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Phytoplankton Dynamics from Remote Sensing:

In the footsteps of Sir Alister Hardy

Continuous Plankton Recorder

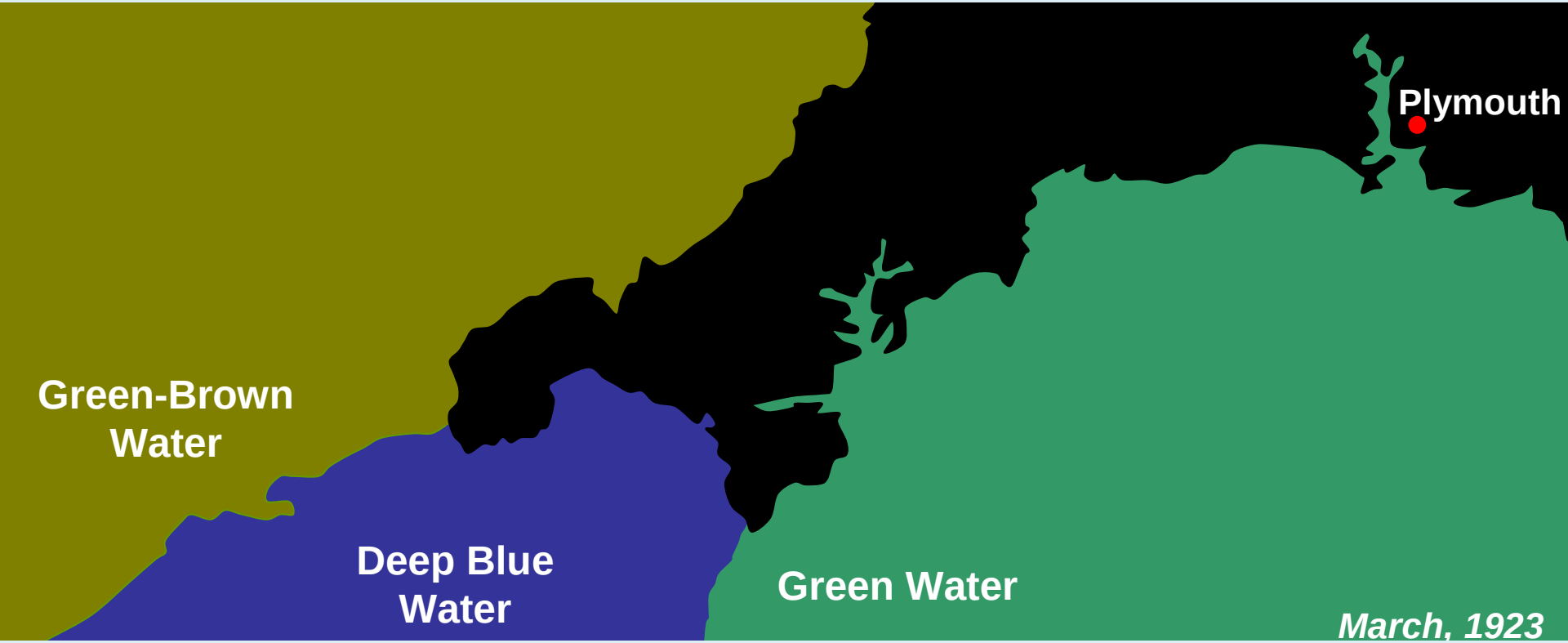
Discovery Expedition (Antarctica), 1925 to 1927

As chief zoologist, Hardy demonstrated the relationship between whales and plankton.

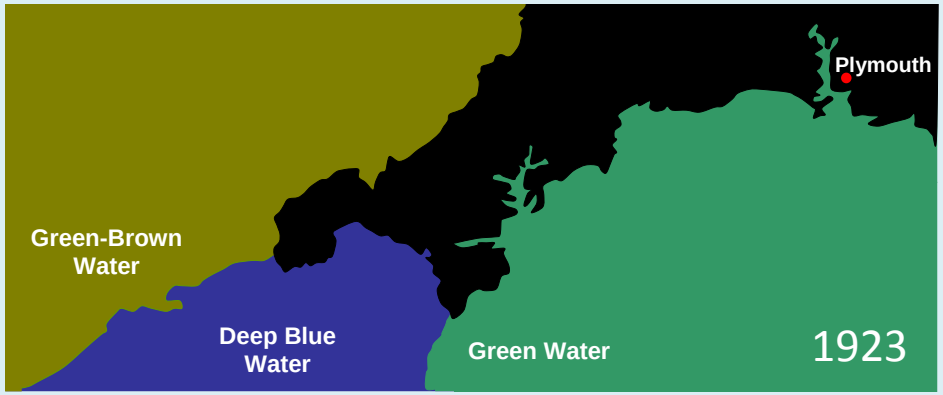
Colour of ocean as seen from ship at different times and places

