

Anticipated impacts of ocean acidification on local societies in Japan



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Outline

1. Introduction
2. Impacts on coral reefs in Japan
3. Impacts on Japanese fisheries and aquaculture

Anticipated direct economic impacts of ocean acidification on Japanese society (million USD per year)



Fisheries & Aquaculture
(14,107)¹⁾



Tourism & Recreation
in coral reefs (2,399)²⁾

Coastal defense services provided by coral reefs
(75-839)²⁾



Jewelry coral fisheries
(85)³⁾

¹⁾Ministry of Agriculture, Forestry and Fisheries (農林水産省統計部 漁業・養殖業生産統計年報)

²⁾サンゴ礁保全行動計画策定会議サンゴ礁価値評価分科会

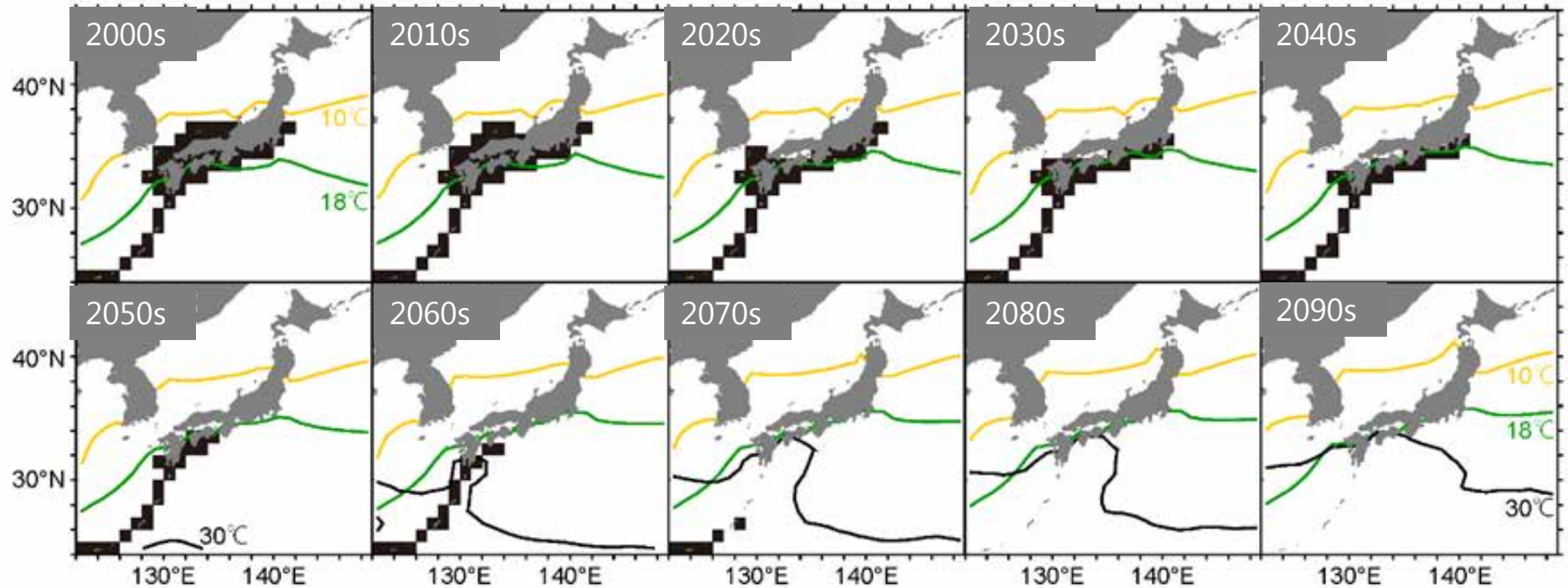
(https://www.env.go.jp/nature/biodic/coralreefs/pdf/project/development/210312_mat01.pdf)

³⁾<http://www.hirobata.com/coral/>

Outline

- Impacts on coral reefs in Japan
- Impacts on Japanese fisheries and aquaculture

Projected coral habitats in response to global warming and ocean acidification (Yara et al., 2012; 2016)



