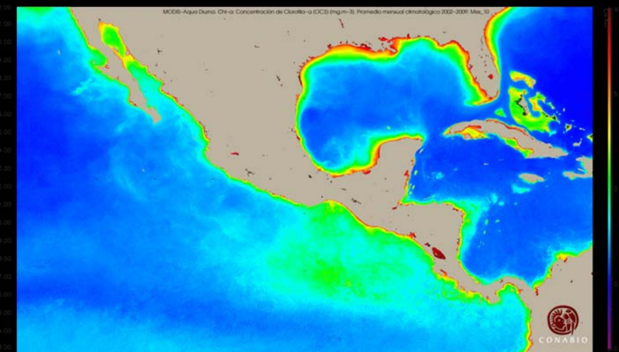




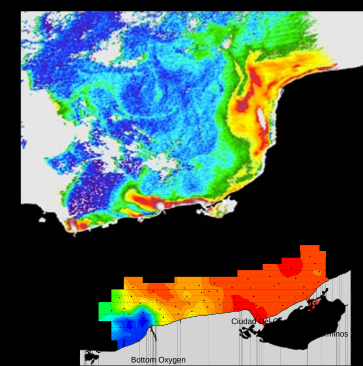
Identified main priorities and challenges under a climate change scenario

Sea Level Rise Flooding

Storm surge Marine Transgression

Hurricanes

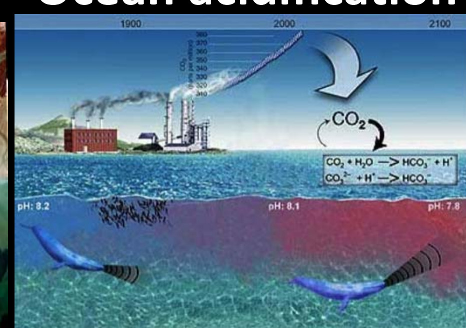
Pollution HABs, Hypoxia, Marine debris



Erosion

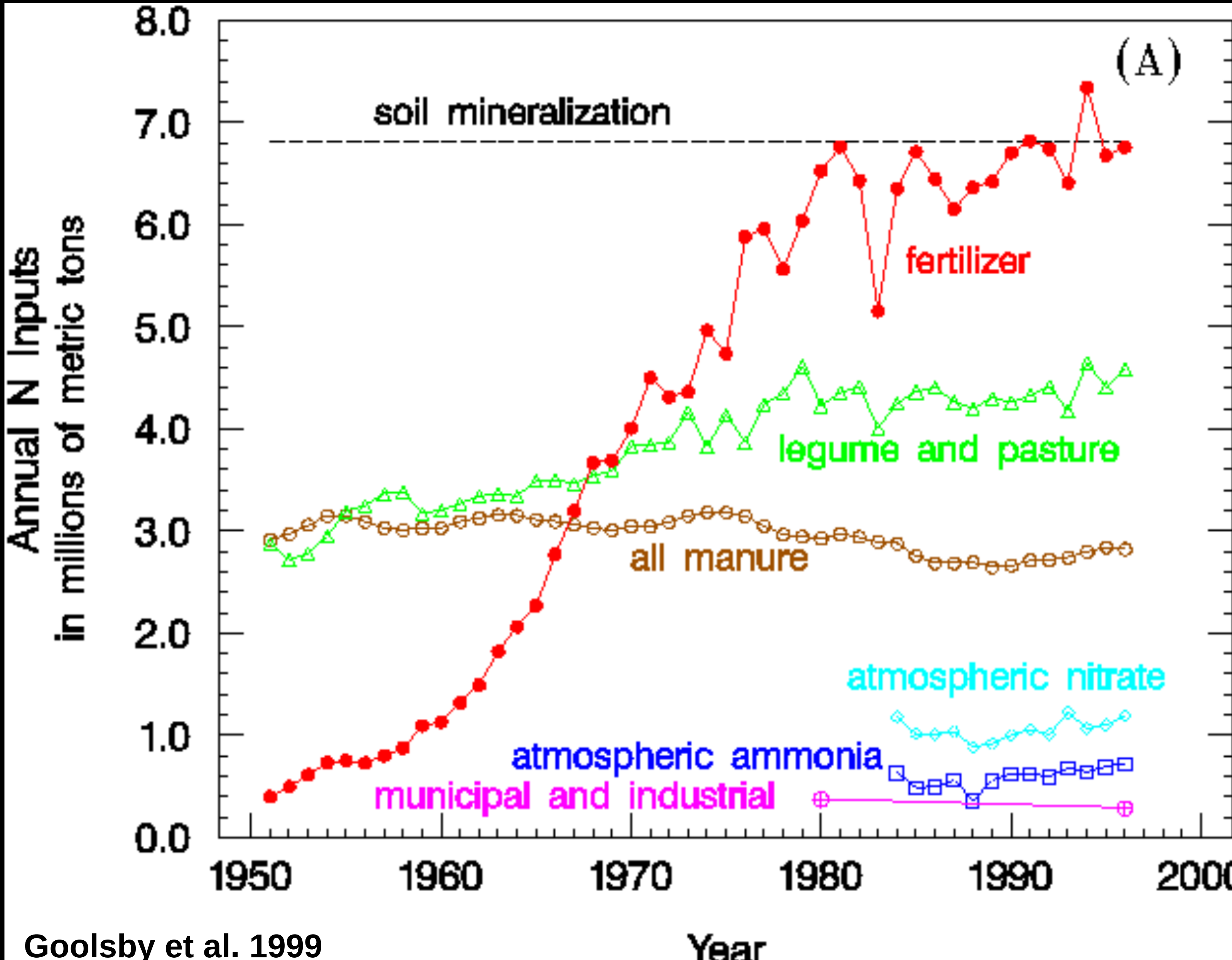
Sediment management

Ocean acidification



Invasive species

Nitrogen Inputs to the Mississippi Watershed



Goolsby et al. 1999

Hypoxia forecast 2014

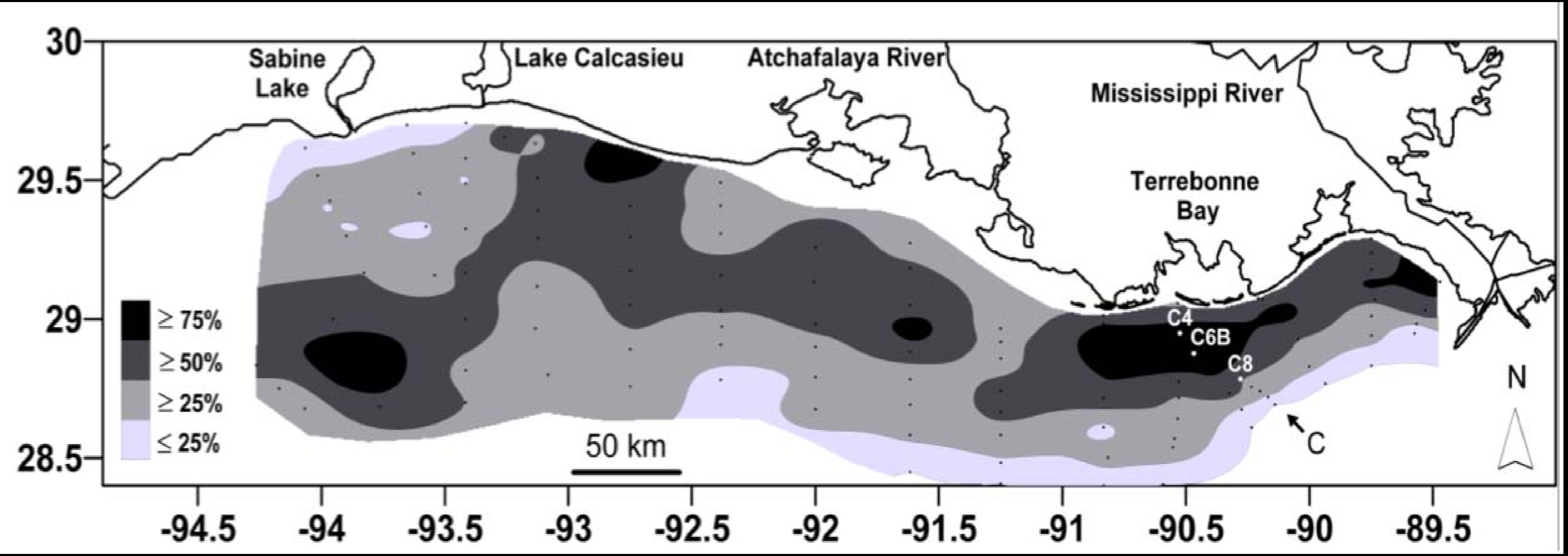


Figure 1. The frequency of mid-summer hypoxia (oxygen < 2 mg l^{-1}) over the 60 to 80 station grid on the Louisiana and Texas shelf during the summer from 1985 to 2008. Stations C4, C6Band C8 are labeled on the C transect. Modified from Rabalais et al. (2007).

