Impact of excessive nutrients on seagrass and kelp

Bart Christiaen, Helen Berry, Pete Dowty, Jeff Gaeckle, Lisa Ferrier

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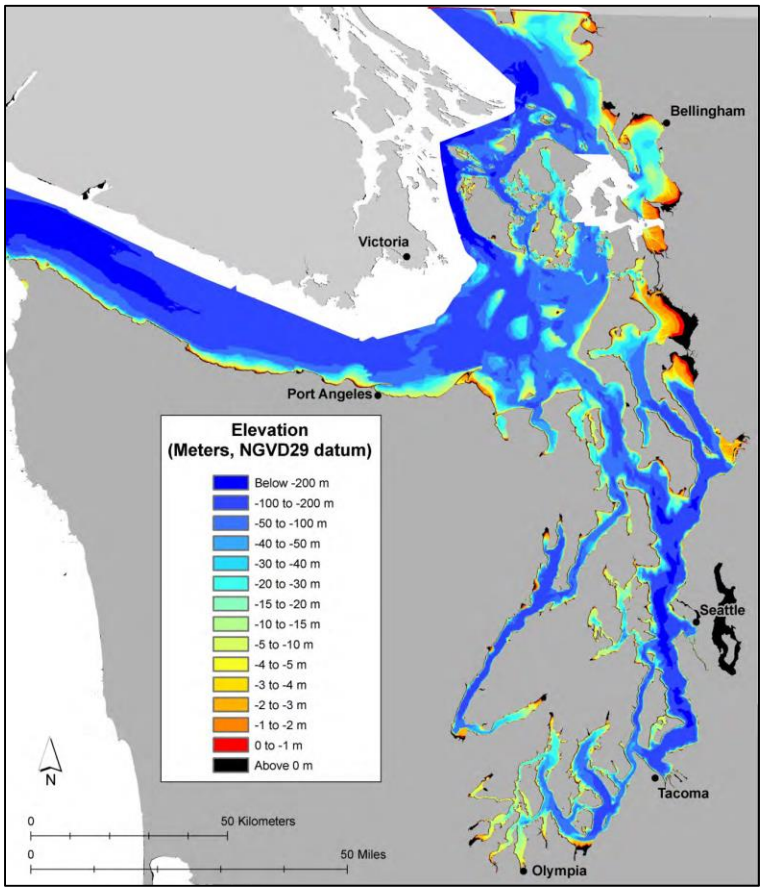
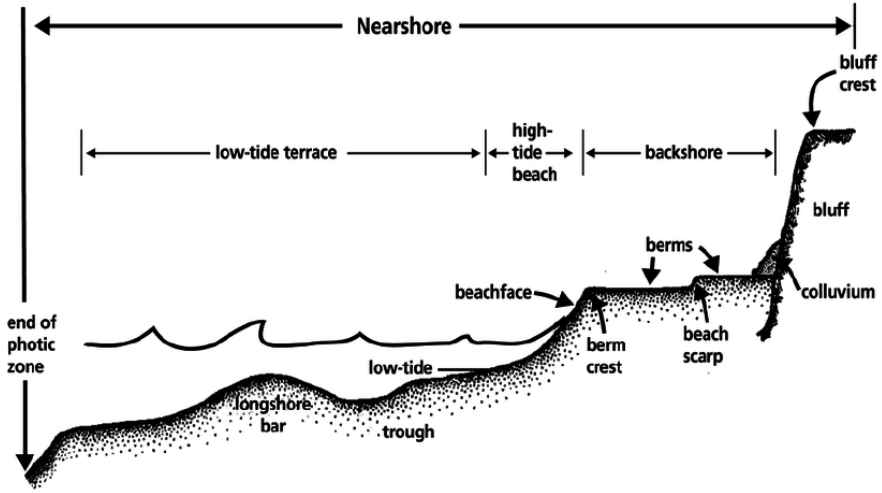
The nearshore habitat



Dowty 2011

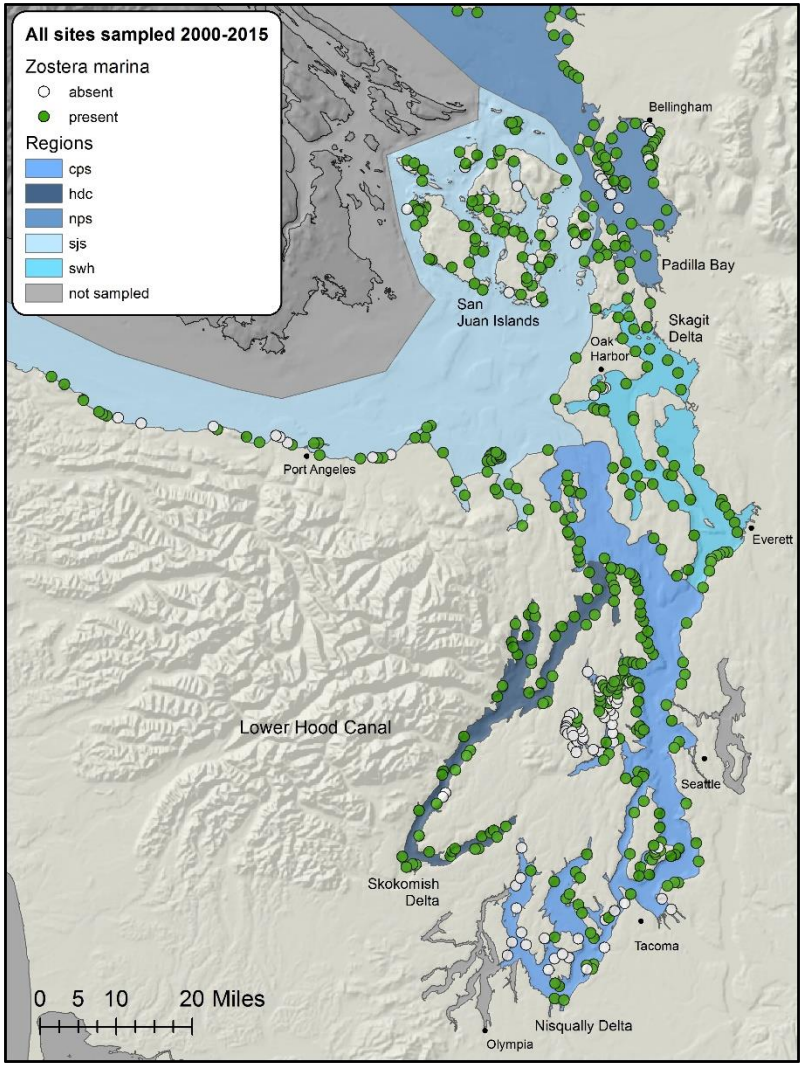


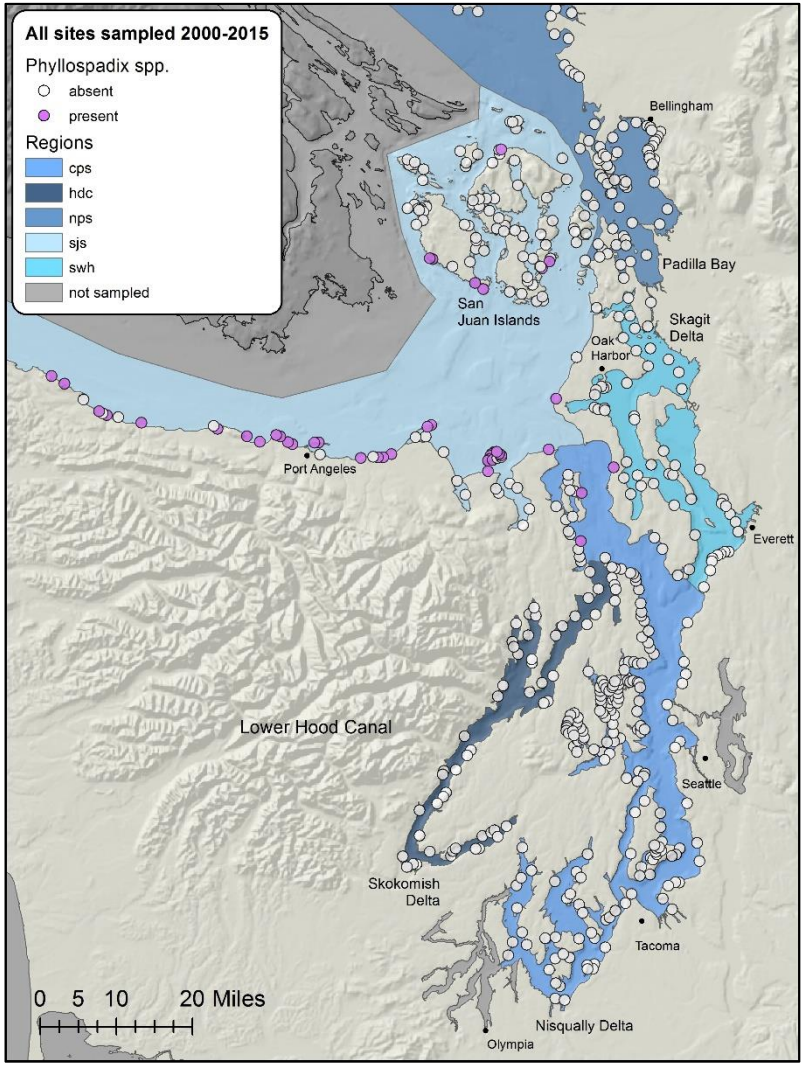
Jonannessen & MacLennan 2007

Seagrasses in Washington State

Eelgrass (*Zostera*)

