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Recurrent large scale macro-algal blooms in the Yellow Sea

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Curtin University of Technology

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Wealth from Oceans

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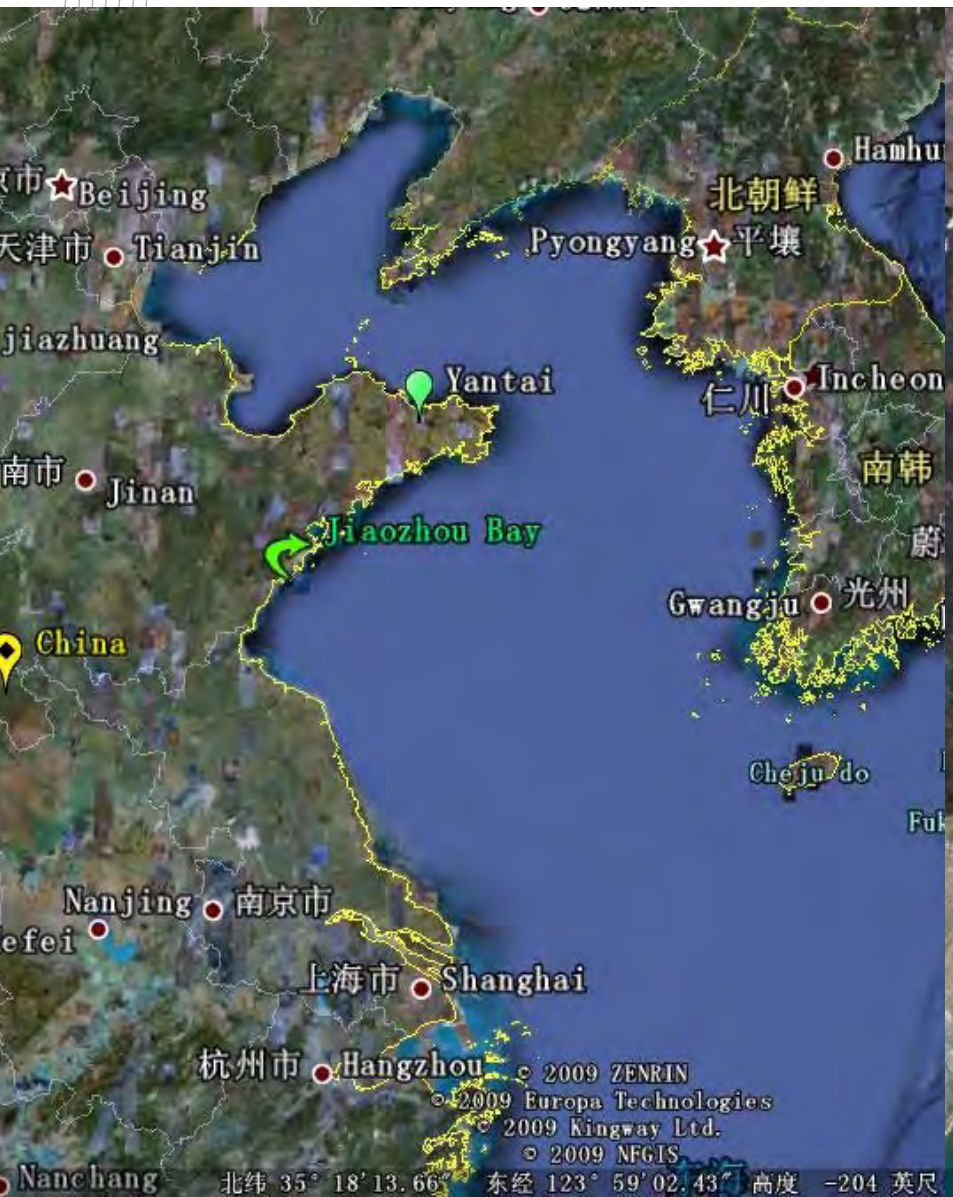
Jiaozhou Bay, Qingdao