Extensive, Severe Low Oxygen Waters

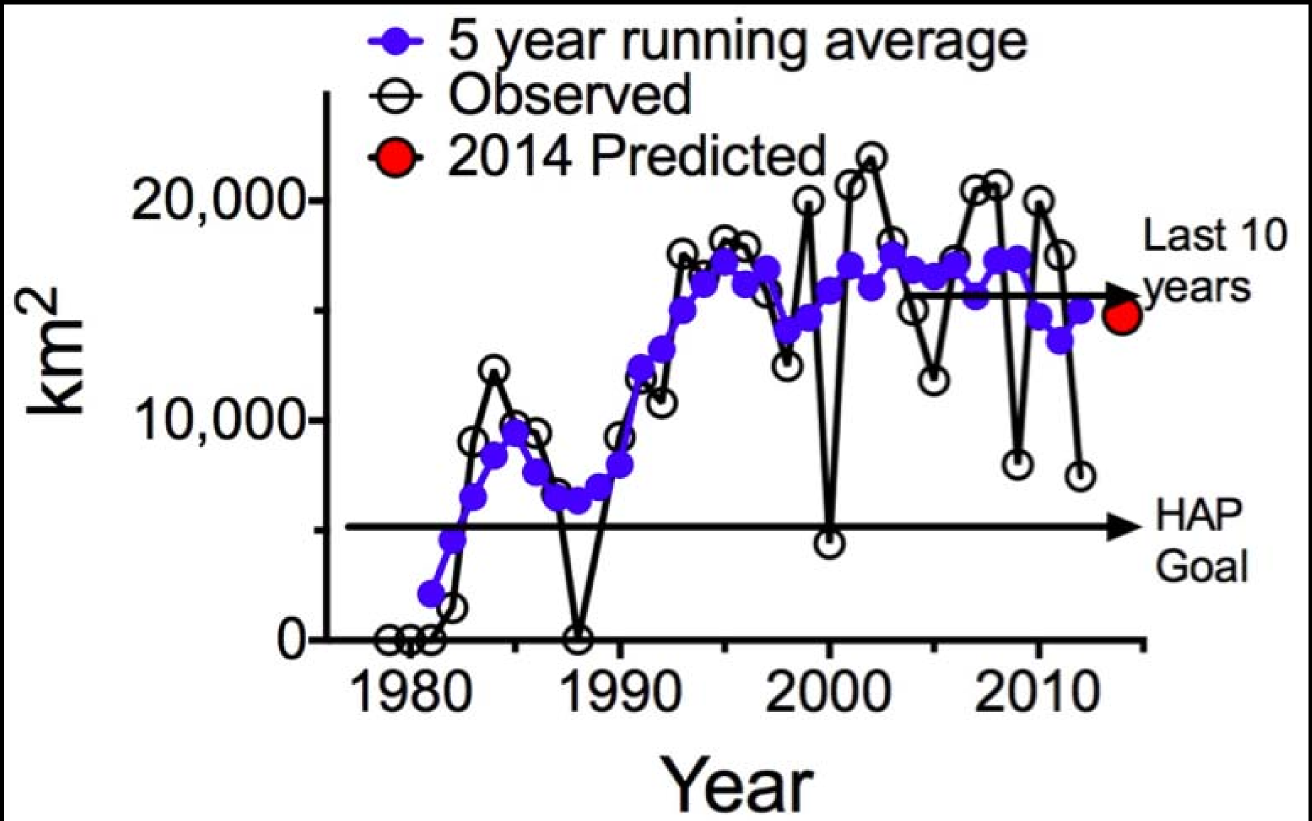
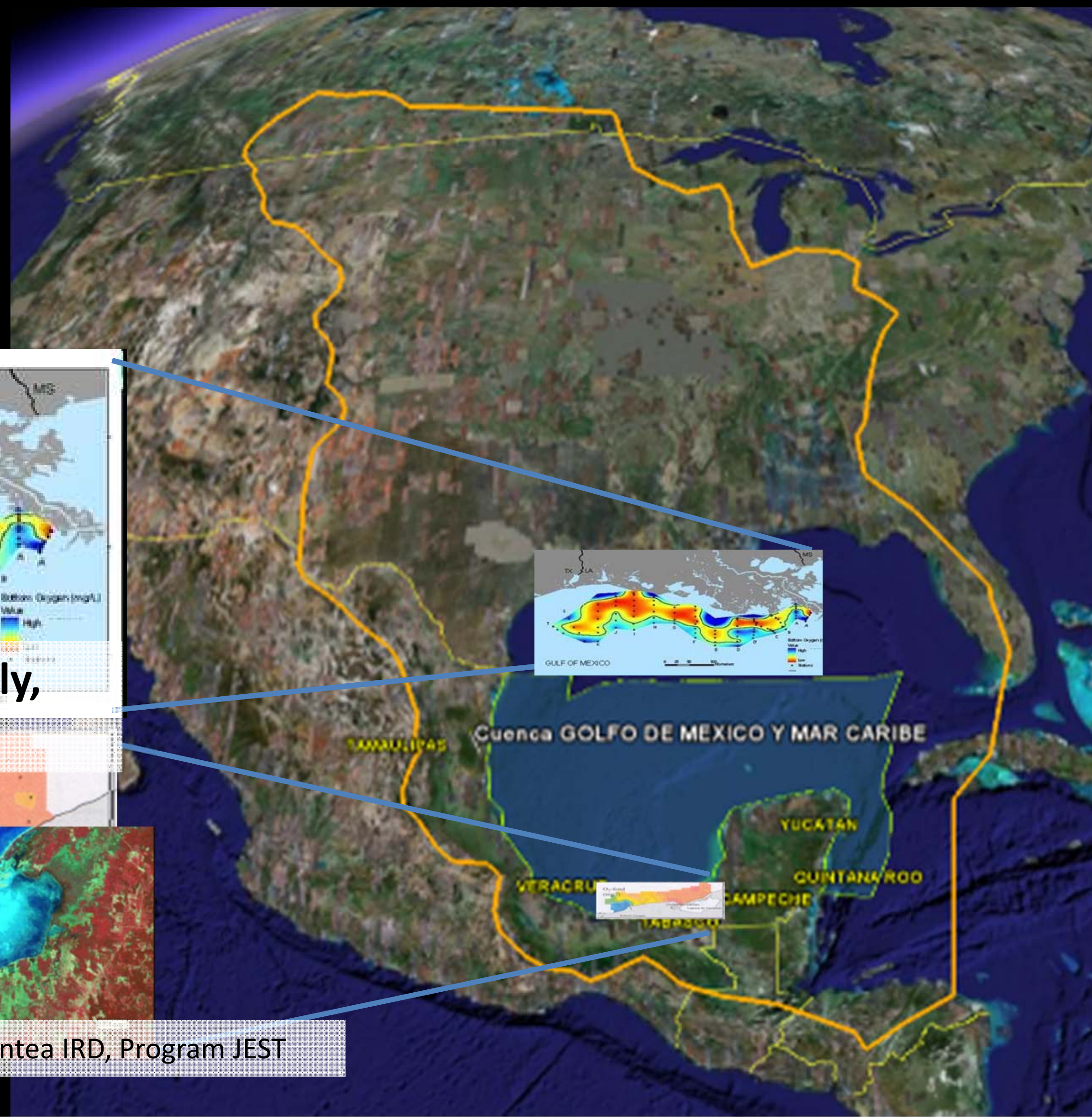
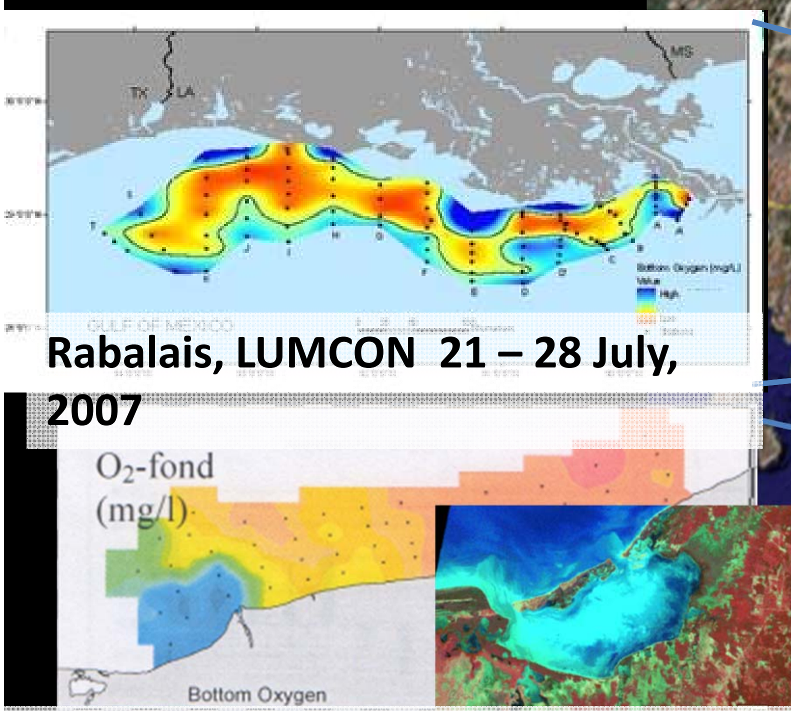


Figure 7. The measured and estimated size of the hypoxic zone from 1979 to 2012 and the predicted size for 2014.

The predicted hypoxic area is about the area of Connecticut. If the area of hypoxia becomes this large, then it will equal about three times the size of the goal of the Hypoxia Action Plan (HAP; less than 5,000 km^2).

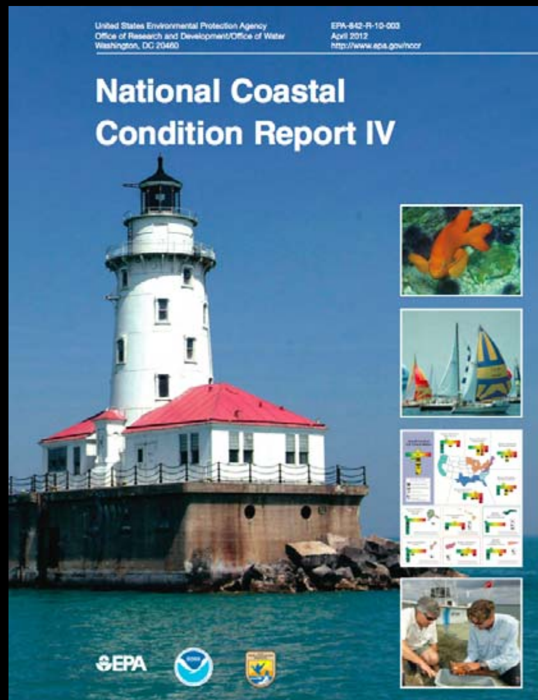
Hypoxia in the Gulf of Mexico





Rabalais, LUMCON 21 – 28 July, 2007

Results from BAHIAS Cruise, june 2008, RV Antea IRD, Program JEST



Coastal Condition Index

Five modules

- Water Quality
- Sediment Quality
- Benthic community
- Coastal habitat
- Fish Contaminants

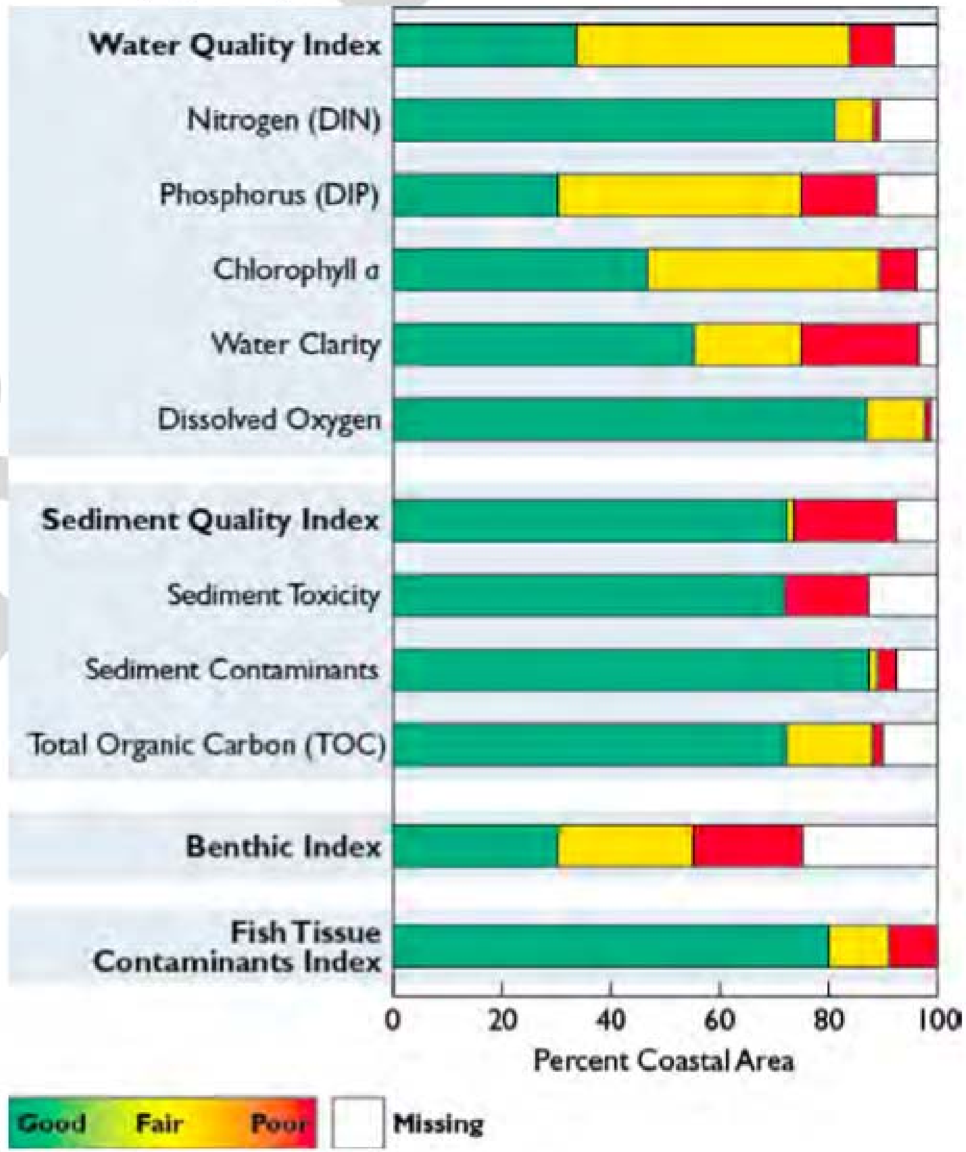
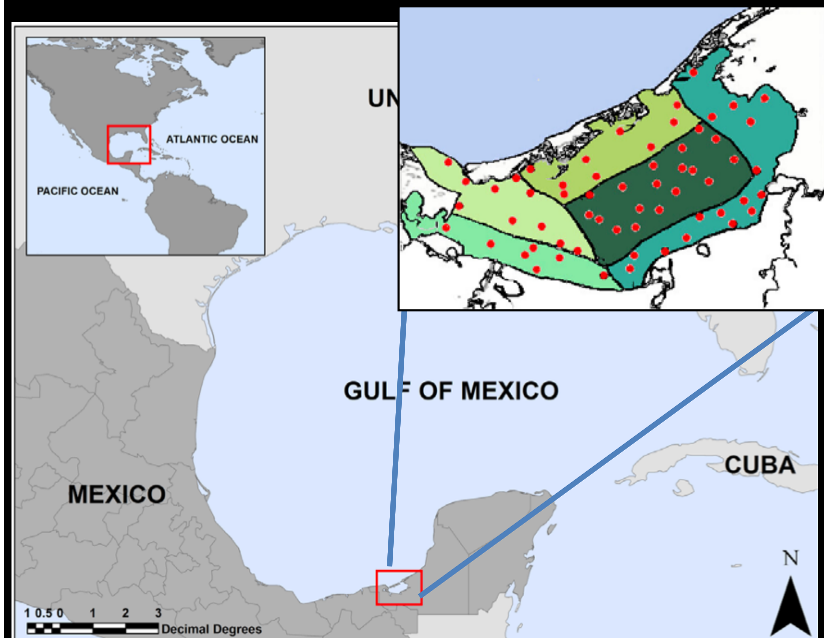


Figure 4. Percentage of coastal area of Gulf Coast region achieving each ranking for all indices and component indicators (EPA 2012).