Surfgrass (*Phyllospadix*)





Christiaen et al. 2016

Zostera marina is by far the most abundant seagrass in Puget Sound

Phyllospadix mostly limited to outer coast, Strait and San Juan Islands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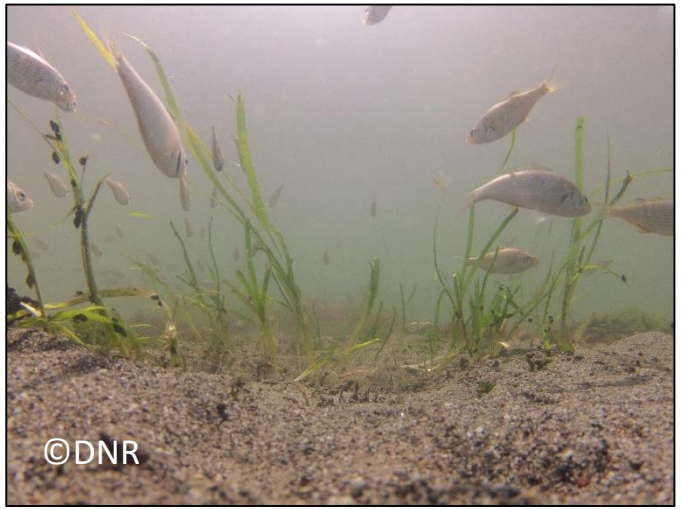
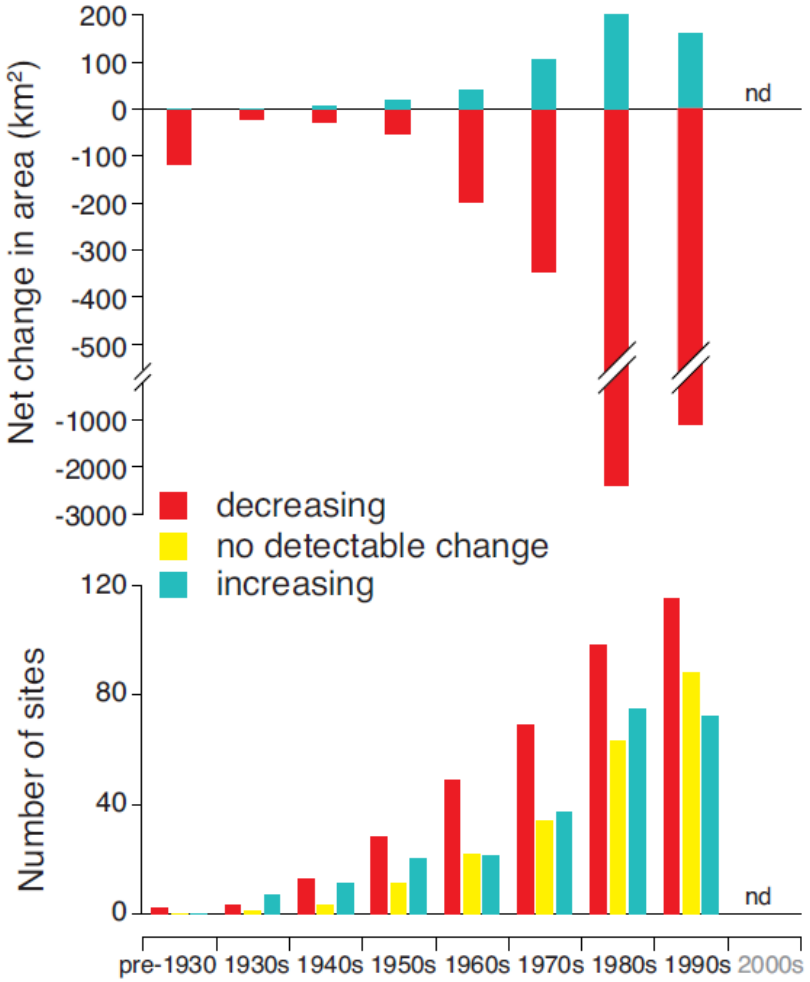
Important habitat



Global declines in seagrass beds

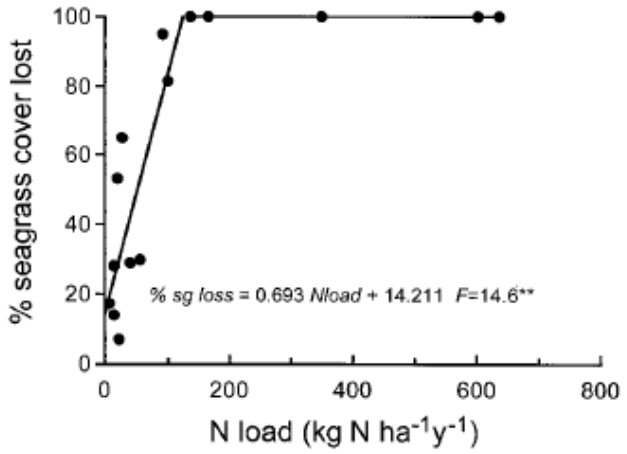
Accelerating loss of seagrass areal cover throughout the world

Associated with increase in human population in coastal watersheds



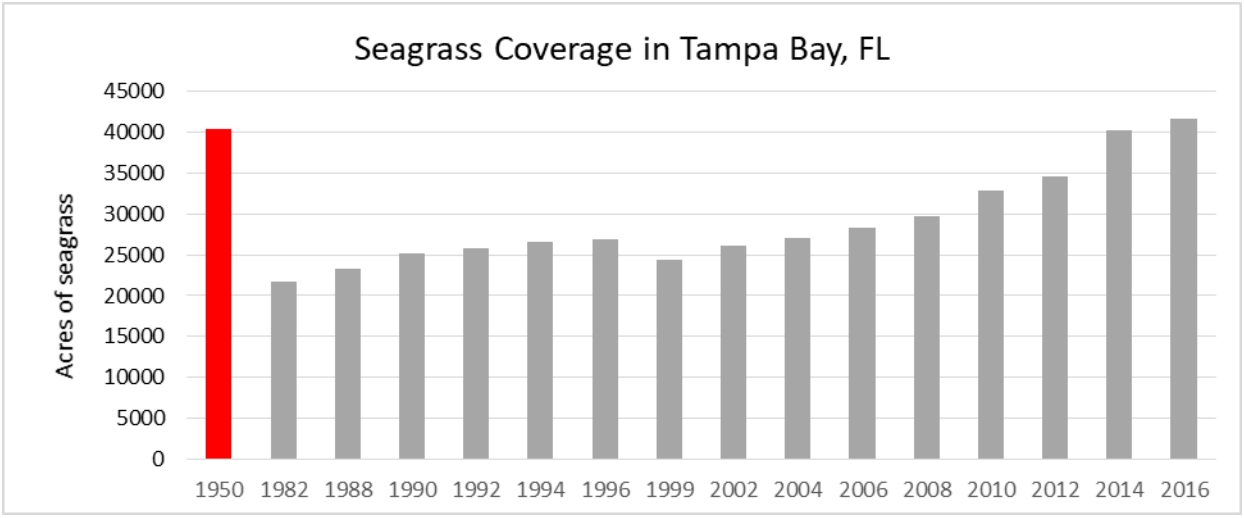
Waycott et al. 2009, PNAS 106(30)

Eutrophication contributed to global loss



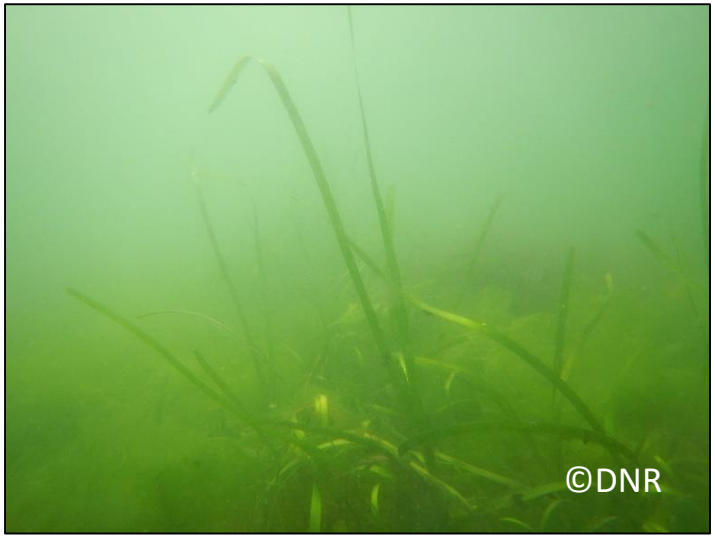
Valiela & Cole 2002, Ecosystems 5(1)

