The Risk Factor: Climate Change Opens Windows of Opportunity for Harmful Algal Blooms

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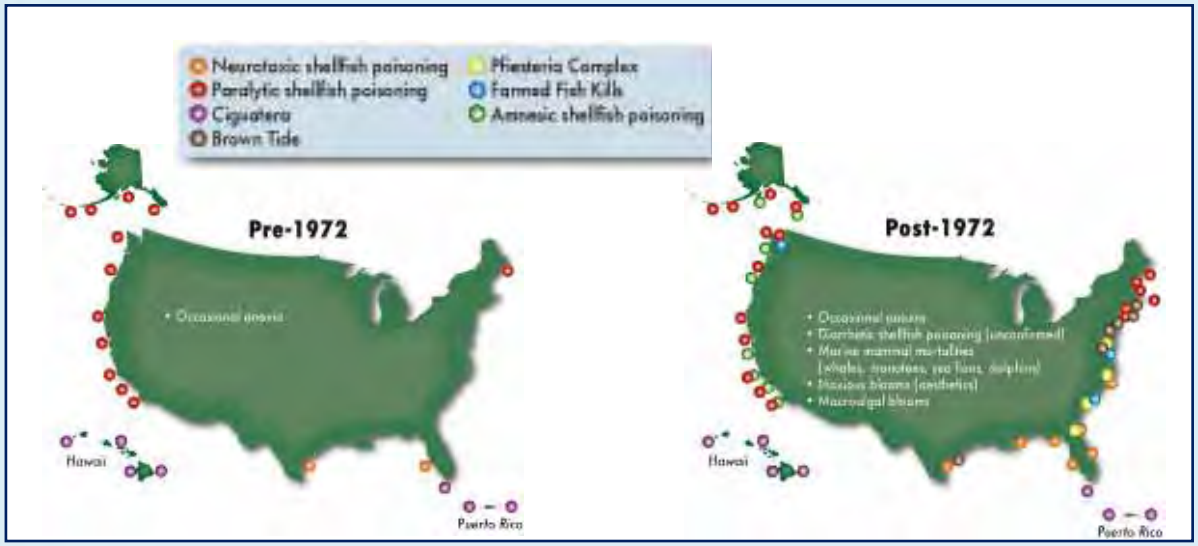
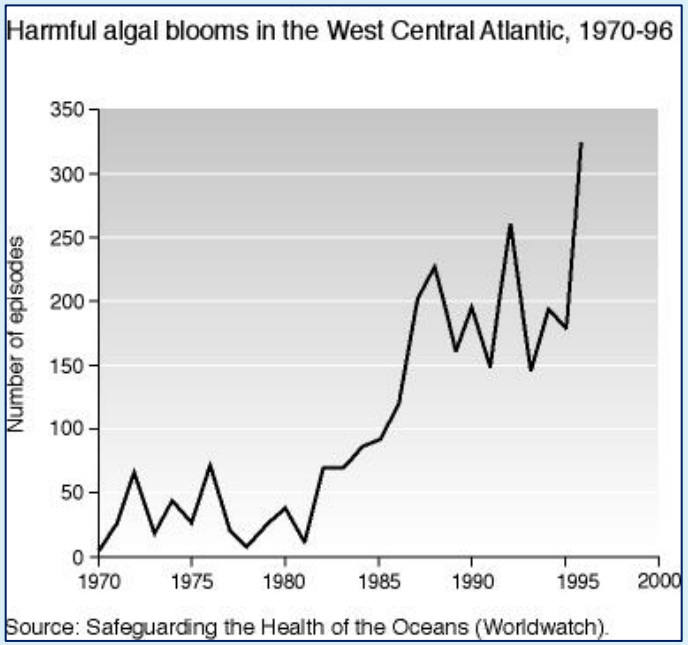
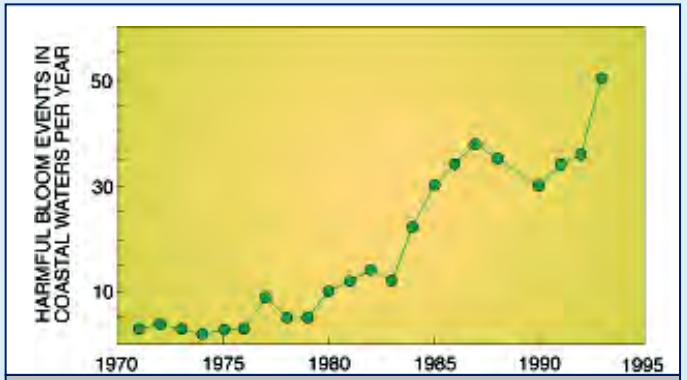
HABs are Increasing in the United States and Around the World







Outbreaks of harmful algal blooms in Chinese coastal waters increased 10-fold from 1975 to 1993 (redrawn from Zhang 1994).

Sources:

Don Anderson and Jayne Doucette, WHOI. Retrieved 13:17, January 12, 2010 from http://www.whoi.edu/page.do?pid=23997&tid=441&cid=26891&ct=61&article=14086

Harmful algal blooms in the West Central Atlantic, 1970-96. (2001). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved 19:42, June 16, 2009 from http://maps.grida.no/go/graphic/harmful_algal_blooms_in_the_west_central_atlantic_1970_96.

GEOHAB, 2001. Global Ecology and Oceanography of Harmful Algal Blooms, Science Plan. P. Glibert and G. Pitcher (eds). SCOR and IOC, Baltimore and Paris. 87 pp.

Climate Change has been Implicated in this Global Increase

CLIMATE

Blooms Like It Hot

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

Hans W. Paerl[1] and Jef Huisman[2]

www.sciencemag.org SCIENCE VOL 320 4 APRIL 2008

Climate Change Affects Harmful Algal Blooms

Scientists Connect Global Warming and Nutrient Runoff to HABs

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Aug 29, 2008

Changes in climate may be creating a marine environment particularly suited to HAB (harmful algal bloom)-forming species of algae, according to a team of scientists.

28 Climate Change and Harmful Algal Blooms

B. Dale, M. Edwards, and P.C. Reid

Environ Health. 2008; 7(Suppl 2): S4. PMCID: PMC25867
Published online 2008 November 7. doi: 10.1186/1476-069X-7-S2-S4.

Impacts of climate variability and future climate change on harmful algal blooms and human health

Stephanie K Moore,[1,2] Vera L Trainer,[2] Nathan J Mantua,[3] Micaela S Parker,[4] Edward A Laws,[5] Lorraine C Backer,[6] and Lora E Fleming[7]

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Climate change and harmful algal blooms in the North Sea

Louis Peperzak

J. Plankton Res. 46, 229–235 (2010)

DOI: 10.1111/j.1529-8817.2010.00815.x

REVIEW

OCEAN CLIMATE CHANGE, PHYTOPLANKTON COMMUNITY RESPONSES, AND HARMFUL ALGAL BLOOMS: A FORMIDABLE PREDICTIVE CHALLENGE[1]

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The annual value of the shellfish industry in Washington State is $108 million

Image from Environment Canada website

Images courtesy of B. Dewey, Taylor Shellfish Farms.