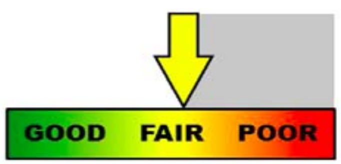
Gulf of Mexico LME Program
Terminos Lagoon Pilot Monitoring



- ✓ Stations were probabilistically assigned to each zone
- ✓ Roughly proportional to surface area
- ✓ 45 sampling stations total

V. García-Ríos et al. / Environmental Development 7 (2013) 72–79

Overall Condition
Terminos Lagoon, Mexico (3)



Indices	Score				
Water Quality Index			3		
Sediment Quality Index	5				
Benthic Index			3		
Costal Habitat Index					1
Fish Tissue Contaminants Index					1

Fig. 3. Overall condition of the Terminos Lagoon.

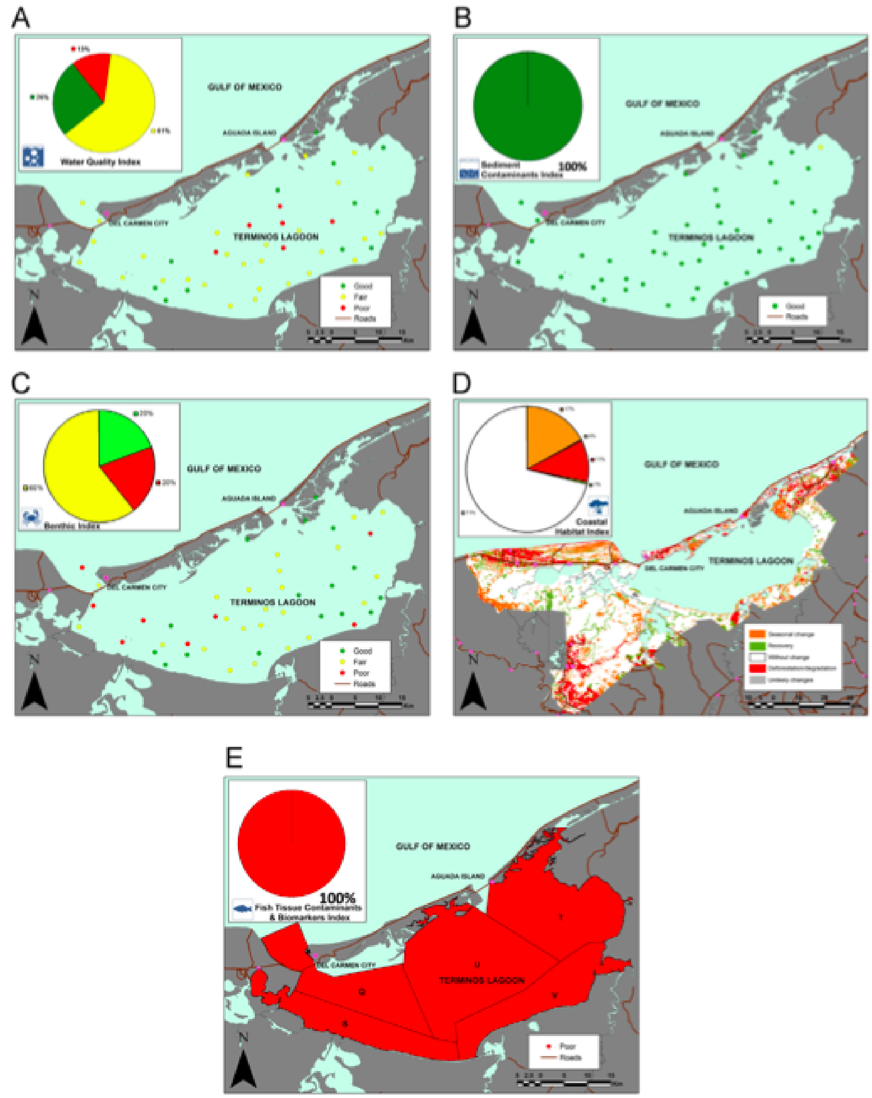


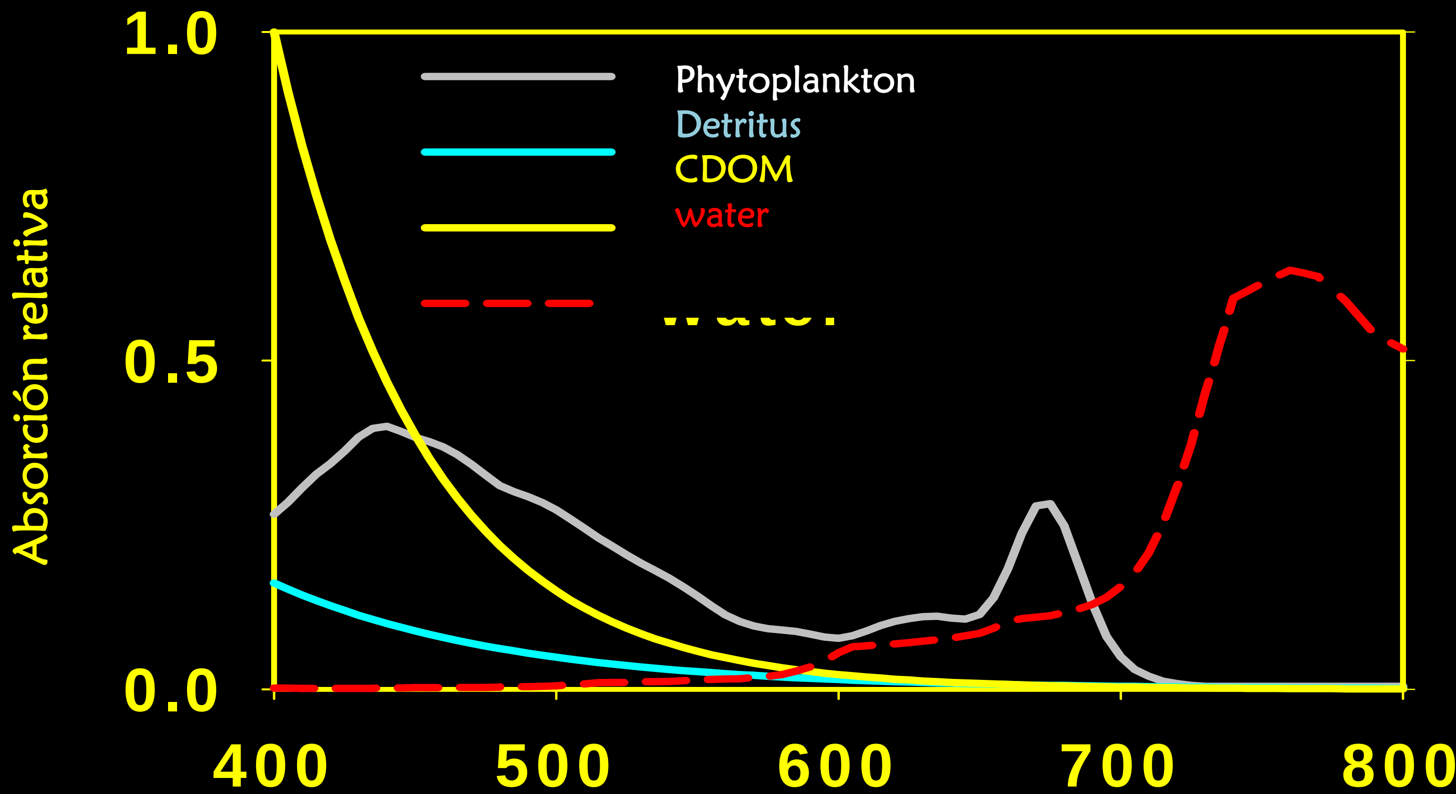
Fig. 4. Environmental condition of the Terminos Lagoon, Mexico. (A) Water quality index. (B) Sediment contaminants index. (C) Benthic index. (D) Coastal habitat index (historical coverage loss between 1991 and 2011). (E) Fish tissue contaminants and biomarkers index.

Harmful Algal Blooms

1) Early detection
2) Prediction of duration and trajectory
3) Timely acces to information on past events and environmental variables
4) Identify environmental conditions that favours HABs to occur

- Complementary tool for monitoring and to identify posible ocurrence, its intensity and movement
- Foster wide coverage in short periods of time

Optic Properties



Ligth absorption

- Phytoplankton: 443 y 675 nm
- Detritus
- (CDOM)
- Water

Algal blooms detection using ocean color images

Steidinger y Haddad (1981): Observed spot with sensor CZCS, associated to *Karenia brevis*.

Stumpf *et al.* (2003): One of the first algorithms for algal bloom detection, abnormal Chl a.

Hu *et al.* (2005): Combination of fluorescense images (FLH), upgraded real color (ERGB) & Chl a to detect red tides.

Stumpf y Tomlinson (2005): Algorithms associated with blooms behaviour and related to thermal fronts and upwalling events (SST).

Cannizzaro *et al.* (2008 y 2009): Detection technique with Chl a, FLH & retrodispersion for *K. brevis* blooms

Classification criteria:

[chl *a*] > 1.5 mg m^{-3} , b_{bp}(550) / b_{bp} (Morel, 1988) <1, FLH< 0.1 mW cm^{-2} μm^{-1} sr^{-1}

