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S1 "Effects of natural & anthropogenic stressors in the North Pacific  
ecosystems: Scientific challenges & possible solutions"

## **The Onset and Development of Green Algal Tide in the Yellow Sea**

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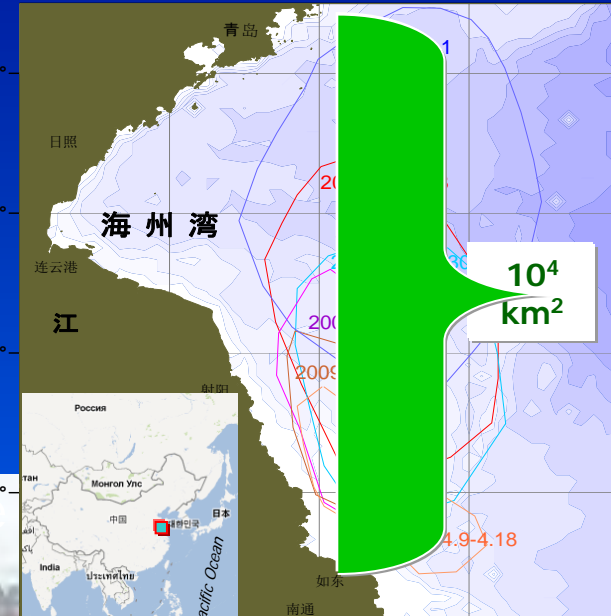
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# Background

- Green tide in the SW Yellow Sea, massive floating algal mat formed of filamentous green algae
- First noted landing in the summer of 2007, and recurrent landing in the summers of through 2012
- Serious impacts on beach tourism and pond culture
- Vast covering scale calls for study of the origin and development
- Huge landing biomass calls for proper counter measure(s)