Qingdao

Late June 2008

Qingdao Beach

Late June 2008

Qingdao beaches important for tourism

Qingdao beaches important for tourism

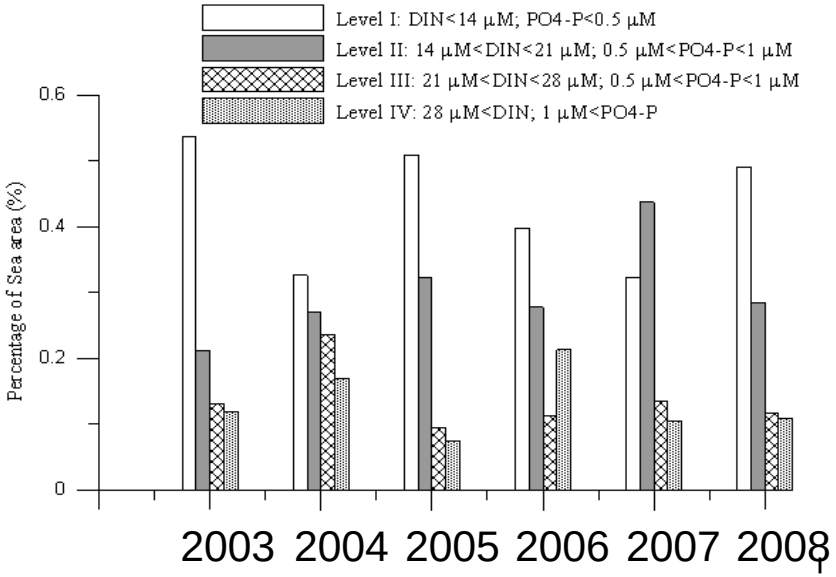
Training for the Olympics

10,000 people cleaned up 1 million tonnes

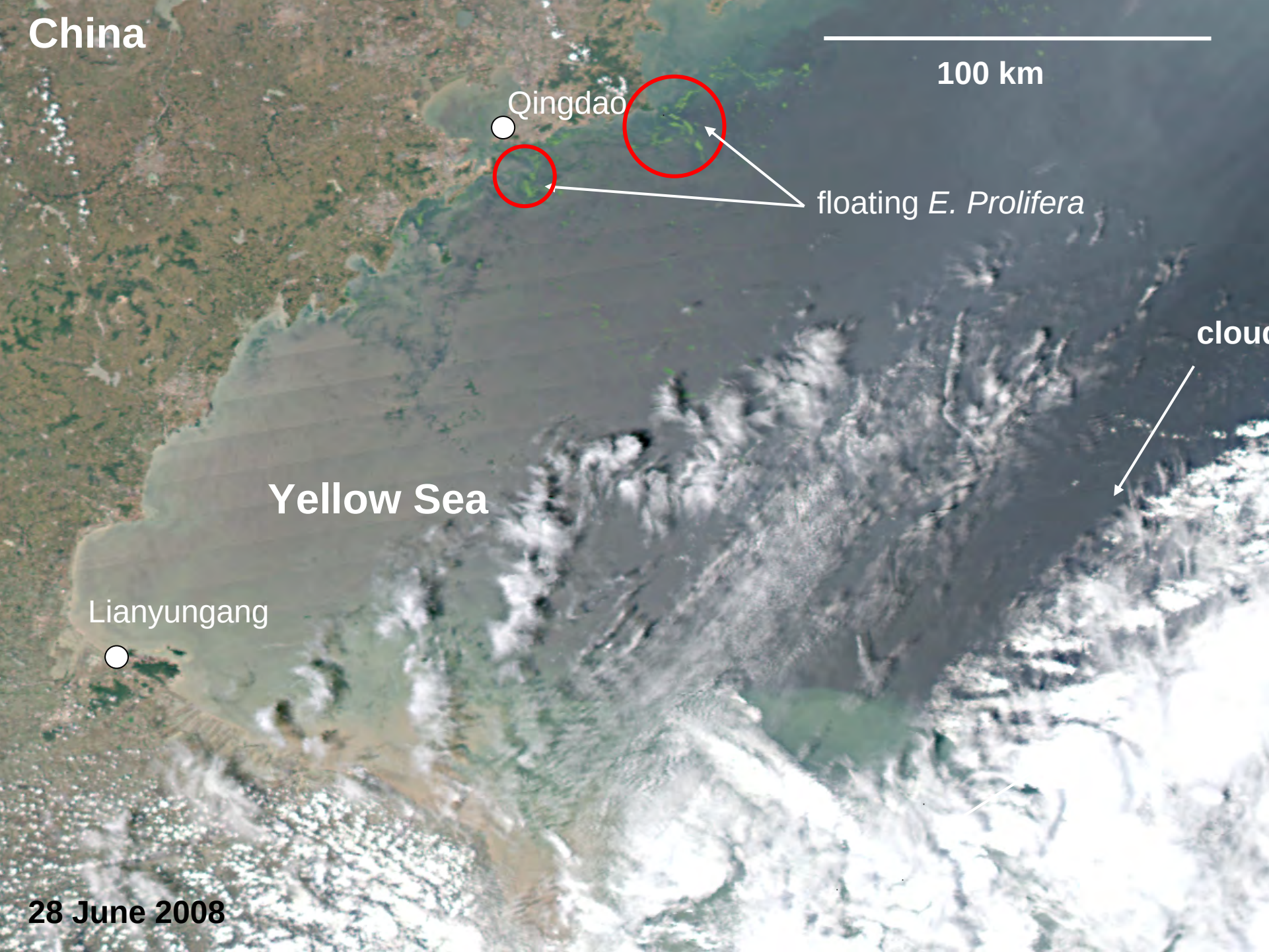
Initial assessment – 2008 green-tide

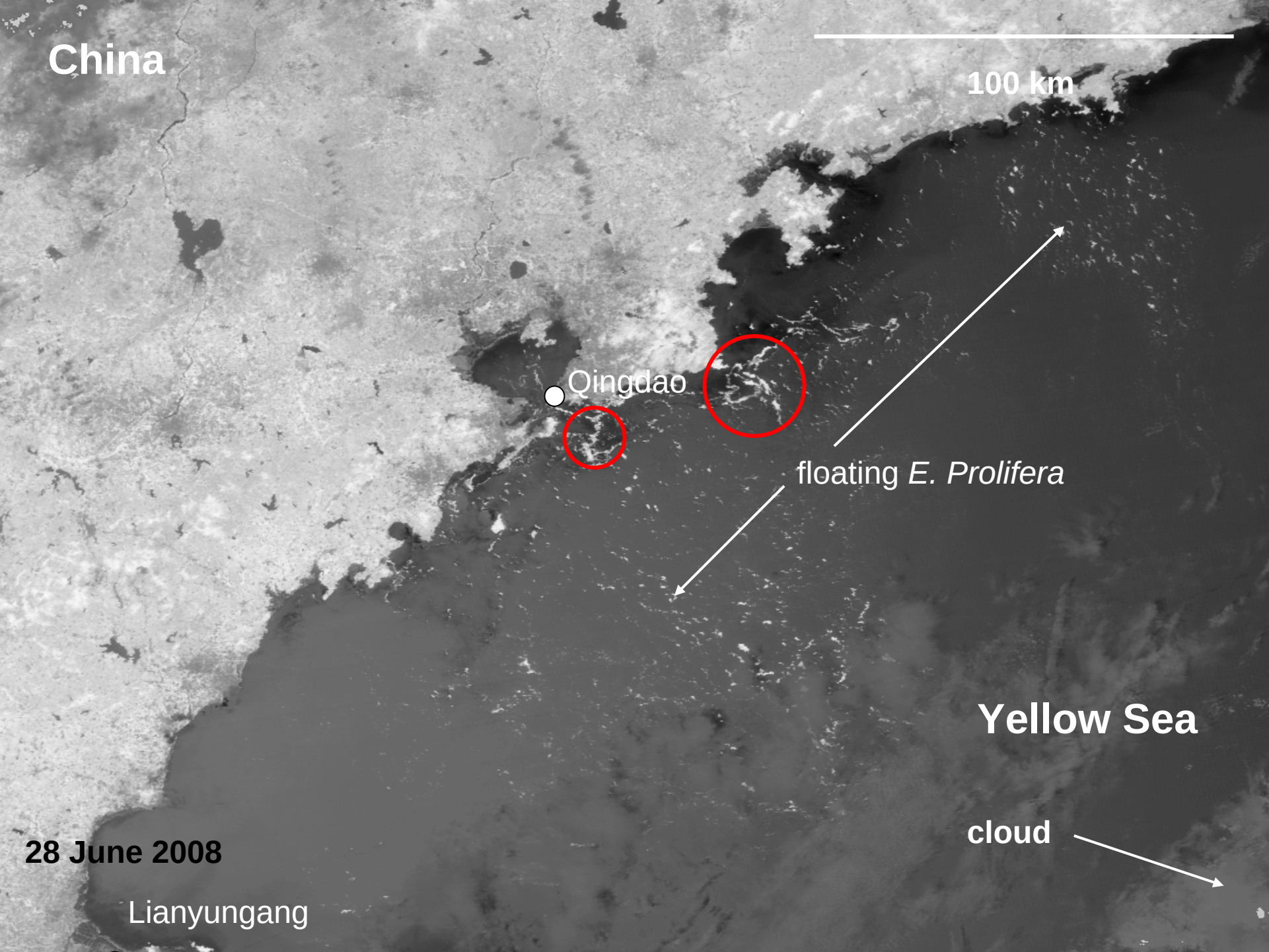
- Washed ashore in Jiaozhou Bay in late June 2008
- Covered 600km^2
- Successful clean up prior to Olympic Games
- Cause initially attributed to eutrophication
  - But the bloom was a novel event, eutrophication wasn't, so we looked for other potential bloom initiation causes

