

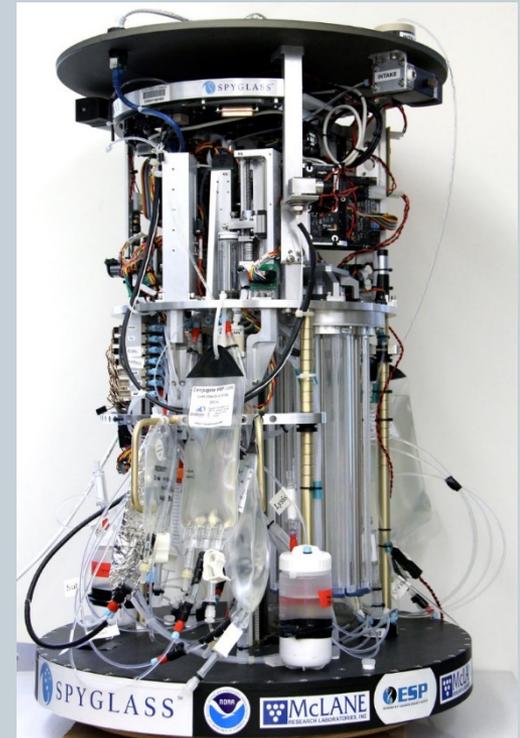
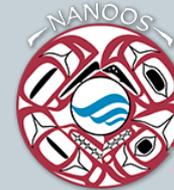
# Harmful algal blooms: Advances in early warnings & forecasts for fishermen and fishing communities

1

**STEPHANIE MOORE, VERA TRAINER,  
AND JOHN STEIN**

**NOAA'S NORTHWEST FISHERIES SCIENCE  
CENTER**

[stephanie.moore@noaa.gov](mailto:stephanie.moore@noaa.gov)



# What is at stake? Annual cost of HABs

2

*Economic impacts of HABs in the U.S. are at least \$82 million/year\**

Commercial Fisheries Impacts: **\$38 million/year**

Public Health Costs of Illnesses: **\$37 million/year**

Recreation and Tourism Impacts: **\$4 million/year**

Coastal Monitoring and Management: **\$3 million/year**

\*2005 dollars, Hoagland and Scatista (2006). Based on subset of outbreaks in 1987-2000.

Source: NOAA CSCOR Economic Impacts Fact Sheet

# True impacts at county and community level are much greater...

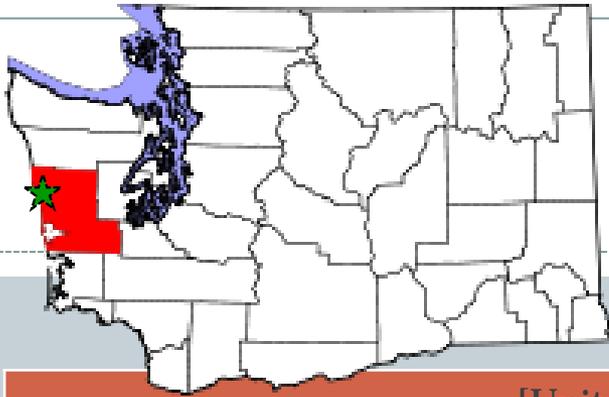
3

- **\$20.4M\*** loss in tourism-related spending in Grays Harbor and Pacific counties, WA, for a full-season closure of recreational razor clam harvest

\*2008 dollars; Dyson & Huppert 2010



[Photo: Larry Workman, Quinault Indian Nation]



# Grays Harbor county, WA

4

[United States Census Bureau]	WA State	Grays Harbor county*	Taholah CDP (Quinault Indian Nation) 
Unemployment	5.6%	7.9%	13.8%
Individuals below poverty line	13.5%	18.8%	40.8%
Median household income	\$60,294	\$43,379	\$28,750
Food stamp/SNAP benefits in last 12 months	14.2%	21.6%	36.8%

*Communities rely on natural resources and the environment  
e.g. timber, seafood & related industries*

***Is this community resilient to large ecosystem change?***

***...2015 West Coast HAB event***

# Biggest-ever toxic algal bloom hits West Coast, shutting down shellfish industries



## California's commercial Dungeness crab season postponed indefinitely over toxin risk



Kory Cropper, left, loads crab traps into the Amber Lynn before the start of the Dungeness crab season in Bodega Bay on Wednesday, November 13, 2015. (Cortier Jay/The Press Democrat)

## QUESTIONS, ANSWERS ABOUT TOXIC WEST COAST CRABS



An imported Dungeness crab sits on ice for sale at Fisherman's Wharf Thursday, Nov. 5, 2015, in San Francisco. (AP Photo/Eric Risberg)

## Dungeness Crabbers Hit Hard By Algae Bloom On Washington Coast

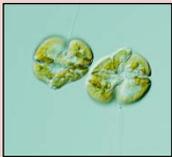
By ASHLEY AHEARN • 18 HOURS AGO

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Crabber Tom Petersen would rather have his crab pots on the floor of the Pacific, but a toxic algae bloom has prompted health officials to close the south Washington coasts to commercial and recreational crabbing.