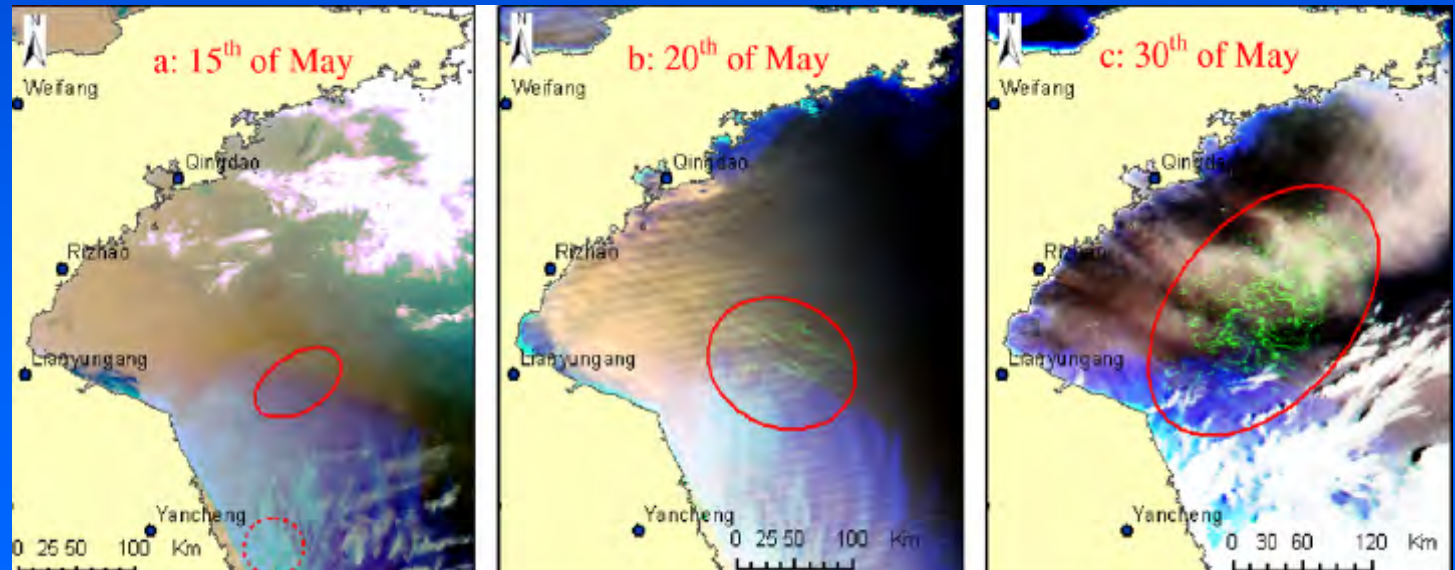


# Onset & development

**Top question:** where the green tide algae came from and how the green algae formed the tide (massive floating slicks)

**View point:** green tide originated from tidal flats of Subei Bank with raft culture of red alga *Porphyra*

- existing lines of supports:
  - Scattered (cloud effect) satellite imageries (without ground truthing)



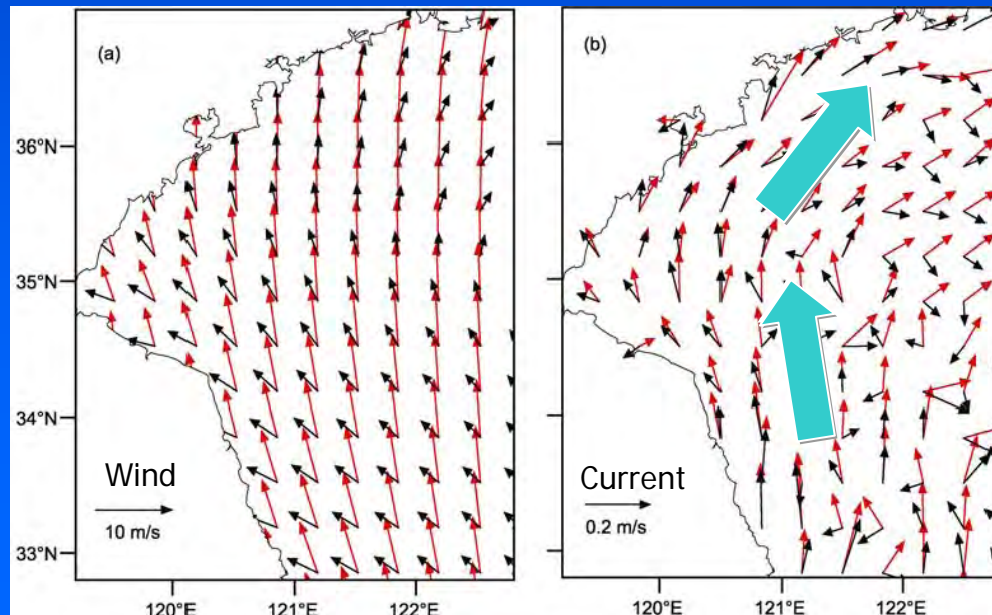
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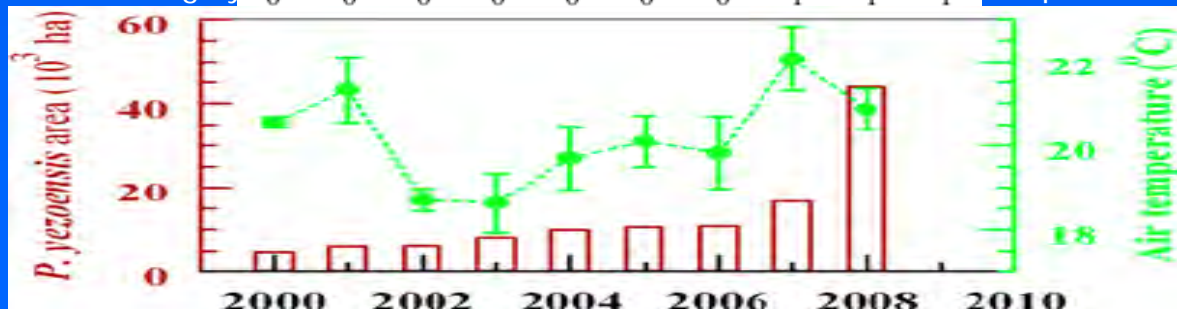
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Hu et al. 2010 JGR 115  
doi:10.1029/2009JC005561  
Satellite imagery