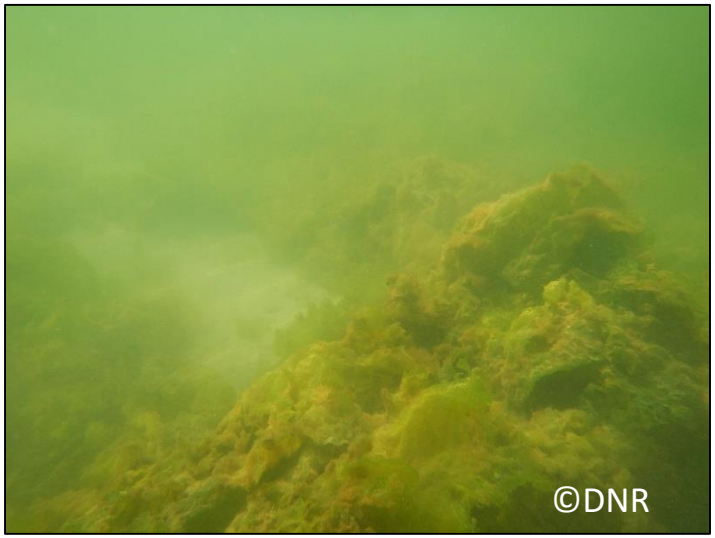
- Estuaries with high nitrogen loading have lost a high % of their seagrass beds
- If nitrogen load is reduced, seagrass beds can recover (Example: Tampa Bay)



Based on data from Southwest Florida Water Management District

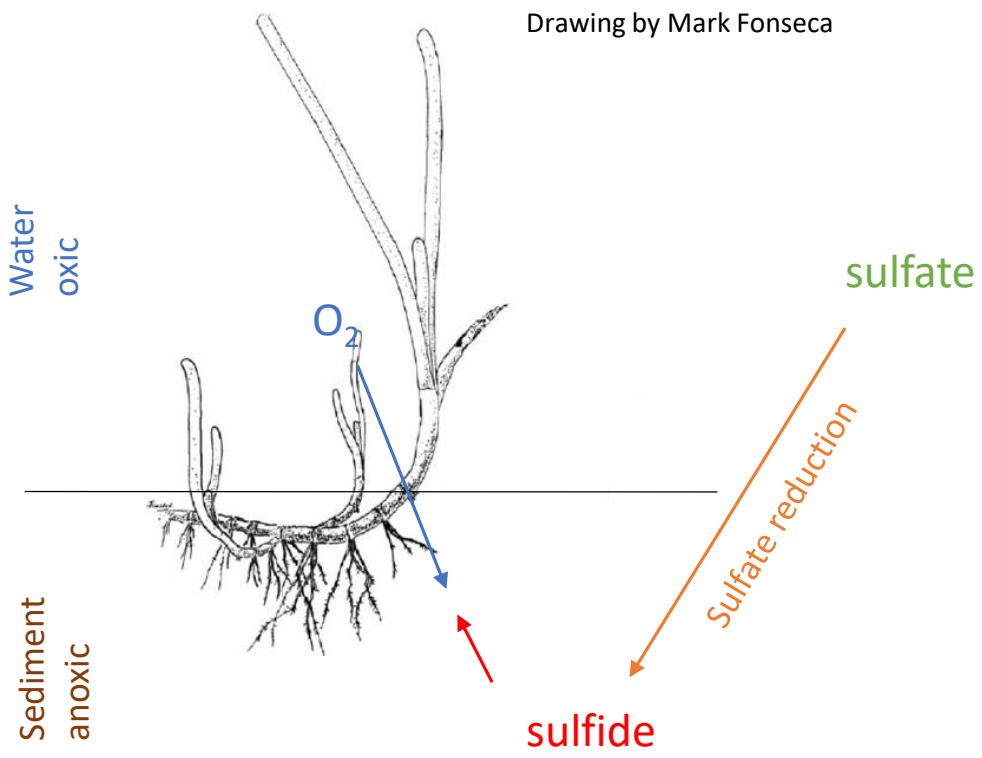
Competition for light

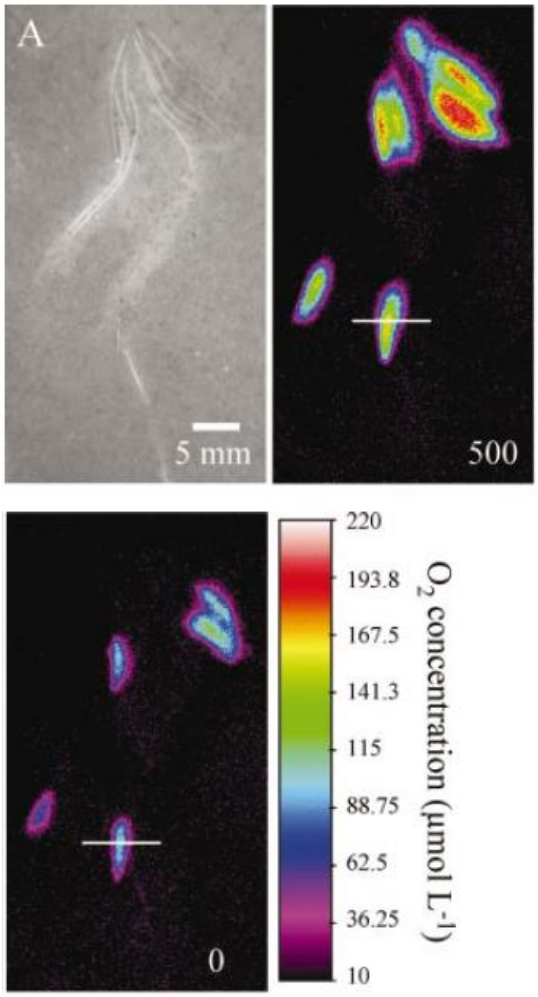




- Phytoplankton blooms, nuisance algae or overgrowth by epiphytic algae
- Lower light availability
- Affects max depth of seagrass beds

High sediment sulfide concentrations





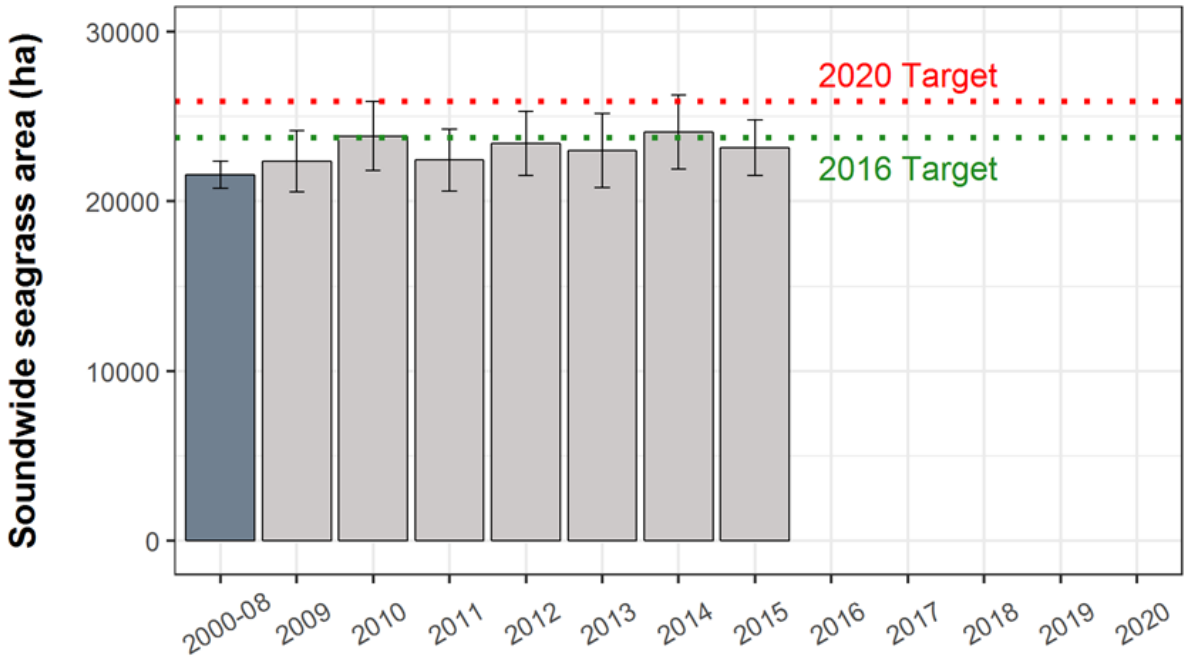
- Seagrasses tolerate moderate sediment sulfide concentrations
- High organic matter/nutrients = high sulfide = seagrass loss

Frederiksen & Glud 2006, Limnol. Oceanogr. 51(2)

What about greater Puget Sound?