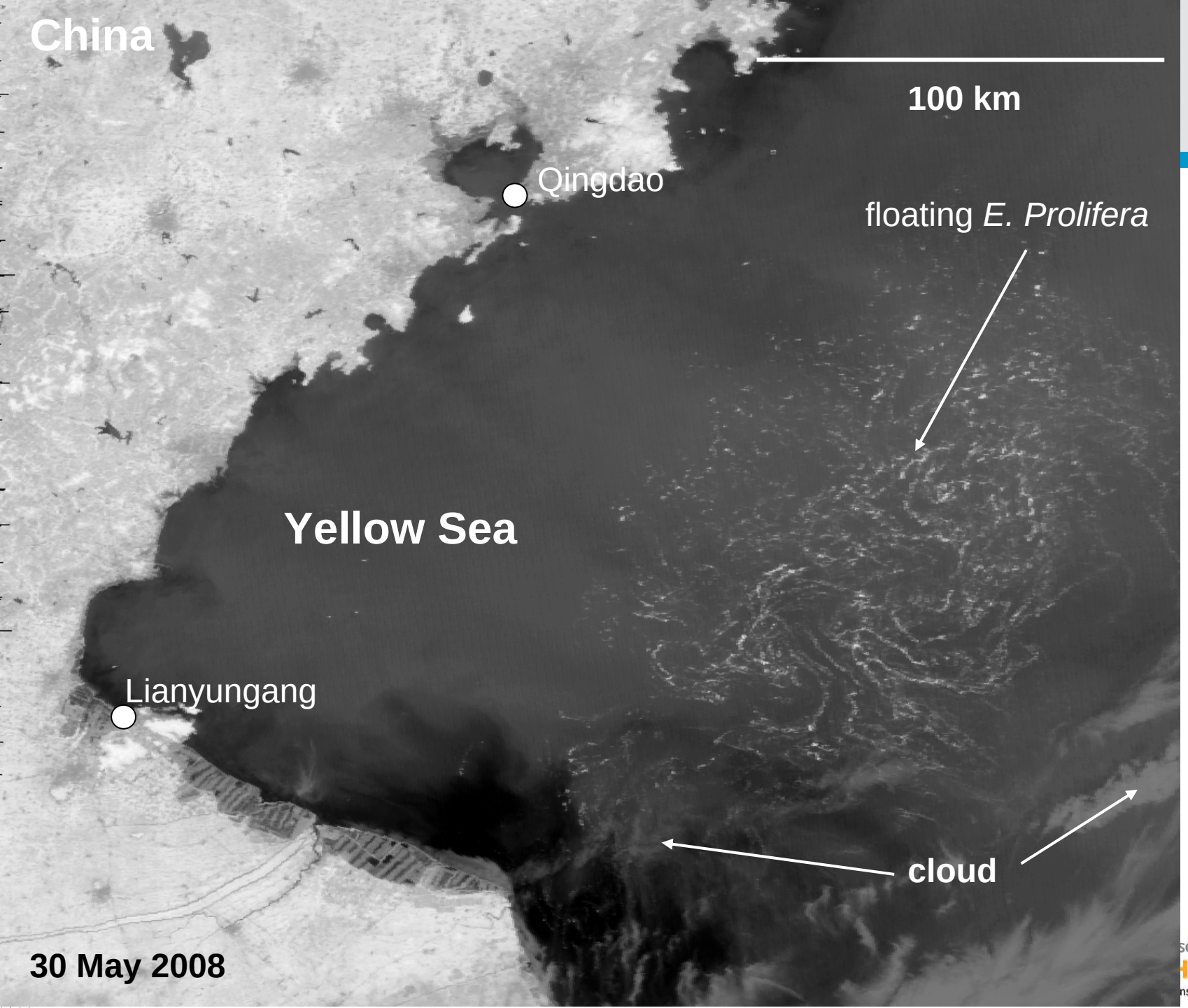
Yellow Sea Nutrients Source: SOA

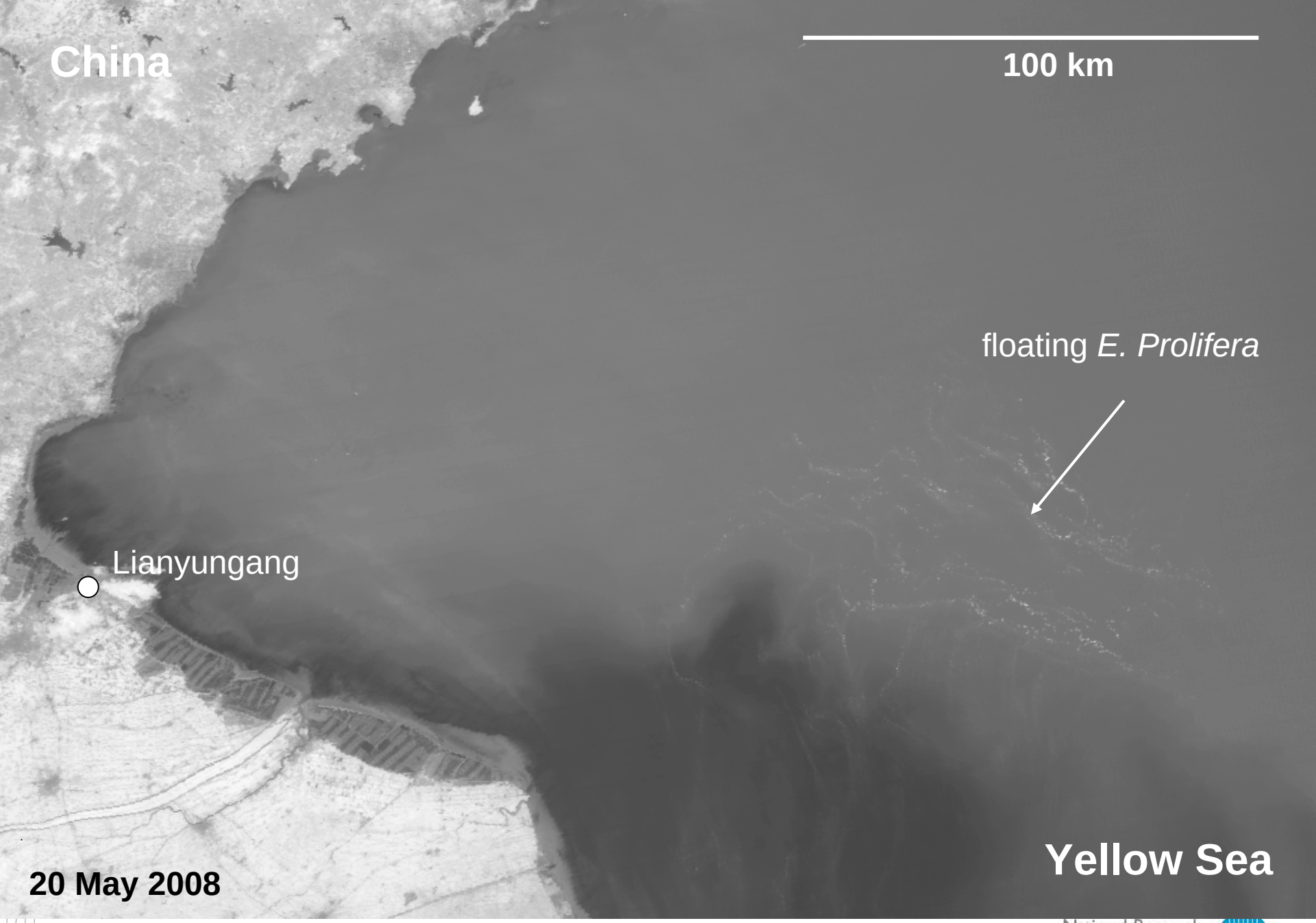


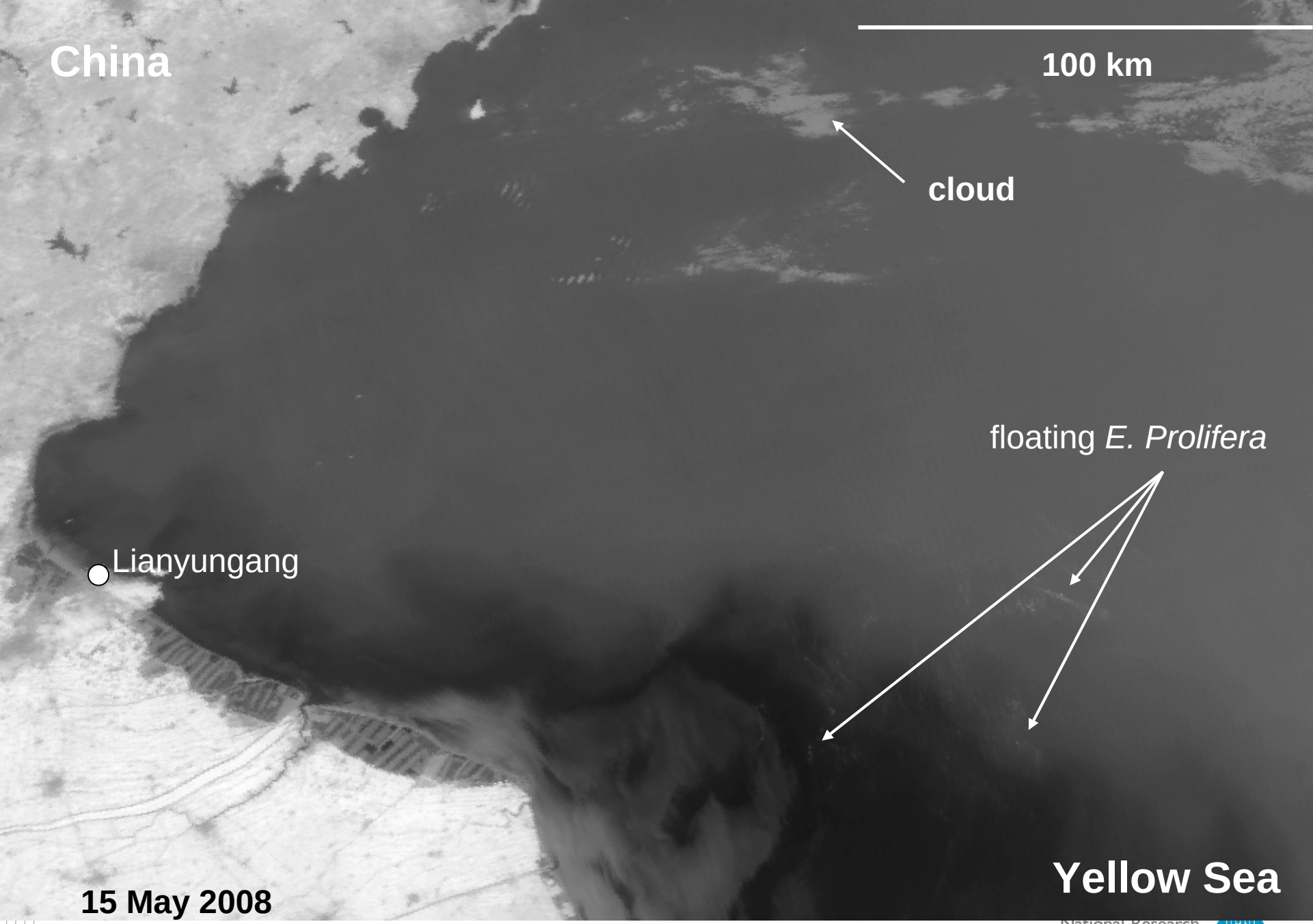
National Research FLAGSHIPS Wealth from Oceans CSIRO


China
100 km
Qingdao
floating *E. Prolifera*
cloud
Yellow Sea
Lianyungang
28 June 2008