Gulf of Mexico Dynamic Regionalization

nLw412: yellow substances signal asociated to the coast

nLw488: absorption of Chl *a* without the CDOM signal

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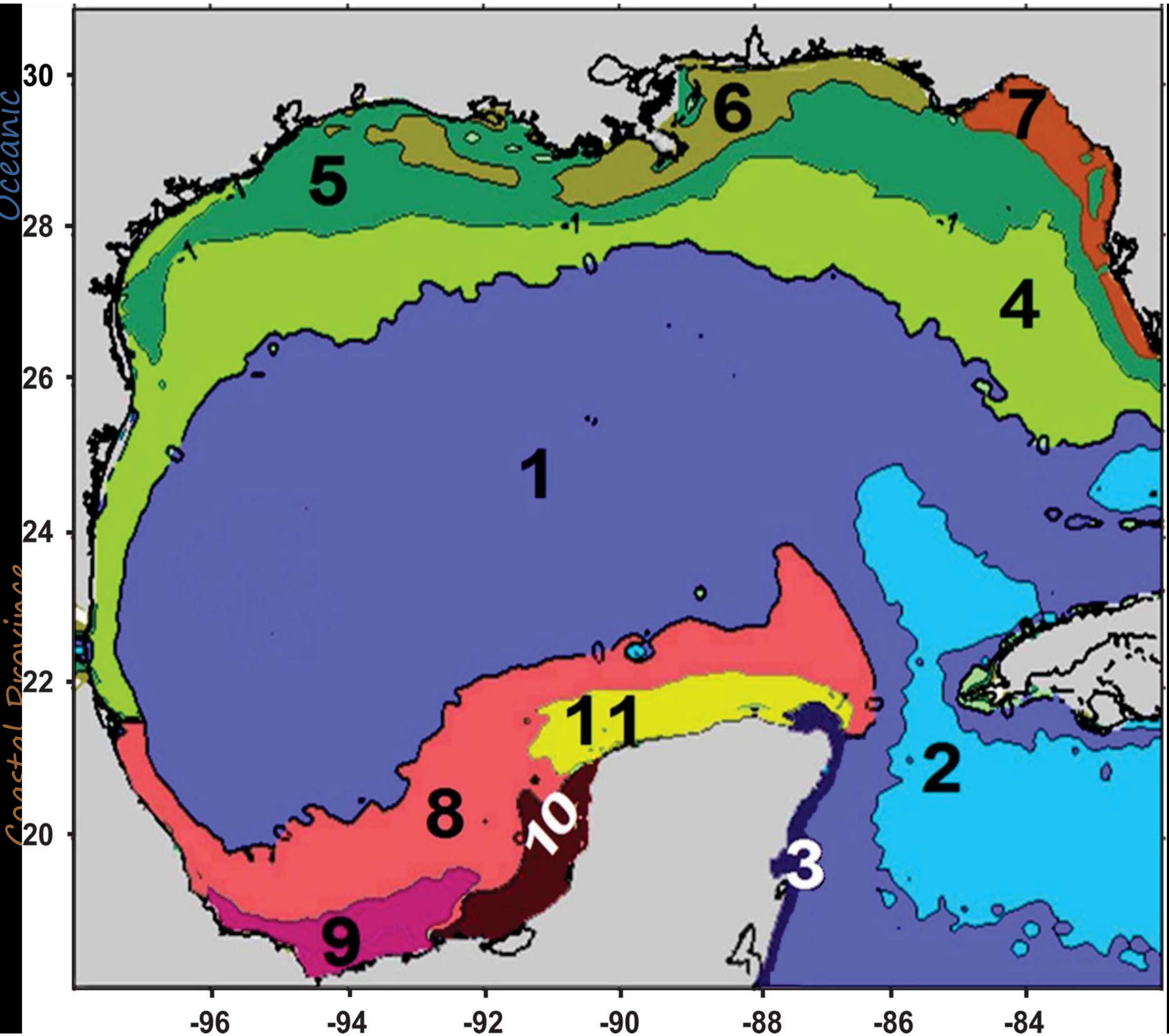
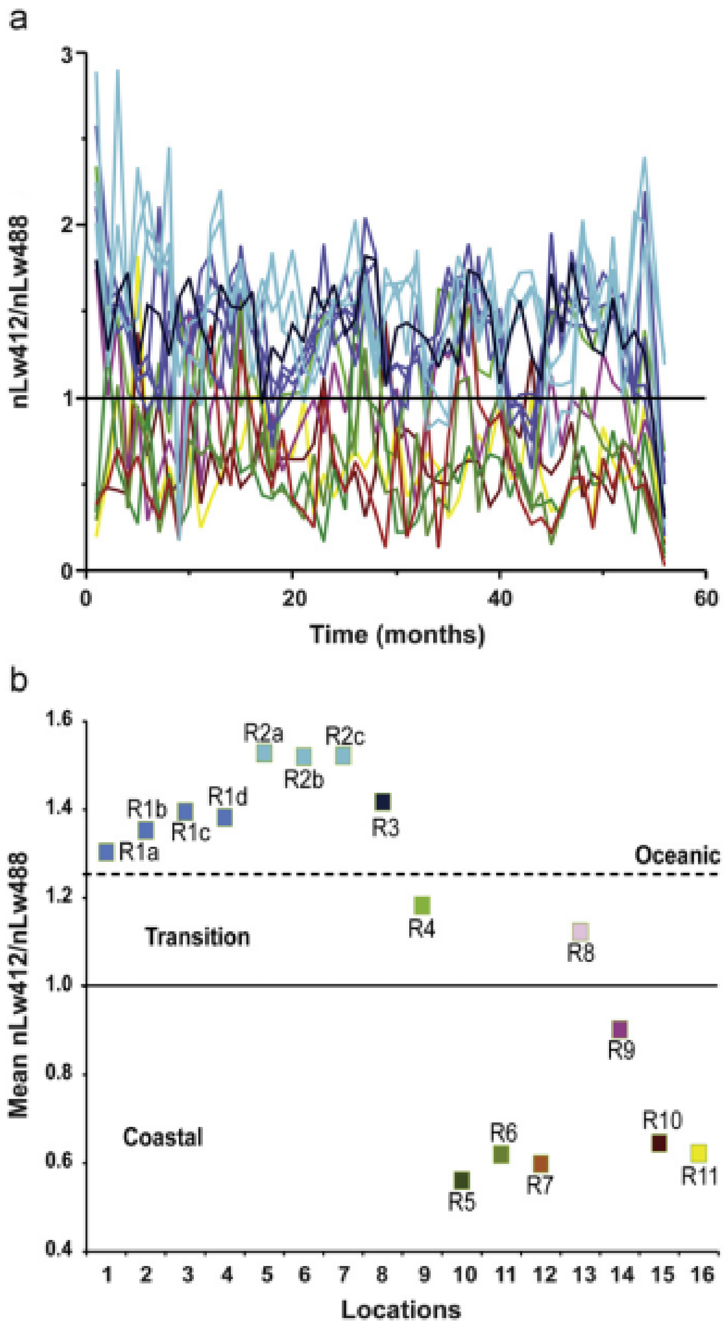




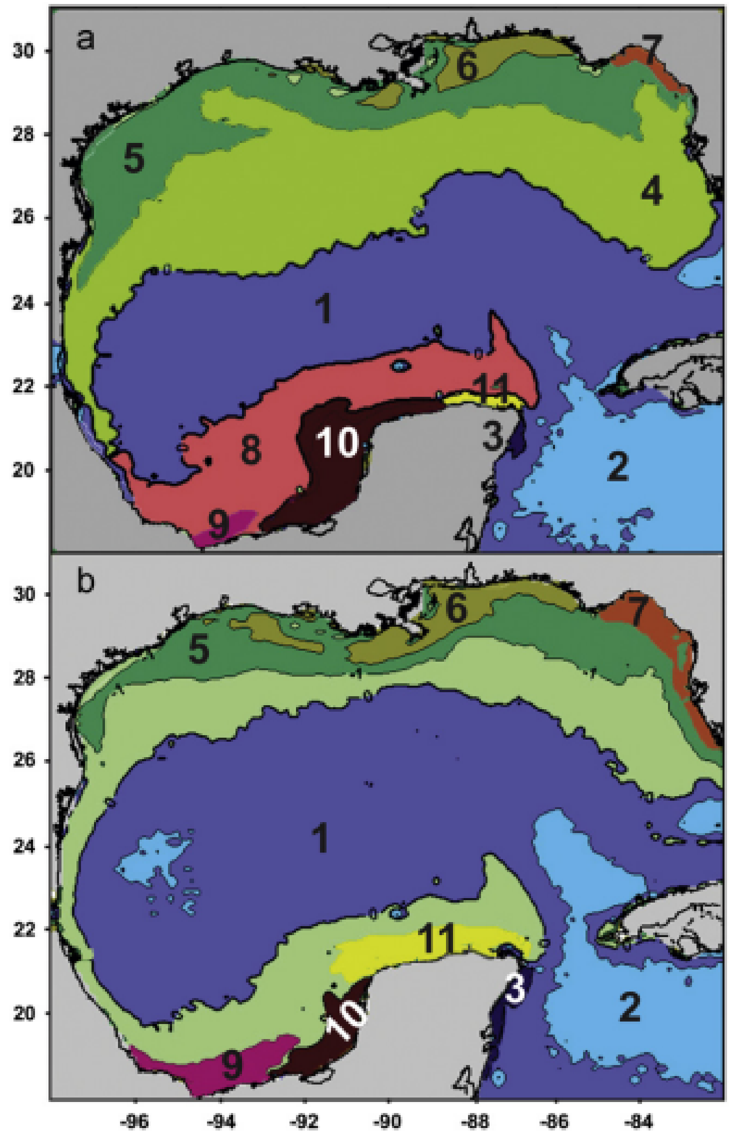


Fig. 4. Graphical representation of the regionalization by scenario. (a) Non-Hurricane season, (b) Hurricane season.

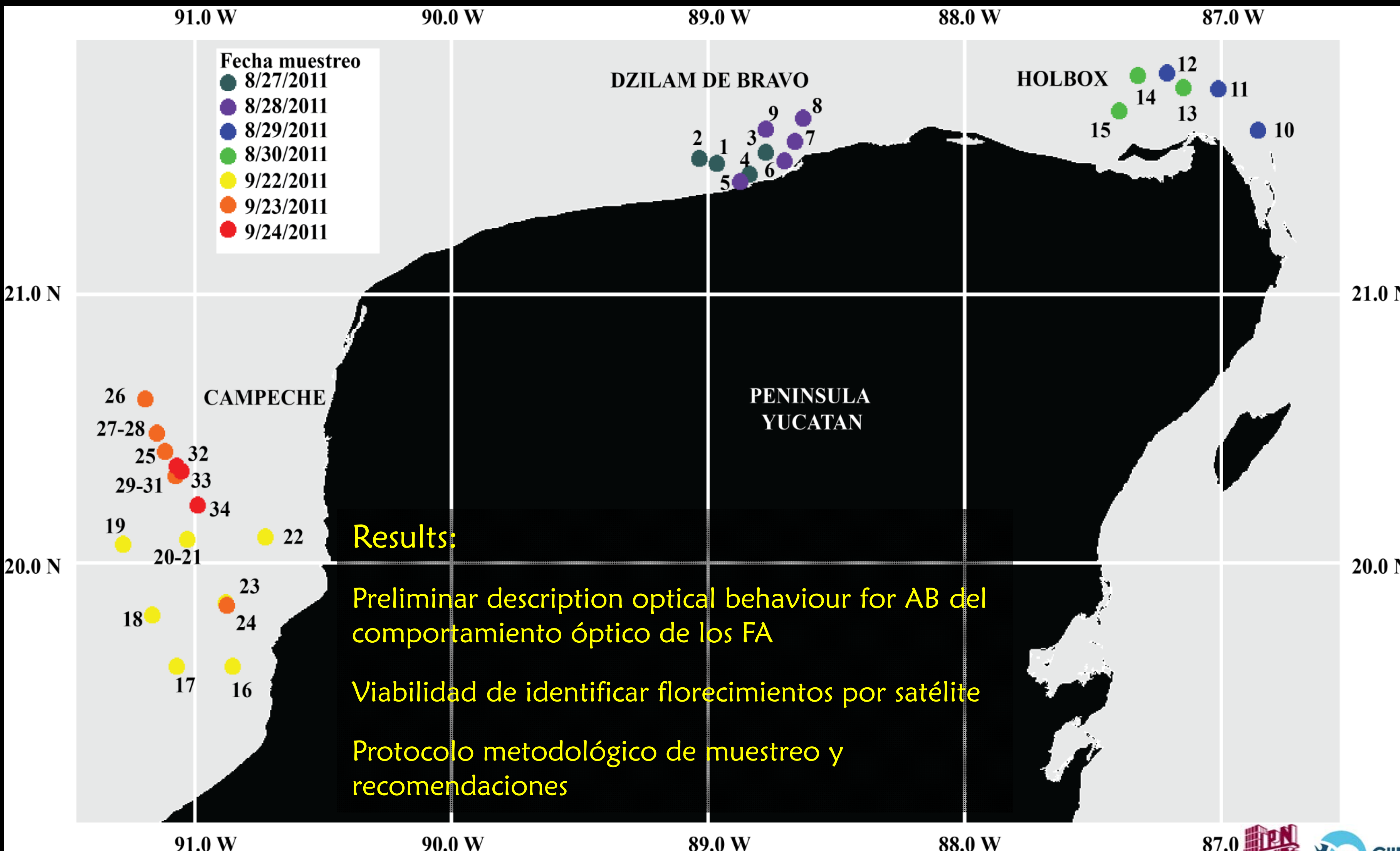
4. Discussion

The dynamic nature of regions is a natural consequence of aqueous media due to the modification of association intensity