# Common coastal HABs in the U.S.

HAB species	Toxin	Illness	Symptoms
<i>Alexandrium</i> spp. 	Saxitoxin & derivatives	Paralytic Shellfish Poisoning (PSP)	Numbness & tingling of lips, mouth, face, neck; nausea & vomiting; muscle paralysis in chest & abdomen; possibly death
<i>Pseudo-nitzschia</i> spp. 	Domoic acid	Amnesic Shellfish Poisoning (ASP)	Nausea, vomiting & diarrhea; headache, dizziness & confusion; permanent short-term memory deficits; seizures, cardiac arrhythmias, & possibly death
<i>Dinophysis</i> spp. 	Okadaic acid & derivatives	Diarrhetic Shellfish Poisoning (DSP)	Nausea, vomiting, severe diarrhea & stomach cramps
<i>Heterosigma akashiwo</i> 	ROS + toxin?	—	
<i>Karenia brevis</i> 	Brevetoxin	Neurotoxic Shellfish Poisoning (NSP)	Gastrointestinal and neurologic illness; aerosolized toxin can cause respiratory distress and eye irritation

# Massive 2015 U.S. West Coast *Pseudo-nitzschia* bloom – *is this the new normal?*

7

- Large geographical extent: Channel Islands to Aleutian Islands
- Long lasting (months)
- “Super” *Pseudo-nitzschia* – large chains, chloroplasts bulging
- Impacts on shellfish, planktivorous fish, Dungeness crab closures
- Marine mammal mortalities

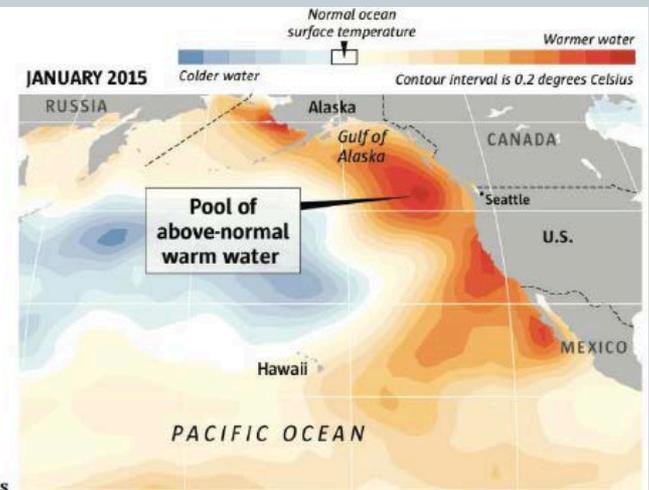


## The blob off our coast

Scientists say a vast pool of warm water off our coast is affecting marine life and local weather, and is part of a bigger pattern that includes California's drought and East Coast blizzards.

Source: Department of Atmospheric Sciences, University of Washington

MARK NOWLIN / THE SEATTLE TIMES



# Impacts of largest West Coast HAB



Closure of razor clam fishery  
~\$7 million lost in WA State alone



Seizing sea lion first ever observed on  
WA coast; Many sea lion, seal mortalities  
in CA