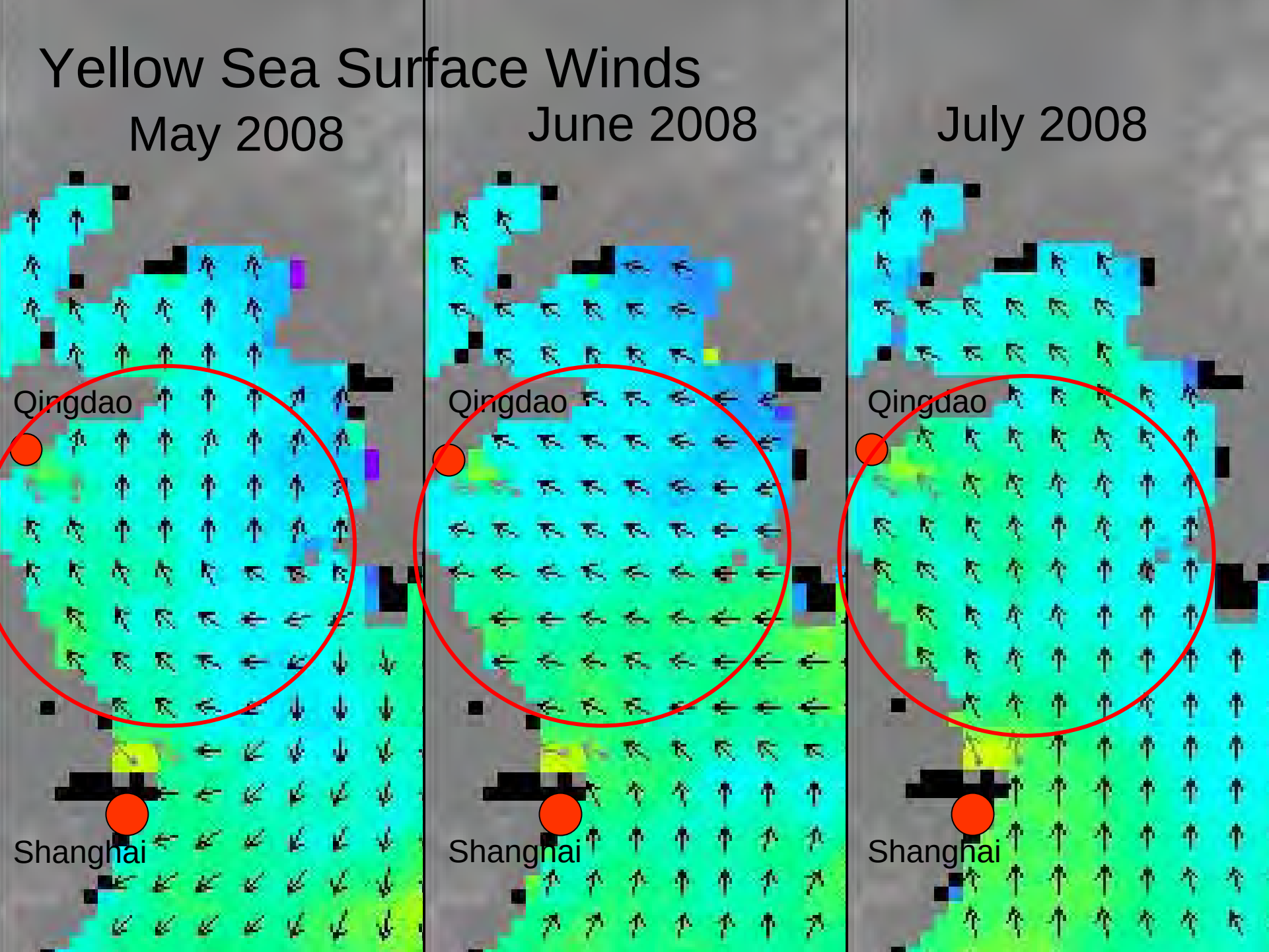

China
100 km
Qingdao
floating *E. Prolifera*
Yellow Sea
cloud
28 June 2008
Lianyungang


China
100 km
Qingdao
floating *E. Prolifera*
Yellow Sea
Lianyungang
cloud
30 May 2008