Algal blooms preliminary bio-optic properties study

1er phase: 15 stations different conditions & type of blooms

2da phase: severe HAB, pre-determined monitoring using satellite images



Results:

Preliminar description optical behaviour for AB del comportamiento óptico de los FA

Viabilidad de identificar florecimientos por satélite

Protocolo metodológico de muestreo y recomendaciones

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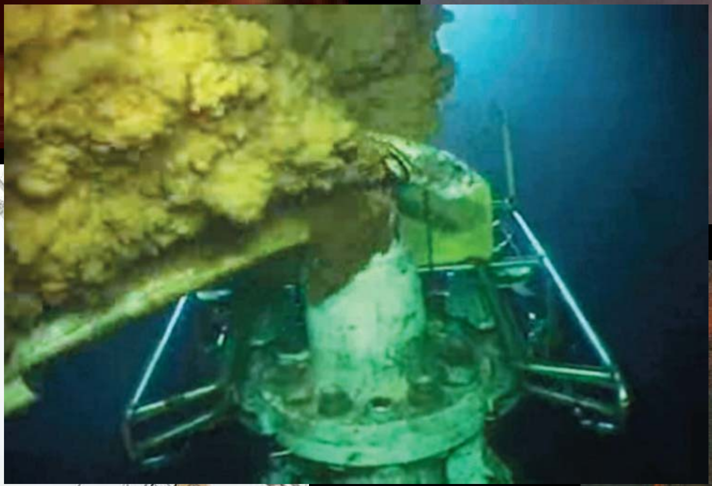
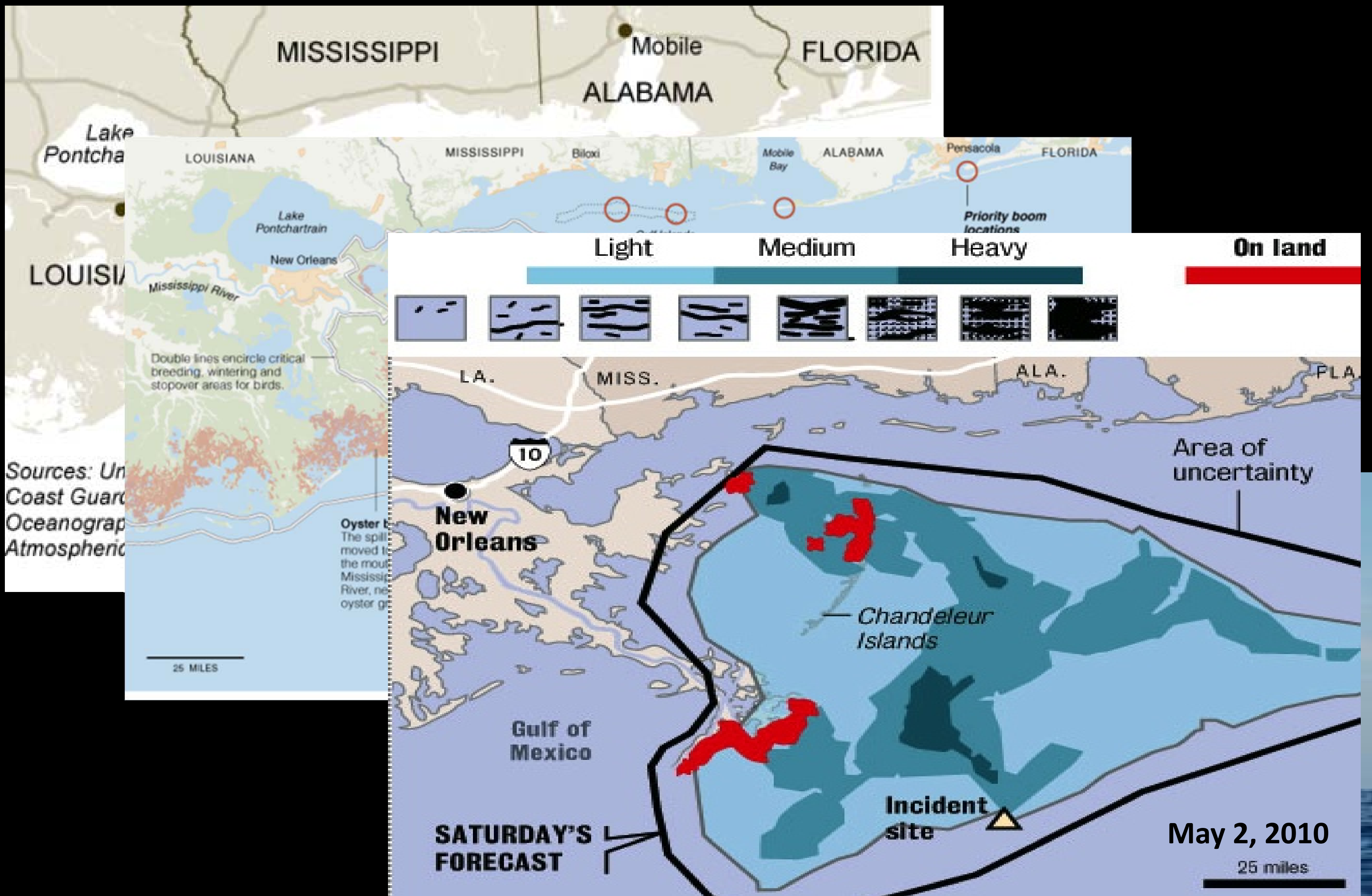
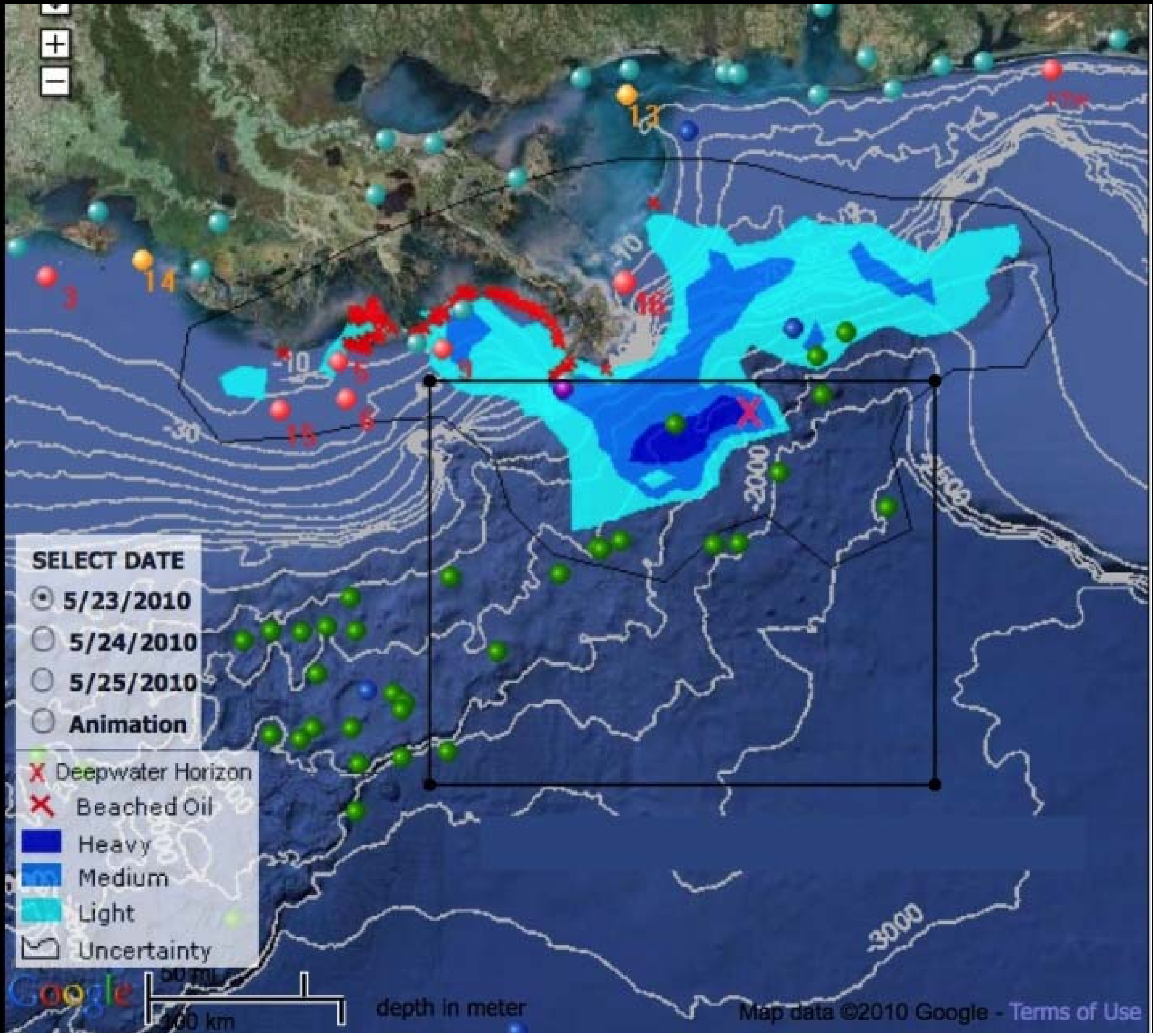
Deepwater Horizon Sequence