Is there a predictability to HAB occurrence?

1. Is there a "**window of opportunity**" for HABs in Puget Sound that is determined by weather and environmental conditions?

2. Has the window of opportunity changed in the past?

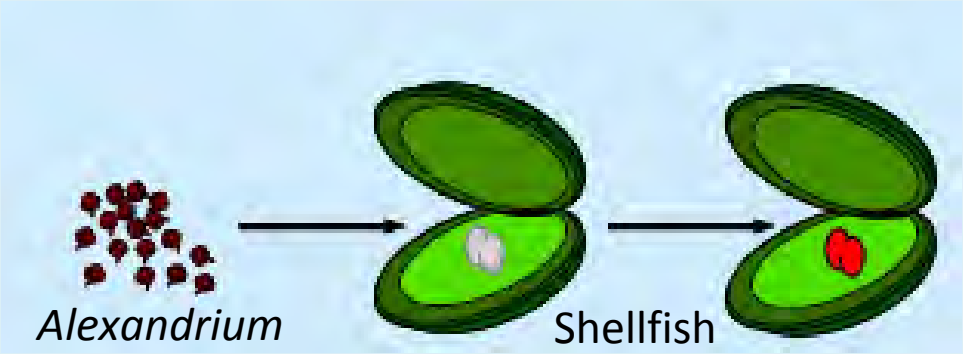
3. Will the window of opportunity change in a future warmer climate?

West Coast Center, Seattle

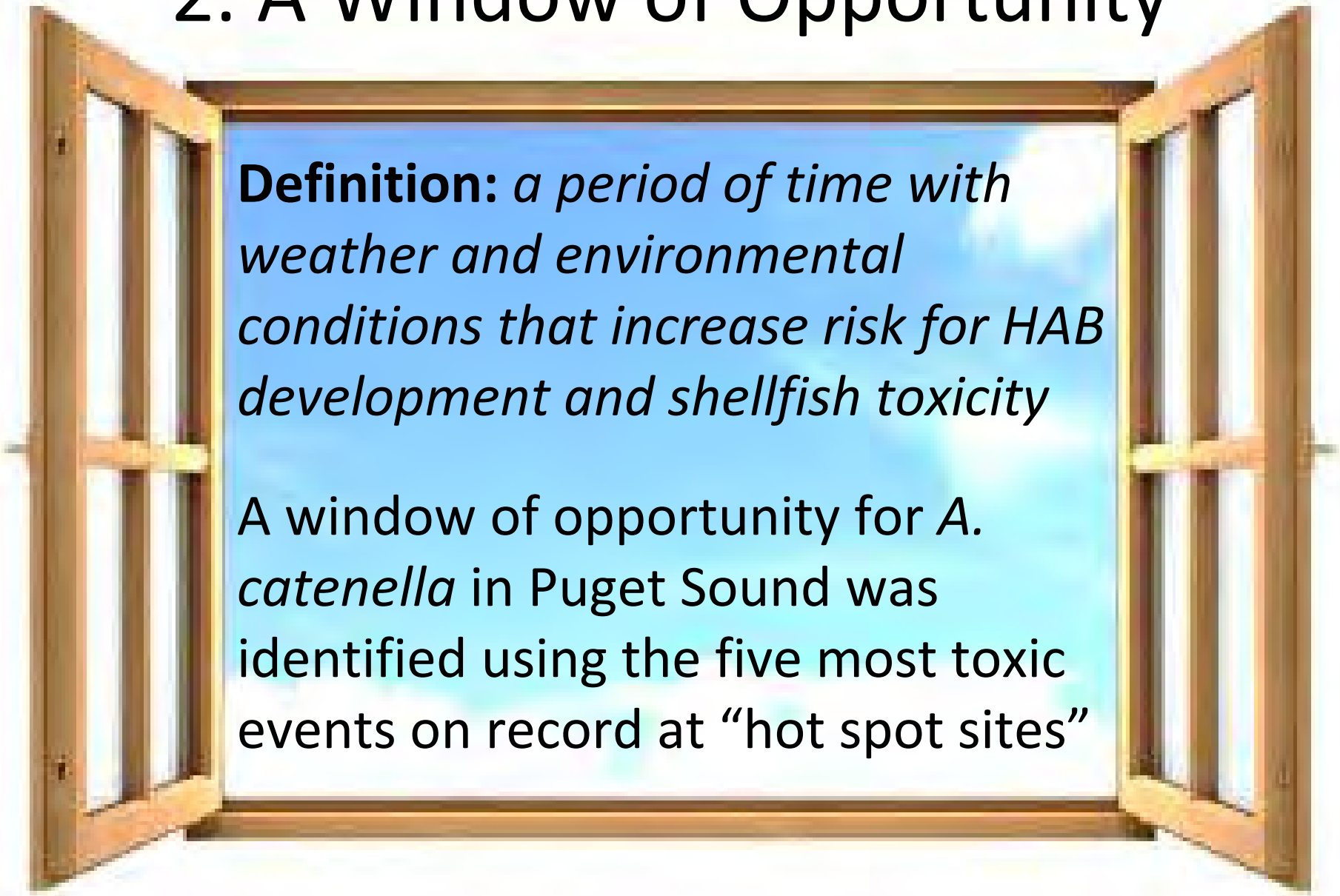
Alexandrium sp.

Alexandrium catenella

- *Alexandrium* produce **saxitoxin** that accumulates in filter-feeding shellfish during blooms, or **"red tides"**
- Consumption of contaminated shellfish causes **paralytic shellfish poisoning**