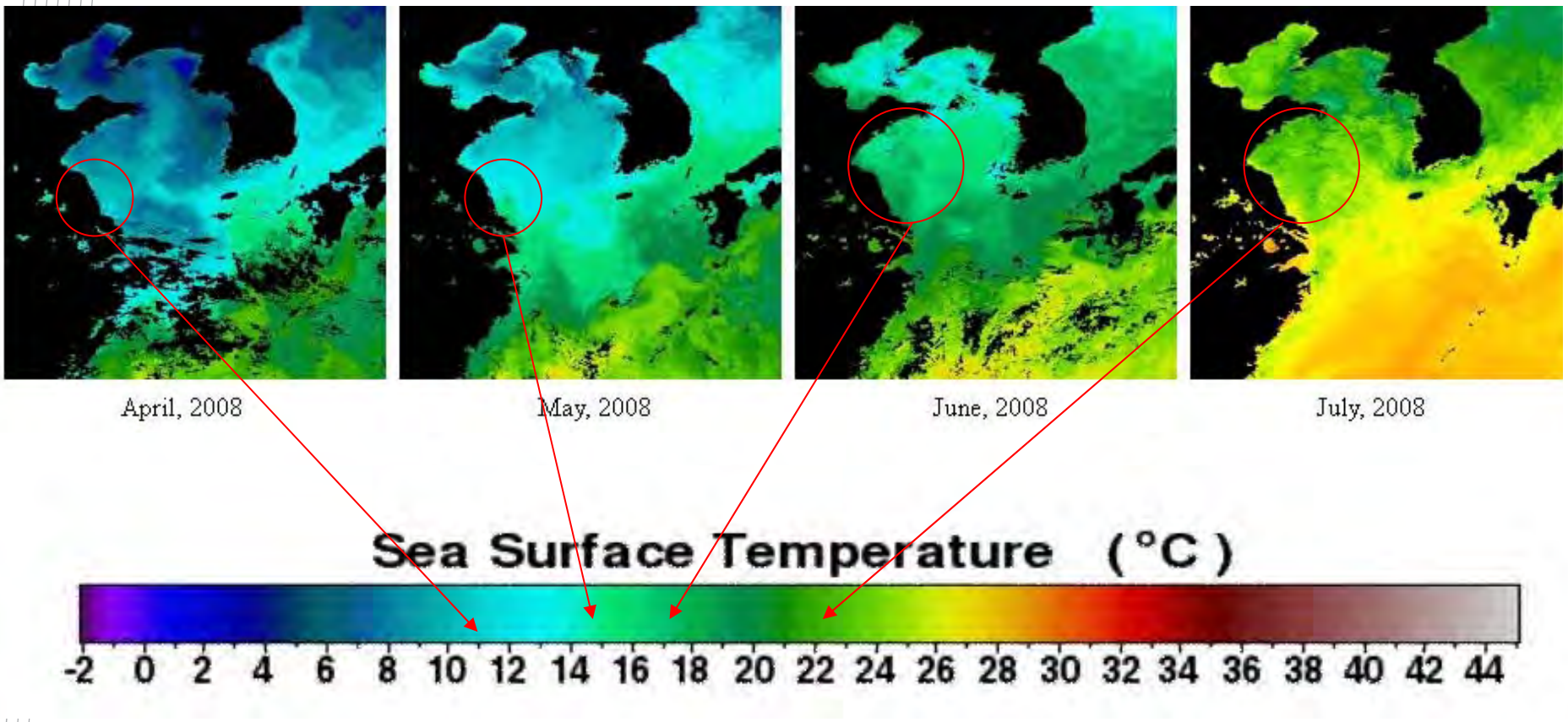


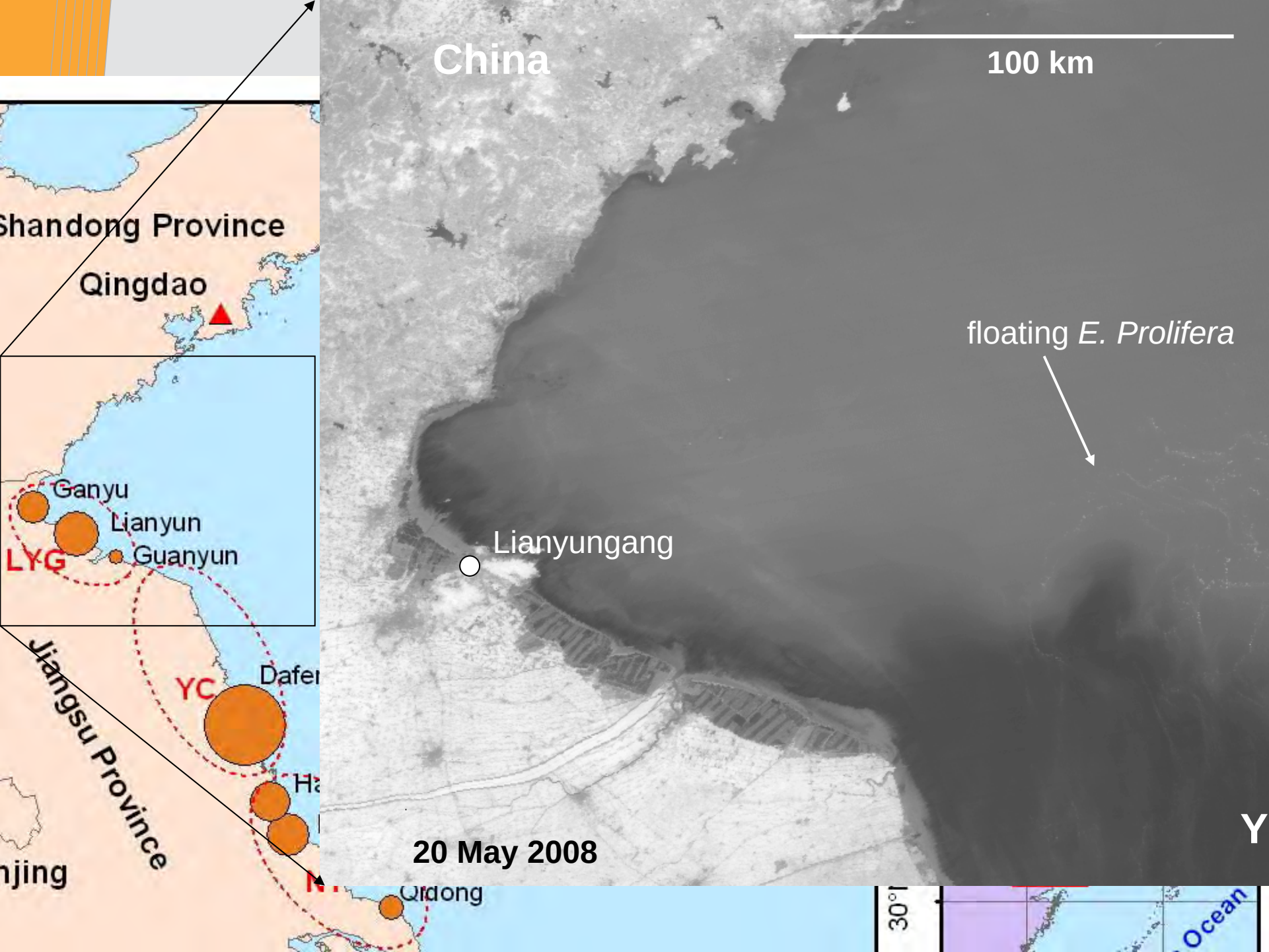

China
100 km
cloud
floating *E. Prolifera*
Lianyungang
Yellow Sea
15 May 2008

Yellow Sea Surface Winds

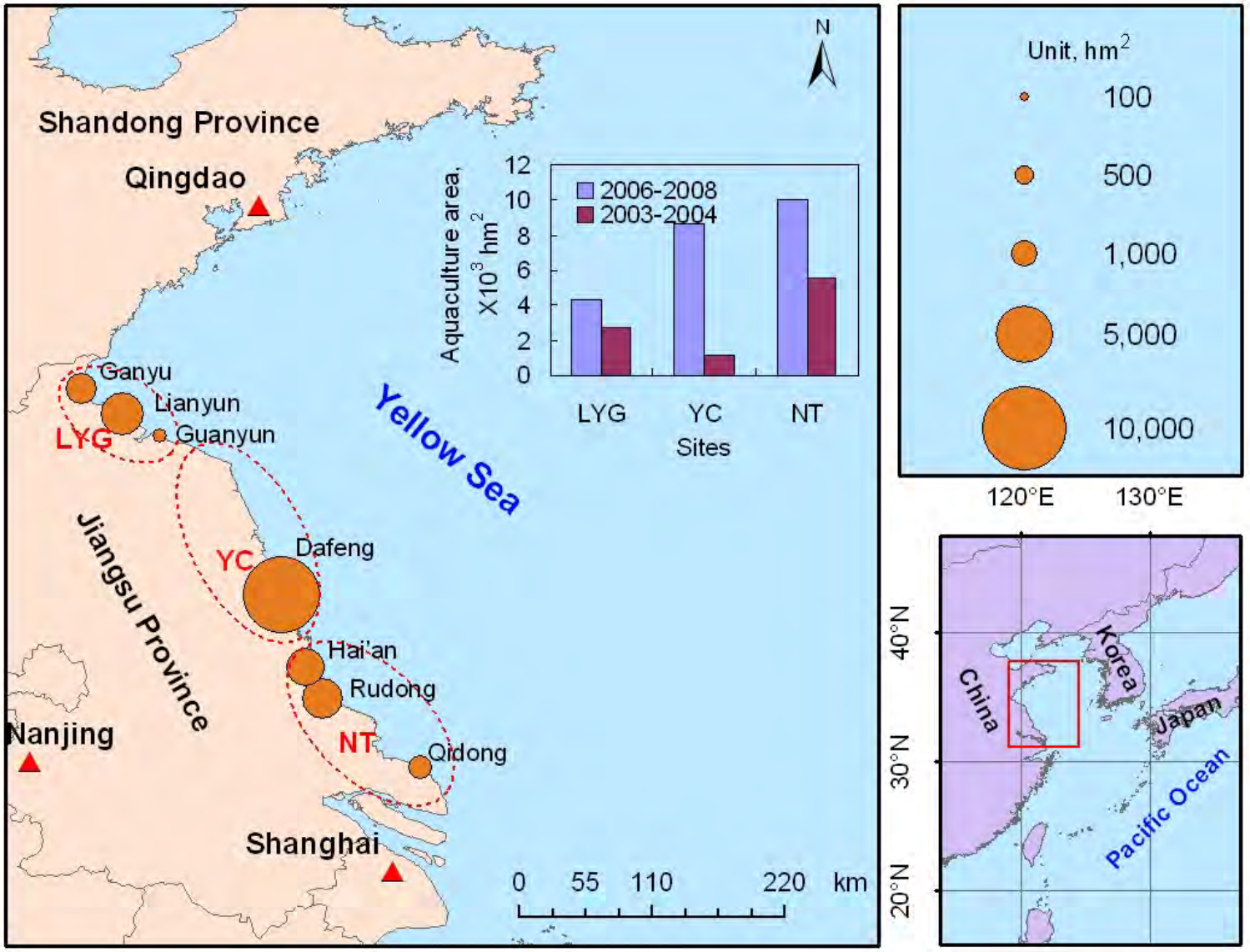


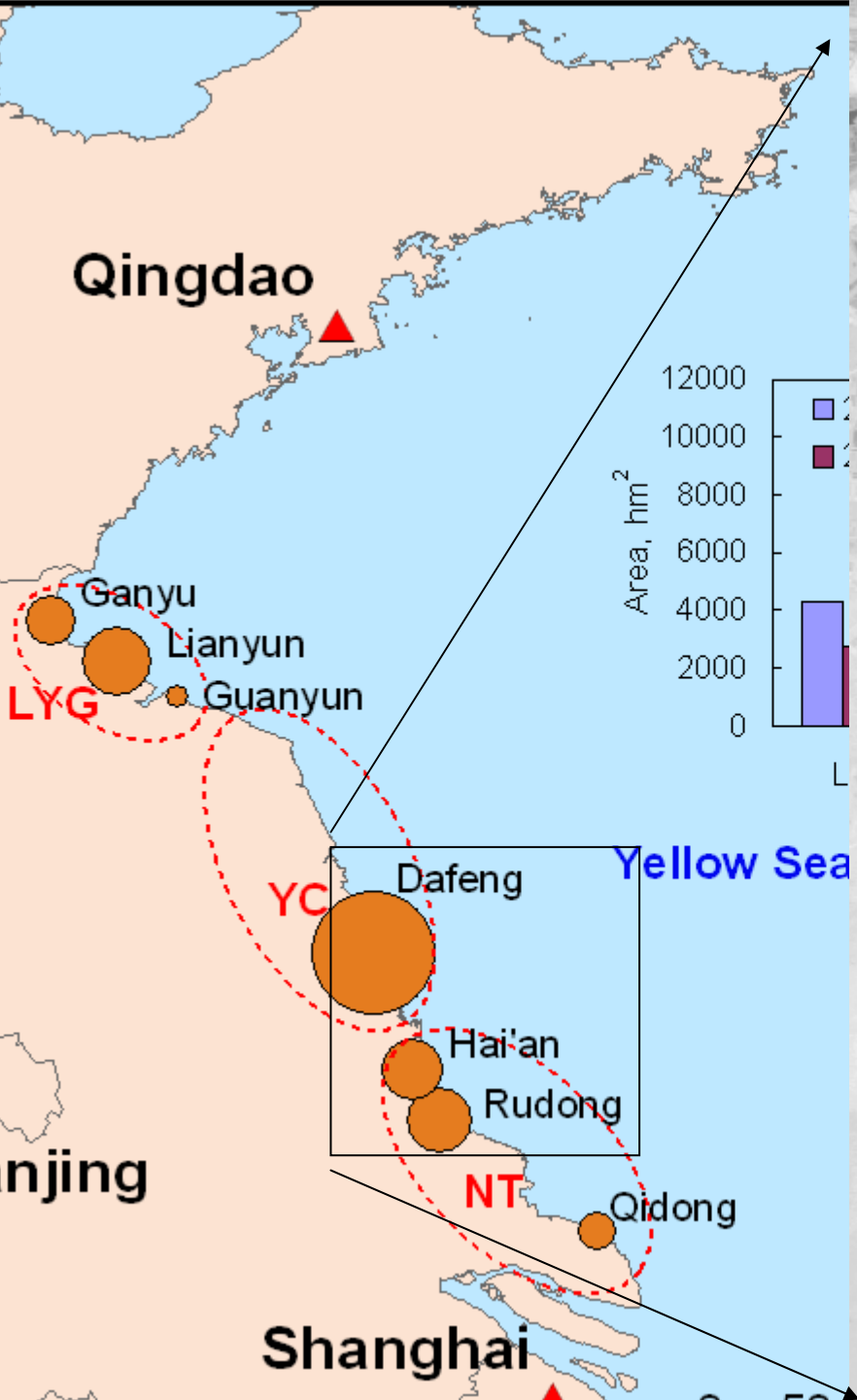
