Adaptation in marine systems

Nippon Foundation Nereus Program
Dana D. Miller, Yoshitaka Ota, U. Rashid Sumaila, Andrés M. Cisneros-Montemayor, William W.L. Cheung

Presented by Rachel Seary, FishAdapt Conference 2016, Bangkok

NEREUS PROGRAM
Predicting Future Oceans

THE NIPPON FOUNDATION

UBC

The IPCC's Fifth Assessment Report

Adaptation:
"…the process of adjustment to actual or expected climate and its effects."

…in natural systems:
adaptation can occur through "*multiple autonomous processes (e.g., phenology changes, migration, compositional changes, phenotypic acclimation, and/or genetic changes)*" and can also be engineered by human interventions.

…in human systems:
"*adaptation seeks to moderate harm or exploit beneficial opportunities.*"

Why focus attention on marine systems?

- Most studies have not separated terrestrial and marine systems
- Different drivers and impacts anticipated
- Adaptation through shifting distribution appears to occur faster than in terrestrial systems (Burrows et al. 2011; Poloczanska et al. 2013; Pinsky et al. 2013).
- Shifting distribution may render baseline stock assessments unreliable (McIlgorm et al. 2010; Mills et al. 2013; Holbrook and Johnson 2014).
- Adaptation in marine systems was discussed mostly in relation to observations in natural systems within the IPCC report
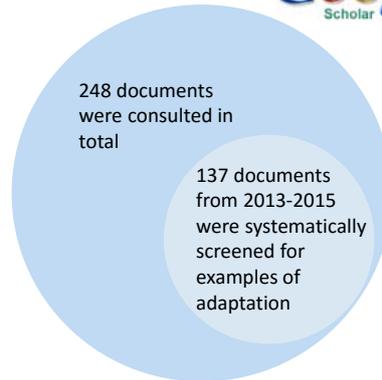
Literature review

Objective: to describe the current status of both natural adaptations to CC and OA in marine systems, and human-assisted adaptation actions with relevance to livelihoods or industries dependent on living marine resources (i.e. fisheries, aquaculture and tourism).
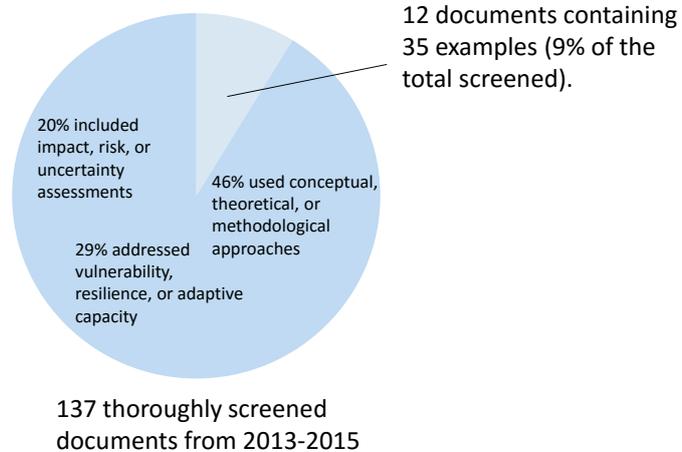
Literature review