Anchovy and sardine fisheries health  
advisory in CA due to high toxins

## Dungeness Crabbers Hit Hard By Algae Bloom On Washington Coast

By ASHLEY AHEARN · 18 HOURS AGO

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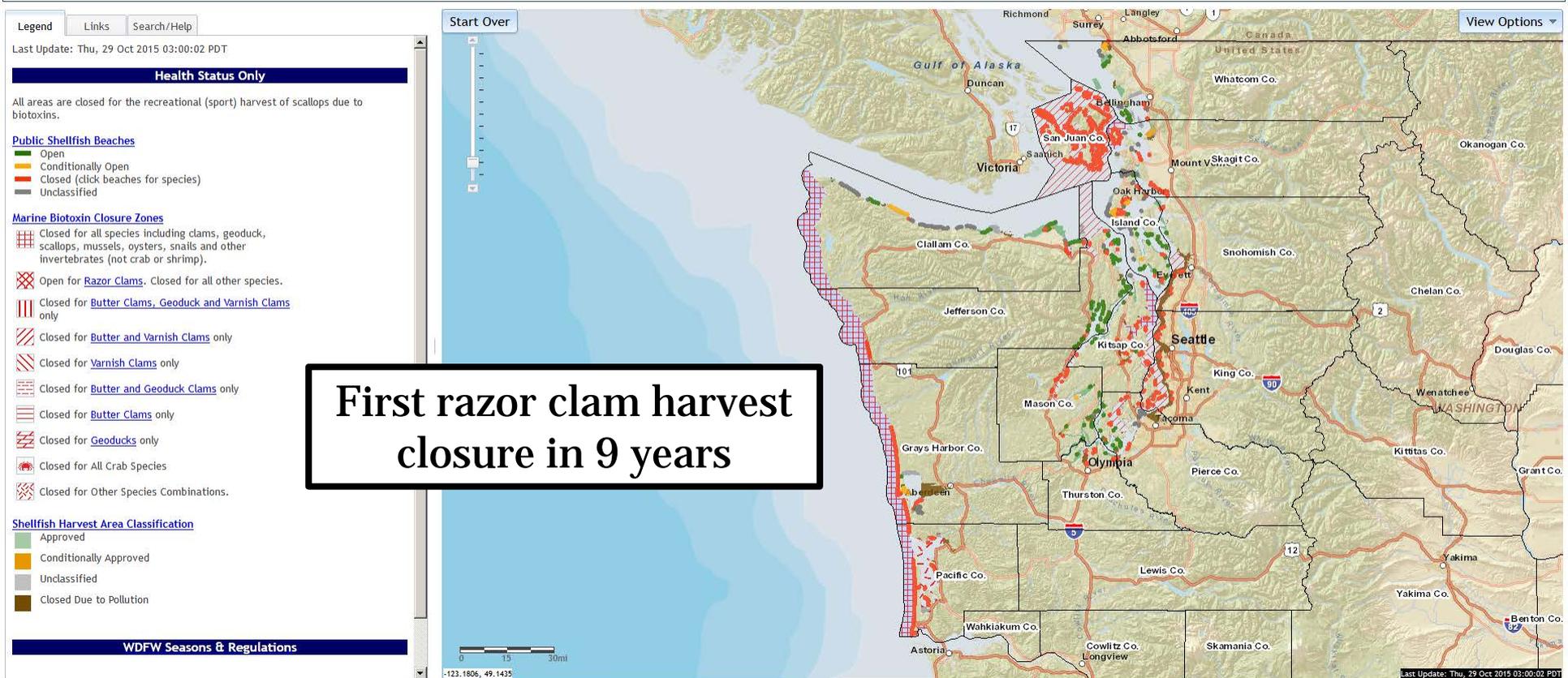
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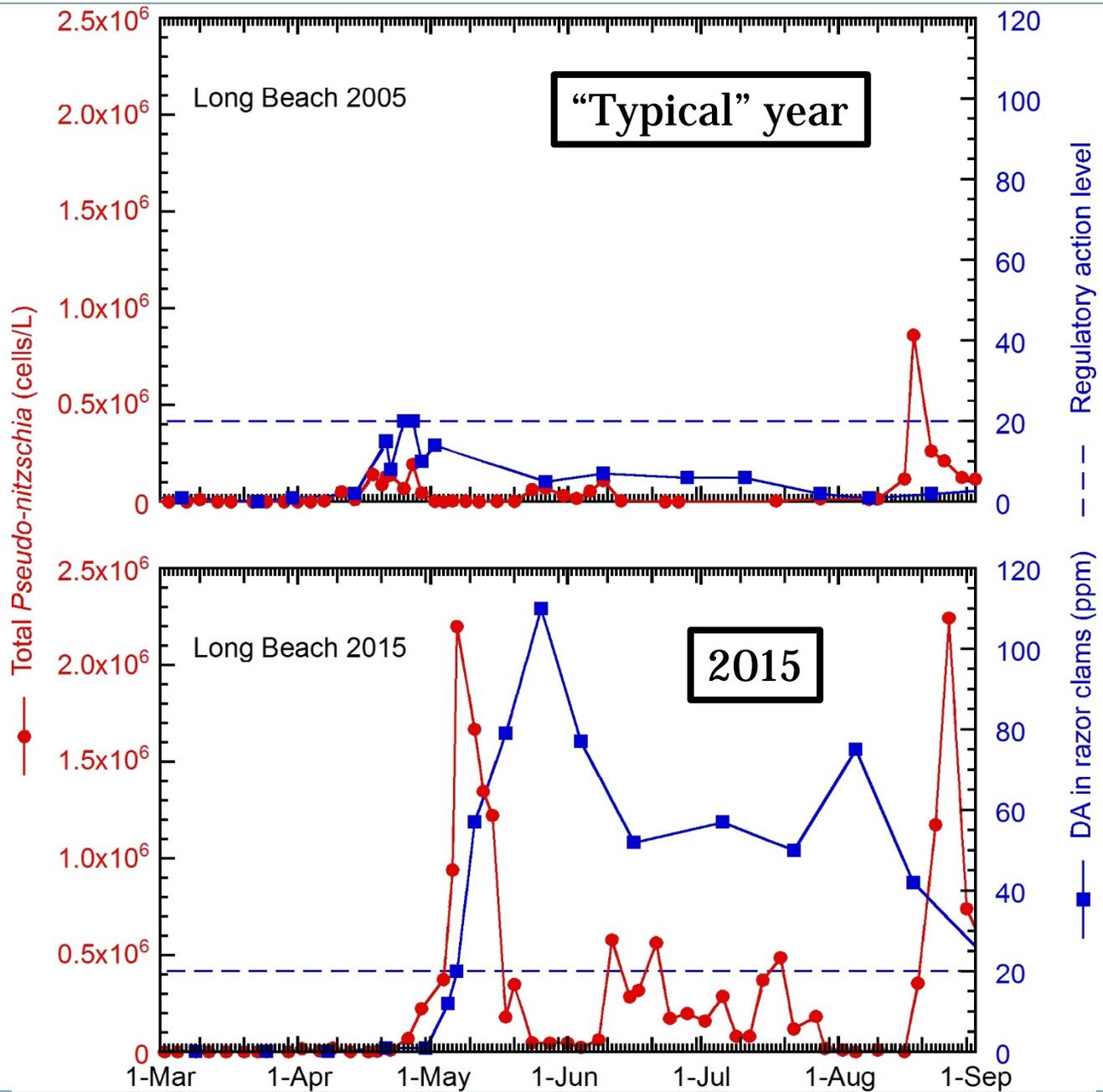