Sea Surface Temperature Yellow Sea 2008

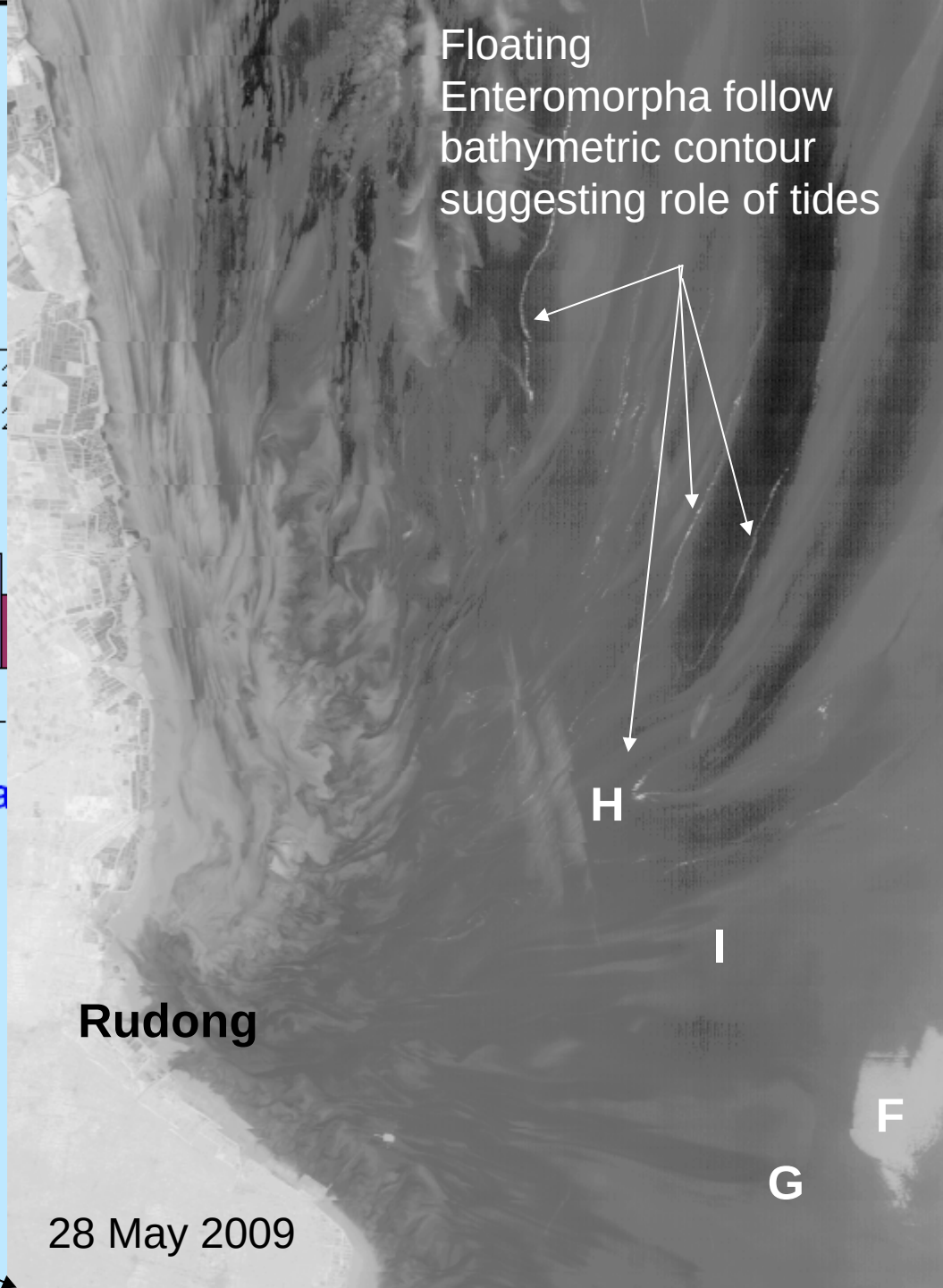


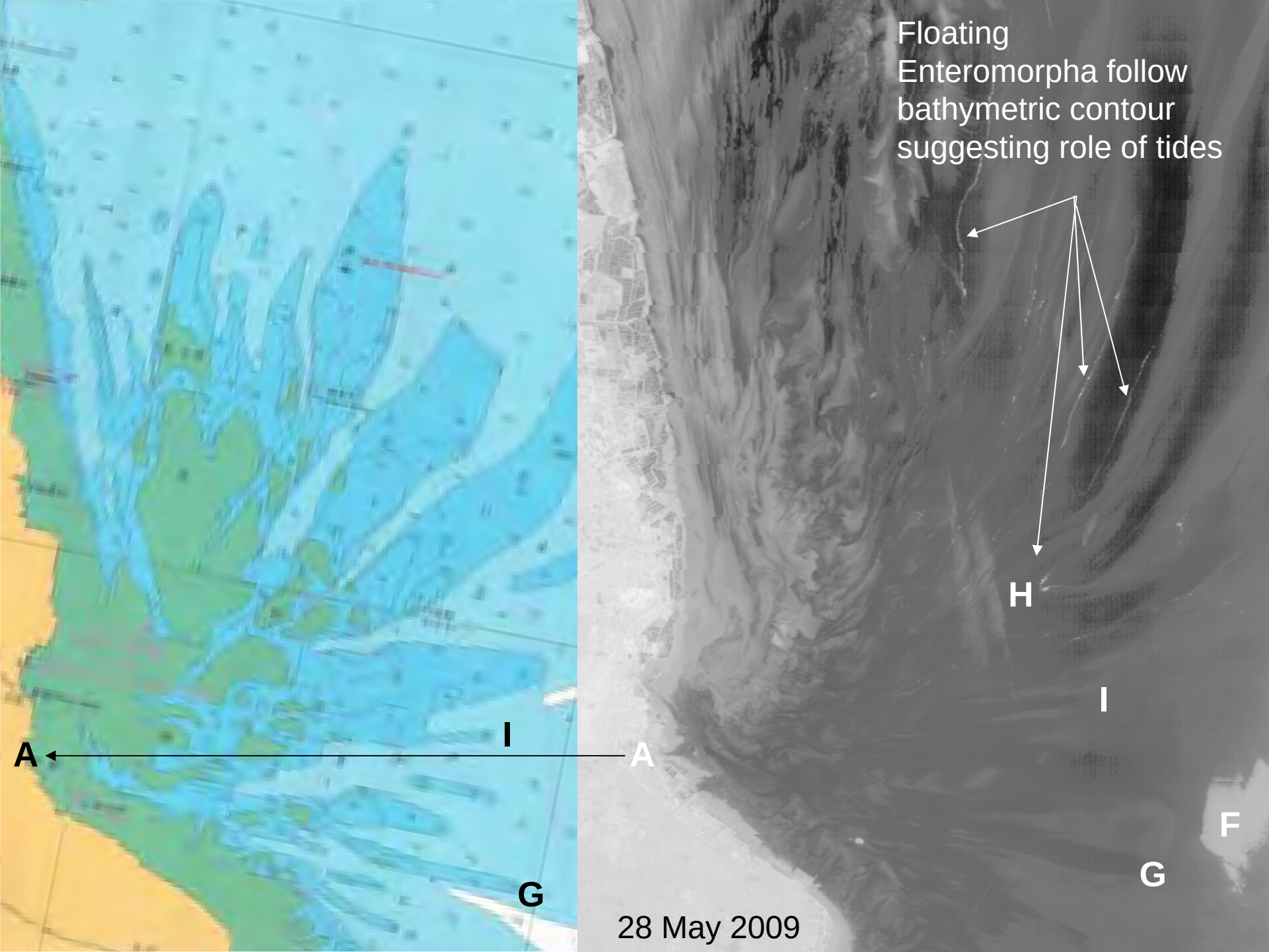

China
100 km
floating *E. Prolifera*
Lianyungang
20 May 2008
Shandong Province
Qingdao
Ganyu
Lianyun
Guanyun
LYG
YC
Jiangsu Province
njing
Qidong
30°
Ocean