- Search terms incorporated a diverse assortment of keywords relevant to natural and human systems.
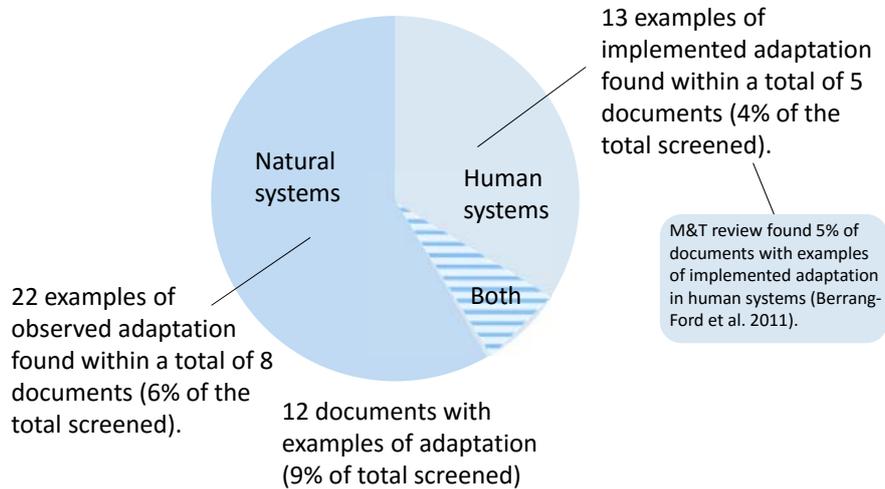- Search conducted through Google Scholar

248 documents were consulted in total

137 documents from 2013-2015 were systematically screened for examples of adaptation

Adaptation in marine systems:
Quantitative overview

12 documents containing 35 examples (9% of the total screened).

20% included impact, risk, or uncertainty assessments

46% used conceptual, theoretical, or methodological approaches

29% addressed vulnerability, resilience, or adaptive capacity

137 thoroughly screened documents from 2013-2015

Adaptation in marine systems:
Quantitative overview

13 examples of implemented adaptation found within a total of 5 documents (4% of the total screened).

M&T review found 5% of documents with examples of implemented adaptation in human systems (Berrang-Ford et al. 2011).

Natural systems

Human systems

Both

22 examples of observed adaptation found within a total of 8 documents (6% of the total screened).

12 documents with examples of adaptation (9% of total screened)

Adaptation in marine systems:
Quantitative overview

Geographic location of studies reported in documents with (N = 12) and without (N = 111) examples of observed or implemented adaptation.

Location	No. of documents (%)	
	Without examples	With examples
Global or N/A	64 (51.2)	3 (27.3)
Australia	18 (14.4)	2 (18.2)
North America and Europe	24 (13.6)	5 (45.5)
Africa and Asia	13 (10.4)	1 (9.1)
Pacific Islands	5 (4.0)	0 (0.0)
Southern Ocean	1 (0.8)	0 (0.0)

Review subheadings:

- Motivation
- Evaluating success
- Limits to success
- Costs
- Timeframe
- Maladaptation

Motivations for adaptation

Natural systems:

- Changes in temperature (Mills et al. 2013; Anderson et al. 2013; Pinsky et al. 2013; Poloczanska et al. 2013; Crozier and Hutchings 2014; Hinder et al. 2014; Reusch 2014; Stenson and Hammill 2014).
- Abrupt and dramatic change in temperature (Mills et al. 2013; Reusch 2014).
- Melting of sea ice (Stenson and Hammill 2014).

Motivations for adaptation

Human systems:

- Stakeholders informed of potential risks (Frusher et al. 2013).
- Stakeholders made observations of changing water temperature and pH (Chang et al. 2013; Billé et al. 2013).
- Legal requirements (Fidelman et al. 2013).
- Extreme weather events (Chang et al. 2013; Mills et al. 2013).

Success in adaptation

- In most examples found, an approach for evaluating success not explicitly described.
- Outcome-based approach can be applied, though examples are uncommon as exposure to CC is ongoing.
- Alternative approaches for measuring adaptation effectiveness (Ford et al. 2013):
  - ➢ Systematic measures of adaptation readiness
  - ➢ Policies and programs implemented to adapt
  - ➢ Measures of the impacts of policies and programs on changing vulnerability

Factors that <u>could</u> influence success

Natural systems:

- Population size, genetic variance, life span, reproduction and dispersal rates (Willi et al. 2006; Bell and Gonzalez 2009; Hoffman and Sgro 2011; Bernhardt and Leslie 2013; Parmesan 2006).

Human systems:

- Horizontal and vertical integration of policies; collaboration; and marketing and communications campaigns (Burton et al. 2002; Wong et al. 2014; Marshall et al. 2011; Evans et al. 2013).

