Potential vulnerability of artisanal fisheries to ocean acidification in the Western Indian Ocean

Kennedy Osuka & Melita Samoilys
kosuka@cordioea.net

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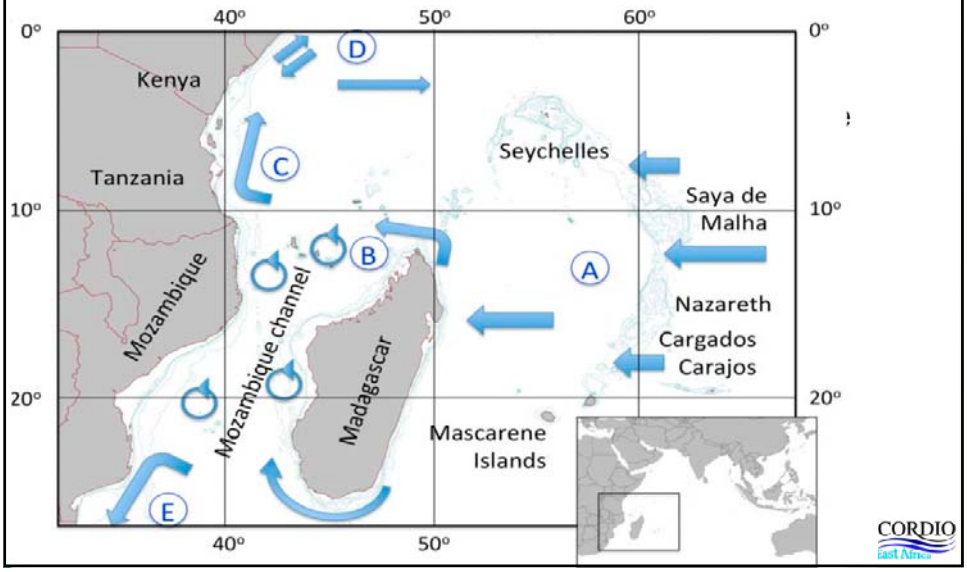
Introduction - WIO

- Extends from East African coasts to Islands e.g. Seychelles



Introduction - WIO

- **Climate change and ocean acidification**
  - Profound effects on the status and **distribution of coastal and oceanic habitats**, the fish and invertebrates they support
  - →productivity of fisheries and aquaculture
  - Limited research on OA in the WIO
  - Quantitative scientific information and community knowledge are often lacking

Goal and objective

- **Goal**
  - To analyse the social and economic impacts of ocean acidification on coastal communities and their fisheries in the WIO and contribute to vulnerability prediction modelling
- **Specific objectives**
  - To determine the **relative proportion of different target taxa** in artisanal fisheries of countries of the WIO
  - To assess potential vulnerability of **OA** through socio-economic and fishery determinants of coastal communities in developing countries of the WIO

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Material and methods

Vulnerability

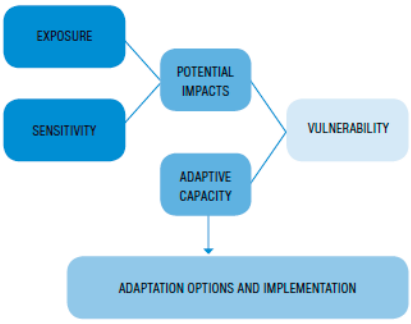
– Referred to vulnerability assessment framework

Exposure & sensitivity

– Reviewed published literature that referred to the WIO

Adaptive capacity

- Referred to literature
- Also assessed from
  - ratios of reef to land area,
  - contribution of artisanal/coastal fisheries to total marine landings and
  - education levels



Johnson et al. 2015

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Material and methods

OA vulnerability taxa categories

– Fisheries landings of 4 countries categorised based on their a *priori* likelihood of being susceptible to OA

Ranking

– Values of future projections of fish biomass of representative taxa groups under a scenario of moderate acidification and fishing by the year 2050

– Moderate acidification → additional mortality of 0.3% per day on the biomass pool, at an atmospheric CO_2 of 560ppm and a surface pH of 7.92