Green lines: Northern limit of subtropical corals regulated by temperature (annual minimum temperature of $>18^{\circ}\text{C}$)

Black lines: Northern limit of bleaching occurrence regulated by temperature (annual maximum temperature of $<30^{\circ}\text{C}$)

Black shades: Coral habitats regulated by CaCO_3 saturation state (annual minimum Ω_{arg} of >2.3)

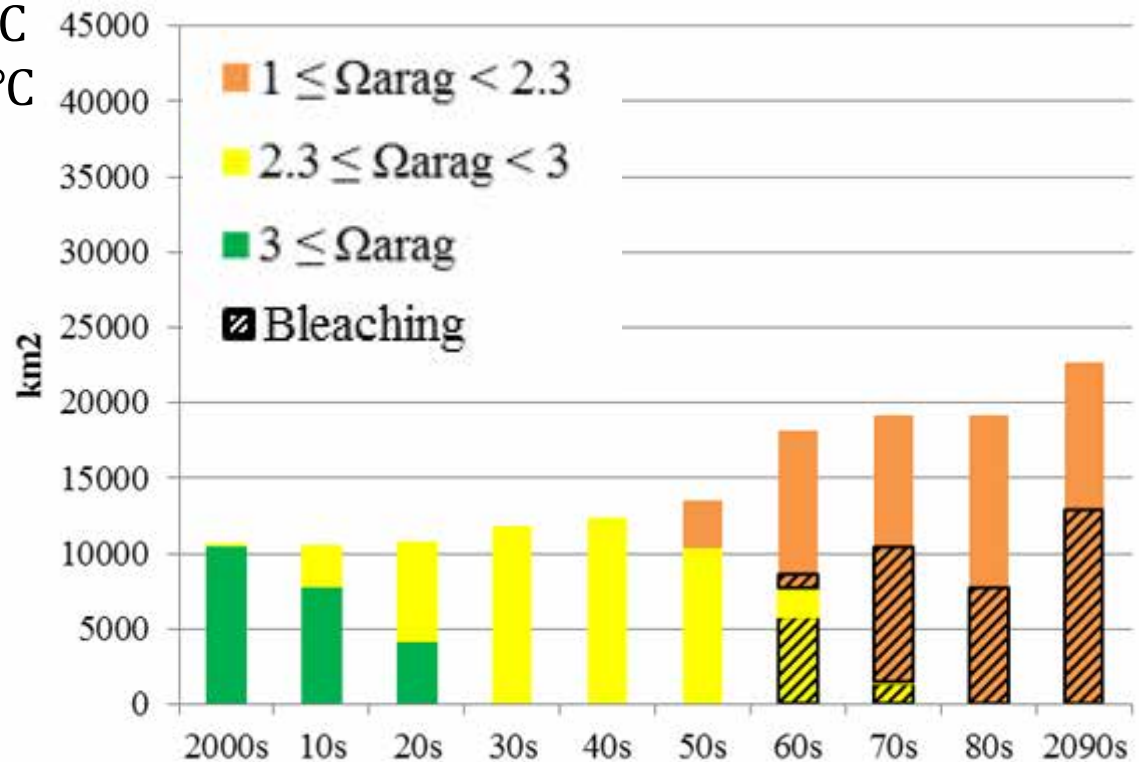
To estimate future change in economic values of Japanese coral reefs

$$\text{Change in economic values} = \int_{2000s}^{2090s} \Delta A(t) \times \Delta H(t) dt$$

$\Delta A(t)$: change in the area of coral reefs (km²) regulated by:

- Annual min. SST of $>18^{\circ}\text{C}$
- Annual max. SST of $<30^{\circ}\text{C}$
- Annual min. Ω_{arg} of >2.3

(Yara et al., 2012; 2016)