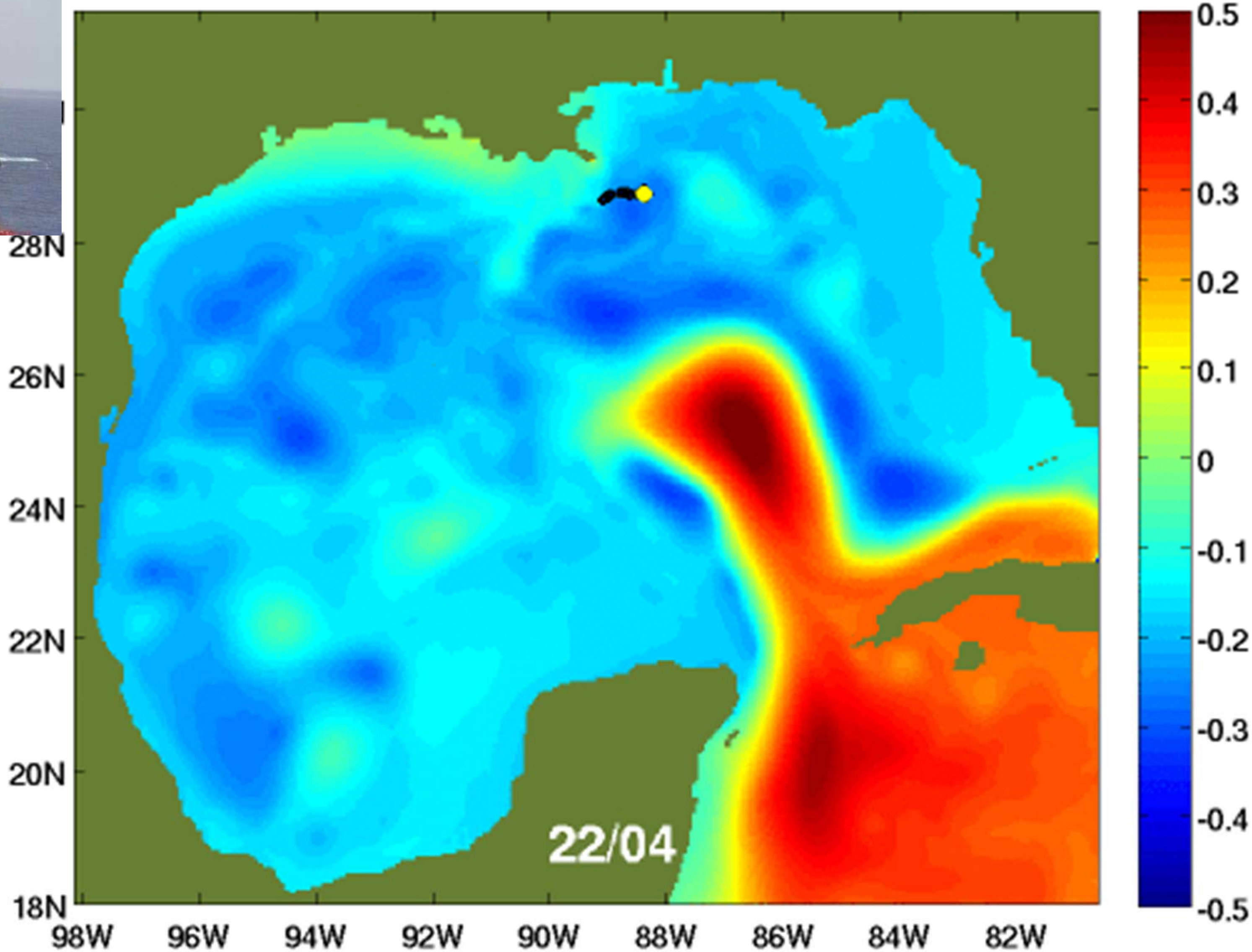
Deepwater Horizon Sequence



Oilmageddon Sequence and its Transboundary consequences



Oil Spill, BP managed Deepwater Horizon,



LIVING MARINE RESOURCES

a. Marine litter
b. Illegal fishing
c. IUU
d. Invasive species

GLOBAL Challenge; Biodiversity loss

Marine litter (micro-plastics), habitat loss

Biodiversity Loss

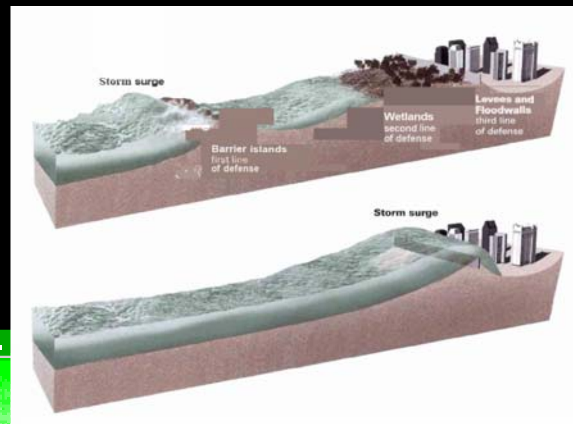
Illegal fishing, shark finning, (pollution,noise)

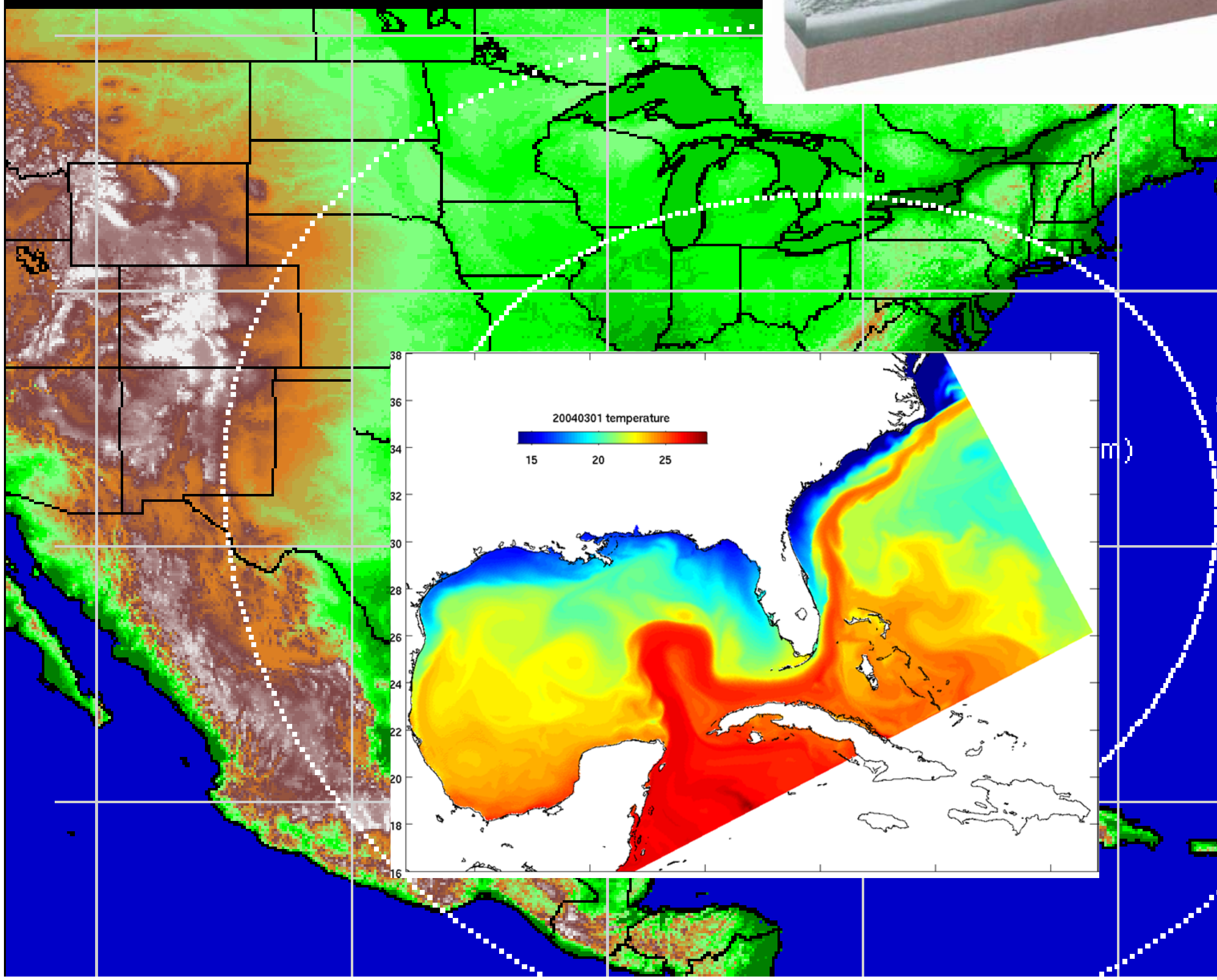
LION FISH INVASION
(*PTEROIS VOLITANS*)

CLIMATE CHANGE AND EXTREME METEOROLOGICAL EVENTS

a. HURRICANES,
b. SEA LEVEL RISE,
c. FLOODS,
d. EROSION,
e. STORM SURGE

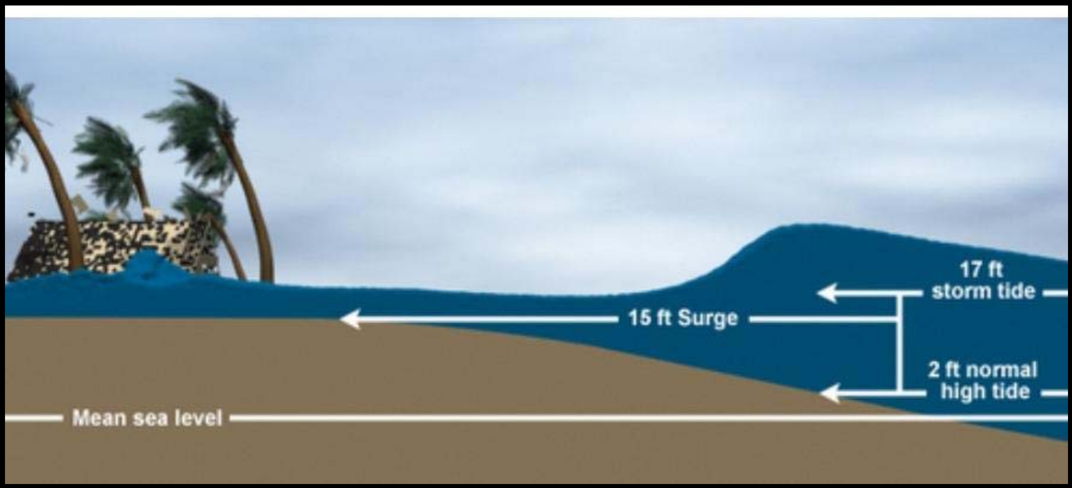
Hurricanes, storm sturge, flooding, etc.





STORM SURGE

Wind and Pressure Components of Hurricane Storm Surge
Storm motion
Eye
Wind-driven Surge
Pressure-driven Surge (5% of total)
Water on ocean-side flows away without raising sea level much
As water approaches land it "piles up" creating storm surge



17 ft storm tide
15 ft Surge
2 ft normal high tide
Mean sea level

COASTAL EROSION and SEA LEVEL RISE

Cortesía Antonio Marquez (UAMI)

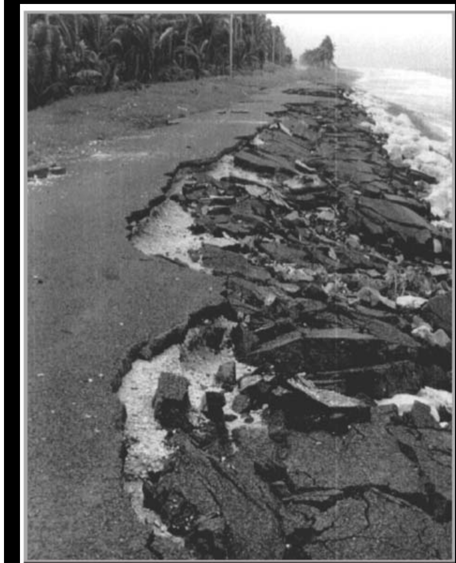
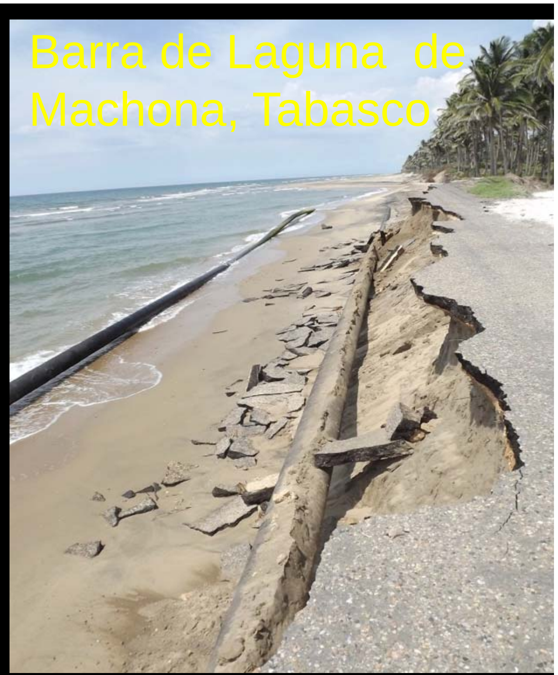


Figura 5. La destrucción de la infraestructura adyacente a la costa, es otro de los problemas que se manifiestan con el ascenso del nivel medio del mar. (Barra de Tupilco, Tabasco).