Griffith et al. 2011

Quantifying fisheries in the context of OA

– Collated fisheries data from CORDIO, national and seaaroundus database

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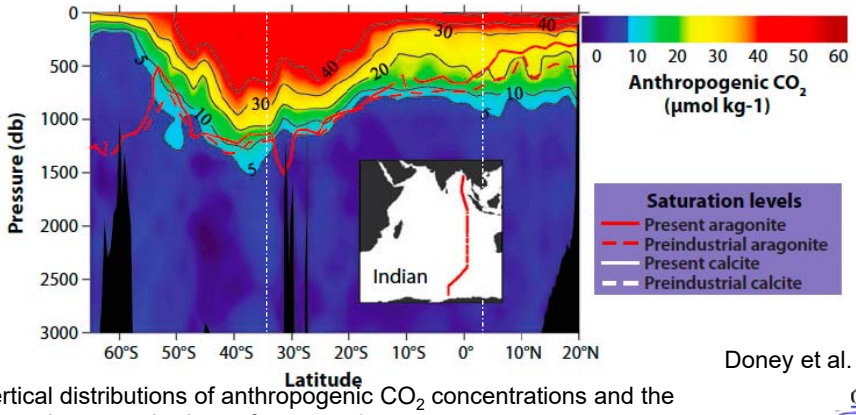
Results: Exposure and sensitivity

- **CO_2 concentrations**
  - Atmospheric CO_2 have increased from ≈280 ppm in pre-industrial to 400 ppm today
  - Global ocean pH has declined from 8.2 to 8.1



Doney et al. 2009

Vertical distributions of anthropogenic CO_2 concentrations and the saturation state horizons for aragonite

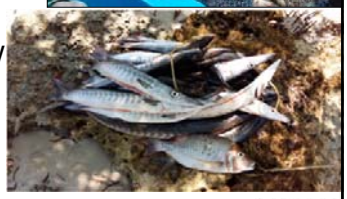
Exposure and sensitivity

- **Coastal invertebrates**
  - Expected to be sensitive to changes in pH of near shore waters because of their exoskeletons, shells or skeletal elements is composed aragonite

Decrease in the pH of animal tissue → physiological costs
Fish → changes in pH can alters sound absorption underwater

Potential impact

- **Marine fish and invertebrates**
  - Greatest impacts during the **early life history** phases
  - Possible effects on **productivity of calcifying organisms** in the oceanic food web
  - Impaired ability of *p*elagic species to asses their **physical and biological** environment
  - Acidosis could lead to **narrowing of optimal thermal** performance window
  - → Increase in **prices** of most vulnerable fisheries categories



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Adaptive capacity

- **Coral associated and pelagic fish**
  - The potential for most organisms to adapt to a rapid reduction in ocean pH has not been tested in the WIO
  - Ocean pH changed little before the industrial era as such organisms may be lacking genetic variation necessary for rapid adaptation to current changes in sea water chemistry

Hoegh-Guldberg et al 2007

- **Coastal communities**
  - No tangible country-based OA adaptation plan/policy
  - Nairobi Convention – recognizes OA as an impact that affect or likely to affect coastal communities

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Vulnerability

- **Coral associated fisheries**
  - Key fisheries species to be impacted **include bivalve and gastropods**
  - **Reduced calcification, growth and survival** of calcifying organism in absence of rapid and effective adaptation
  - Impaired larval behaviour could affect **replenishment of population**, increasing the risks of declines in the stocks that support coastal fisheries
  - Calcifying organism **may not sustain significant commercial and subsistence fisheries** in future
  - **Compound the negative effects of SST** on fish and invertebrates

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OA vulnerability taxa categories

- 8 OA fisheries vulnerability categories were determined
- Categories were reviewed and ranked

OA fishery vulnerability category		OA Impacts	Future projection 2050
Shelled molluscs (Gastropods)		Reduced survival and calcification rates shell dissolution	0.35
Coral reef associated (Snappers, parrot fish..)		Loss and degradation of coral reefs	<0.73
Shallow non coral reef (Rabbit fish, flounder)		Egg mortality	0.73
Crustaceans (Crabs, lobsters, prawns)		Reduction in growth and calcification rates	0.72 - 1.31
Sharks and rays		Erratic swimming, loss of food planktonic food source	1.53 - 2.21
Pelagics (Mackerels, tuna, jacks and cavalla, dolphinfish)		Reduced production of zooplanktons	0.67 - 3.05
Unshelled molluscs (Octopus, squid, cuttlefish)		Shorter mantle length, increased time to hatching	8.62
Sea cucumber		Potential effects on spicule formation likely to reduce growth	NA