Mariners have known for centuries that such differences in ocean colour provide important information for fishermen: whaling captains, notably William Scoresby, were particularly observant

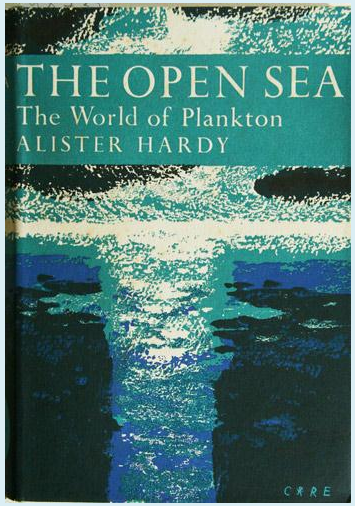
Alister Hardy (1923): Pioneering steps in Ocean-colour remote sensing



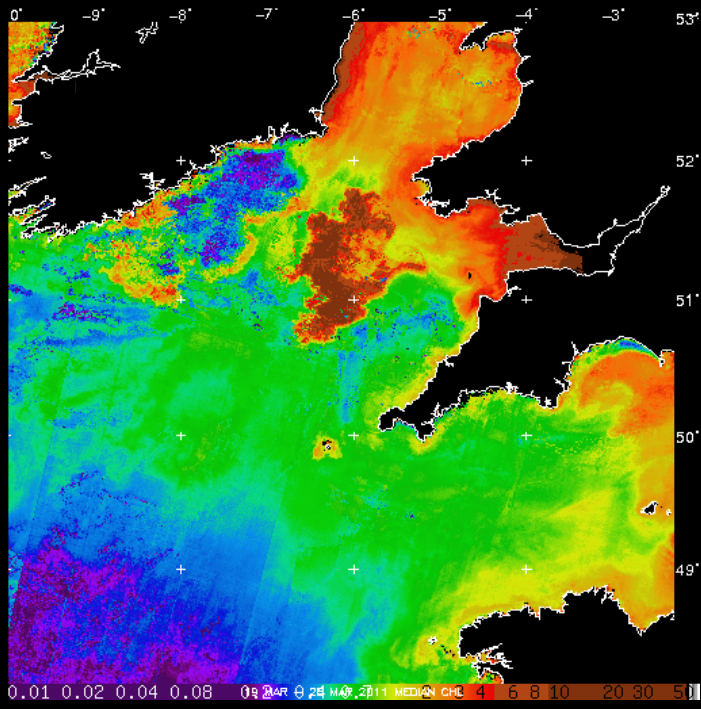
"…we passed over a sharp line separating the green water of the Channel from the deep blue of the Atlantic."



"If these marked colour-changes can be correctly interpreted we may in the future find aircraft being used to make rapid surveys of surface conditions in relation to fisheries."



Fisheries Applications are many:



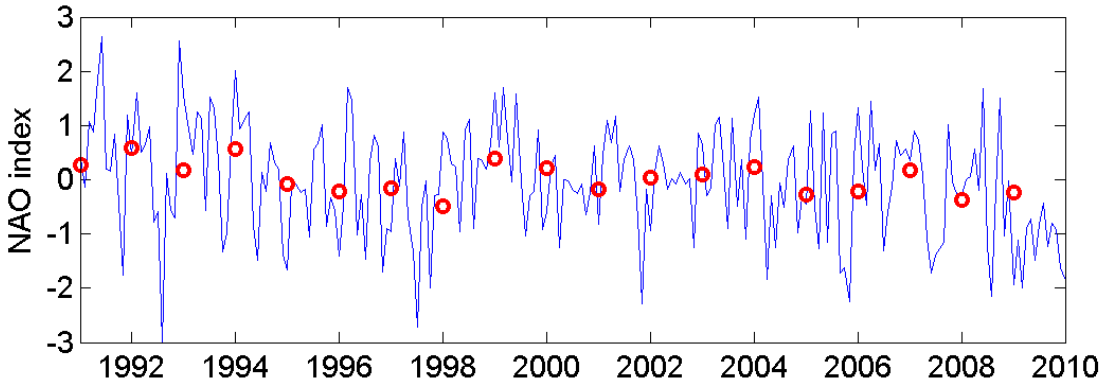
- Harvest Fisheries
  - economies of fuel and time
- Fisheries Management
  - intelligence on ecosystem fluctuations and effect on future states of exploited stocks
- Aquaculture Industry
  - carrying capacity, harmful algal blooms
- Protection of Species at Risk
  - exclusion zones and reduction of by-catch
- Marine Protected Areas & Vulnerable Marine Ecosystems
  - delineation of these
- Ecosystem Health and Ecosystem Services
  - monitoring health, evaluating services, biodiversity, ecosystem indicators
- High Seas Governance
  - international governance strategy, ecosystem delineation, straddling stocks