Success in adaptation

- Case study of fishing communities in Thailand adapting by engaging with alternative livelihoods (Bennett et al. 2014) found success largely dependent on:

  - o Suitability of sites for tourism.
  - o Access to land and local land ownership.
  - o Hiring of locals vs. outside laborers.

Costs of adaptation

- Costs not mentioned in relation to any adaptation examples found.
- Anticipated to vary strongly between and within regions (Wong et al. 2014).
- Combined value of economic losses in landed catch and the costs of adapting fisheries (under 2° temp rise by 2050) estimated at between USD 10 to 31 billion (Sumaila et al. 2011).

Time frames for adaptation

- Information found in the literature fragmented and inconsistent in meaning.
- Period of time from stimulus to implementation varied from immediately (e.g., Chang et al. 2013; Pinsky et al. 2013; Poloczanska et al. 2013) to over one year (Frusher et al. 2013).
- Time frame of response or action ranged from days (e.g., Chang et al. 2013), to indefinite periods of time (Frusher et al. 2013).

Time frames for adaptation

- Aquaculture may have an advantage over wild fisheries, as artificial selection can operate at much faster time scales in order to maintain production rates (Branch et al. 2013).
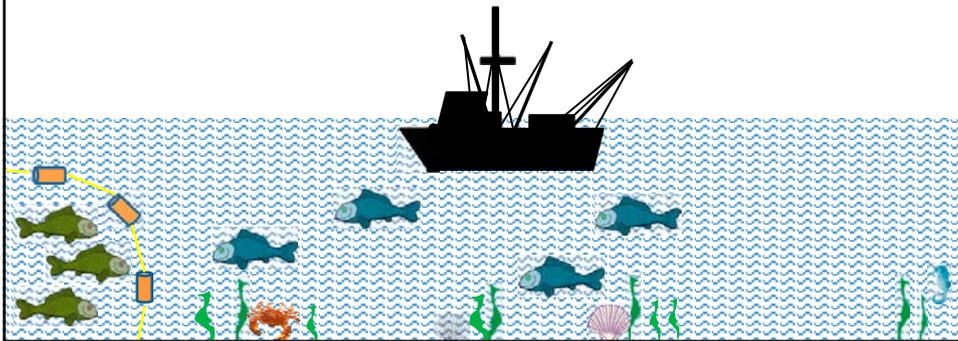
Maladaptation

"Actions, or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to CC, or diminished welfare, now or in the future."

- Research in this area important as valuable lessons can be learned through analyzing undesirable or failed attempts at adaptation.

Maladaptation

In human systems:

- Large, managed release of hatchery fish in Taiwan following cold water event

Intended to boost wild stocks but had negative ecosystem effects (Chang et al. 2013).

- NW Atlantic Lobster fishery heatwave in 2012

Although fishers and management measures were able to adapt to a shift in the lobster fishing season, markets were overwhelmed and prices collapsed (Mills et al. 2013).

Maladaptation

In natural systems:

- Adaptive phenological responses can cause decoupling of ecological relationships
- CC induced trophic mismatch within marine plankton communities (Edwards and Richardson, 2004).

Knowledge gaps

- Examples of observed or implemented adaptation are uncommon in the literature.
- Gaps exist in all aspects of implementing, monitoring, and evaluating adaptation.
- Notably missing was information relating to costs, time frames, identified limits or barriers, and evaluations of success.
- Further studies are needed that evaluate and report on adaptations relating to marine systems, separately to those relating to terrestrial systems.

Conclusions

- Marine systems have different stressors to terrestrial; adaptive strategies must take this into account
- Rapid and flexible responses to impacts on livelihoods required
- Management of marine resources will be challenging due to shifting distributions and adaptations plans should anticipate this
- Unclear whether literature reflects extent adaptation exists in the real world; documentation required.

Thanks for your attention!

www.nereusprogram.org