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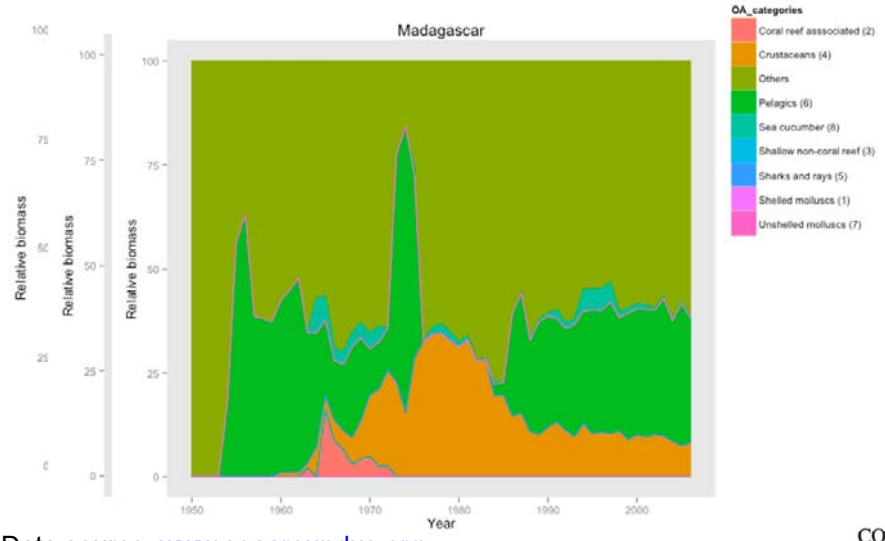
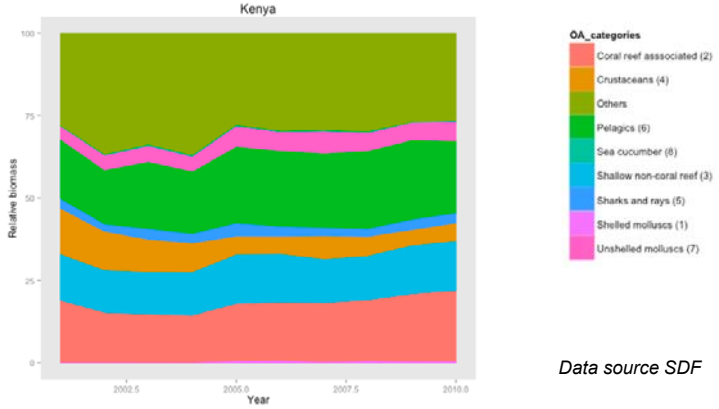
Quantification of WIO fisheries – OA context



Data source: www.seaaroundus.org

Quantification of WIO fisheries – OA context

Contribution of OA fishery categories to Kenya's artisanal fisheries

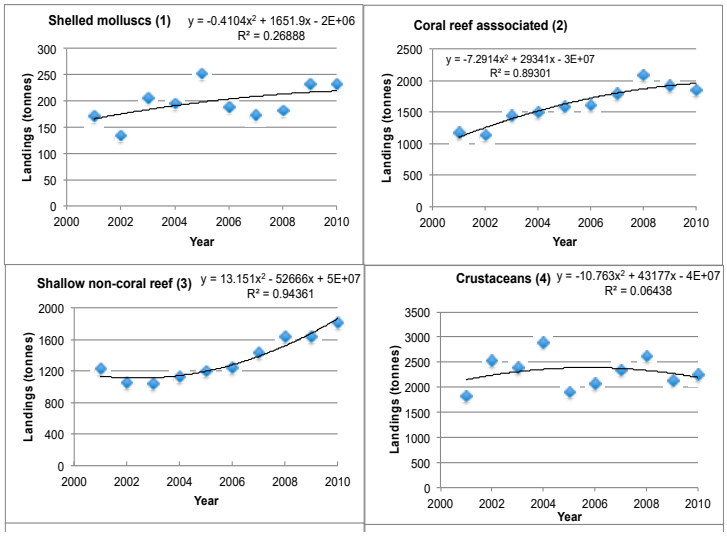


Data source SDF

- Coarse classification of landings
- Mean contribution
  - Pelagic fishes (6) – 21.6%
  - Coral associated (2) – 17.9%