2. A Window of Opportunity

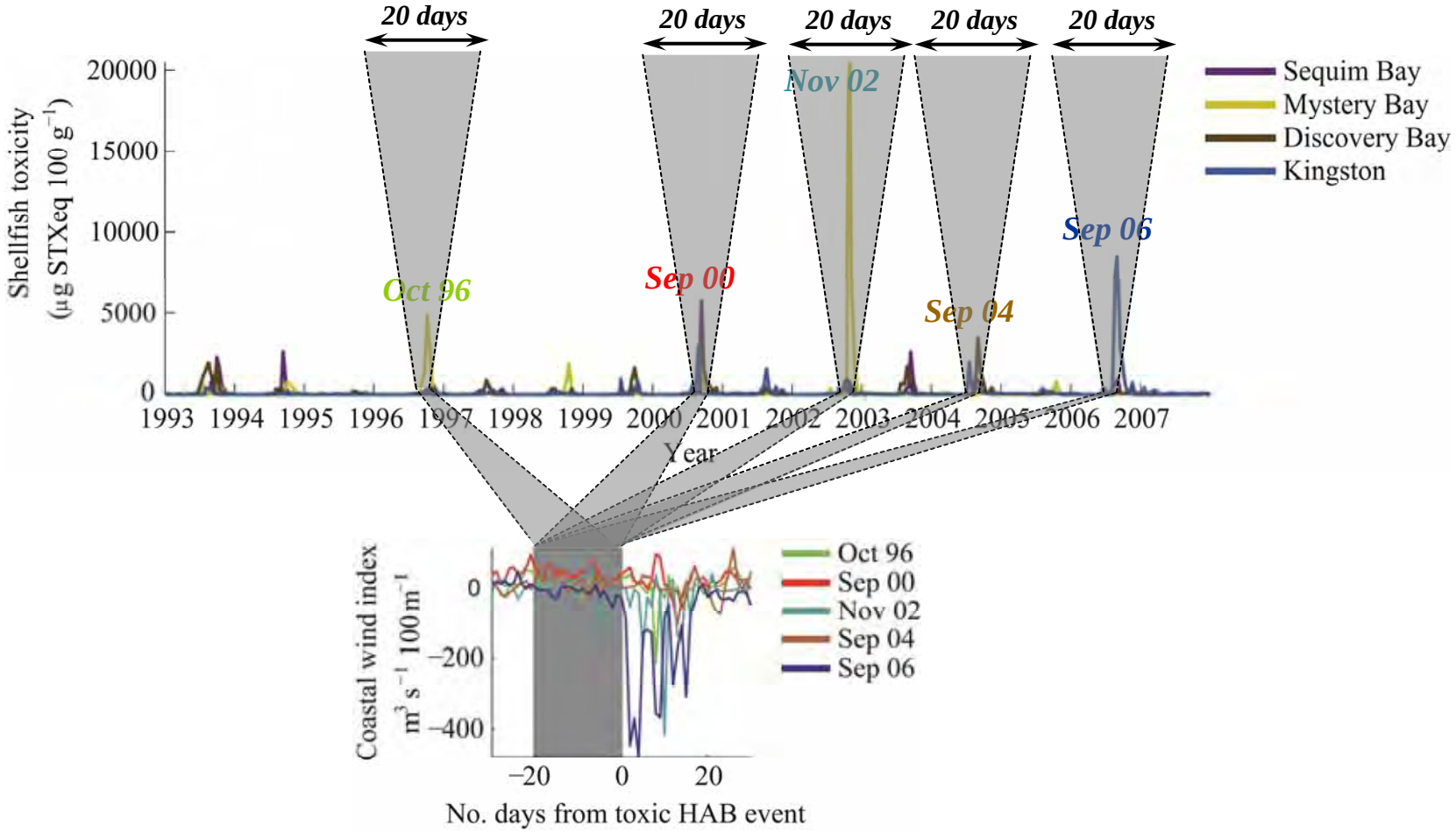


Definition: *a period of time with weather and environmental conditions that increase risk for HAB development and shellfish toxicity*

A window of opportunity for *A. catenella* in Puget Sound was identified using the five most toxic events on record at "hot spot sites"

Moore et al. (2009): Harmful Algae

Five most toxic HAB events at hot spot sites

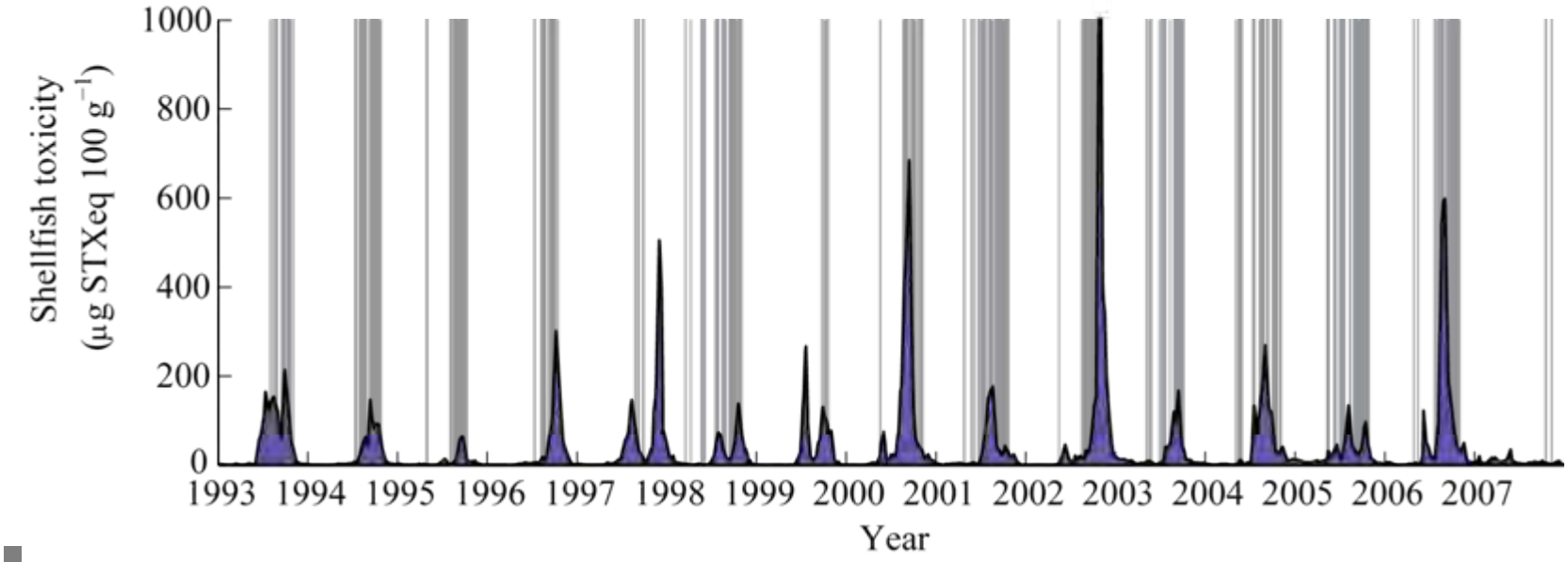


What did the weather and environmental parameters look like during these events?

A window of opportunity exists when all eight of the parameters are within 1.5 SD from the mean of values calculated during the 20 days leading up to the most toxic events

The window of opportunity for *Alexandrium* in Puget Sound is primarily driven by warm air and water temperatures, weak winds, low streamflow and small tidal variability