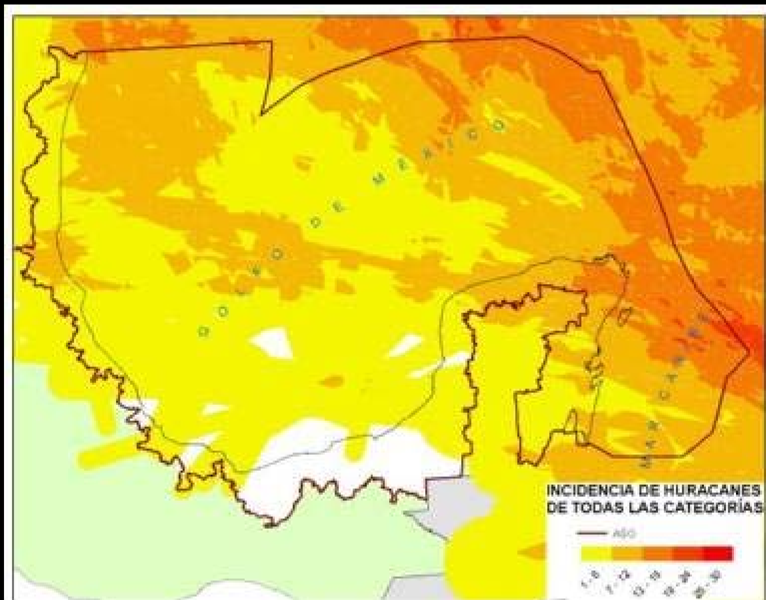
Grijalva Este, Tabasco

Mecoacán, Tabasco

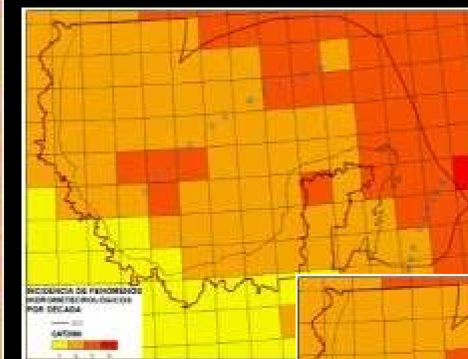
Barra de Machona

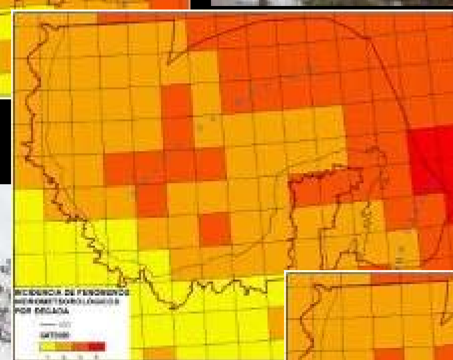
Climate dynamics and impact scenarios in coastal areas

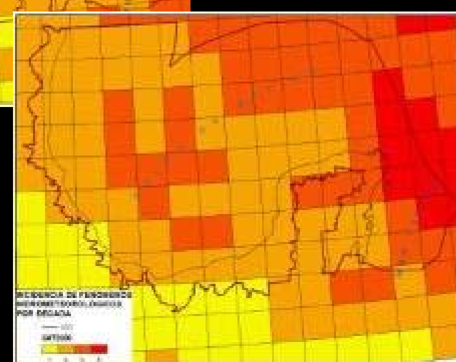
Hurricanes



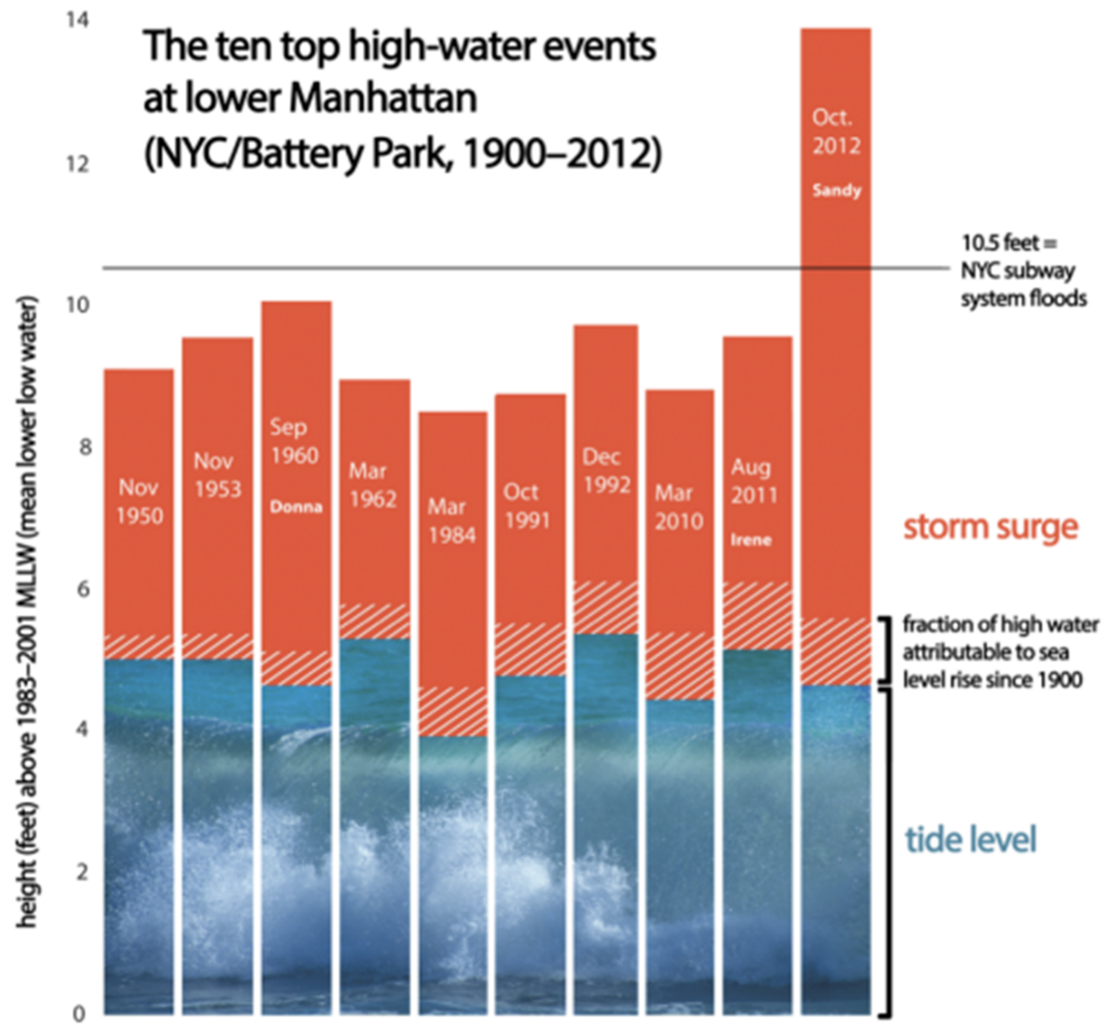
Trends







Sea Level Rise and Storm Surge

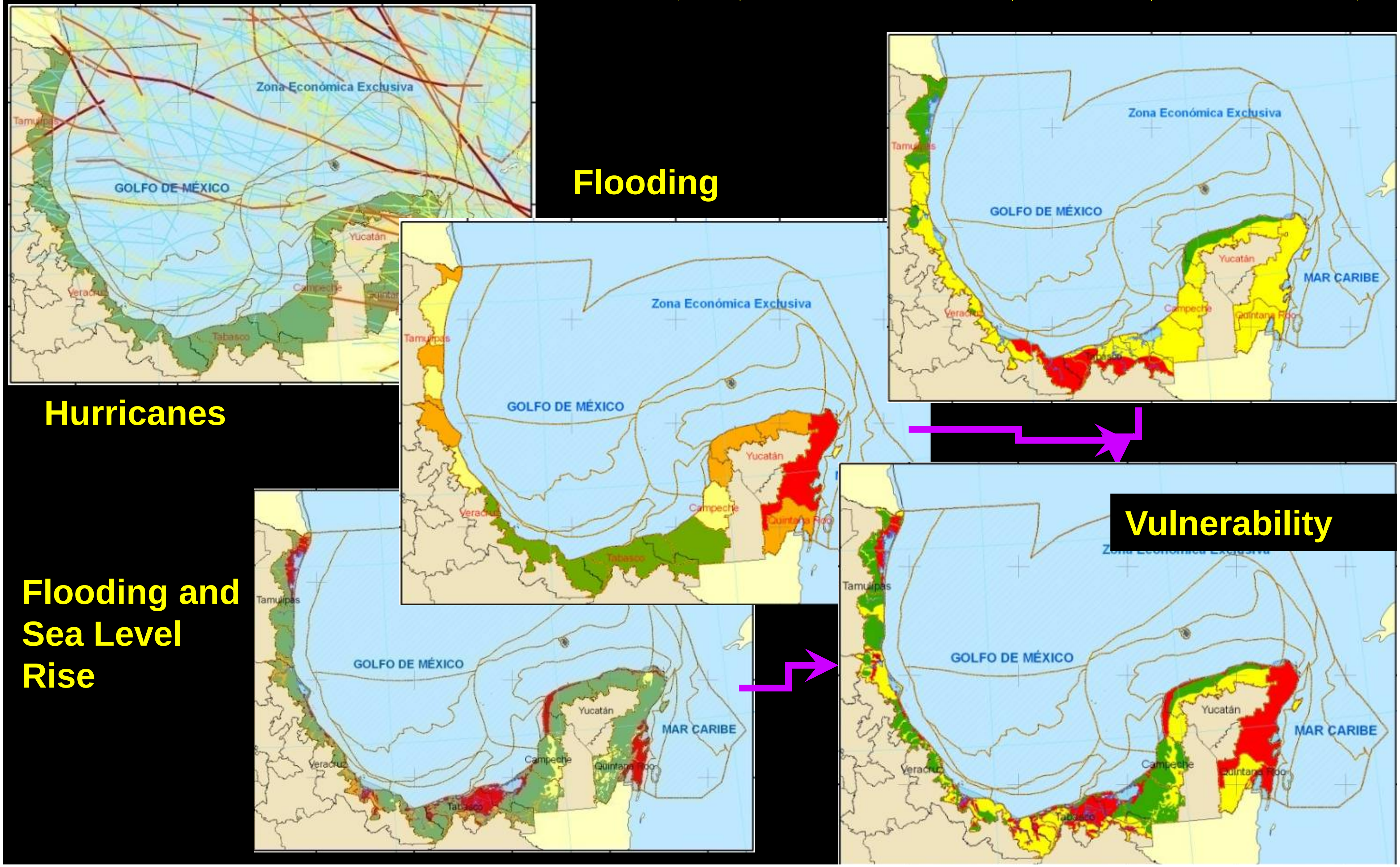


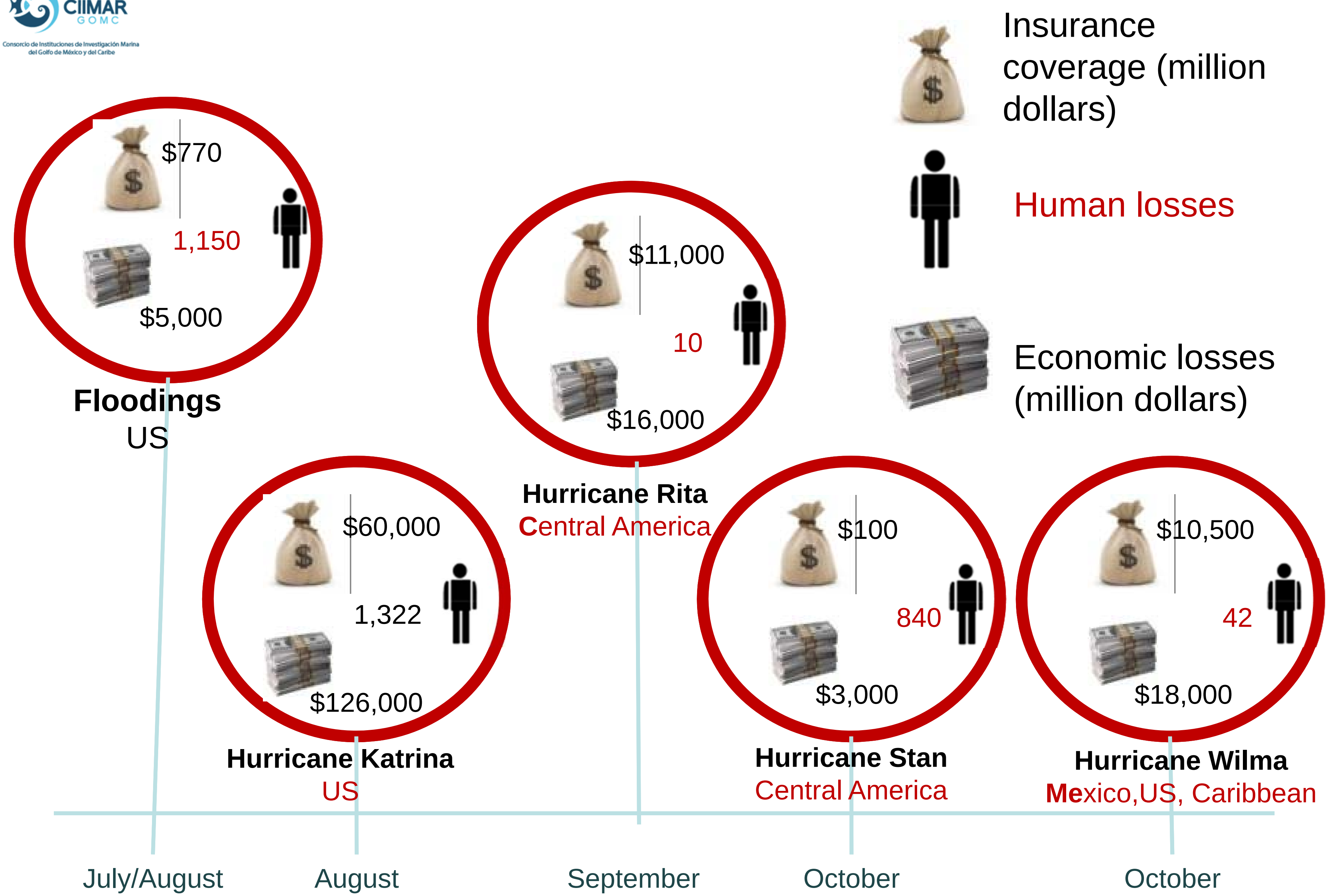
This graphic shows factors that contributed to the top 10 high-water events measured at New York's Battery Park from 1900 to present. The water height for each event is shown here against the benchmark of mean lower low water averaged between 1983 and 2001. Sea level rise (about a foot since 1900) is depicted as a component of storm surge. Although Sandy's surge peaked close to high tide, other events had even higher tide levels.