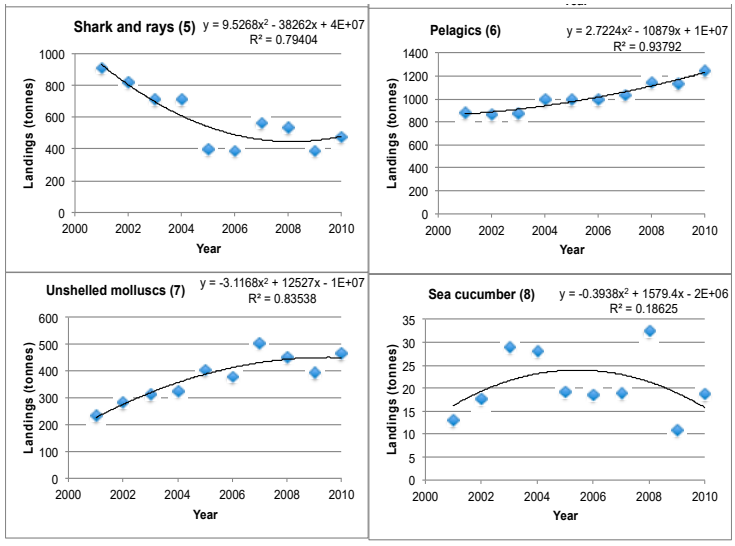
Quantification of WIO fisheries – OA context

Annual trends - Kenya



Quantification of WIO fisheries – OA context

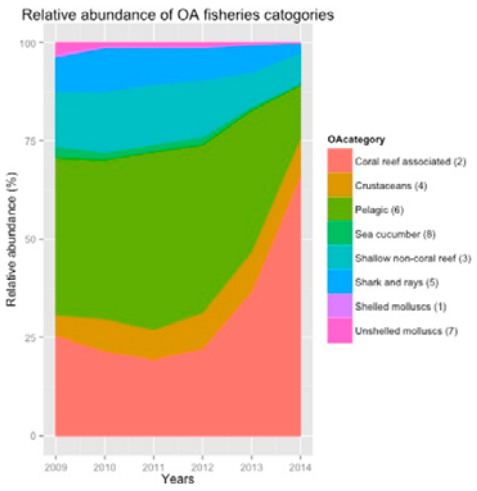
Annual trends - Kenya



Quantification of WIO fisheries – OA context

Reconstruction of catch data at one site in Kenya

- Increase in contribution of coral reef-fishes
- Suggest that the impacts of OA at local scale is likely to be significant



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Quantification of WIO fisheries – OA context

– Rates of change and percentage contribution at local scale - Kenya

Fisheries categories	Linear rate of change	% contribution
Shelled molluscs (1)	-91.239	**0.33**
Coral reef associated (2)	8,453.9	**34.47**
Shallow non-coral reef (3)	-770.01	**12.28**
Crustaceans (4)	1,011.9	**8.28**
Shark and rays (5)	-869.86	7.42
Pelagic (6)	-2,550.9	34.80
Unshelled molluscs (7)	-343.26	0.98
Sea cucumber (8)	-352.56	1.43

- Impacts of OA at local scale is likely to be significant
- Pelagic and coral associated fish still contribute significantly indicating high to moderate impacts of OA on the fisheries
- Top four vulnerable categories contribute to >55%

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Adaptive capacity WIO countries

Country	Reef to land area	Education levels	Dependancy on costal fisheries
Kenya	0.0011	0.722	0.8000
Mozambique	0.0024	0.506	0.7500
Madagascar	0.0038	0.645	0.7300
Tanzania	0.0038	0.678	0.9000

Policy response (Kenya)

- Climate Change Act (2016)
  - no recognition of OA
- Draft National Climate Change Framework Policy – OA is mentioned as one of the great challenges to the health structure and function of marine ecosystem

Summary

- Pelagic fisheries contributes substantially to the landings in the WIO and management of the fisheries at both national and regional levels is crucial in mitigating the likely impacts of OA on coastal people
- Coral reef associated species are showing increasing contribution in landings and efforts to reduce their dependence presents part of the solution as the impacts of OA manifest and marine resources decline
- The potential for most organisms to adapt to a rapid reduction in ocean pH has not been tested in the WIO
- The declines in productivity of fisheries vulnerable to OA are likely to affect the regional and national plans and policies
- Adaptive capacity of coastal communities to OA is relatively low and will need targeted assistance to adapt as ocean acidification accelerates

Acknowledgement

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NACA

FishAdapt secretariat

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