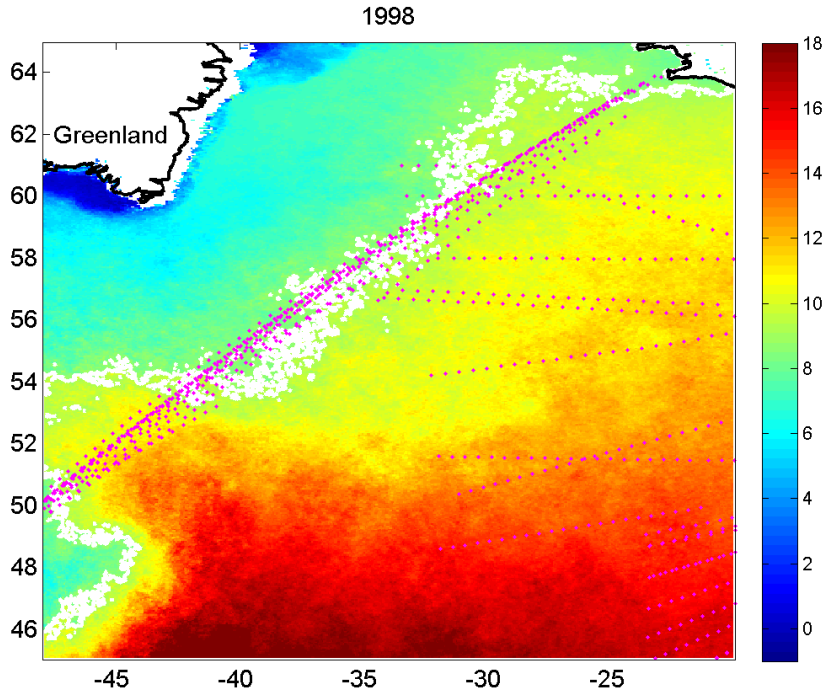
Phytoplankton Observed by CPR and Remote Sensing of Ocean Colour

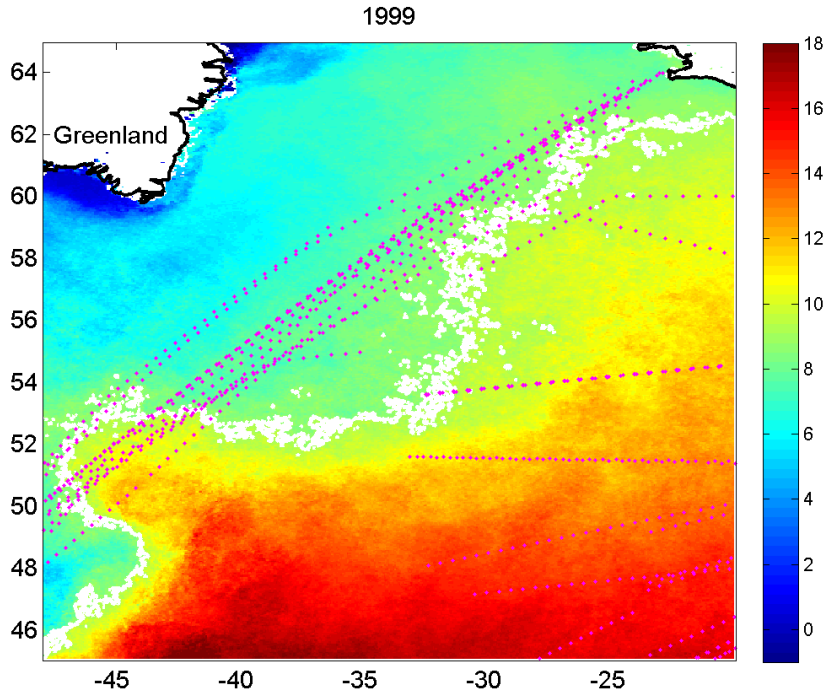
	Continuous Plankton Recorder	Visible Spectral Radiometry
Duration	80 Years	14 Years
Time Resolution	Monthly	Weekly (daily)
Spatial Resolution	15 km	1 km or better
Coverage	Linear and Fixed	Planar (Basin Scale)
Pigment Retrieval	Colour Index	Chlorophyll concentration
Taxonomic Information	Species Level (large cells)	Functional Groups
Calibration	Evidence in hand	Required absolutely