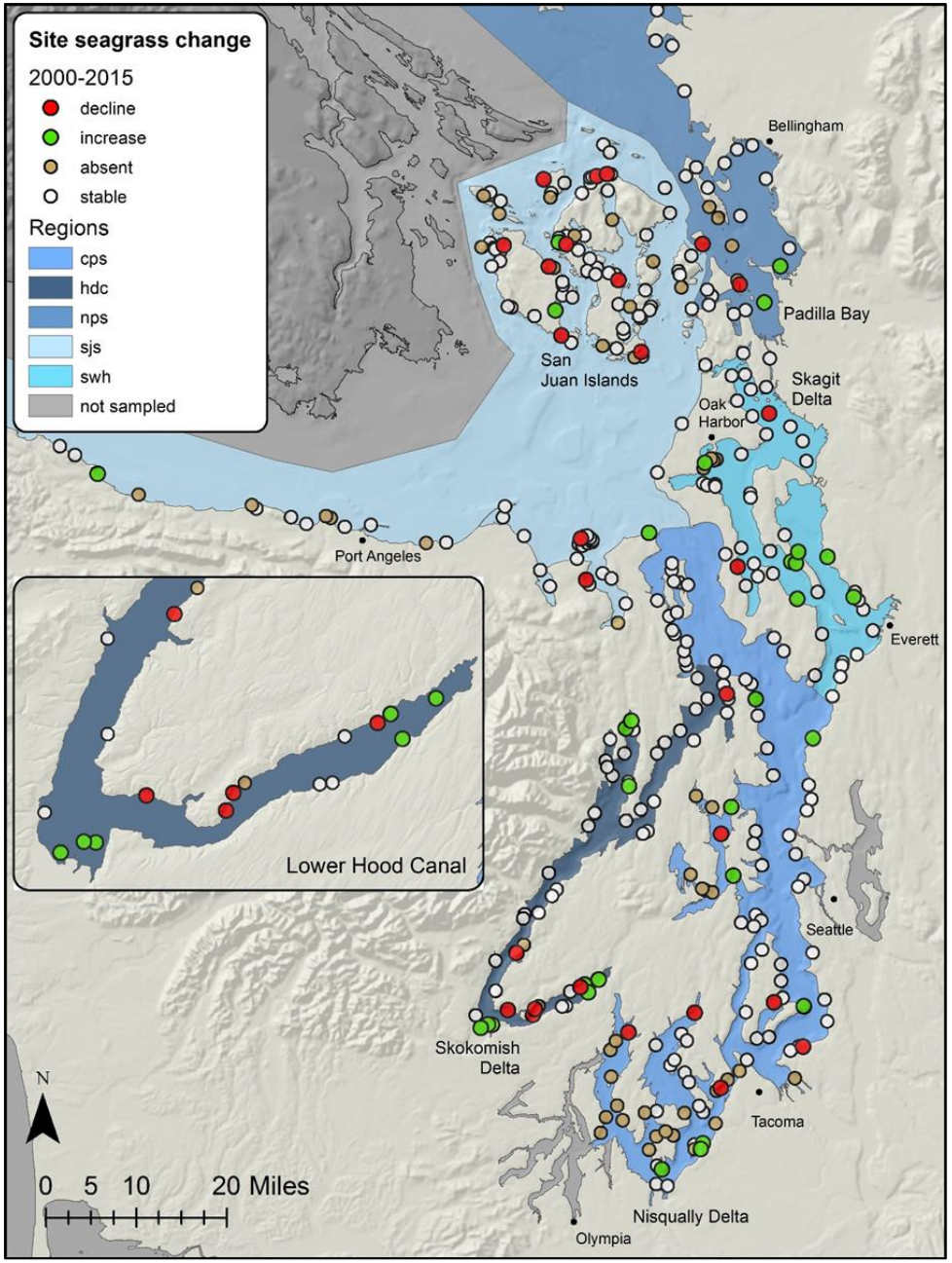
- Declines in eelgrass?
- Regional differences in depth limits of eelgrass beds in greater Puget Sound?
- Other signals of eutrophication in nearshore vegetation?

Soundwide eelgrass area relatively stable



Christiaen et al. 2016

- On a soundwide scale: eelgrass area has been relatively stable since 2000 (DNR – SVMP)
- A study by NOAA found no major declines in eelgrass cover in herring spawn areas in Puget Sound over the last 40 years (Shelton et al. 2016)



Christiaen et al. 2016

Local trends in eelgrass cover

- Increases/declines in eelgrass cover when looking on a smaller spatial scale
- Declines at the end of inlets & areas with longer residence times
- Associated with water quality?

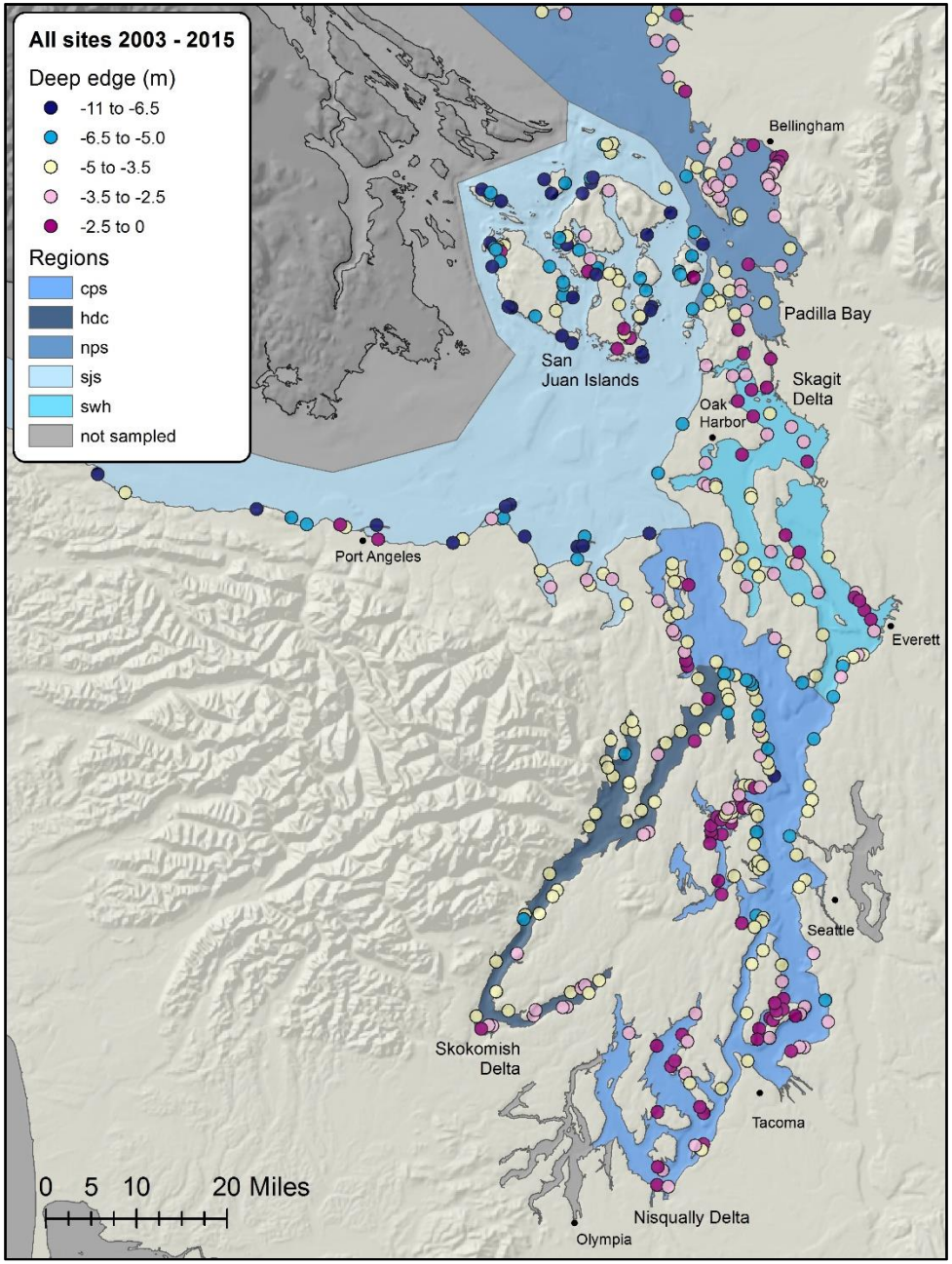
Regional pattern in max eelgrass depth

Eelgrass grows to greater depths near the Strait and the San Juan Islands

Eelgrass does not grow as deep in the southern and eastern parts of Puget Sound

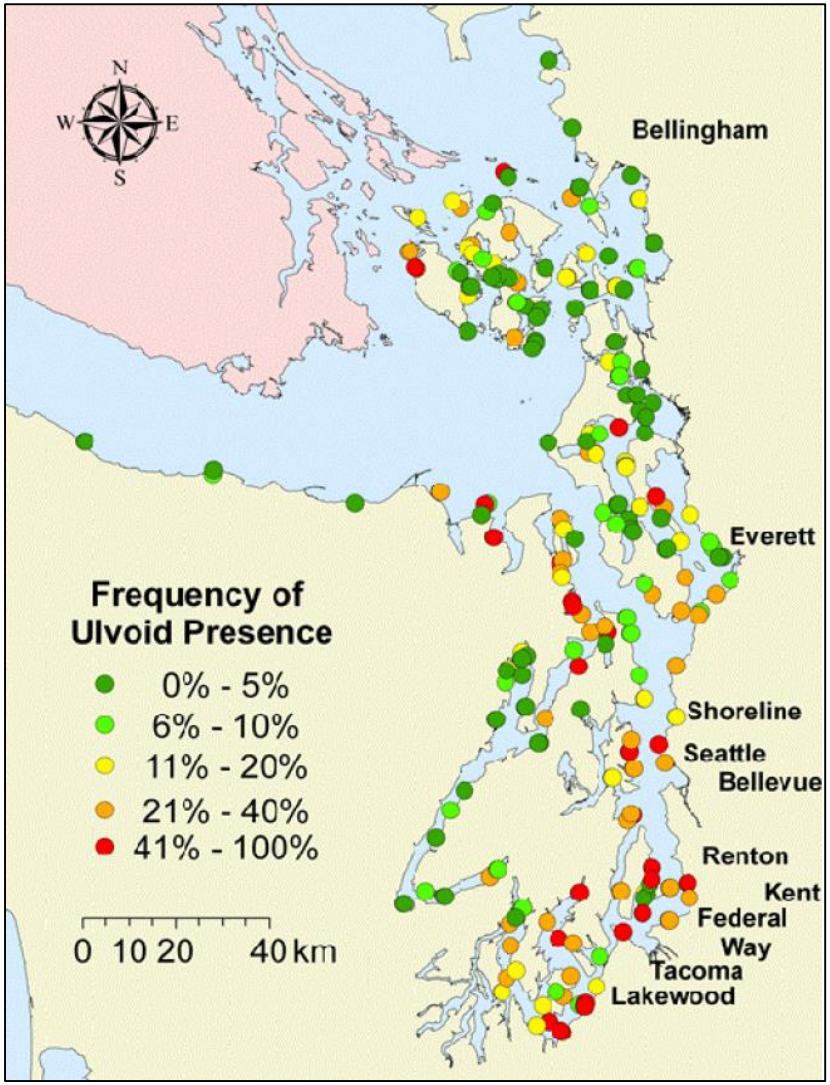
Possible causes:

- Sediment from rivers?
- Gradient in tidal range?
- Regional differences in water quality?