Dungeness crab fisheries closed in  
multiple states; WA crab fishery valued  
at \$84 million

# *Pseudo-nitzschia* and the Olympic Coast

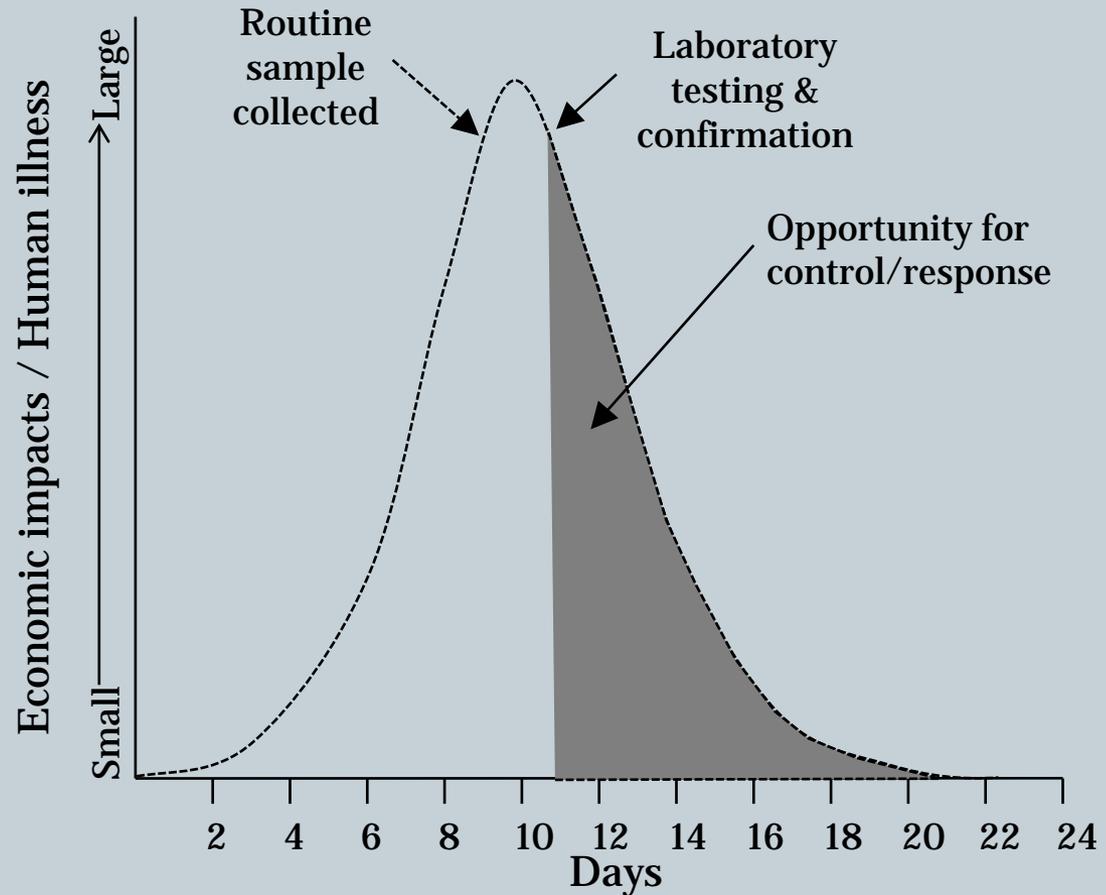
9





[Data courtesy of the ORHAB program and WDOH]