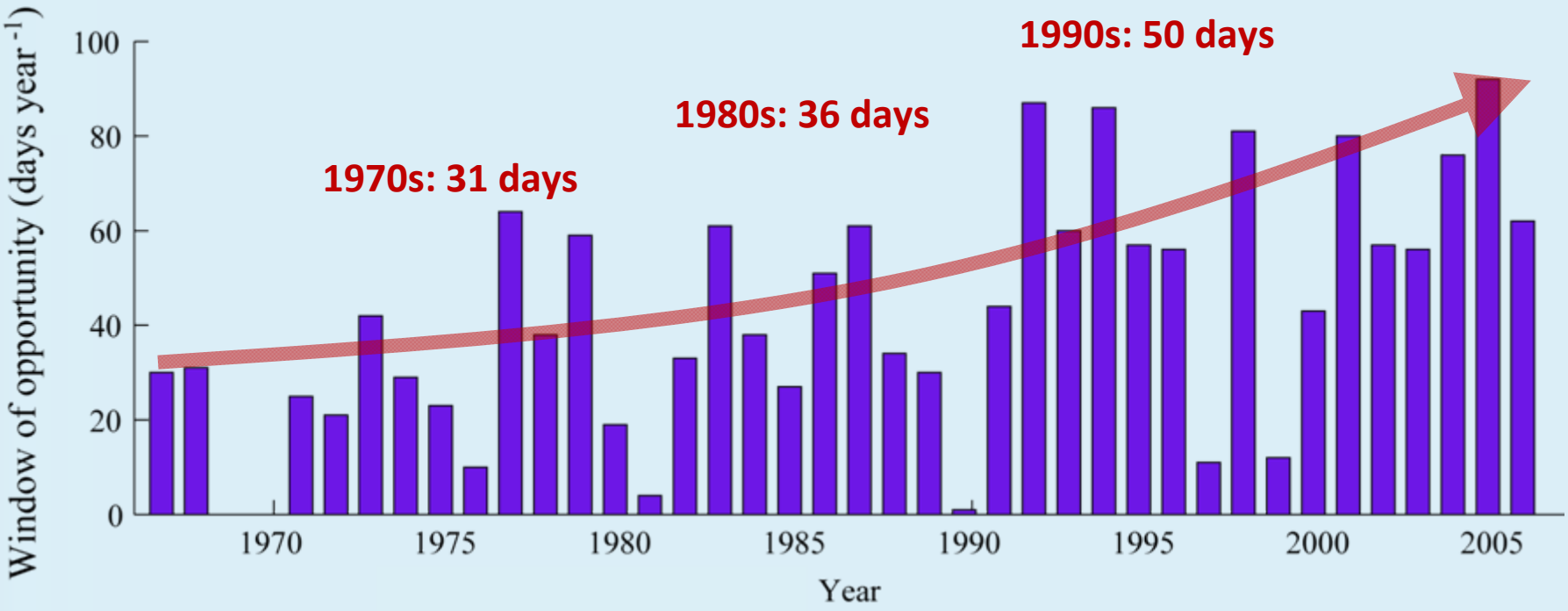
"Windows of Opportunity" Correspond with Historical Shellfish Toxicity Records in Puget Sound



= Windows of Opportunity, i.e. days with ideal weather and environmental conditions for toxic HAB development

Moore et al. (2009): Harmful Algae

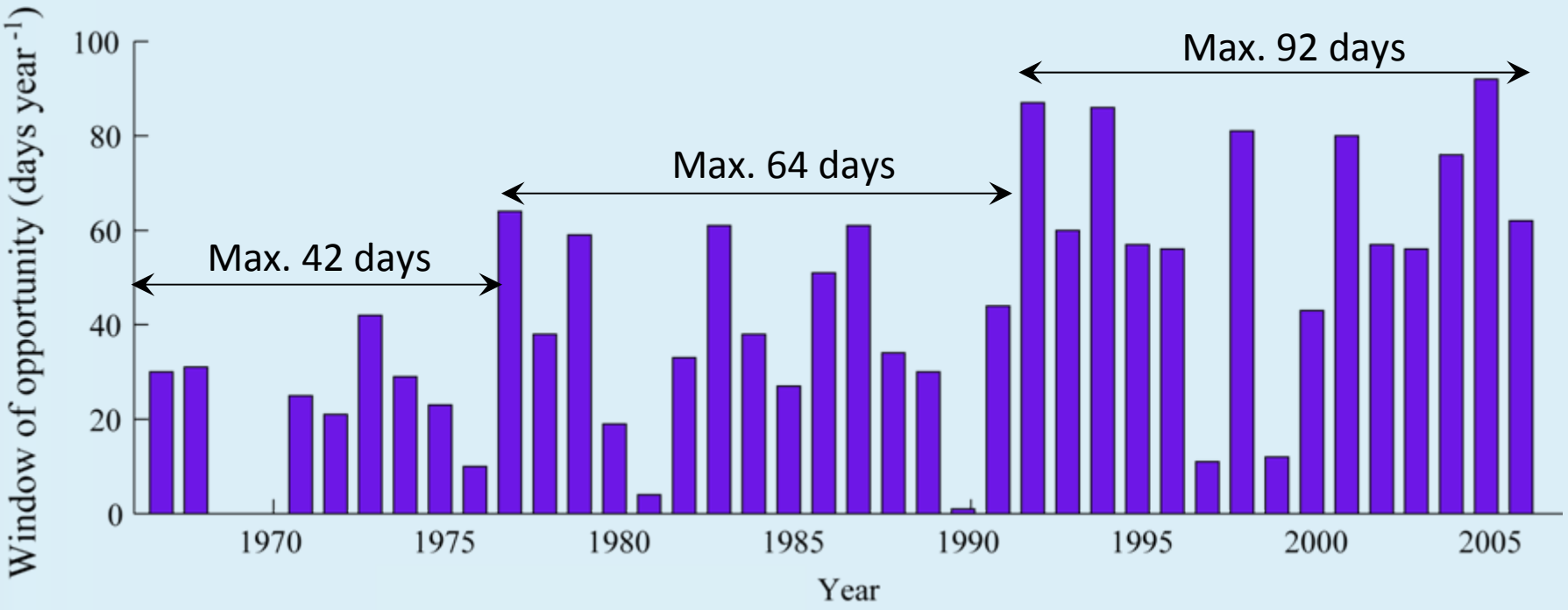
Has the Window of Opportunity Changed in the Past?



The window of opportunity for HABs of Alexandrium in Puget Sound has increased in duration since 1967

Moore *et al.*, 2011

Has the Window of Opportunity Changed in the Past?



These increases occurred in "steps" in 1977 and 1991 marking new ceilings for values attained by the window of opportunity