Expansion in coastal *Porphyra* aquaculture




Qingdao
Ganyu
Lianyun
Guanyun
LYG
YC
Dafeng
Yellow Sea
Hai'an
Rudong
NT
Qidong
Shanghai
njing
12000
10000
8000
6000
4000
2000
0
Area, hm2


Floating
Enteromorpha follow
bathymetric contour
suggesting role of tides
H
I
Rudong
F
G
28 May 2009


Floating
Enteromorpha follow
bathymetric contour
suggesting role of tides
H
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F
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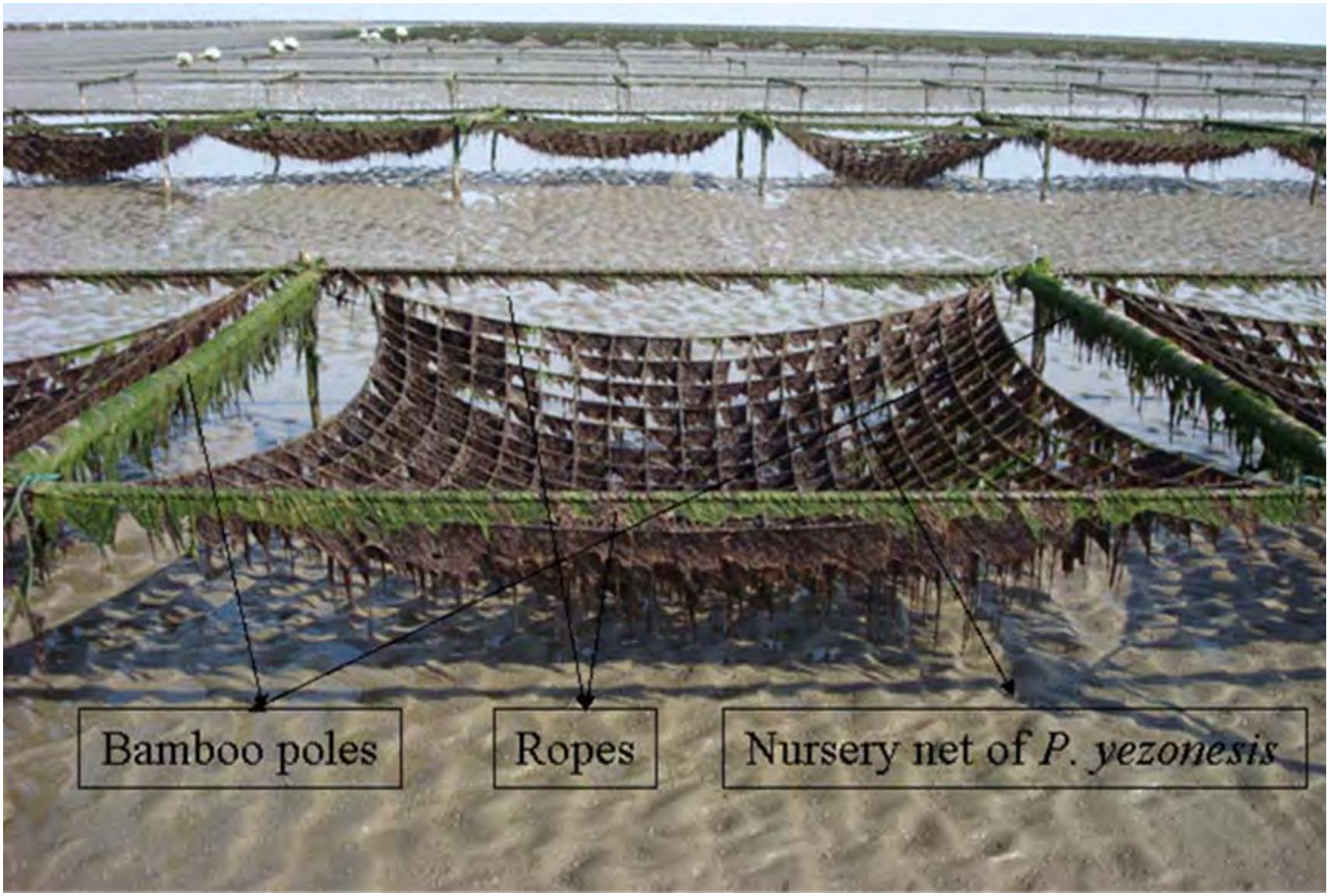
A
I
A
G
28 May 2009

Porphyra culture infrastructure

Porphyra culture infrastructure



Conclusions – 2008 green-tide study

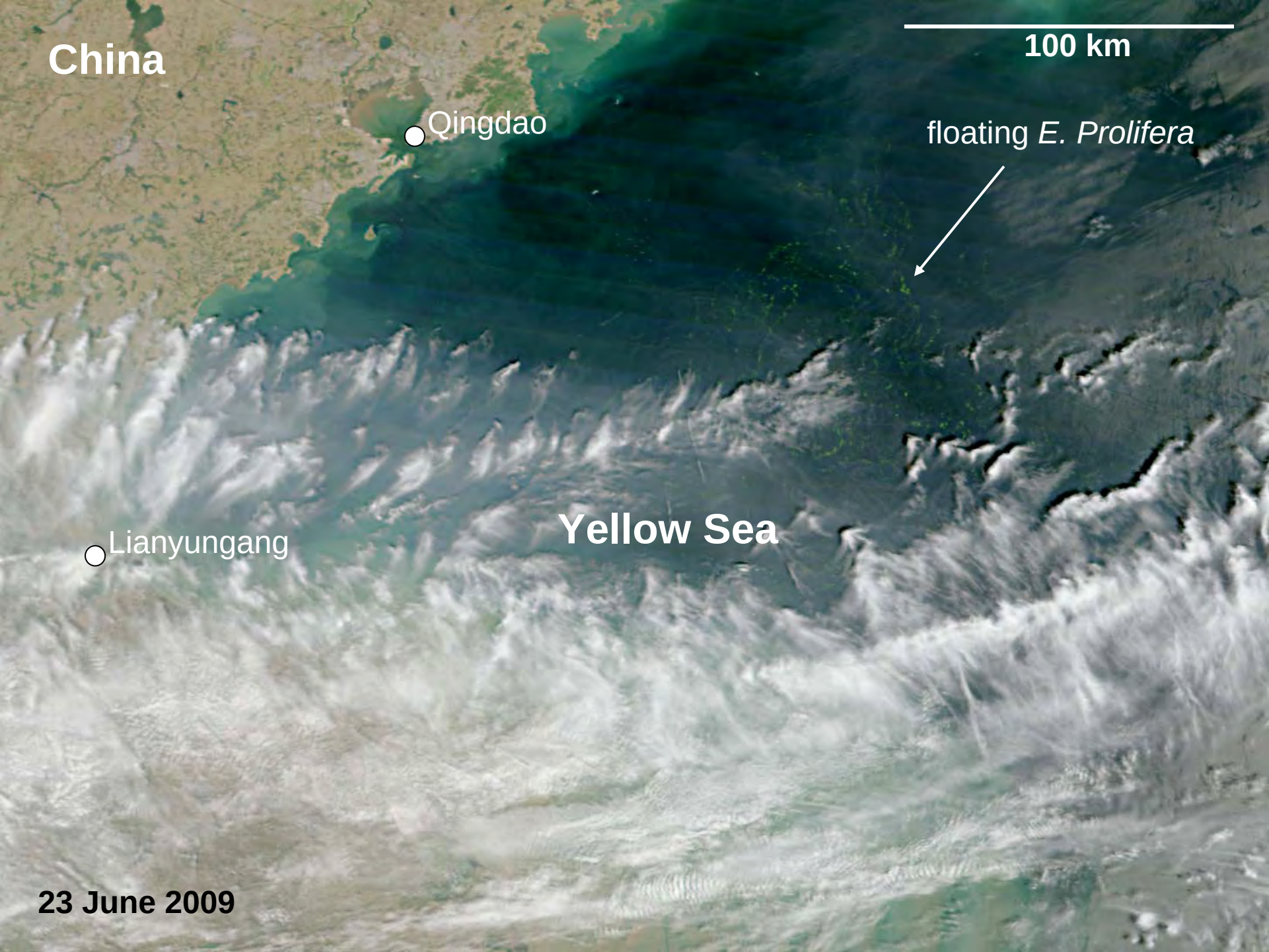
- Formed off Jiangsu Province early May 2008
- Grew to cover 1200 km^2 spread over 40,000 km^2
- Typical weather and oceanography
  - Favourable winds and currents to transport bloom north towards Shandong Province
  - Favourable temperatures to accumulate bloom biomass
  - Sufficient nutrients
- Biology of *Enteromorpha prolifera*
  - growth habit and growth rates vs temperature
  - plausible modelling of biomass accumulation over 6 weeks
- *Porphyra* aquaculture implicated
  - Area expanded from 9,460 ha in 2003 to 22,974 ha in 2008
  - *Enteromorpha* nursery hypothesis formed
- Novel event in 2008
  - In December 2008 it was predicted to occur again in summer 2009