Superior time resolution and huge footprint make ocean-colour radiometry ideal for regional studies of phytoplankton seasonality (phenology)

North Atlantic Oscillation and Sea Surface Temperature

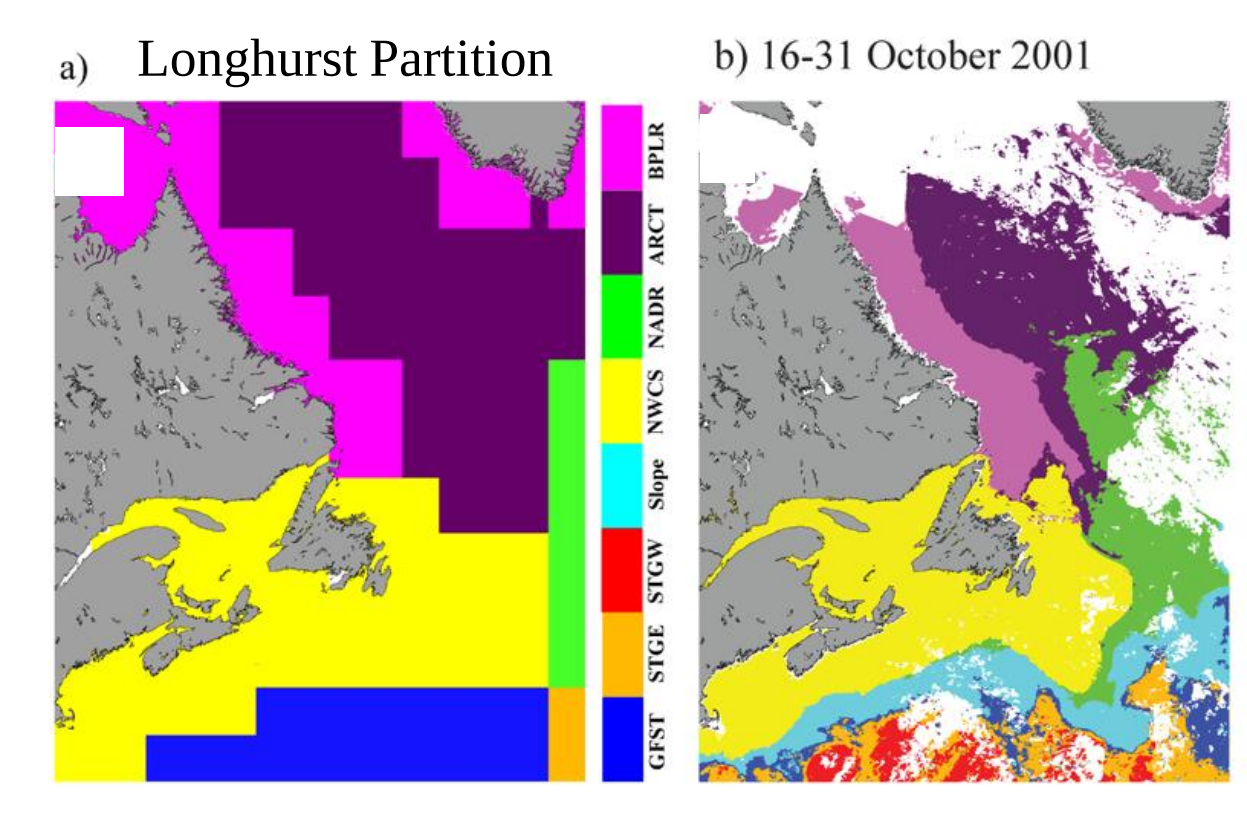






Water-mass structure moves between years relative to CPR tracks, white line denotes average position of 9°C isotherm in each year: 1998 (low NAO year) and 1999 (high NAO year)