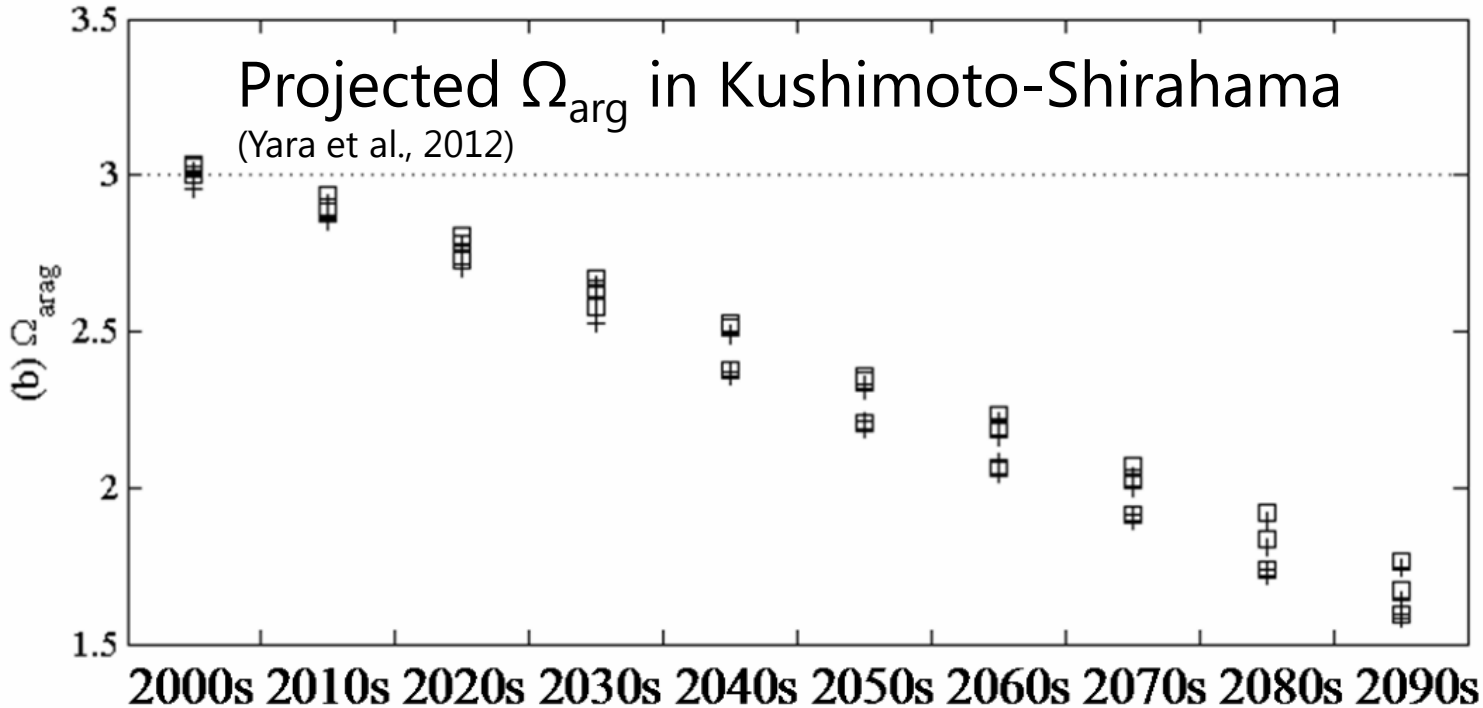


To estimate future change in economic values of Japanese coral reefs

$$\text{Change in economic values} = \int_{2000s}^{2090s} \Delta A(t) \times \Delta H(t) dt$$