# Early warning requires improved detection



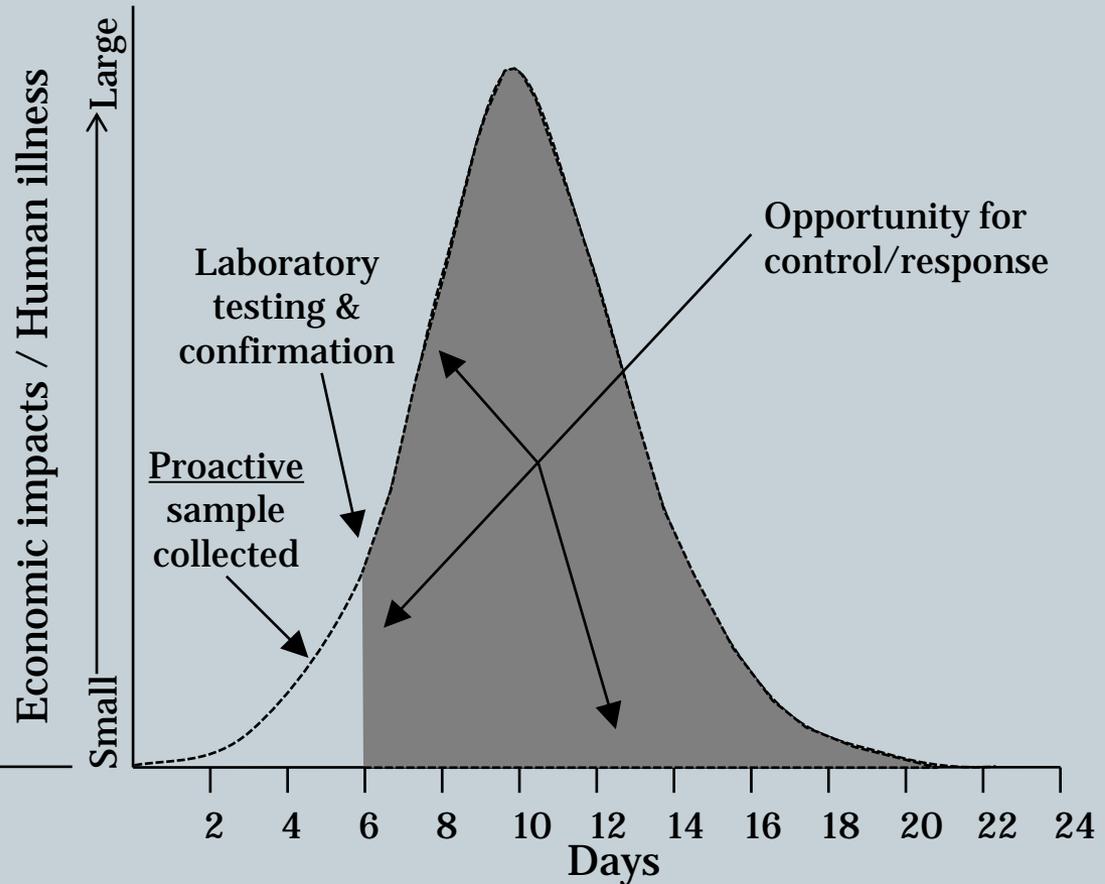
# Early warning requires improved detection

Real-time detection => early warning => increased resiliency

## **\*\*EARLY WARNING\*\***

**Autonomous  
monitoring & real-  
time detection**

Economic  
value of HAB  
early  
warning > \$3  
million\*



[\*Jin & Hoagland, 2008]

# Current monitoring regime

## Beach Monitoring by the ORHAB Partnership

13

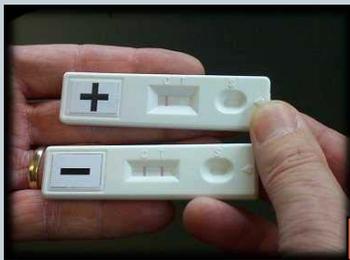
### 1. Collect plankton



### 2. Look for Pn



### 3. Test for toxin (sw & clams)

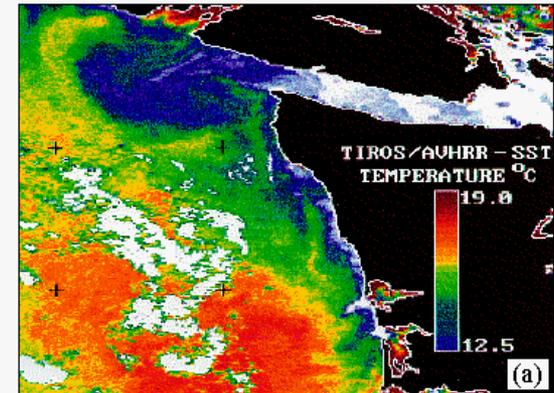


### 4. Test clams at WDOH

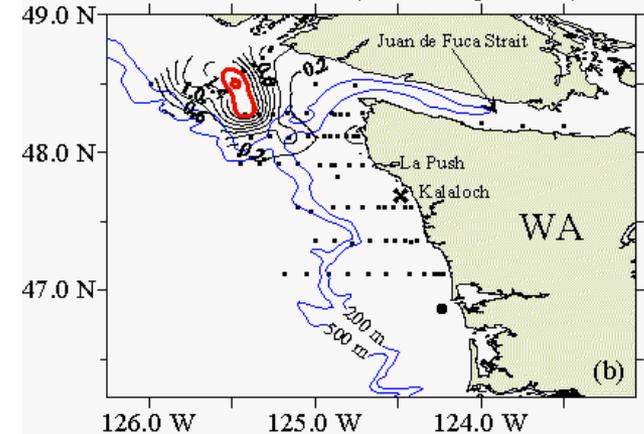


### Offshore bloom initiation site: Juan de Fuca eddy

AVHRR (18 July 1997)