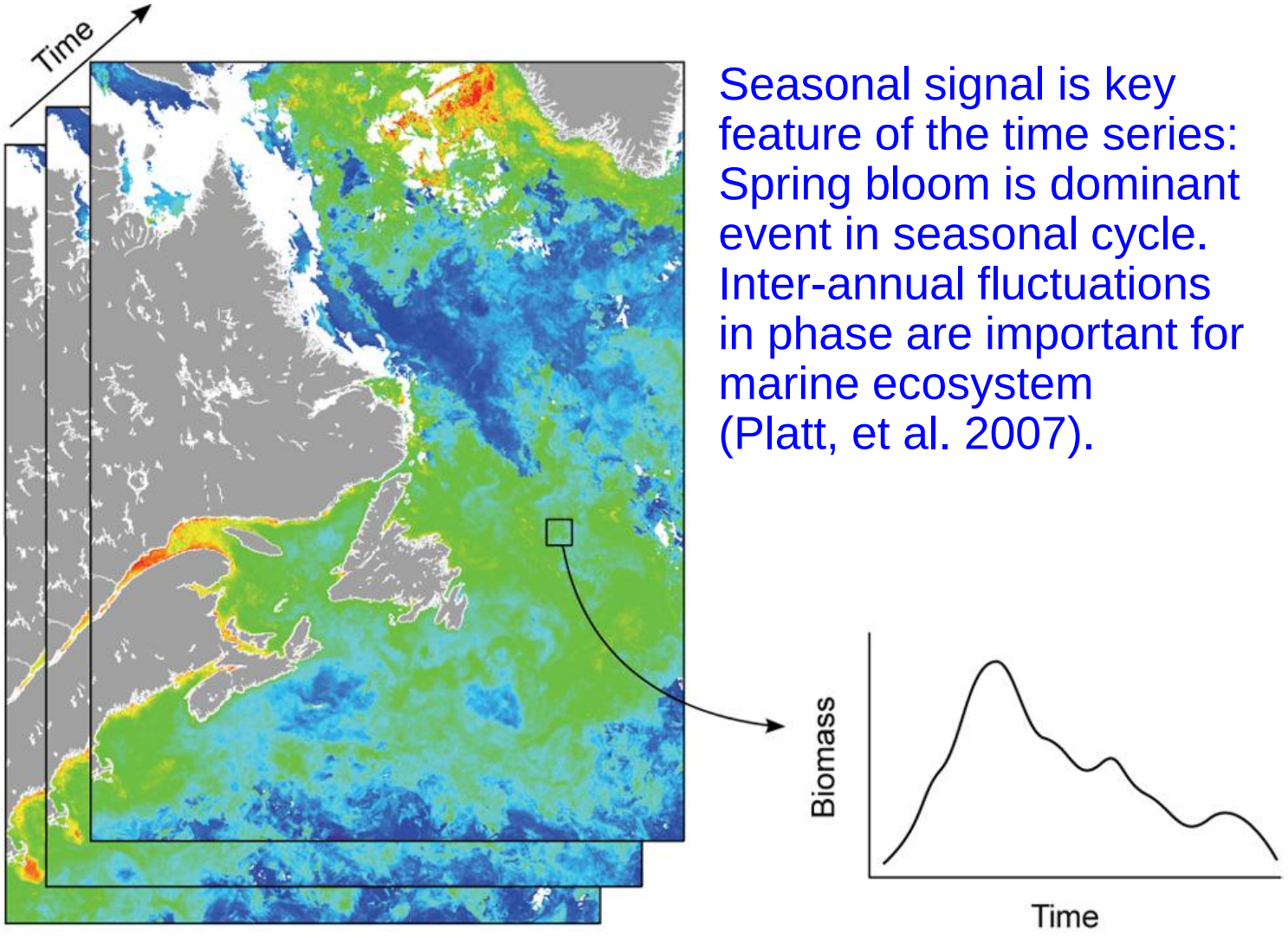
Ecological structure from remote sensing



Boundaries may move seasonally; partition may be developed as time series. Legal uses of "ecosystem" always specify a particular spatial context. Important for IGS, straddling stocks, boundary disputes, VMEs and MPAs.