Christiaen et al. 2016

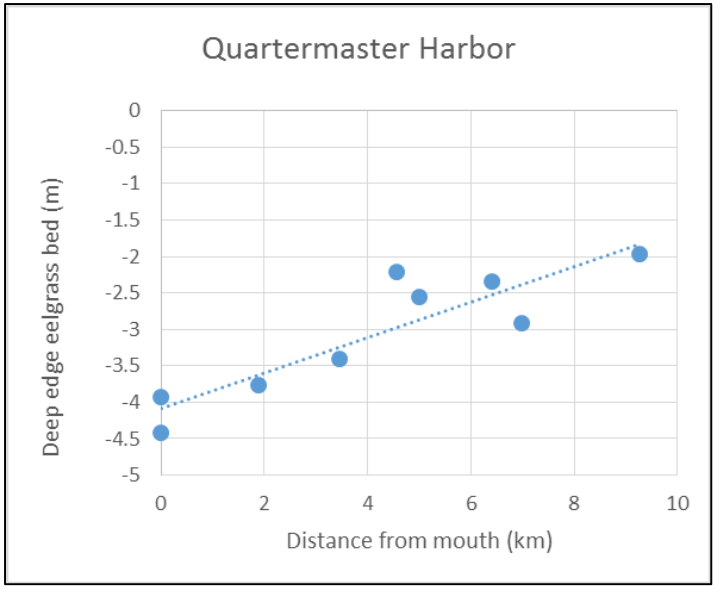
Presence of ulvoid algae

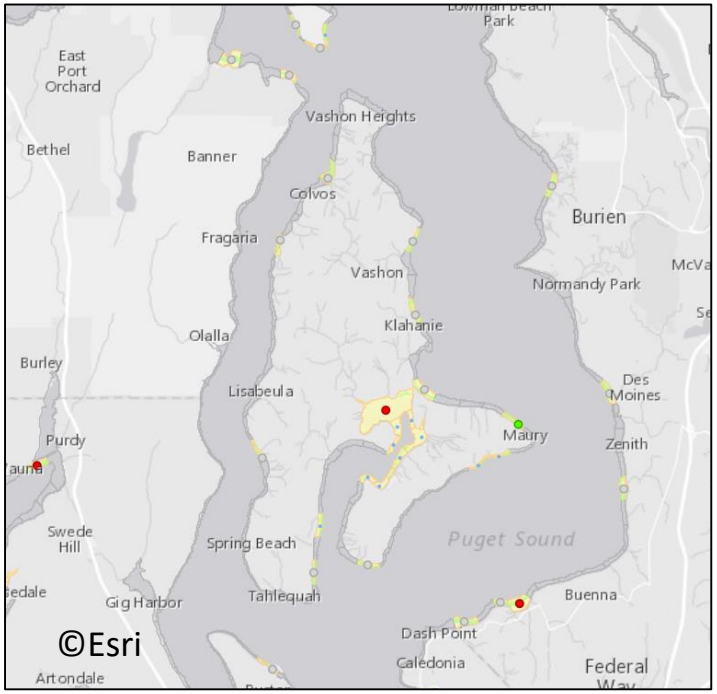


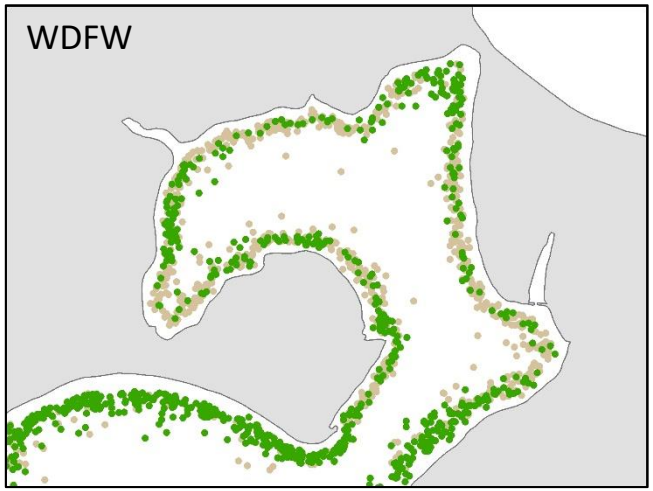
Nelson & Melton 2011

- High abundance of *Ulva sp*. is often associated with ecosystems that are enriched in nitrogen
- Central & South Puget Sound have a higher frequency of occurrence