$\Delta H(t)$: change in health condition of coral reefs

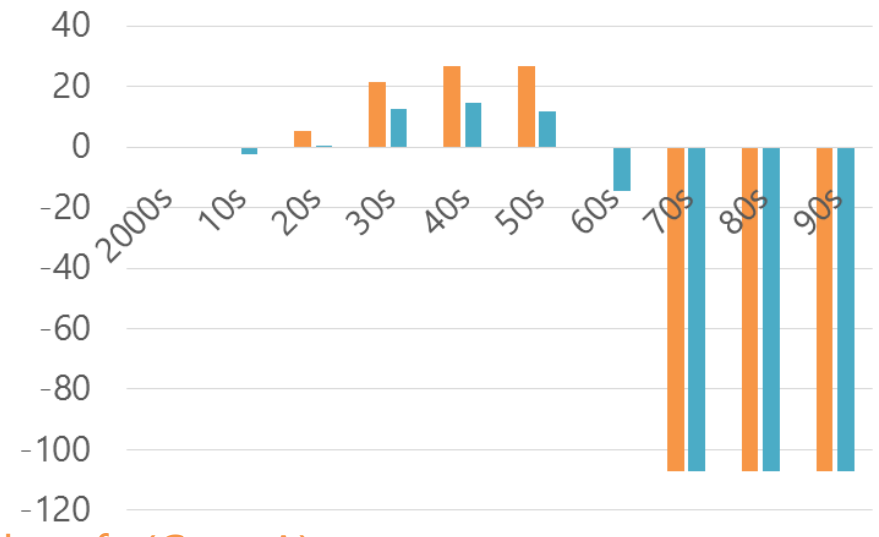
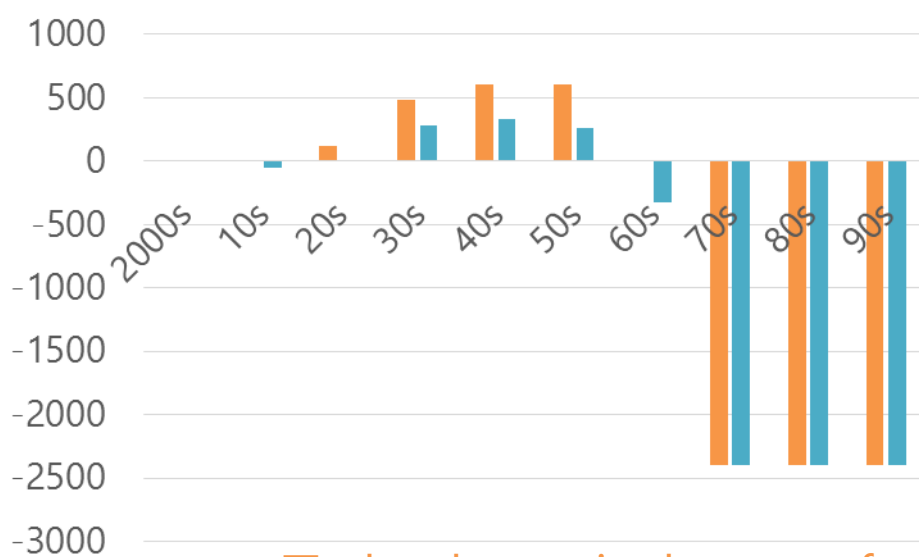
- Decrease by 15% per Ω_{arg} (Chan and Connolly, 2013; van Hooidonk et al., 2004)



Estimated future change in economic values of Japanese coral reefs

Tourism (million USD/year)

Fisheries (million USD/year)



- by change in the area of coral reefs (Case A)
- by changes in the area and health condition of coral reefs (Case B)

Estimated total economic loss in the 21st century

- Tourism: 54 billion USD (Case A) and 67 billion USD (Case B)
- Fisheries: 2 billion USD (Case A) and 6 billion USD (Case B)

Outline

- Impacts on coral reefs in Japan
- Impacts on Japanese fisheries and aquaculture

Fish catch in Japan (of FY2014)

Total catch: 14,107 (million USD per year)

Fisheries (69%)



Shellfish (7%)



Shrimps (2%)



Crabs (2%)



Sea urchins (1%)



Non-calcifiers (57%)

Aquaculture (31%)



Shellfish (6%)



Pearls (1%)



Shrimps (1%)



Non-calcifiers (24%)

Source: Ministry of Agriculture, Forestry and Fisheries (農林水産省統計部 漁業・養殖業生産統計年報)

How about sushi in future ?



Present



by OA?



by global warming?