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    - associated growth of green algae with *Porphyra* culture and the culture poles occurring in the green tide
  - gaps: direct supporting lines from biology and ecology, e.g.
    - identification of green algae from rafts and floating slicks
    - on site tracking and experiments on the process of green tide (floating slicks) onset and development

# Onset & development

## Identification of green algae from rafts and floating slicks:

morphology and molecular (RFLP, FISH) taxonomies agreed with each other

- *Enteromorpha prolifera* dominated in floating slicks (often with single species), it's the causal species of green tide
- At least 6 green algae, incl. *E. prolifera*, grew on *Porphyra* culture facilities, *E. prolifera* became abundant only in late spring
- Potential micro-propagules (spores or any other micro-size forms of green algae, as potential early phase of algal frond) in the water column seldomly dominant with *E. prolifera* (mostly <20%)





# Onset & development

## Origin of green tide slicks

- Green algae detached from culture facilities upon retrieval after *Porphyra* being harvested
- *E. prolifera*, favored with its biophysical speciality, became floating/suspended from the detached algae and soon grew out other species

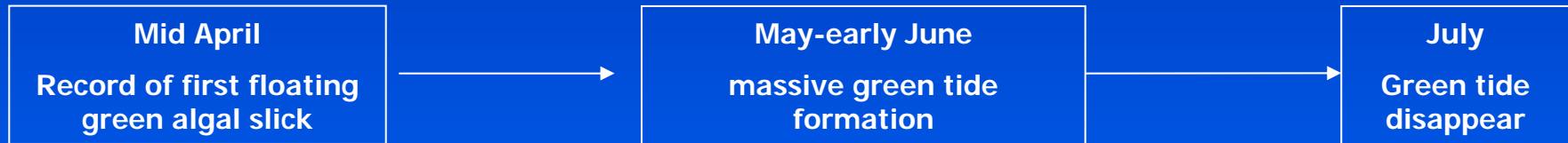
# Onset & development

## Development of green tide in 2012

Porphyra  
culture



Green  
tide



- Drifter tracking experiment in 2009\2010\2012 confirmed the proposed onset and passage of green tide

# Green tide: nuisance or opportunity?

**Question 1 - Will green tide re-occur by controlling the green algae on *Porphyra* culture?**

**Answer - probably no**

- **Potential micro-propagules in the water column did not develop into algal frond without nutrient spiking (lab incubation)**
- **Potential micro-propagules in the water column seldomly dominant with *E. prolifera***
- **Distribution of potential micro-propagules in the water column closely associate with *Porphyra* culture area, but not preceded or sustained after the massive floating slicks of green algae**

# Green tide: nuisance or opportunity?

Question 2 - Will green tide cause serious environmental problem without landing?