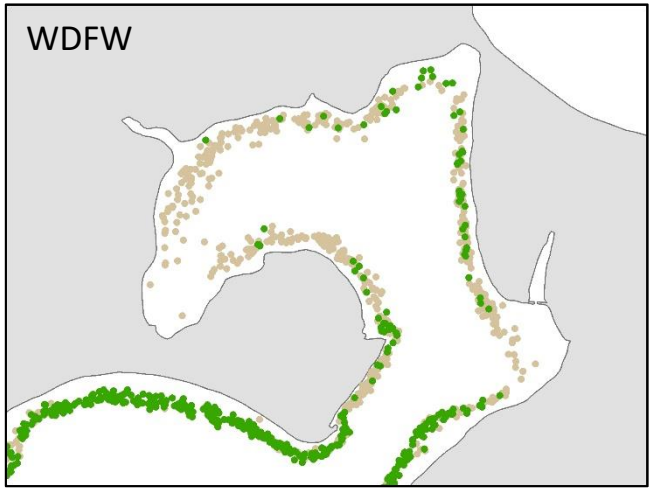
Case study: Quartermaster Harbor





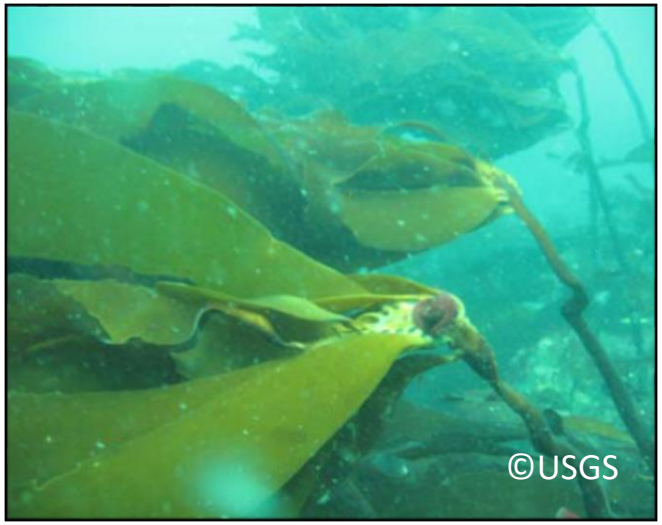


1980-1985

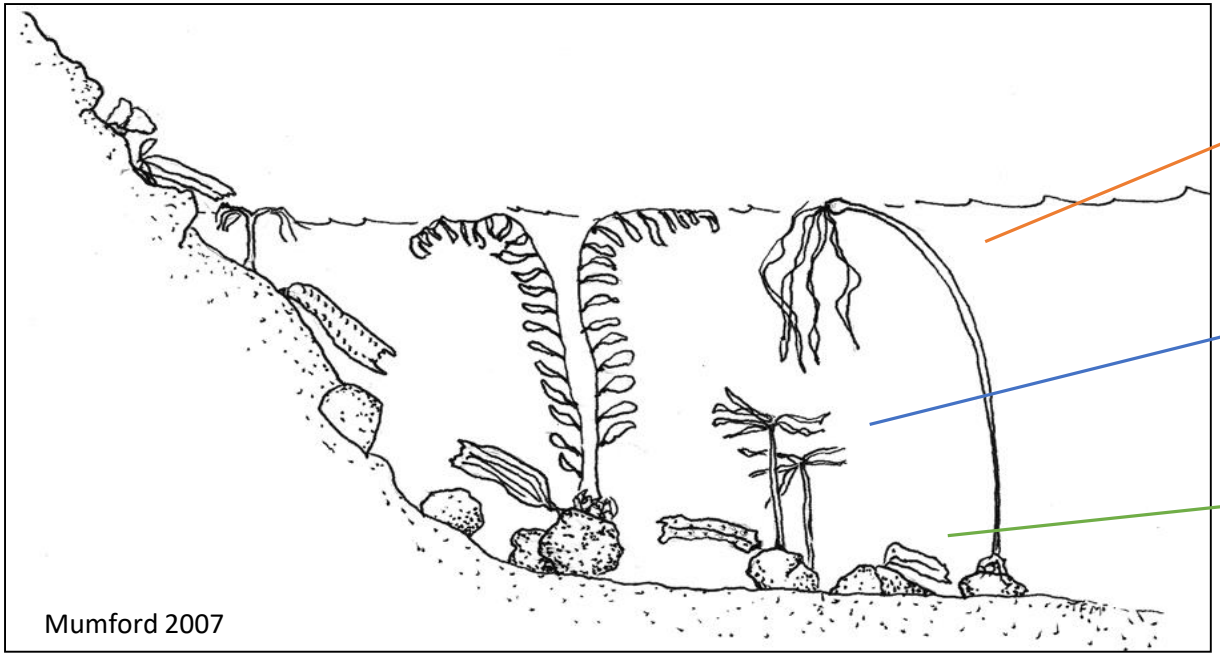


2005-2010

Kelp in Washington State



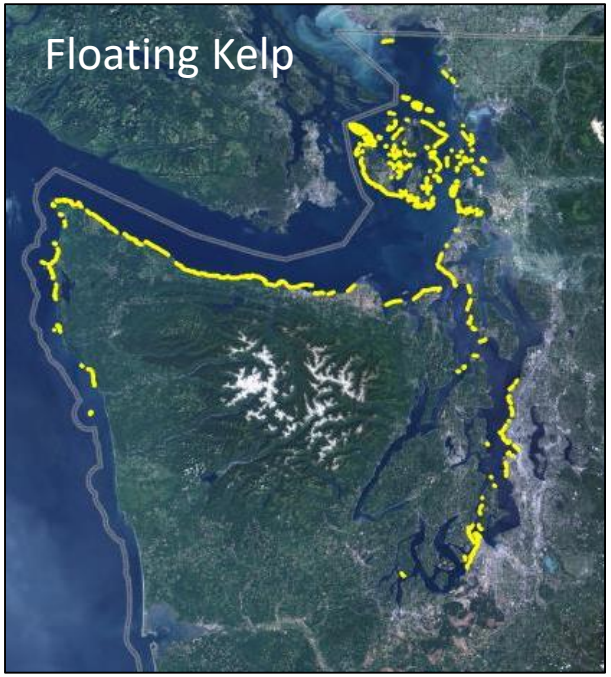
- 625 species of seaweeds
- Kelp = brown algae from order Laminariales
- 23 species of kelp = one of the most diverse kelp communities in the world!

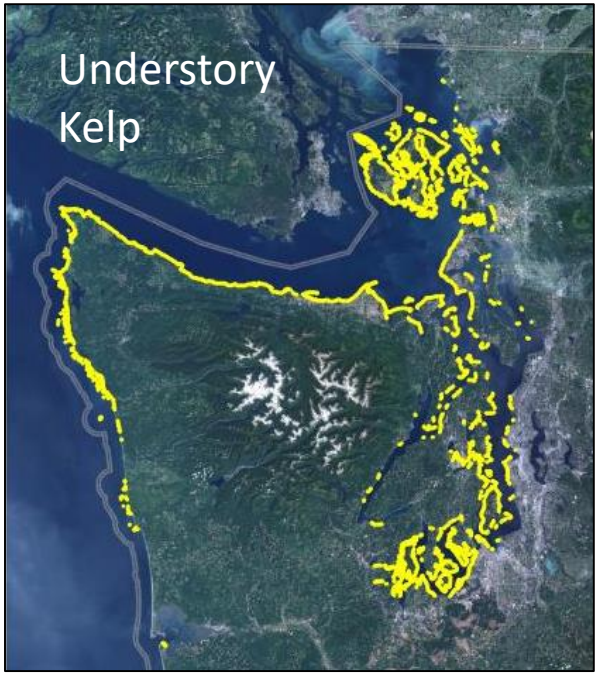


Floating kelp

Stalked kelp

Prostrate kelp

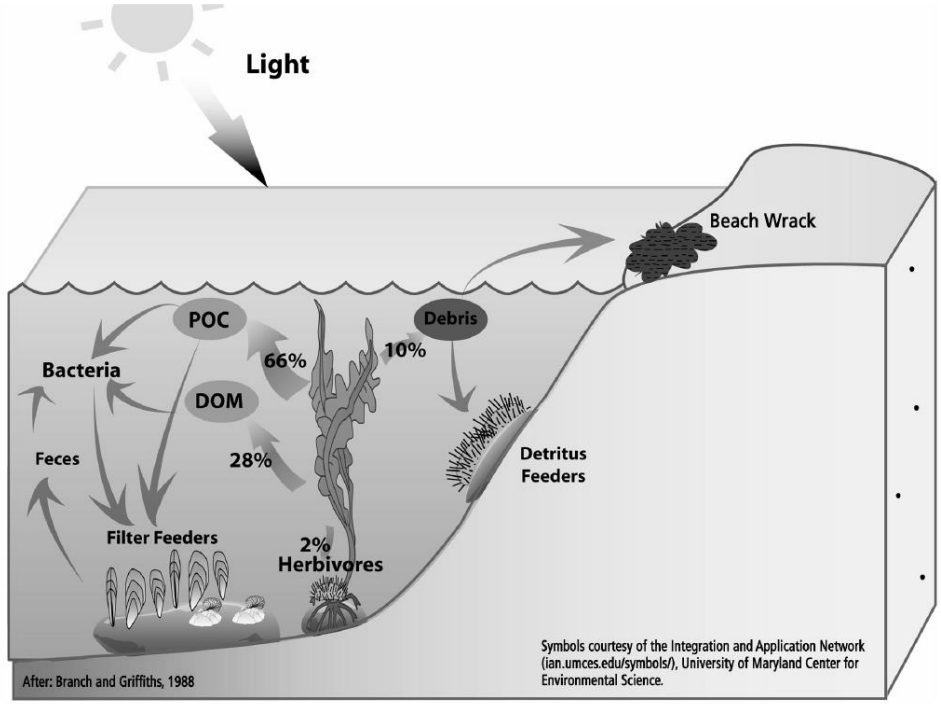




Floating kelp:
11% of shoreline

Understory kelp:
31% of shoreline

Ecological importance: primary productivity

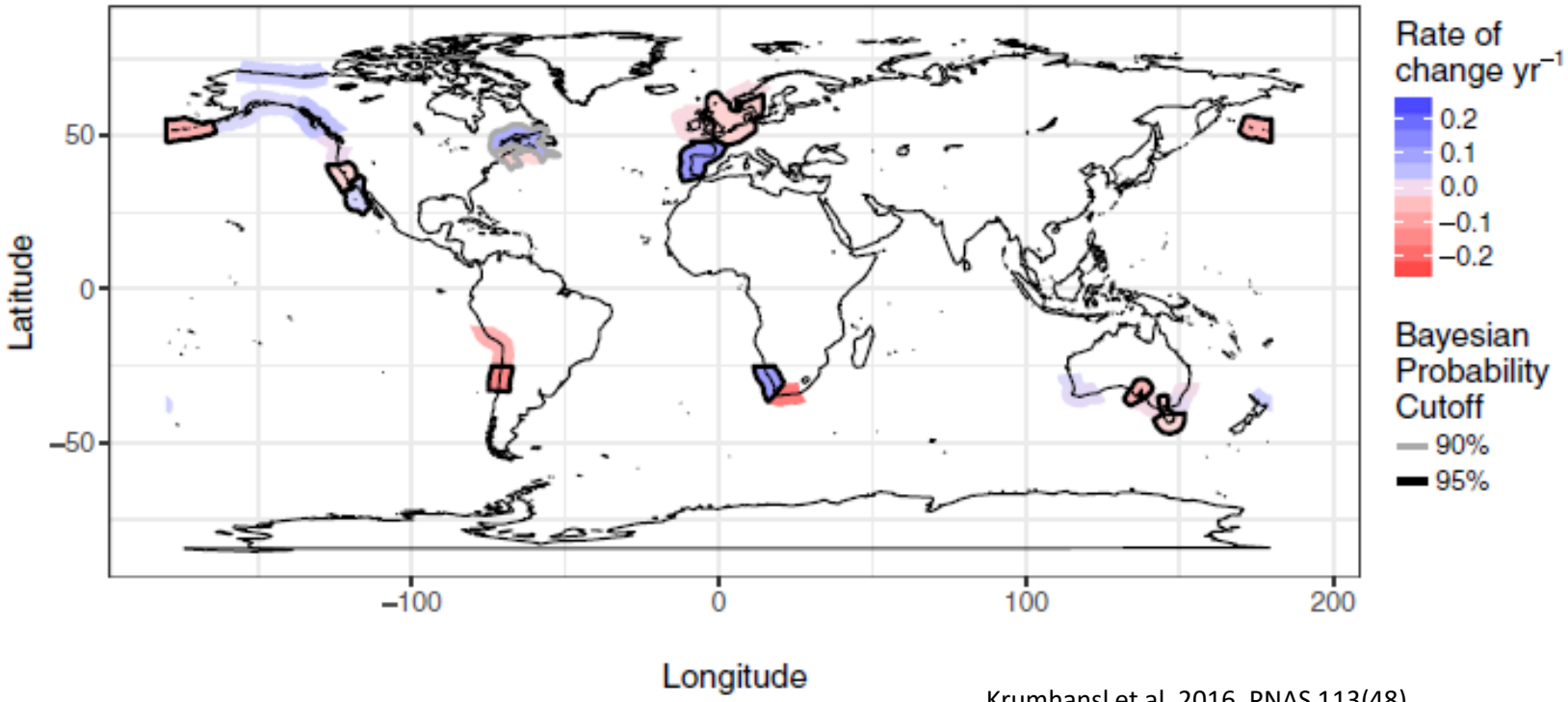


Mumford 2007

- Kelp and eelgrass fuel the detrital food web
- Export of particulate and dissolved organic matter