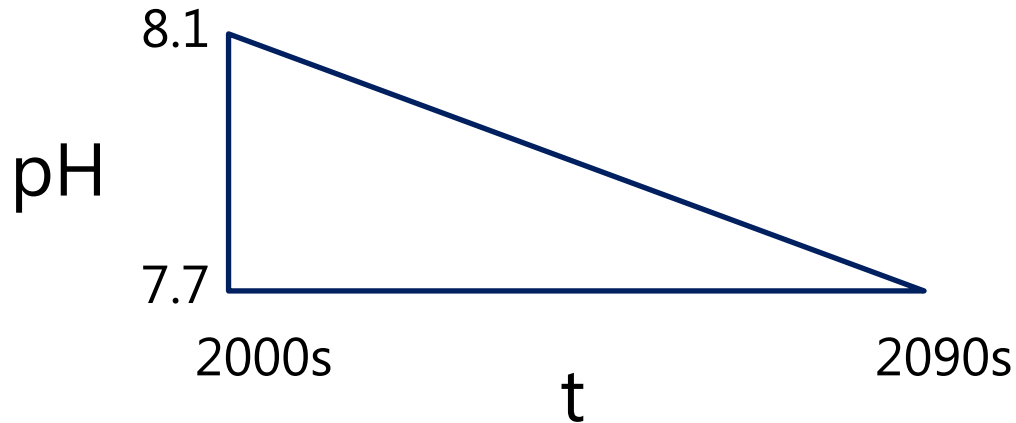


by overfishing ?



by OA + global warming + overfishing?

To estimate future change in economic values of Japanese fisheries and aquaculture