Moore *et al.*, 2011

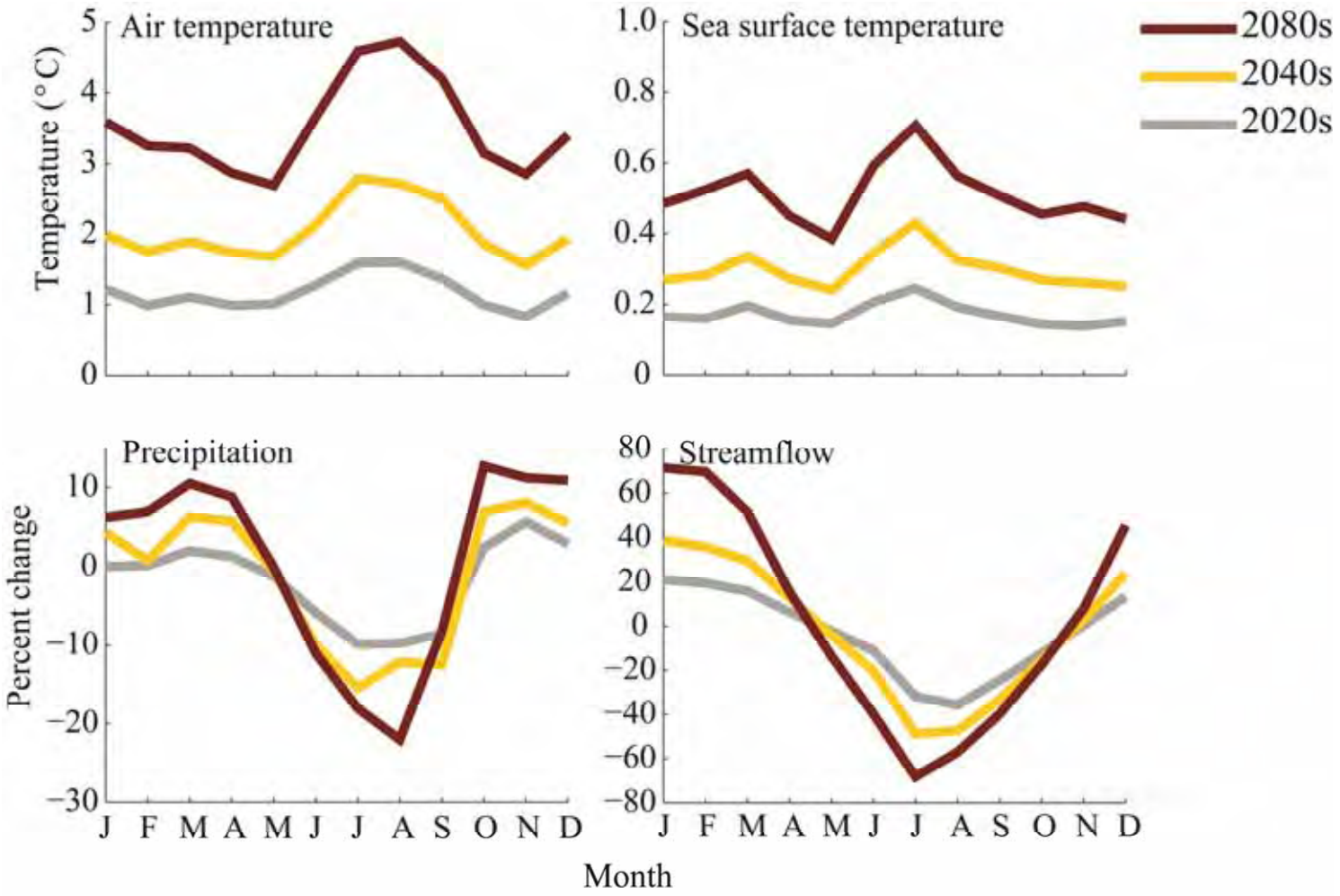
Will the Window of Opportunity Change in a Future Warmer Climate?

- Calculate the window of opportunity for HABs of *Alexandrium* using climate change projections into the future for the Puget Sound region

- Calculate using the SRES A1B emissions scenario
  - Characterized by rapid economic growth, a global population that peaks in the mid-21st century, and rapid adoption of new technologies

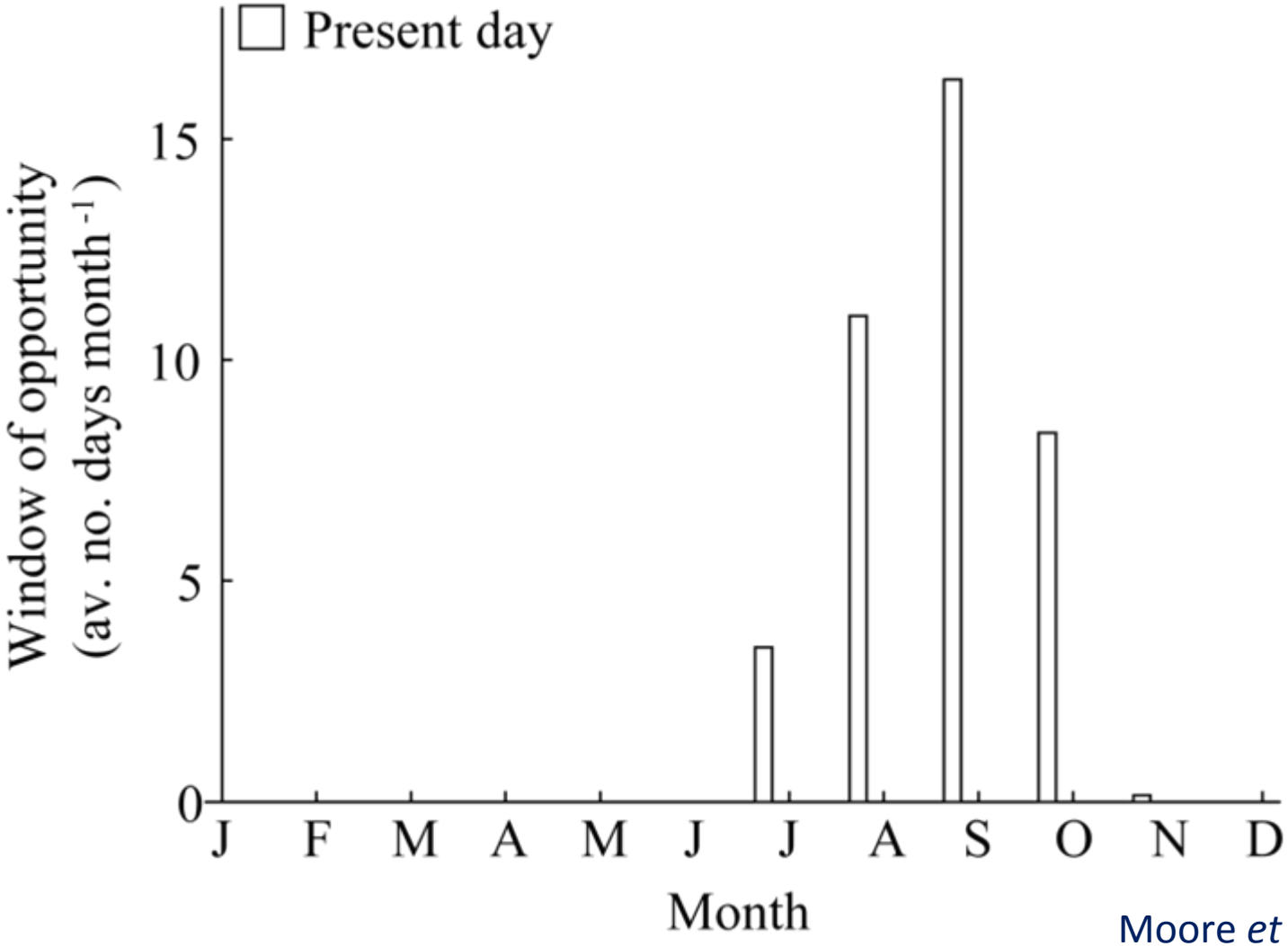
Future Average Changes to Parameters

Relative to the present-day (i.e., 1980s)