Answer - so far no observed problem

- hints

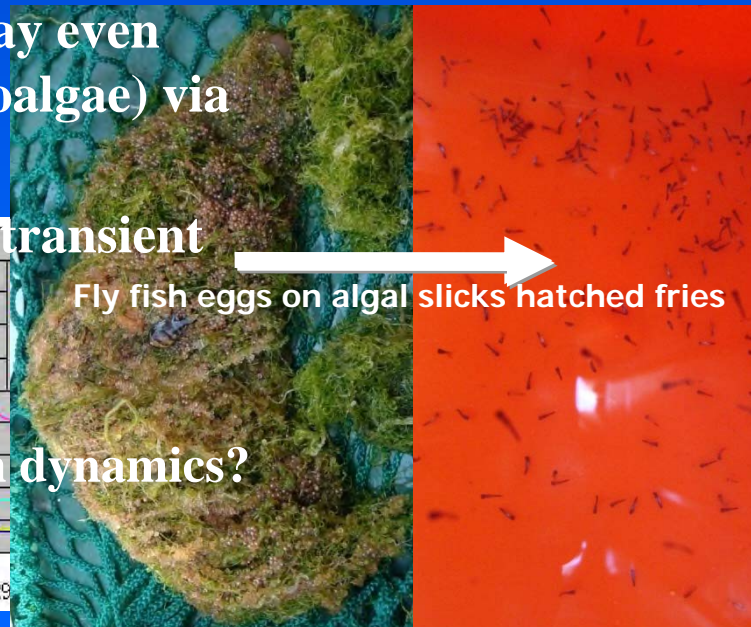
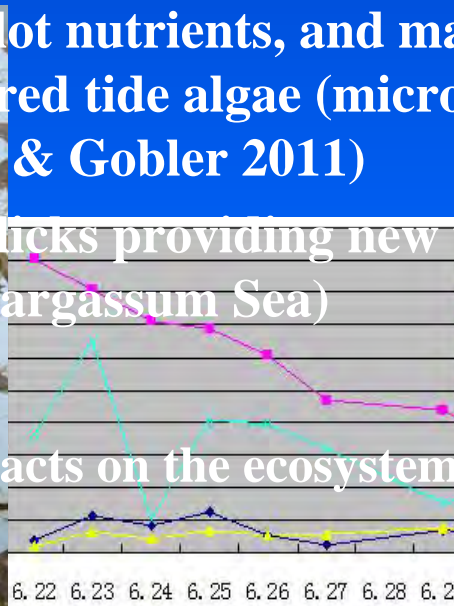
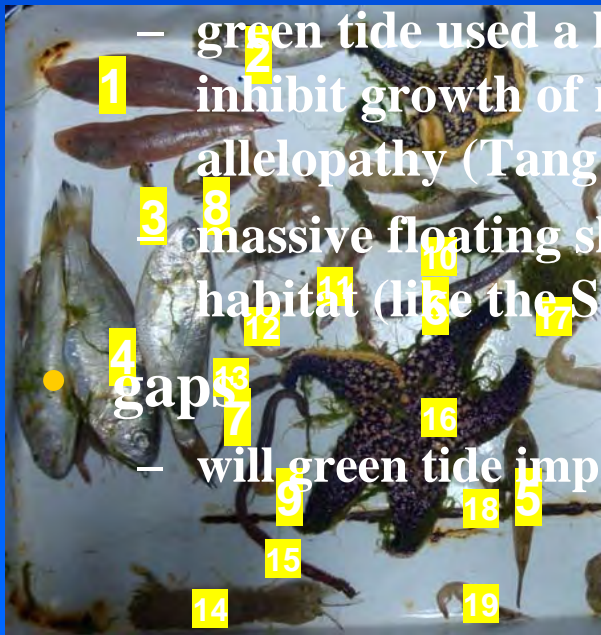
- sunk green algae in the coast not observed for problem, maybe favorable for benthic production

- green tide used a lot nutrients, and may even inhibit growth of red tide algae (microalgae) via allelopathy (Tang & Gobler 2011)

- massive floating slicks providing new transient habitat (like the Sargassum Sea)