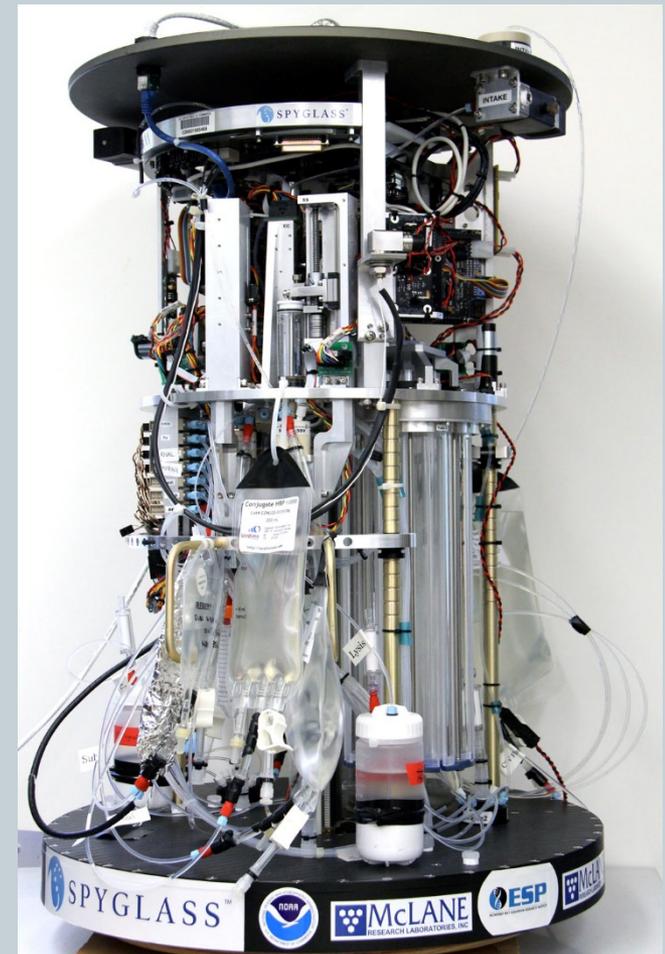
Domoic acid (7-19 July 1997)



# Environmental Sample Processor (ESP)

14

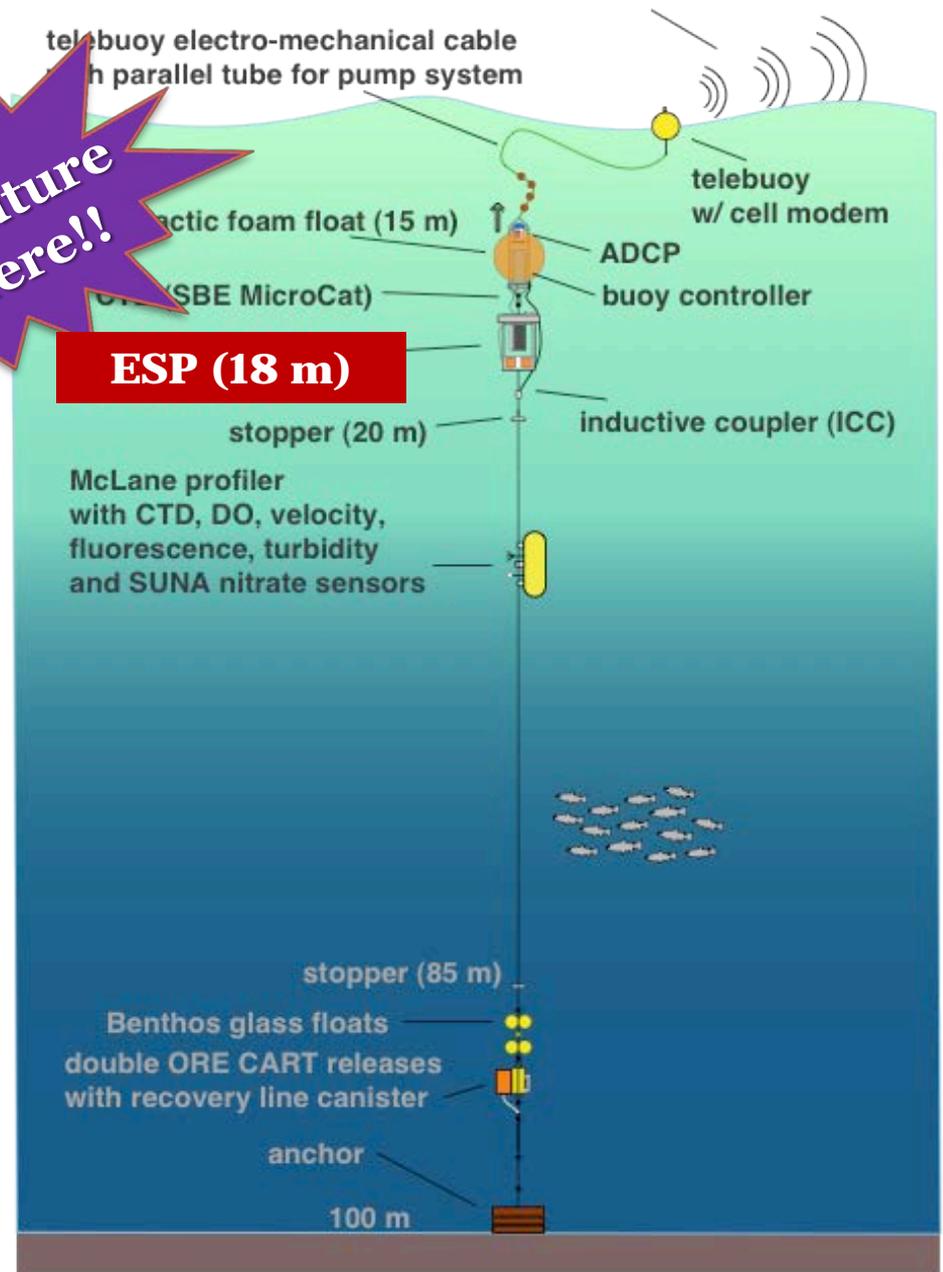
- Advanced, automated, quantitative, in situ, biological sensing system
- Extended, high frequency, and responsive surveys
- **Near real-time data delivery**
- **Early warning of HABs and their toxins**