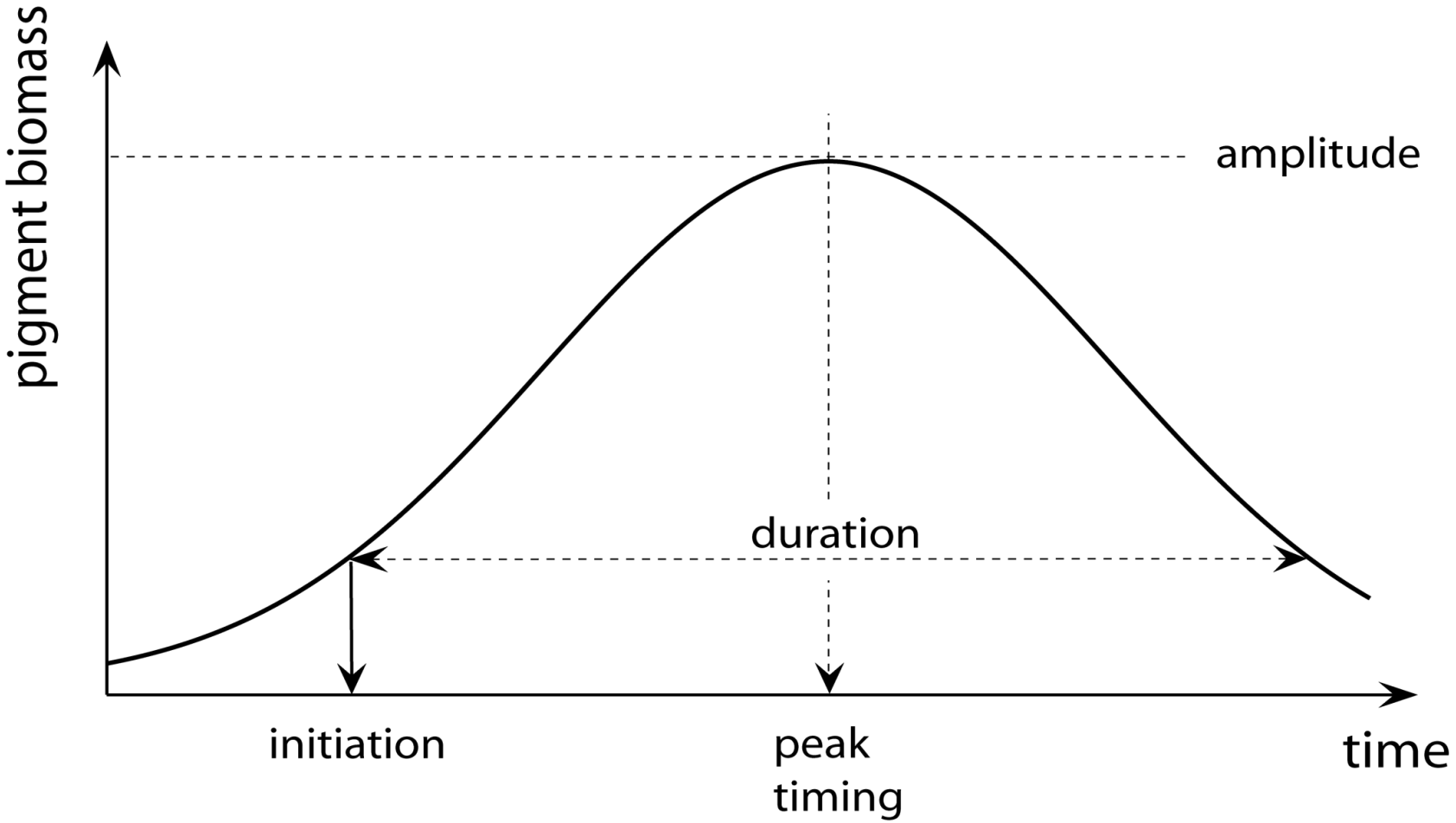
Devred et al. 2007

Construction of time series possible at any chosen scale of spatial averaging



Seasonal signal is key feature of the time series: Spring bloom is dominant event in seasonal cycle. Inter-annual fluctuations in phase are important for marine ecosystem (Platt, et al. 2007).