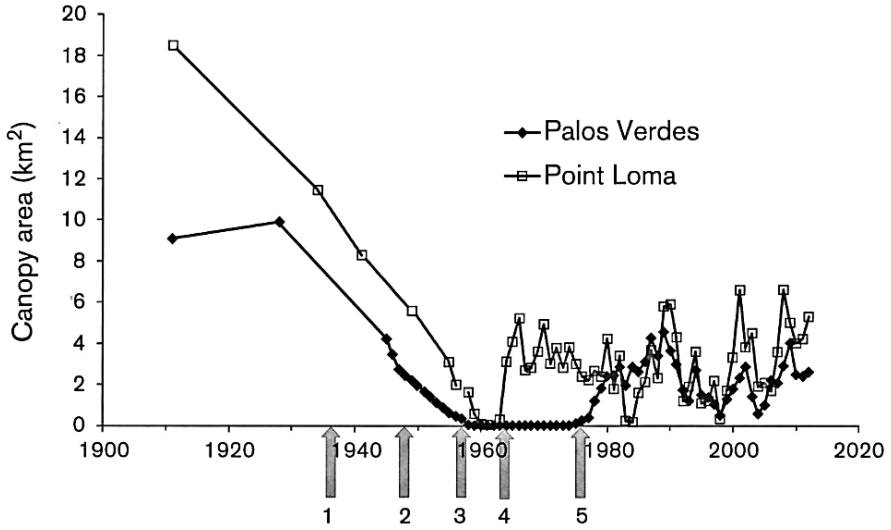
Global declines in kelp beds

- Limited long-term datasets
- Small global average decline
- High degree of geographic variation in trends

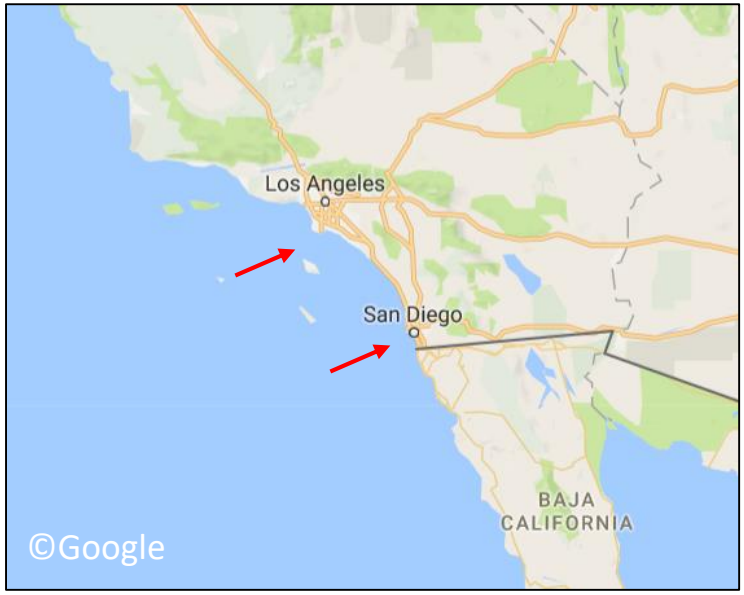


Krumhansl et al. 2016, PNAS 113(48)

Kelp declines related to pollution



Schiel & Foster 2015

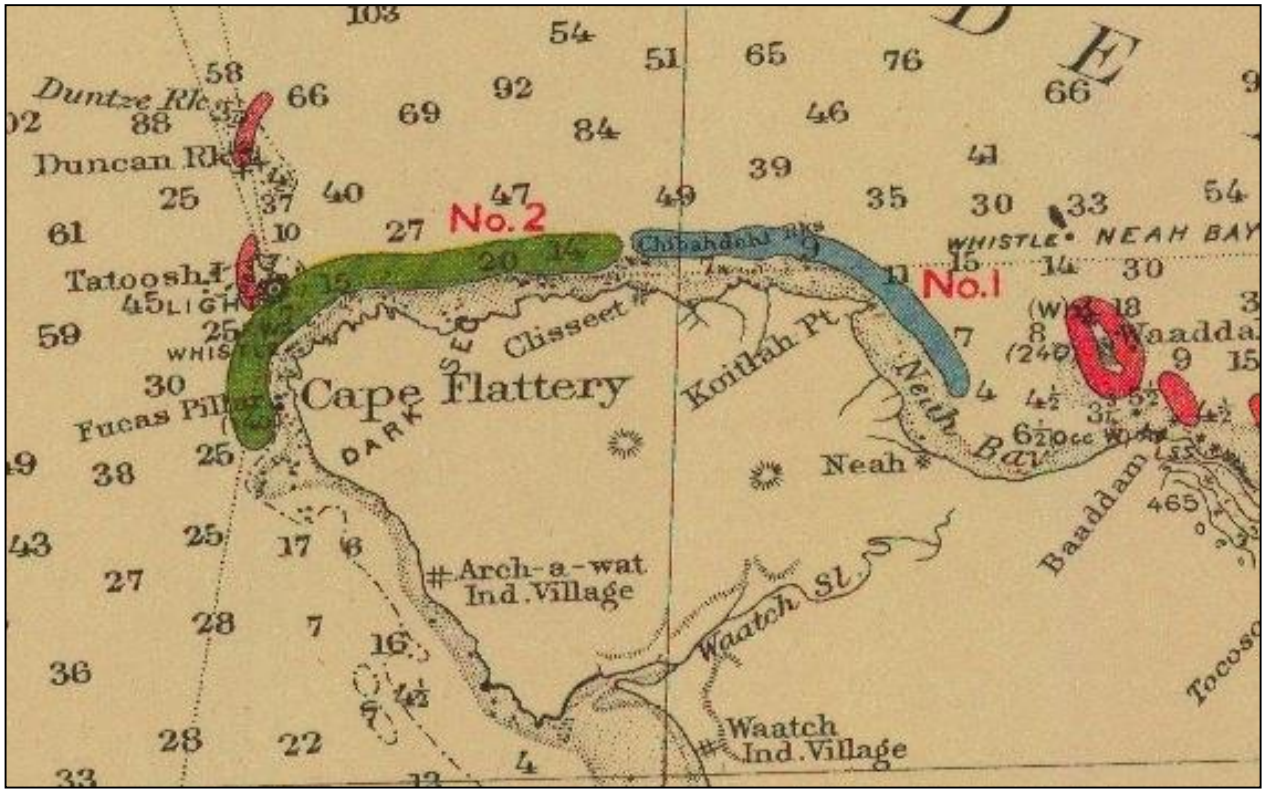


- Best known research = interactions between grazers and kelp, climate and pollution are also important
- Most famous examples of sewage impact on kelp: *Macrocystis* beds near Palos Verdes and Point Loma
- Documented declines associated with pollution in Europe and Australia

Low light, siltation & competition

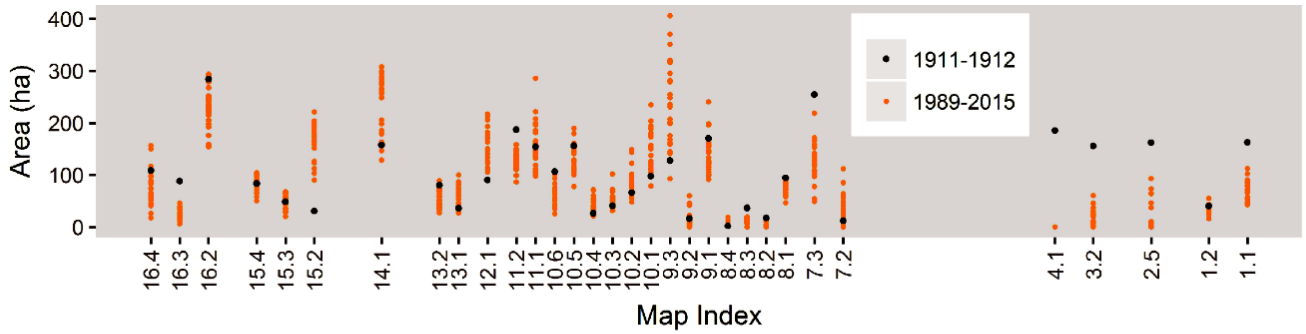
- Deep edge of kelp beds can be limited by light
- Gametophyte life stage sensitive to siltation
- Competitive interactions with turf algae and *Sargassum*