- gaps

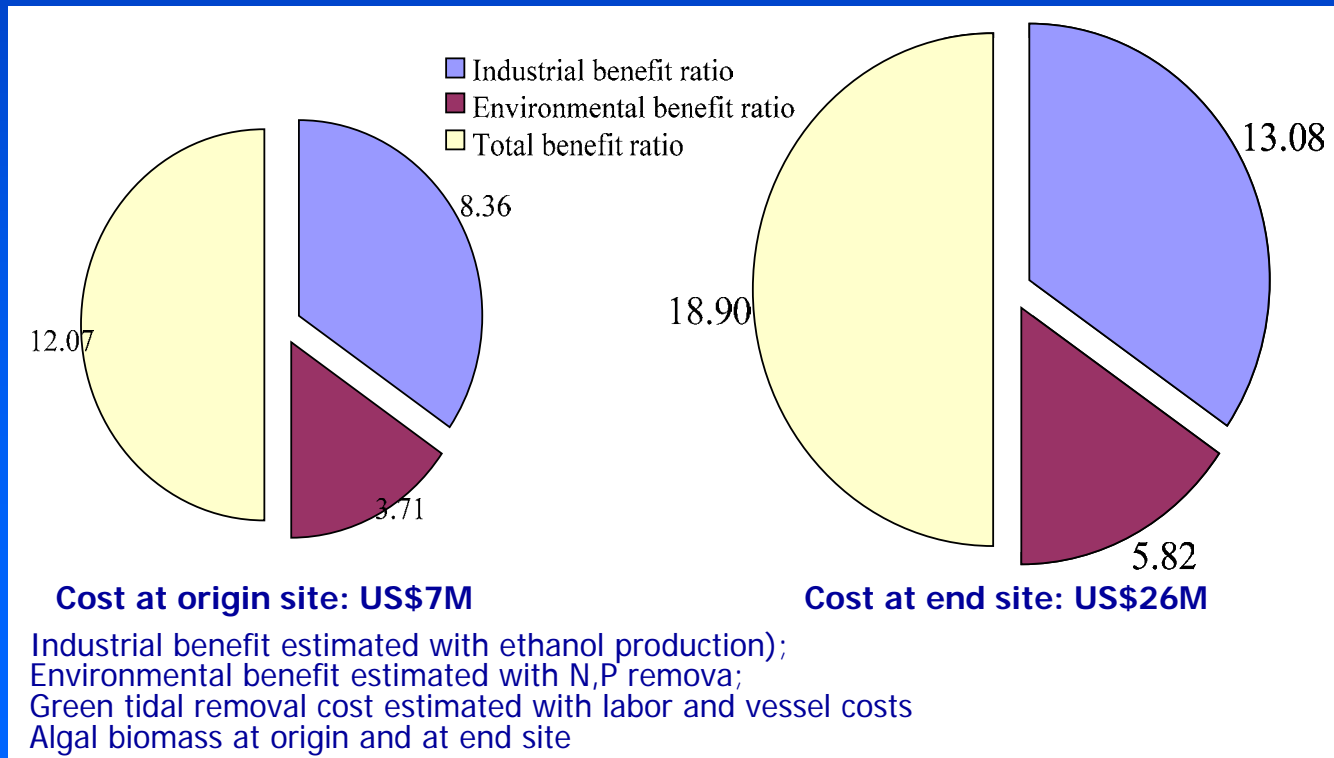
- will green tide impacts on the ecosystem dynamics?



# Green tide: nuisance or opportunity?

**Question 3 - Social-economical difference between counter measure at the origin and the end (right before landing)?**

**Answer - preliminary analysis indicates counter measure at the origin site less costly, however less beneficial**



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- **hints**

- there are many potential and beneficial usages of the green tide algae: e.g. biofuels, bio-fertilizers, animal feeds, human food, cosmetics, pharmacy, etc.
- **requirement: to develop sound mode (system) of green tide algae exploitation, coping with the once a year nature, both consuming huge biomass and producing high added value**

# Summary and future perspectives

- Causal species of the green tides in SW Yellow Sea defined as *E. prolifera*, detached from *Porphyra* culture in spring when culture facility retrieved
- The green tides originated from tidal flats of Subei Bank where *Porphyra* culture is located, then moved toward Shandong Peninsular by wind driven surface currents and develop into green tides
- Further research is in need to assess effect(s) on marine ecosystem dynamics in the region
- Efforts are called for to develop sound mode (system) of green tide algae exploitation

# Thank you

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