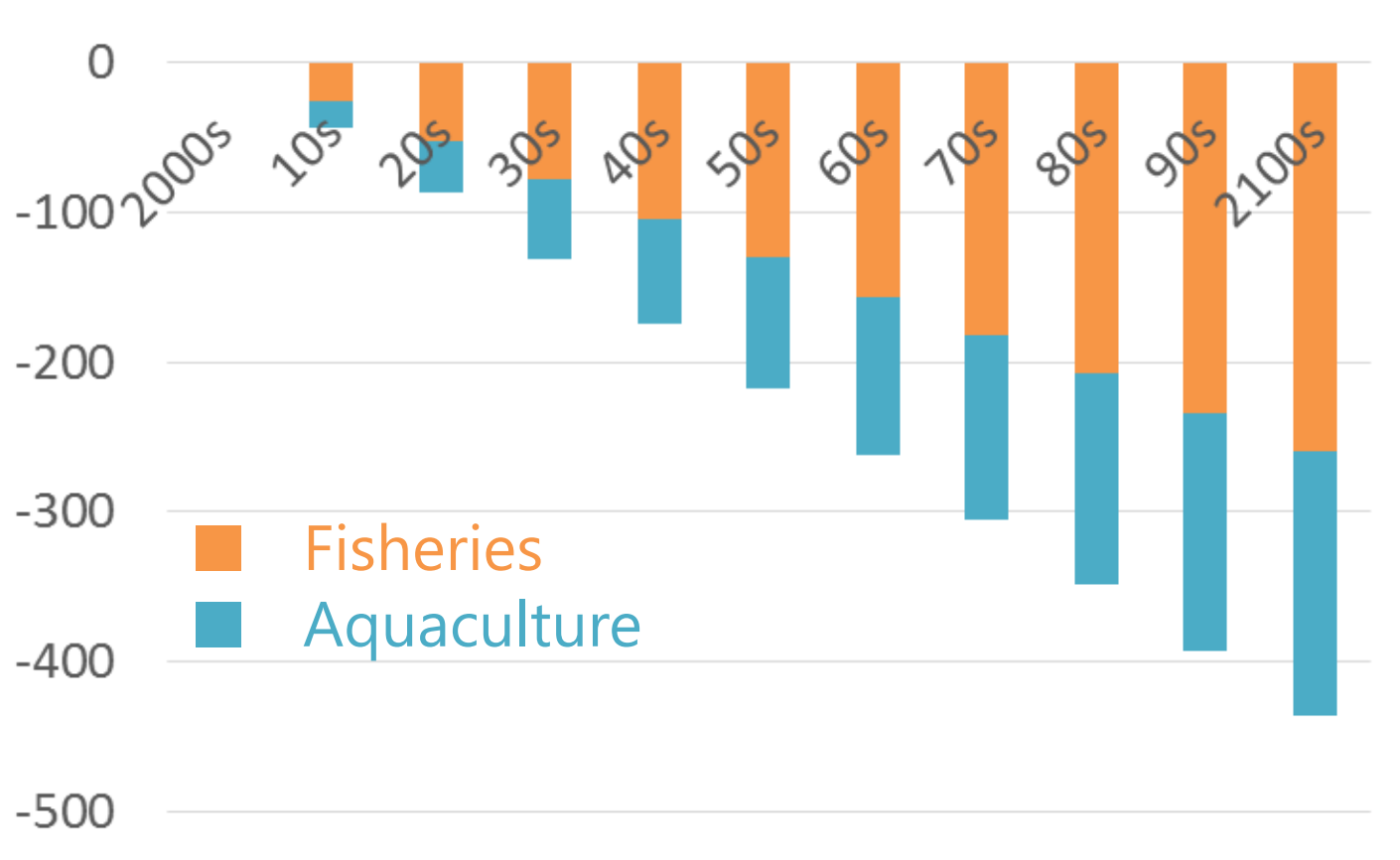


$$\text{Economic change} = \int_{2000s}^{2090s} \Delta G(t) dt$$

$$\Delta G(t) = \alpha \times \Delta \text{pH}(t)$$

$$\alpha = -0.1 \text{ through } -0.4 \text{ (Wootton et al., 2008)}$$

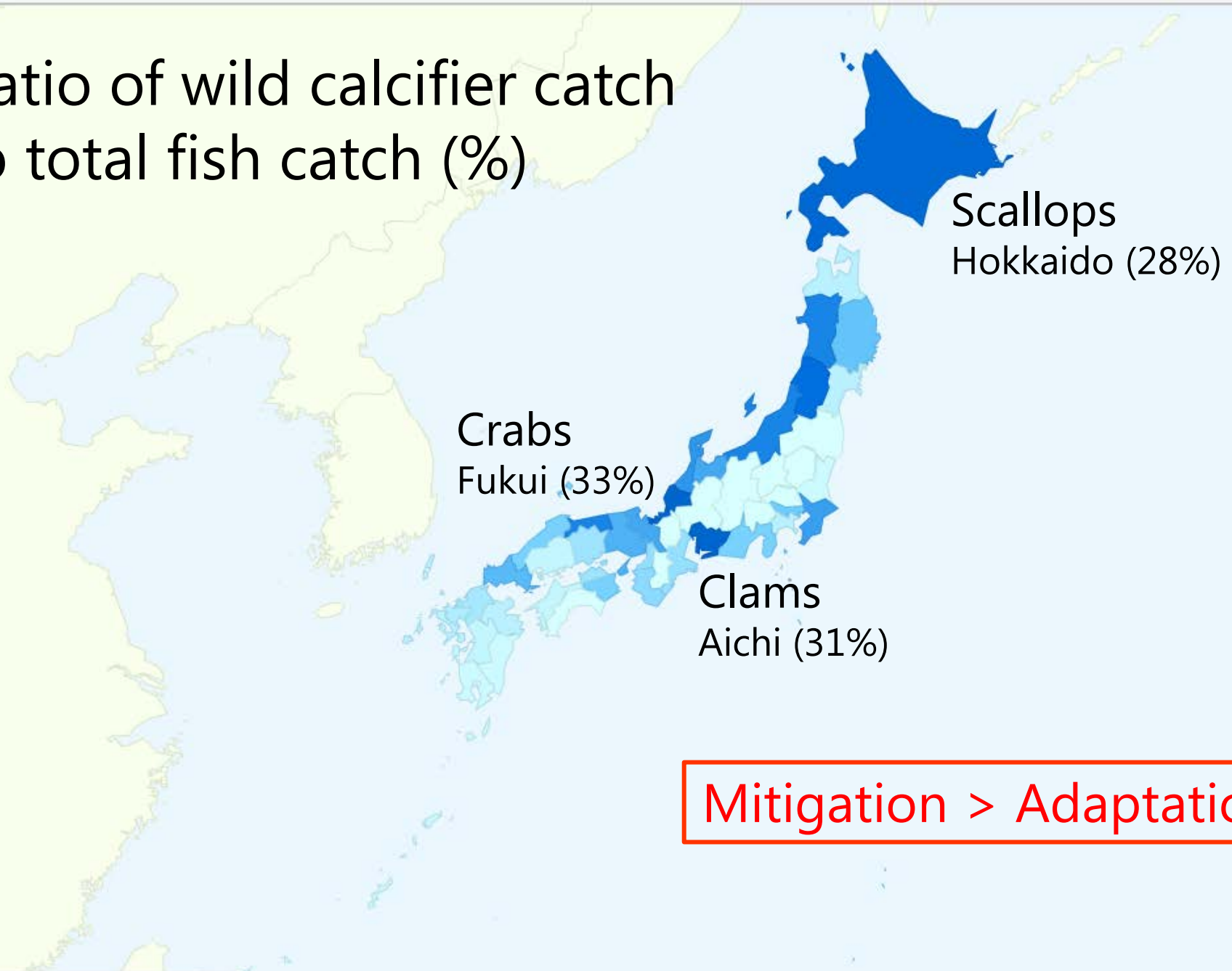
Estimated future change in economic values of Japanese fisheries (million USD/year)