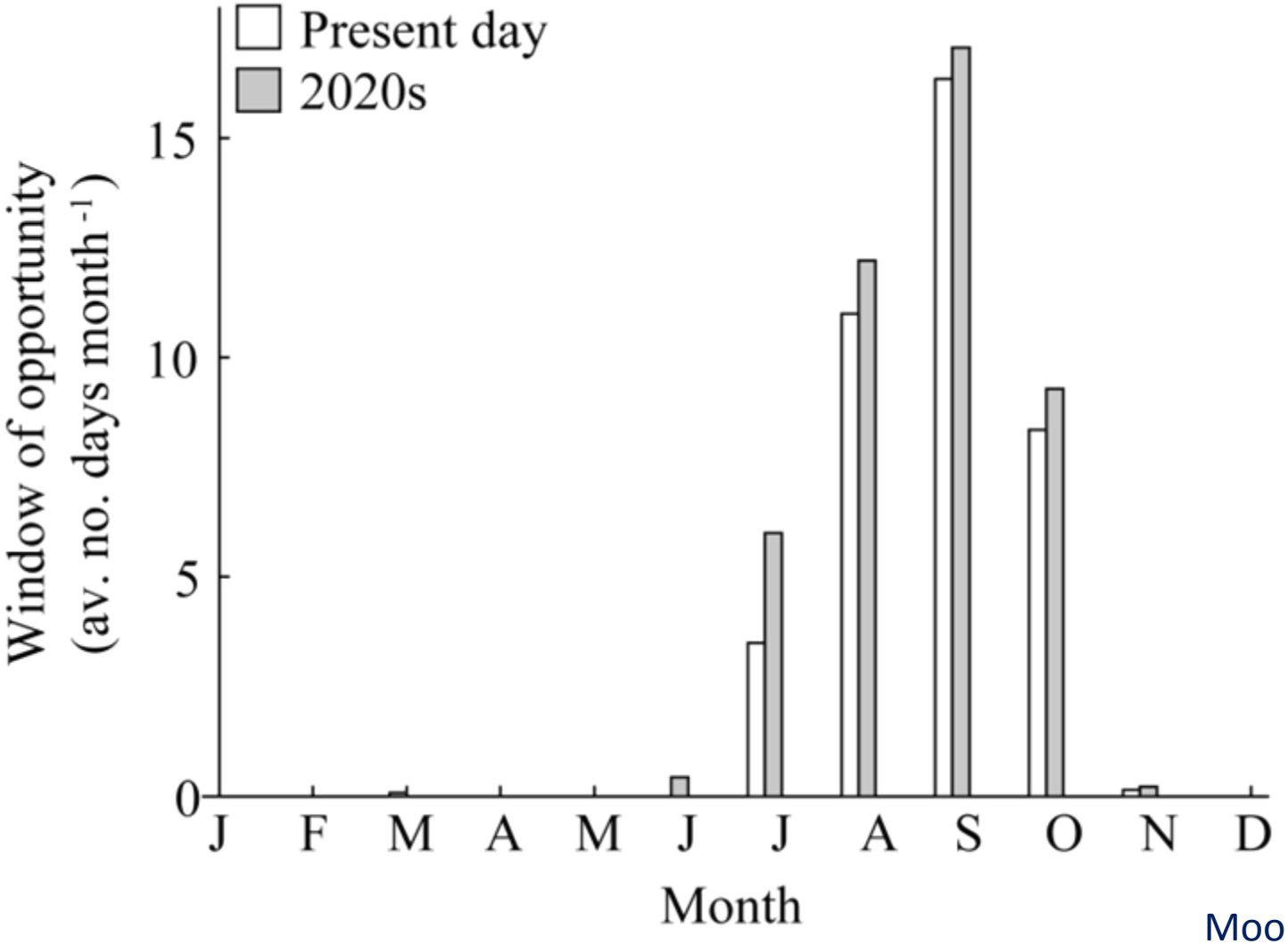
*** Perturbations to (i) air temperature and precipitation calculated using the mean values of 20 GCMs with simulations for SRES A1B (Mote and Salathé, In press), (ii) streamflow calculated from the variable infiltration capacity regional hydrological model (Elsner et al. 2009), and (iii) sea surface temperature using a regression relationship with surface air temperature (Moore et al. Submitted)*