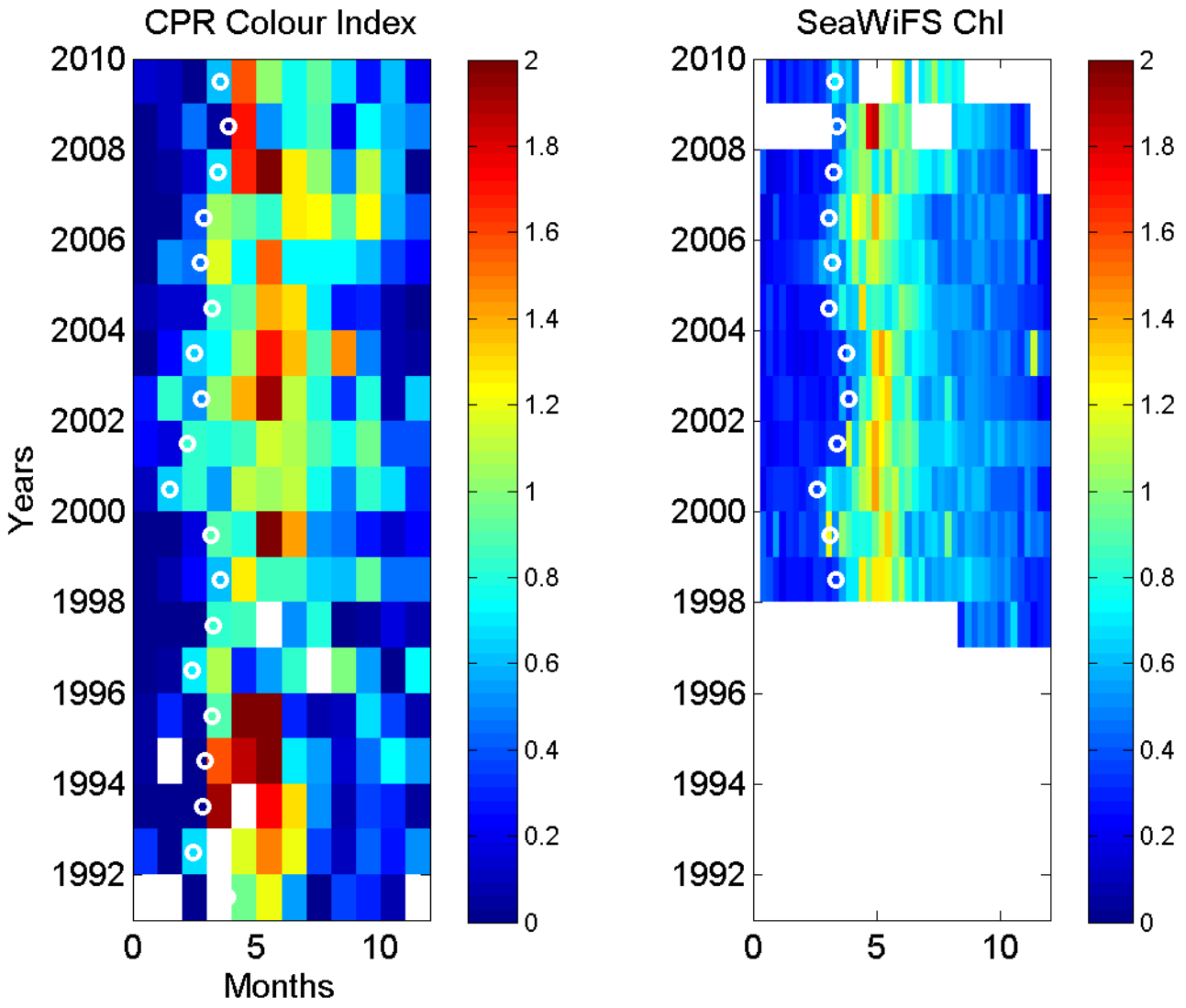
Quantifying the Seasonality



Any or all of these indices may vary between years
(at any or all of the pixels in the region of interest)