Click image to enlarge. *Credit: Carlye Calvin and Bob Henson, UCAR; data courtesy Chris Zervas, NOAA National Ocean Service.*

LAND AND SEA USE PLANNING

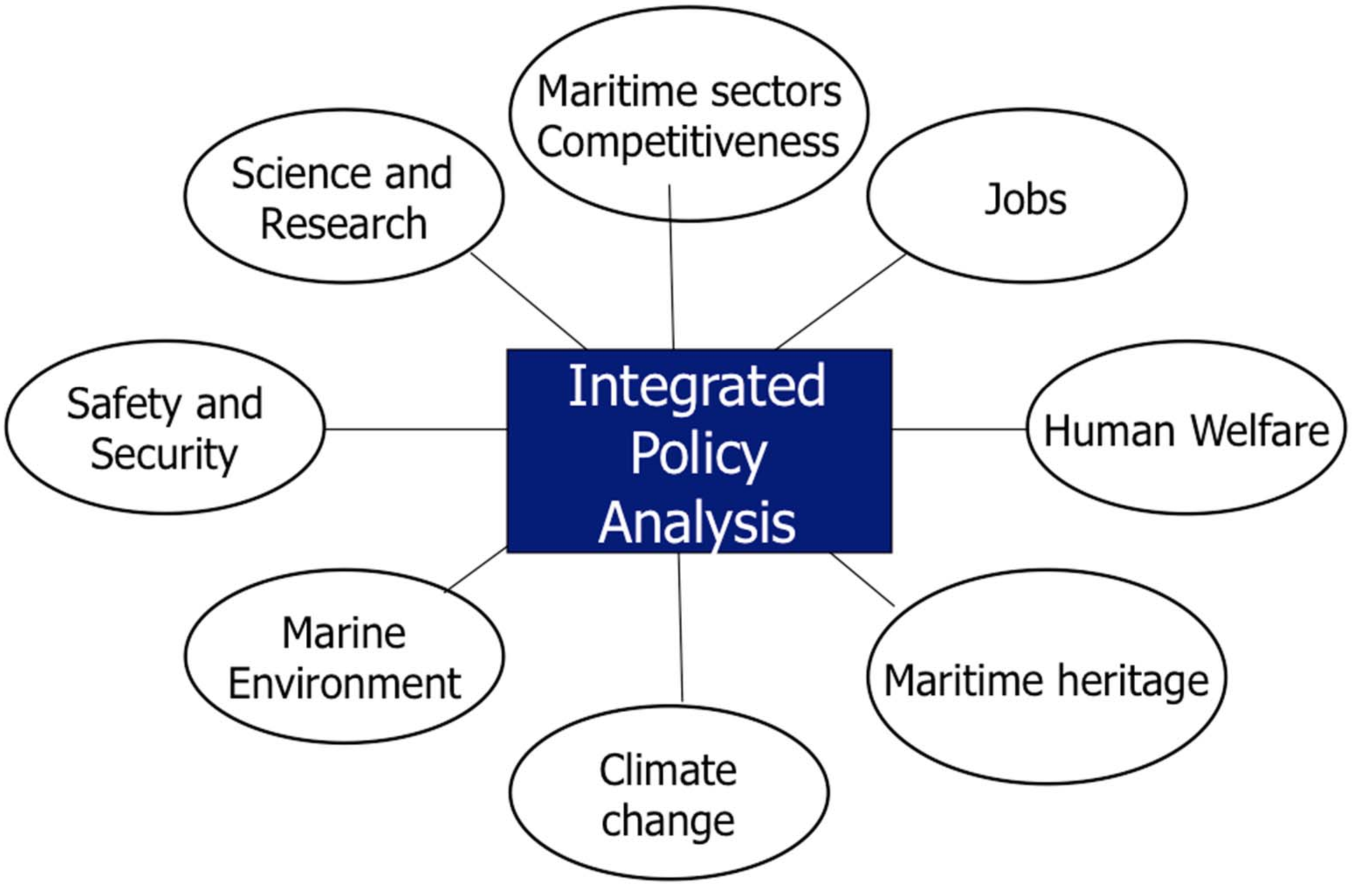
RISK FACTORS, EXTREME HYDRO-METEOROLOGICAL EVENTS AND CLIMATE CHANGE





Global losses due to the five major hydro-meteorological events in 2005.
Source: Cepal, 2009

What we are doing:
Ocean Policy implementation



General Objective 1:

Improve living conditions and human wellbeing

General Objective 2:

Strenghthen local economies, regional and sectoral productivity.

General Objective 3:

Ensure the structure and function of marine and coastal ecosystems

➢ *MEXICOOS*

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Instituto Politécnico Nacional
"La Técnica al Servicio de la Patria"

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SECRETARÍA DE MARINA

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CONABIO

TECHNOPÔLE BREST-IROISE

AEM
AGENCIA ESPACIAL MEXICANA

MexICOOS

An international cooperation project to set up the

Mexican Integrated Coastal and Ocean Observing System

MEXICOOS

A model of coastal and ocean observing system that provides continuous information

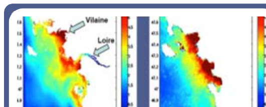

Natural hazards (met-ocean monitoring) / alerts


Oil spill drift forecast


Environment monitoring & evolutions forecast & management


Renewable marine energies

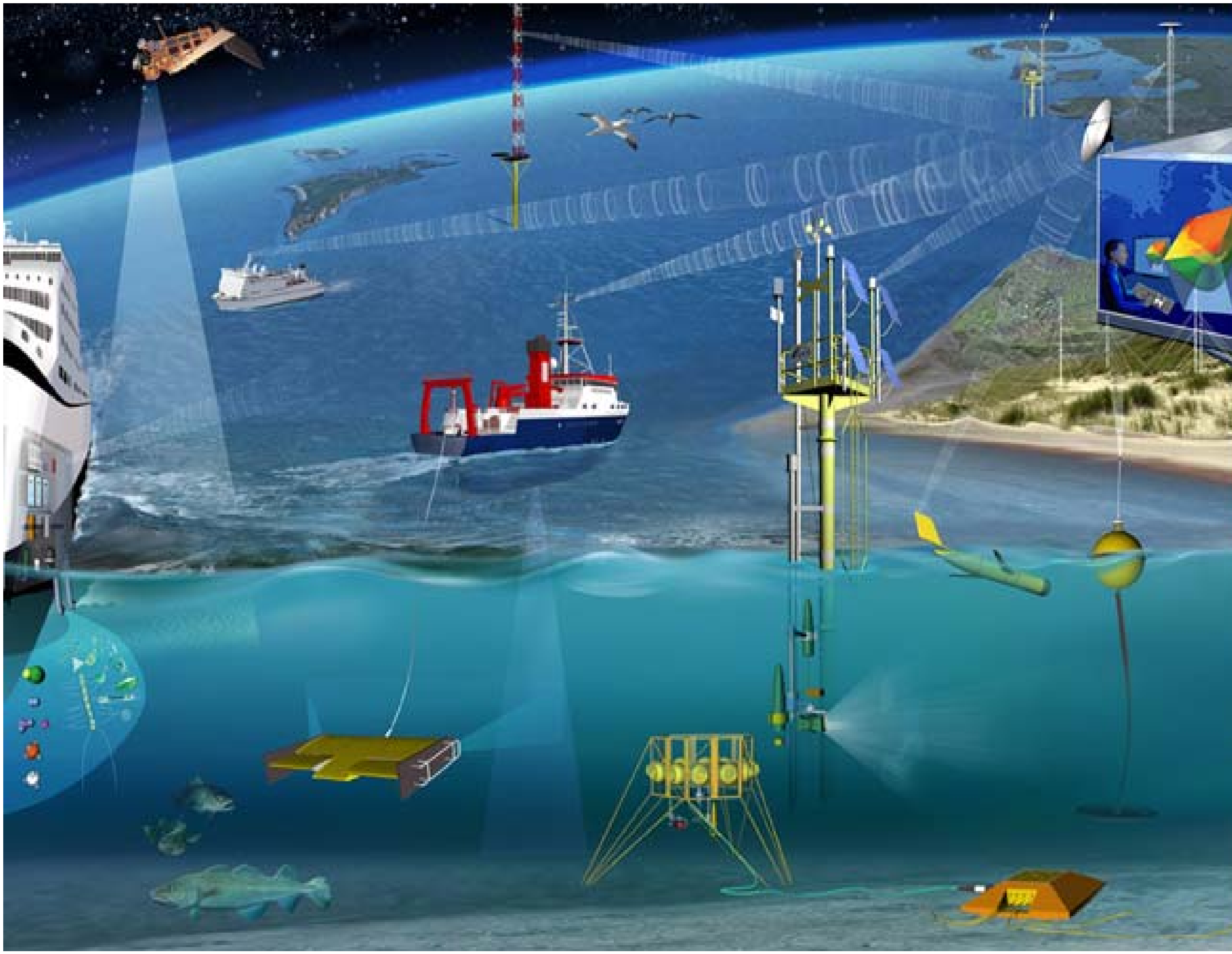

Turbidity / sedimentology

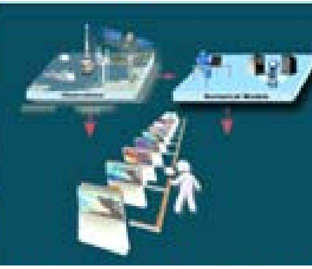


Eutrophication, Harmful algal blooms, ..

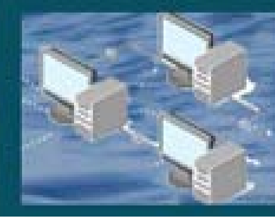

Hydrodynamics and biogeochemistry around islands (Indian and Pacific Oceans)

Future development of MexICOOS

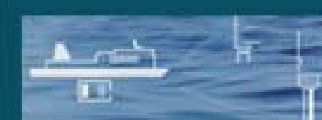




APPROACH & USERS



PRODUCTS



OBSERVATION

MODELS

Conclusions

Urgent need to:

- ❑ Invest in ocean observing systems
- ❑ Develop a strong baseline to monitor the ocean ecosystem health
- ❑ Support countries to build enhance or implement their Ocean and Coastal Observing Systems
- ❑ Implement the network of infrastructure for harmonized monitoring
- ❑ Develop robust indicators based on pressure-status-response models
- ❑ Obtain good quality near real time data
- ❑ Strengthen networking and observing systems
- ❑ Use of simple sound science based indicators