Projected Window of Opportunity for *Alexandrium* in Puget Sound



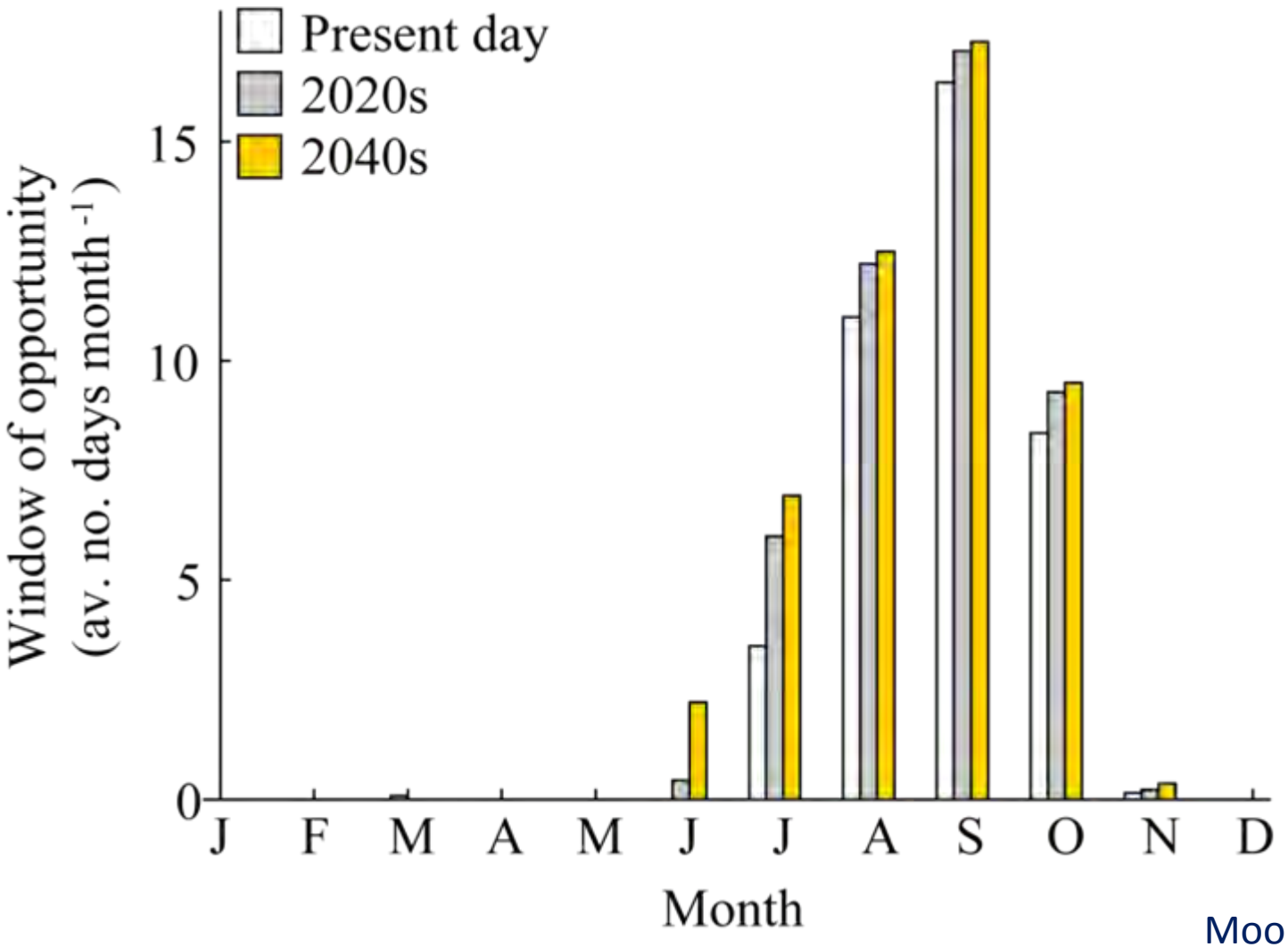
Moore *et al.,* Submitted

Projected Window of Opportunity for *Alexandrium* in Puget Sound



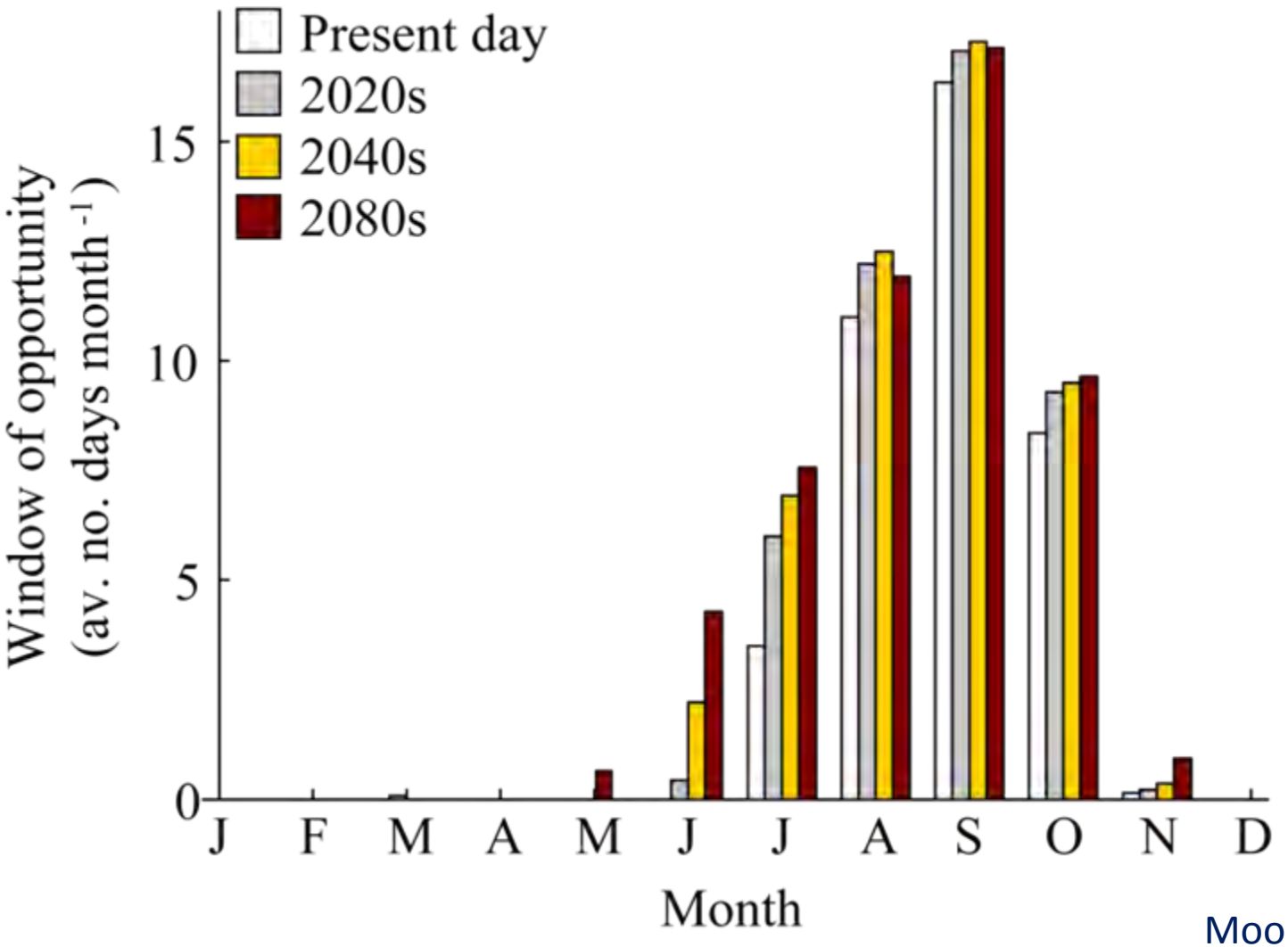
Moore *et al.*, 2011

Projected Window of Opportunity for *Alexandrium* in Puget Sound



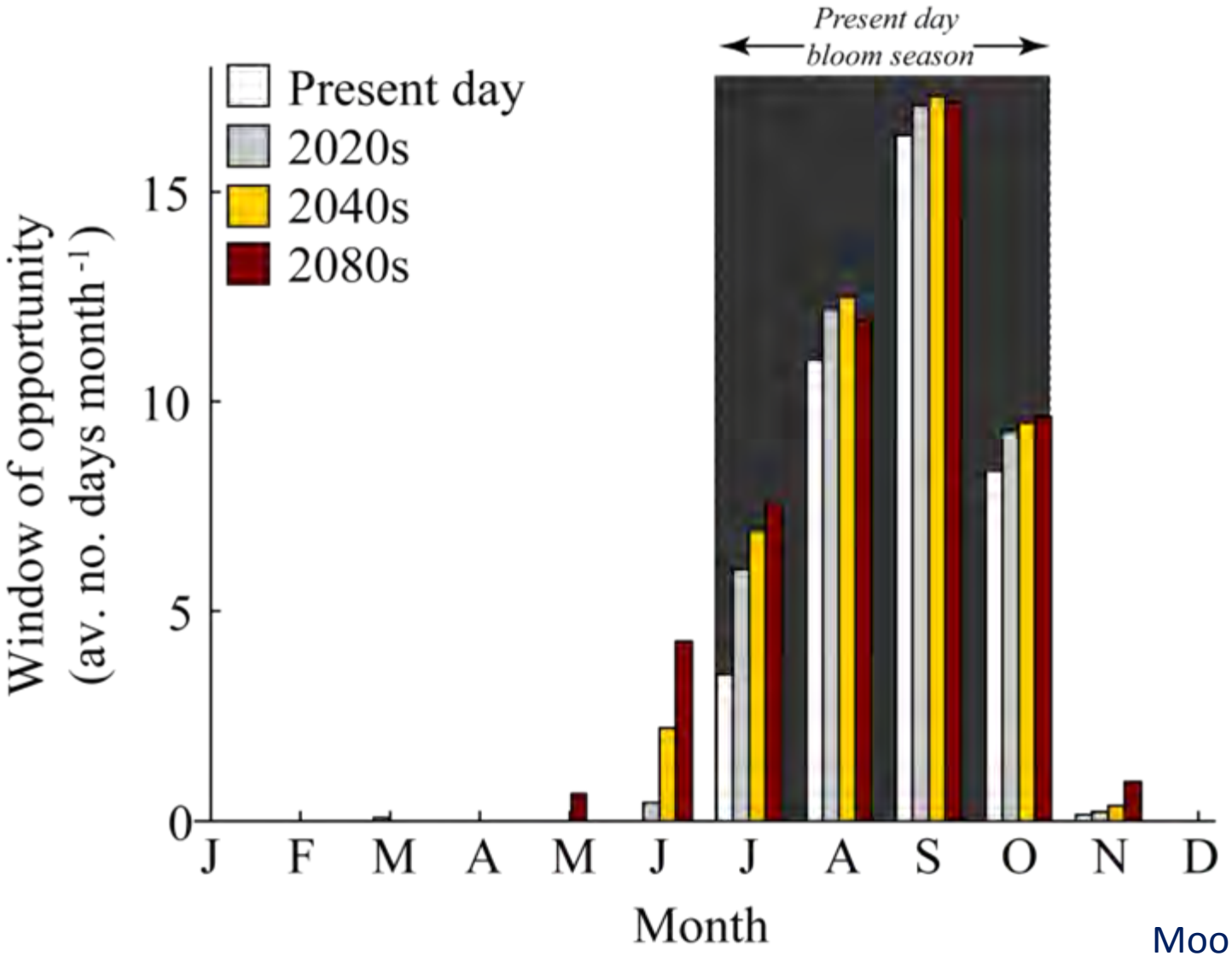
Moore *et al.*, 2011

Projected Window of Opportunity for *Alexandrium* in Puget Sound



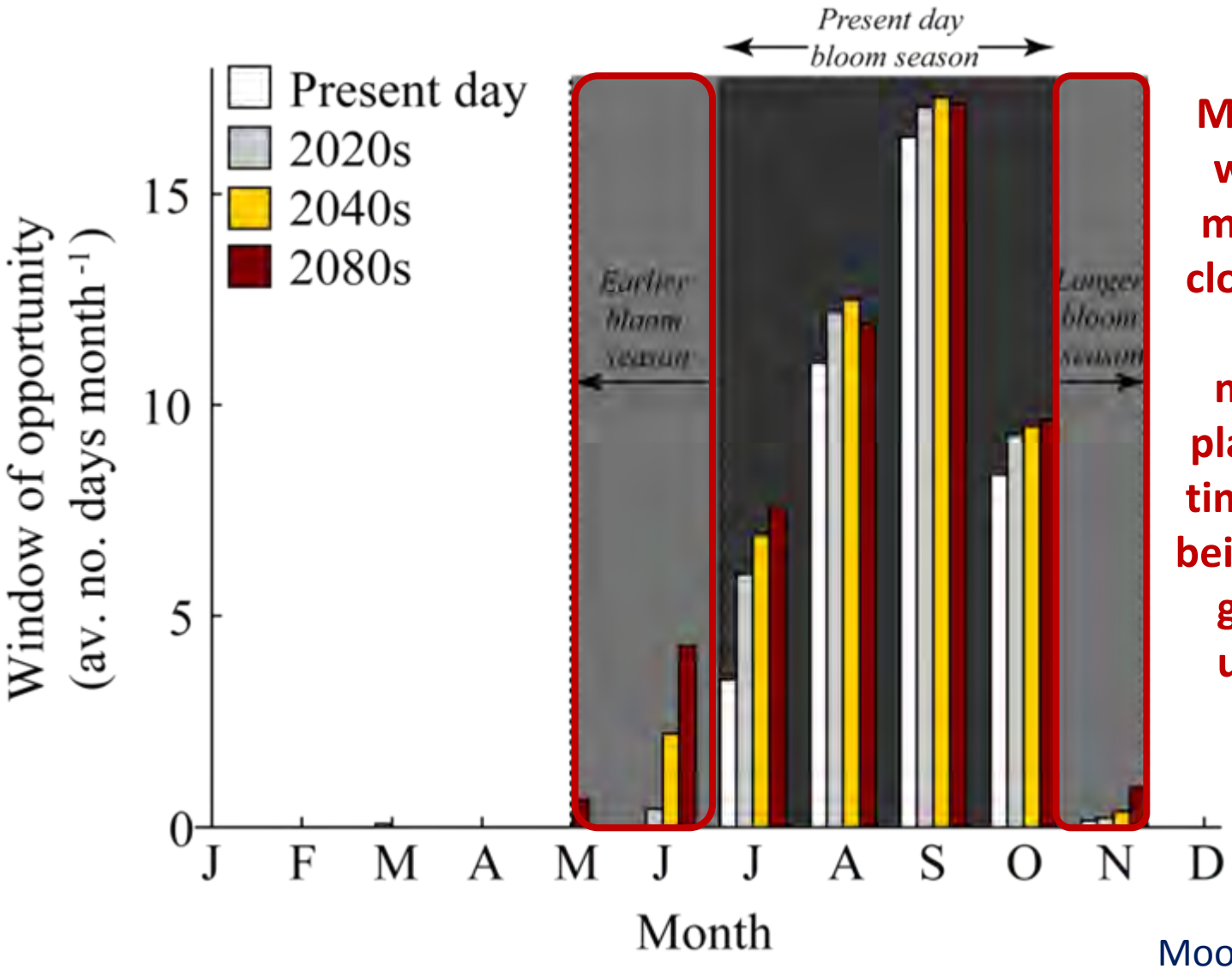
Moore *et al.*, 2011

Projected Window of Opportunity for *Alexandrium* in Puget Sound



Moore *et al.*, 2011

Projected Window of Opportunity for *Alexandrium* in Puget Sound



Managers can watch these months more closely and put mitigation measures in place ahead of time instead of being caught off guard by an unexpected bloom

Moore *et al.*, 2011

Compared to the Present day

2020s

- Blooms may begin **1 month** earlier
- Blooms may last up to **14 days** longer
- Average increase of **6 days**

2040s

- Blooms may begin **1 month** earlier
- Blooms may last up to **15 days** longer
- Average increase of **9 days**

2080s

- Blooms may begin **2 months** earlier
- Blooms may last up to **19 days** longer
- Average increase of **13 days**

Conclusions

- A window of opportunity exists for HABs of *Alexandrium* and can significantly increase the risk for toxic blooms in Puget Sound
- This window has been widening since at least the late 1960s
- Under a moderate greenhouse gas emissions scenario, we project that blooms may begin up to 2 months earlier in the year and persist for up to 1 month later
- Changes will be felt within 30 years, and maybe felt as early as next decade