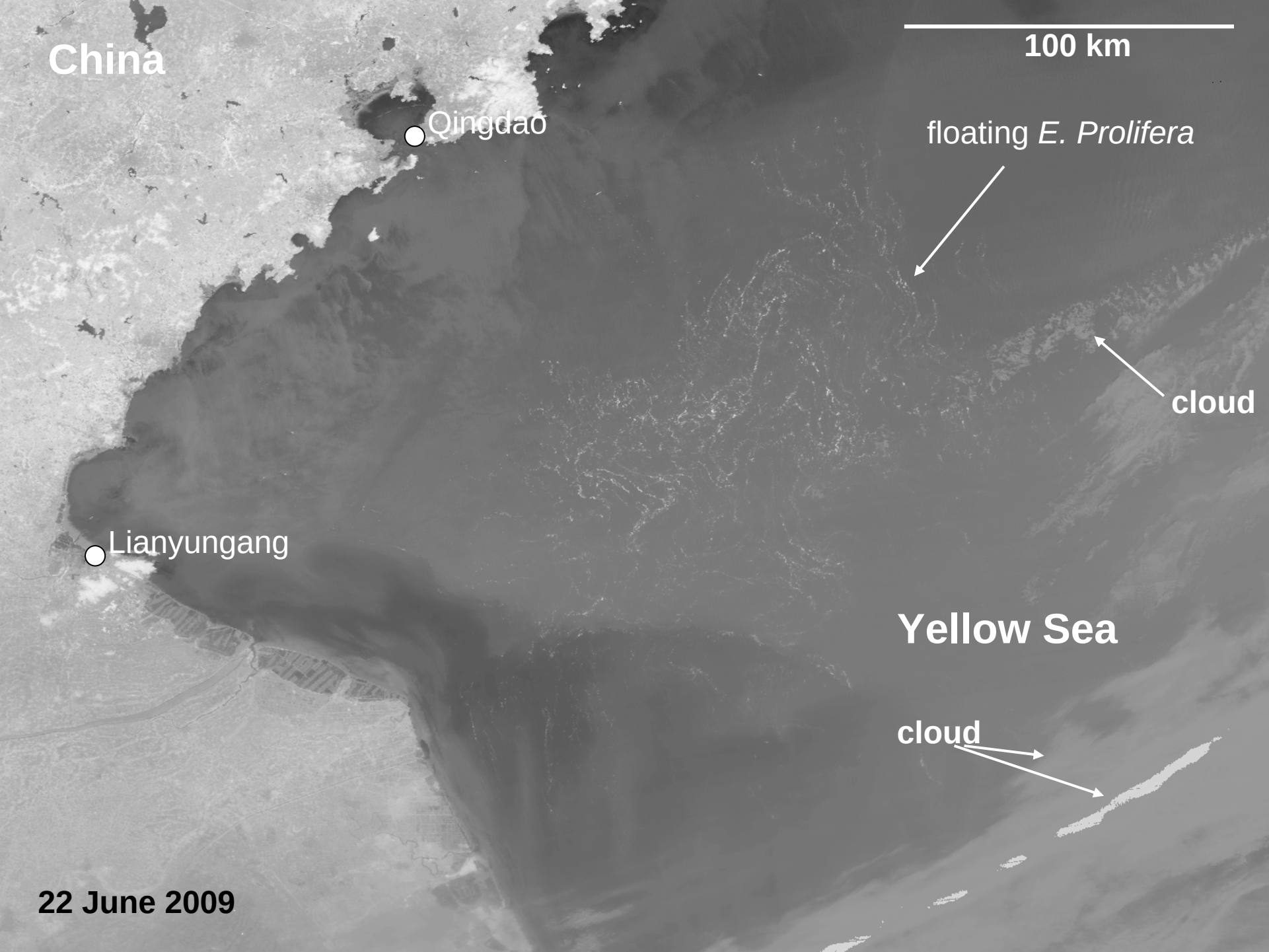
(Liu et al, 2009)

Winter-Summer 2008/09 study

- Investigate genetic relatedness of Jiangsu Province *Enteromorpha* and that from 2008 Qingdao green-tide – Dongyan Liu presentation (Tuesday, S4)
- Measure biomass accumulation of *Enteromorpha* on aquaculture infrastructure – Dongyan Liu presentation
- Monitor for evidence of post-harvest bloom of *Enteromorpha*
  - *Ship (opportunistically)*
  - *Media/ State Ocean Administration*
  - *Satellite*

2009 Yellow Sea green-tide


China
Qingdao
100 km
floating *E. Prolifera*
Yellow Sea
Lianyungang
23 June 2009

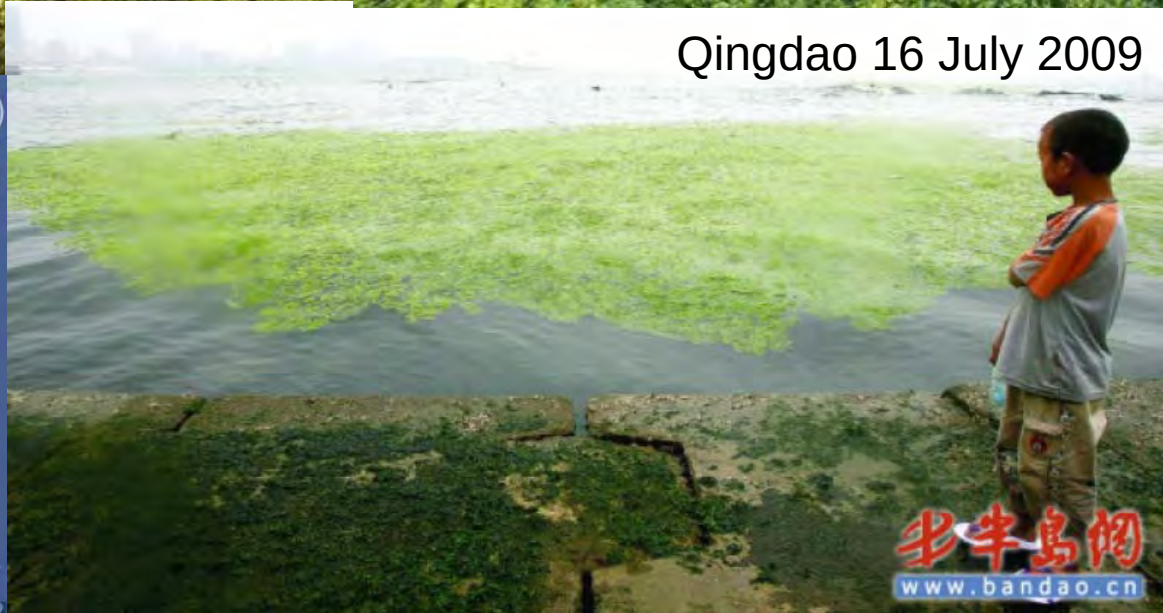

China
Qingdao
100 km
floating *E. Prolifera*
cloud
Lianyungang
Yellow Sea
cloud
22 June 2009

2009 green tide spread along Weihai Peninsula

Rushan 16 July 2009

15 July 2009

Qingdao 16 July 2009



2009 green-tide clean-up efforts

2009 green-tide

- Dispersed by storms in early July
- Affected extensive section of Shandong Province coast in mid July
- Impacts more widespread than in 2008 but not as severe

Conclusions – Winter-Summer 2008/09 study

- Strong evidence that *Porphyra* aquaculture provided a nursery for *Enteromorpha* that caused 2008 and 2009 blooms
  - Link between time course of biomass accumulation and harvest and appearance of floating patches and formation of larger bloom established
  - Genetics of *Enteromorpha* from Qingdao in 2008 and Jiangsu aquaculture raft in 2009 a close match (99.6%) – Dongyan Liu talk (Tuesday S4)
  - ca. 5000 tonnes *Enteromorpha* accumulated prior to *Porphyra* harvest was sufficient to seed bloom – Dongyan Liu talk
- Recommendation
  - to modify raft cleaning method to dispose of *Enteromorpha* on land
- Next steps
  - Validate hypothesis about role of tide in export of waste *Enteromorpha* to Yellow Sea
  - Better understand complex dynamics of *Enteromorpha* biomass accumulation on rafts and in sea
    - water temperature/air temperature
    - immersion/emersion

Thankyou

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For more information:

World's largest macroalgal bloom caused by expansion of seaweed aquaculture in China

Dongyan Liu [a,*], John K. Keesing [b], Qianguo Xing [a], Ping Shi [a]

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