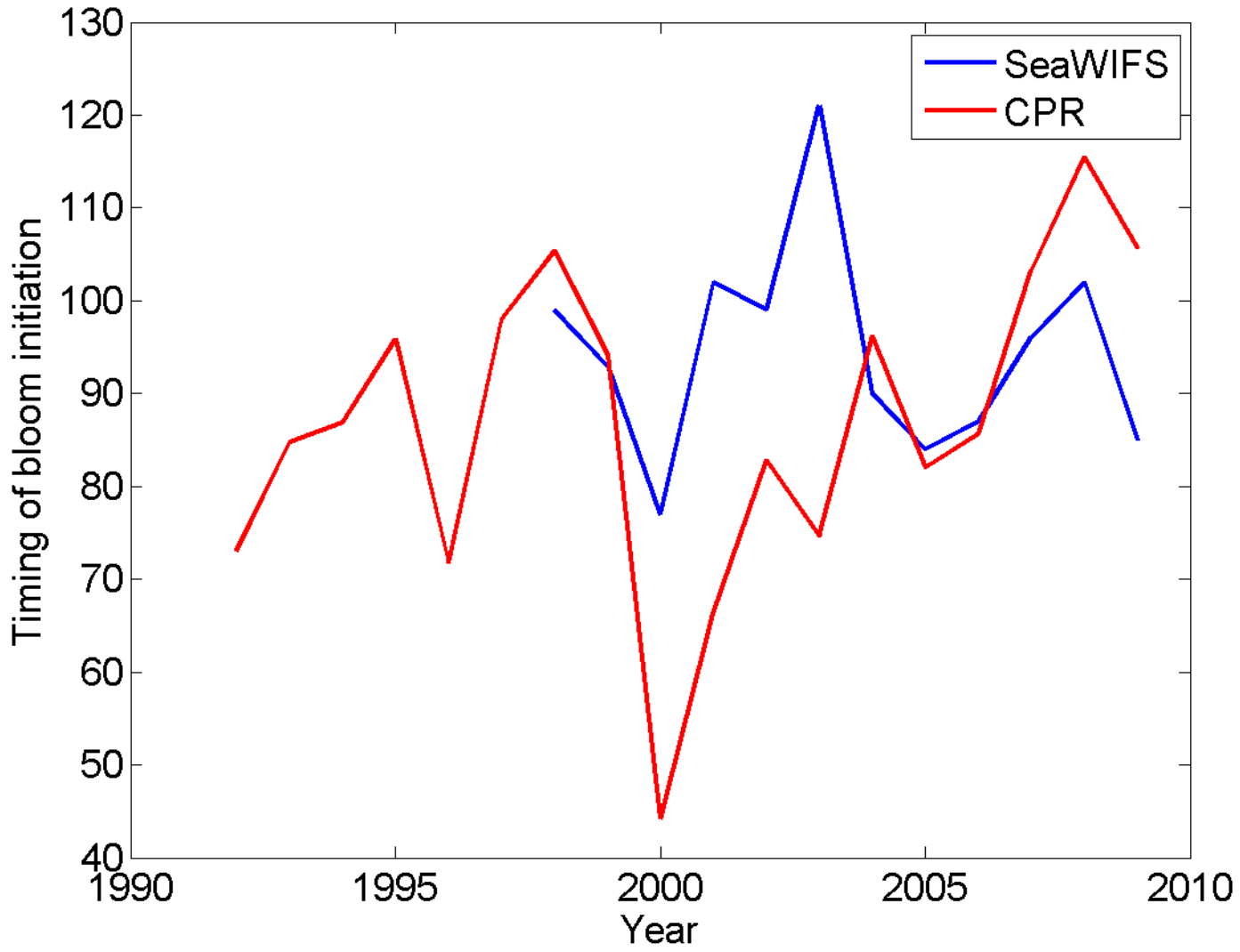
Platt, Sathyendranath & Fuentes-Yaco, 2007

CPR colour index and SeaWiFS chlorophyll concentration



White circles indicate initiation time of Spring phytoplankton bloom

Initiation of spring bloom timing, estimated from remote sensing and from CPR



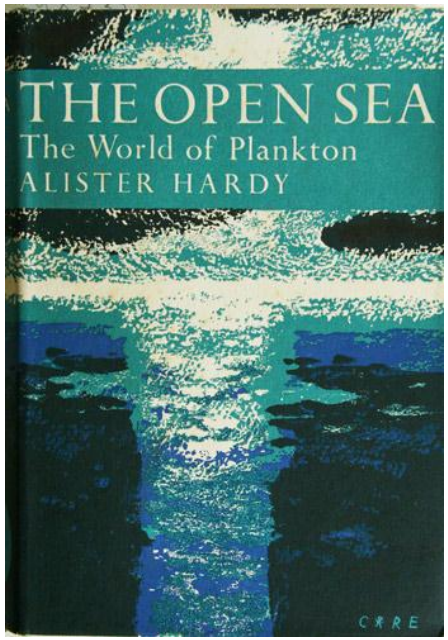
Looking to the Future

- Remote sensing and CPR time series should be seen as being complementary
- The grand synthesis of CPR and ocean colour radiometry remains to be done

Acknowledgements

Heather Bouman, Peter Miller,
Marie Racault, Venetia Stuart, Tony Walne

Inspiration



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