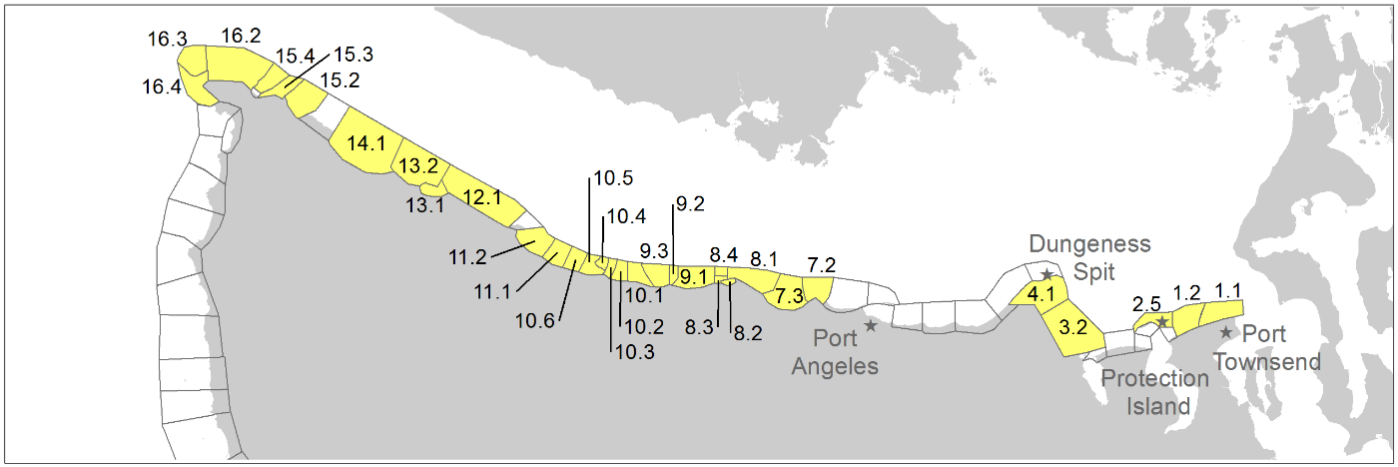
Floating kelp in greater Puget Sound



Historical data from navigational maps, and kelp surveys for resource utilization and habitat management. Earliest surveys go back to 1852

Floating kelp stable in the Strait

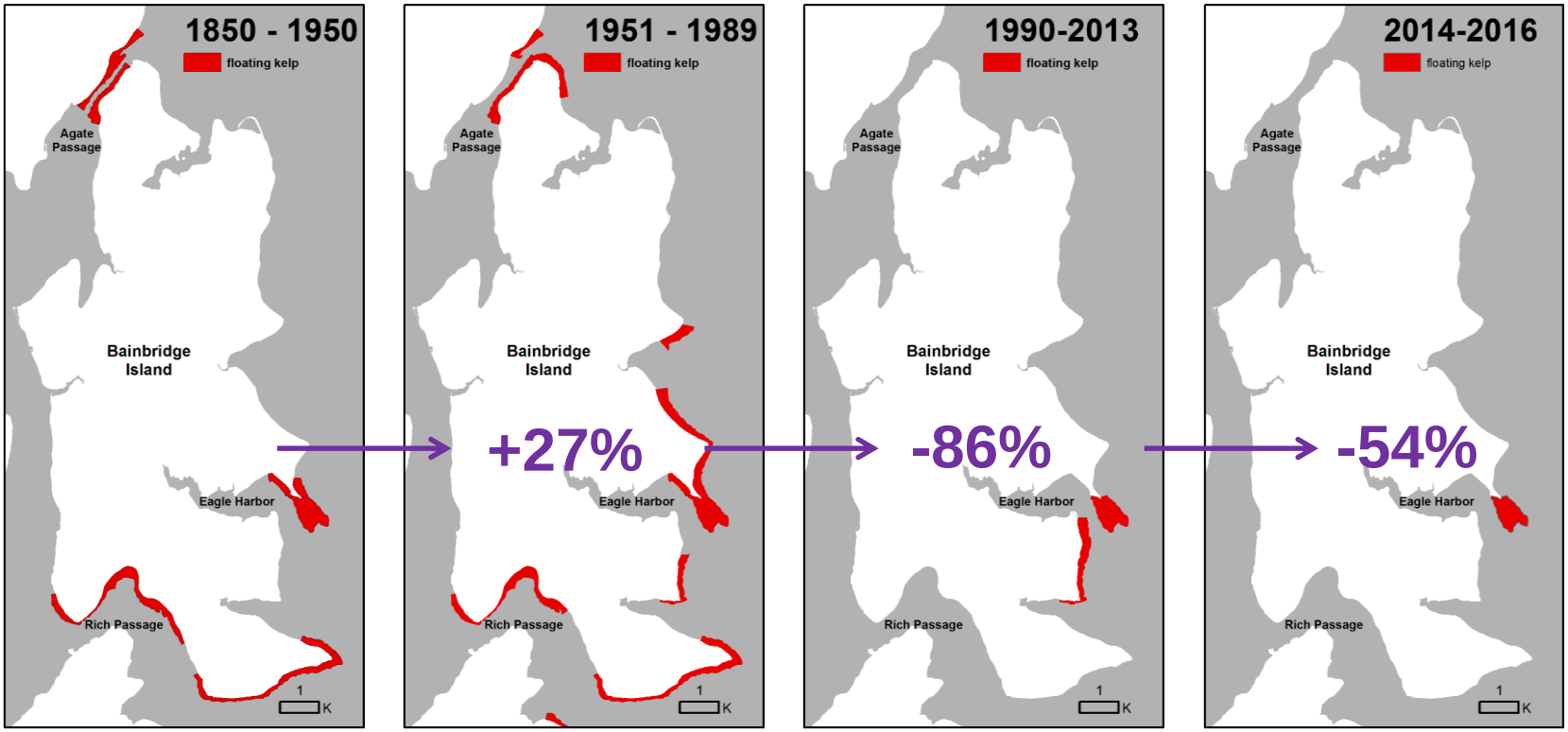




Phister, Berry & Mumford, in prep

- Floating kelp populations in the Strait of Juan de Fuca have not declined since 1911-1912! Some decline possible on east side.
- Large inter-annual variability, likely due to climatic factors

Large declines around Bainbridge Island



Berry et al. , in prep

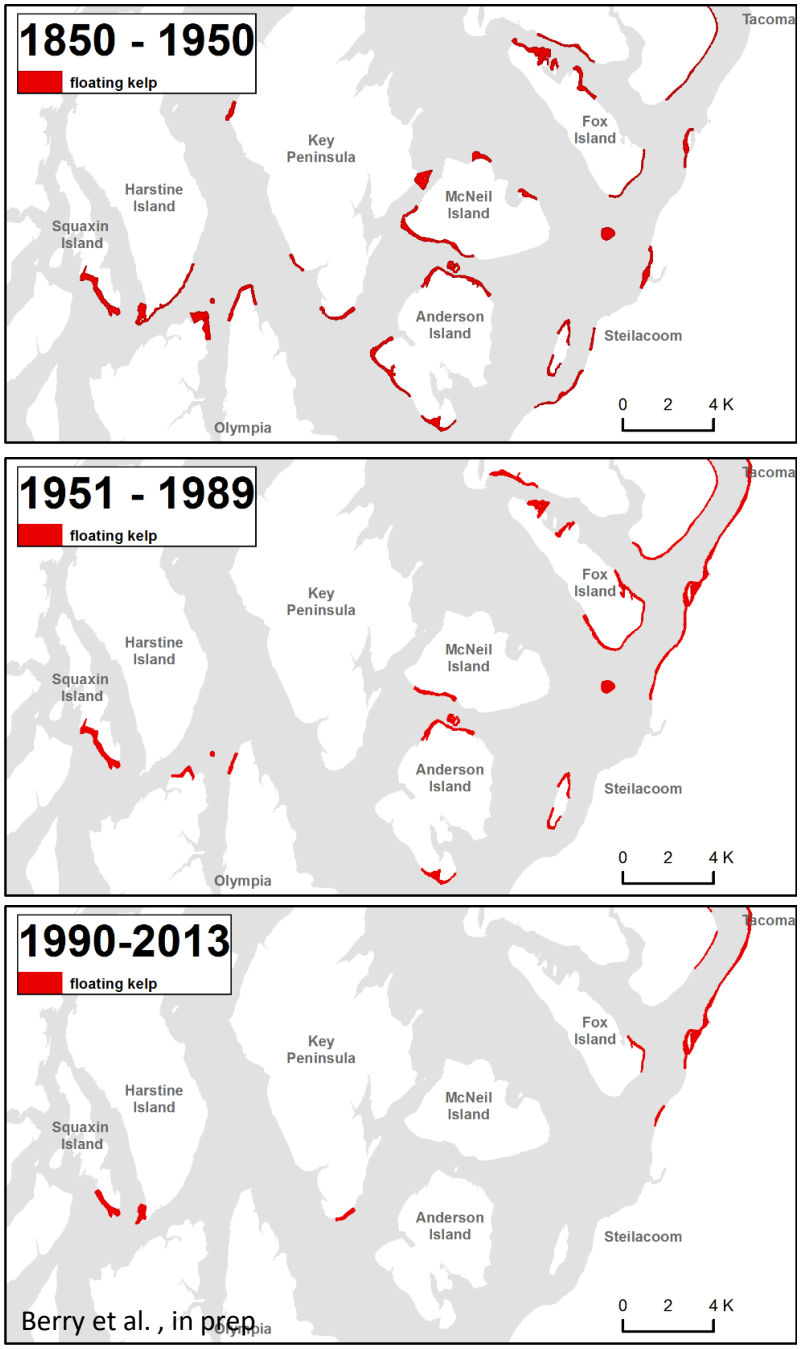
- Floating kelp beds have almost completely disappeared from around Bainbridge Island

Large losses in South Puget Sound

Cumulative loss in floating kelp of more than 75% since 1850/1950

Candidate stressors:

- Increases in temperature
- Boat damage
- Competition with other algae
- Changes in water quality



Case study: Squaxin Island

Conclusions

- Eelgrass and kelp are important components of nearshore habitats, both worldwide and in greater Puget Sound

- Global research indicate that eelgrass and kelp are vulnerable to excessive nutrient input through
  - Reduction of water clarity
  - Changes in sediment biogeochemistry / substrate
  - Competitive interactions with other algae

- Local trends in eelgrass and kelp suggest that some locations in Puget Sound may be affected in similar way
  - Protected embayments
  - Areas with longer residence times.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