[The NWFSC's ESPfriday]

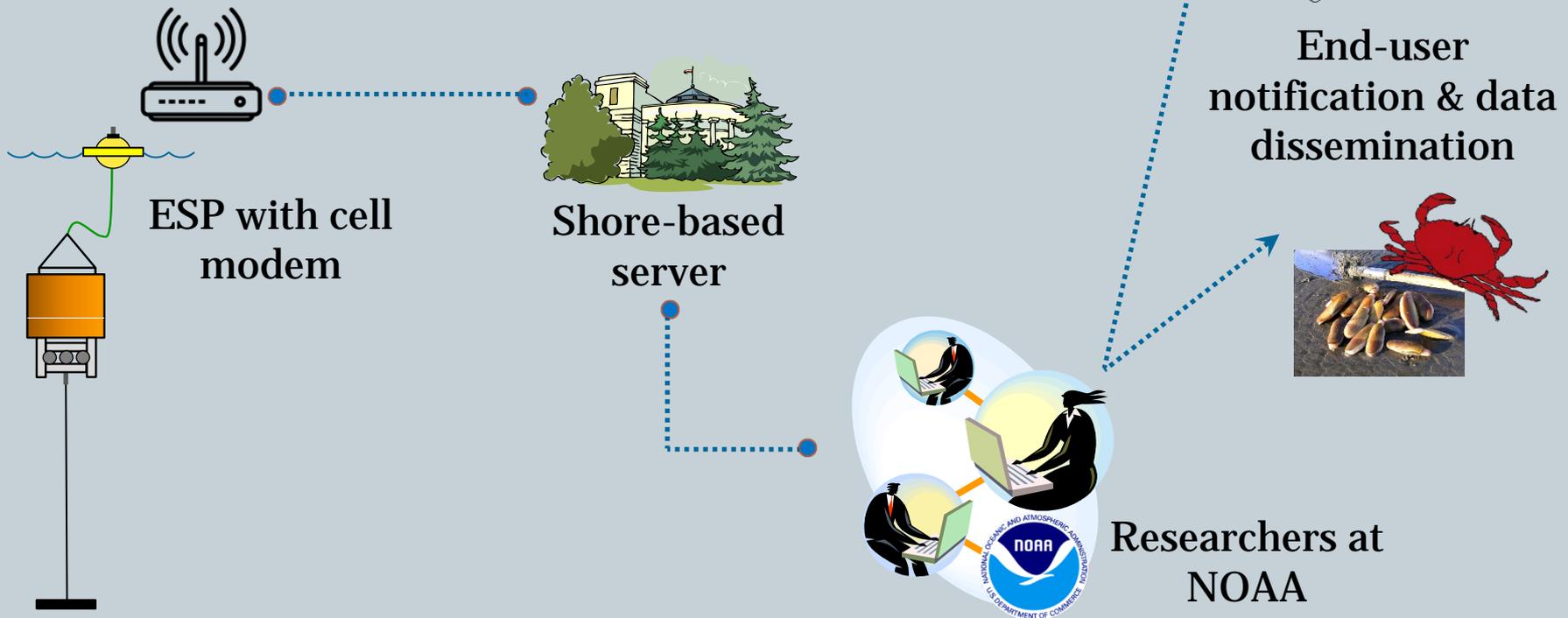
Near-real time  
offshore  
monitoring data  
→ early  
warning of toxic  
HABs!

The future  
is here!!