Estimated total economic loss in the 21st century

- Fisheries: 9-22 billion USD
- Aquaculture: 6-15 billion USD

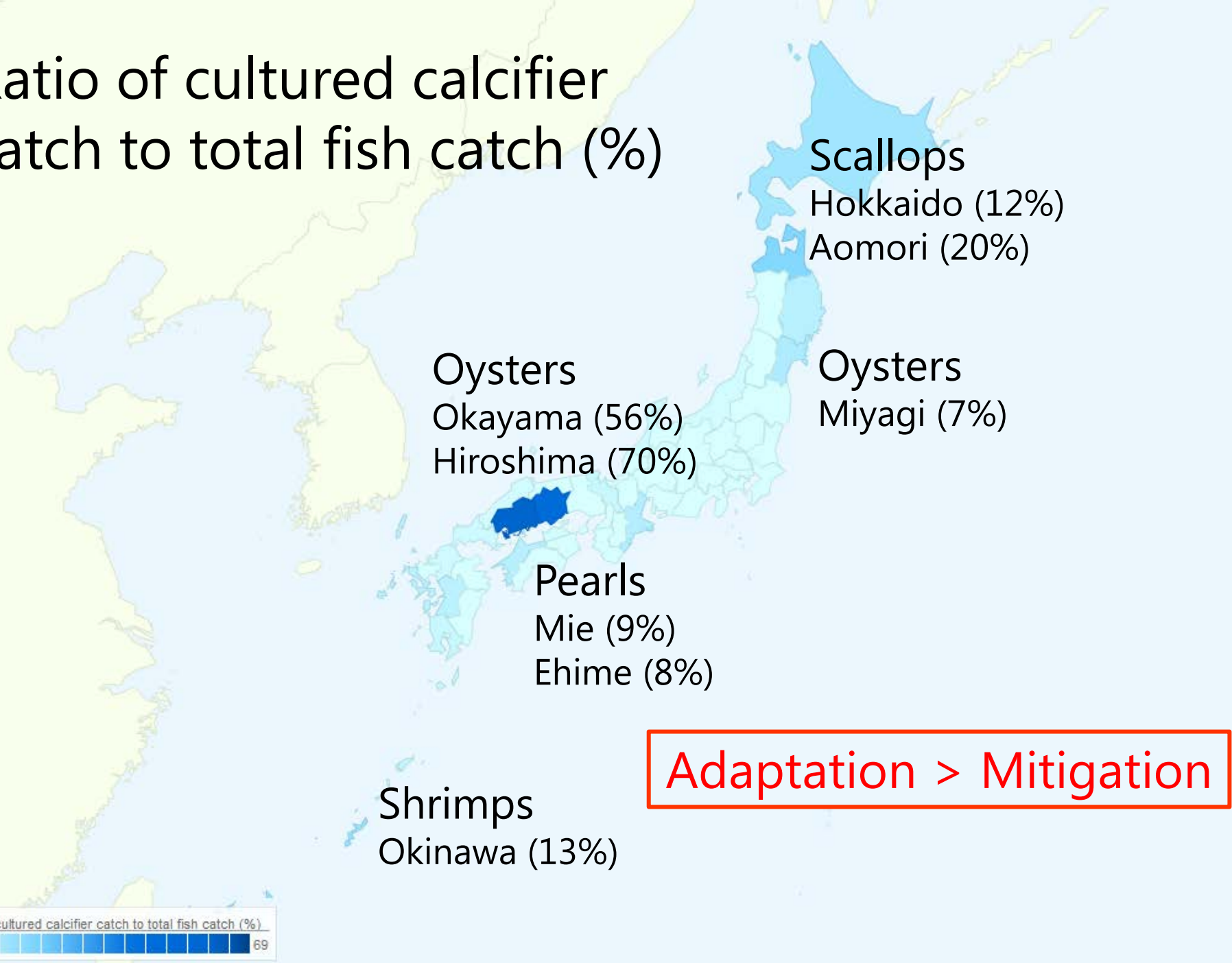
Ratio of wild calcifier catch to total fish catch (%)



Mitigation > Adaptation



Ratio of cultured calcifier catch to total fish catch (%)

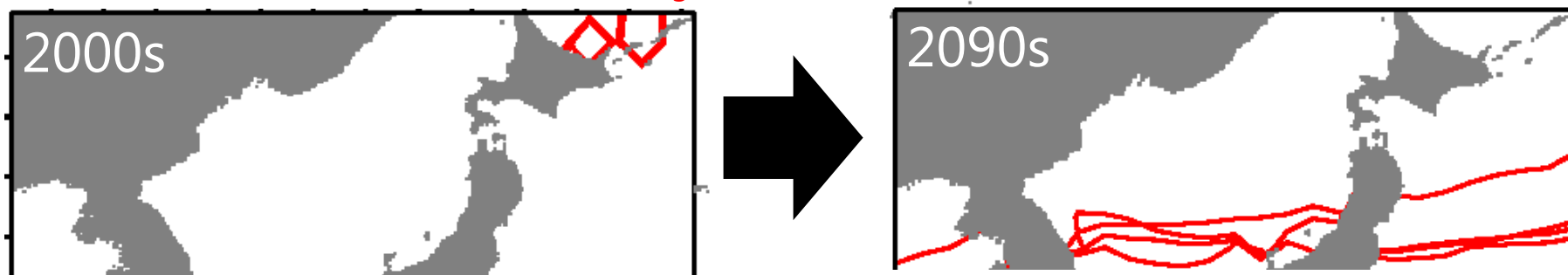


Adaptation > Mitigation

Ratio of cultured calcifier catch to total fish catch (%)
0 69

Suitable scallop culture areas regulated by ocean acidification and warming

Southern shift of suitable areas regulated by OA
(defined by annual minimum Ω_{arg} of >1) (Yara et al., 2012)



Northern shift of suitable areas regulated by warming
(defined by annual maximum temperature of $<23^{\circ}\text{C}$) (Shibano et al., 2014)



No suitable scallop culture areas by the end of this century

Conclusion and Remarks

Estimated OA-derived economic loss in Japan in the 21st century

- Tourism in coral reefs: 54-67 billion USD
- Fisheries in coral reefs: 2-6 billion USD
- Fisheries and aquaculture in Japan: 15-37 billion USD

→ Relatively large economic loss in coral reefs due to the extinction in future

Adaptation needed for aquaculture, esp. scallops, oysters, pearls and shrimps, all of which are very important to the local industries (for tourism as well as fisheries)

Many uncertainties in future projection to be reduced, esp.

for those caused by:

- Climate model structure
- Future scenario of greenhouse gas emissions
- **Biological adaptation to changing environments**
- **Other human impacts (population growth, overfishing etc.)**

I am not an economist. More social and human scientists needed!!