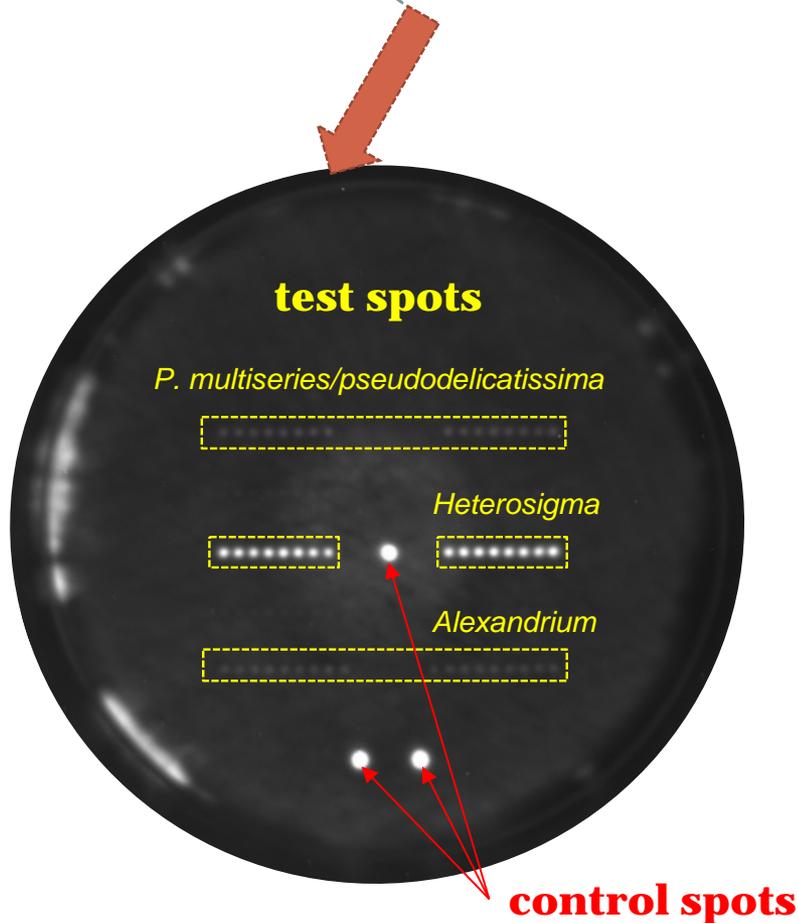


# ESP data dissemination

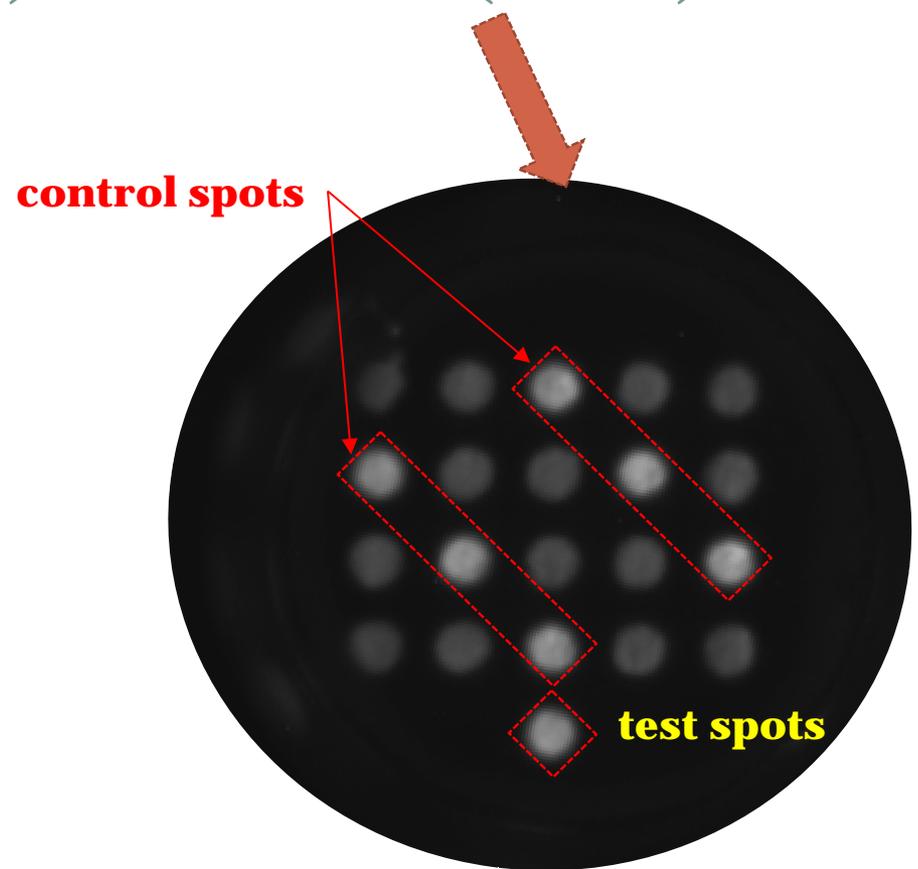
- Sophisticated, near real-time data visualization and dissemination
  - ✦ As little as 3 h after sample collection



# Analytical capabilities: SHA (nucleic acid) and ELISA (toxin)



Direct hybridization;  
65,764 cells L<sup>-1</sup>



Competitive immunoassay;  
53 ng L<sup>-1</sup> domoic acid

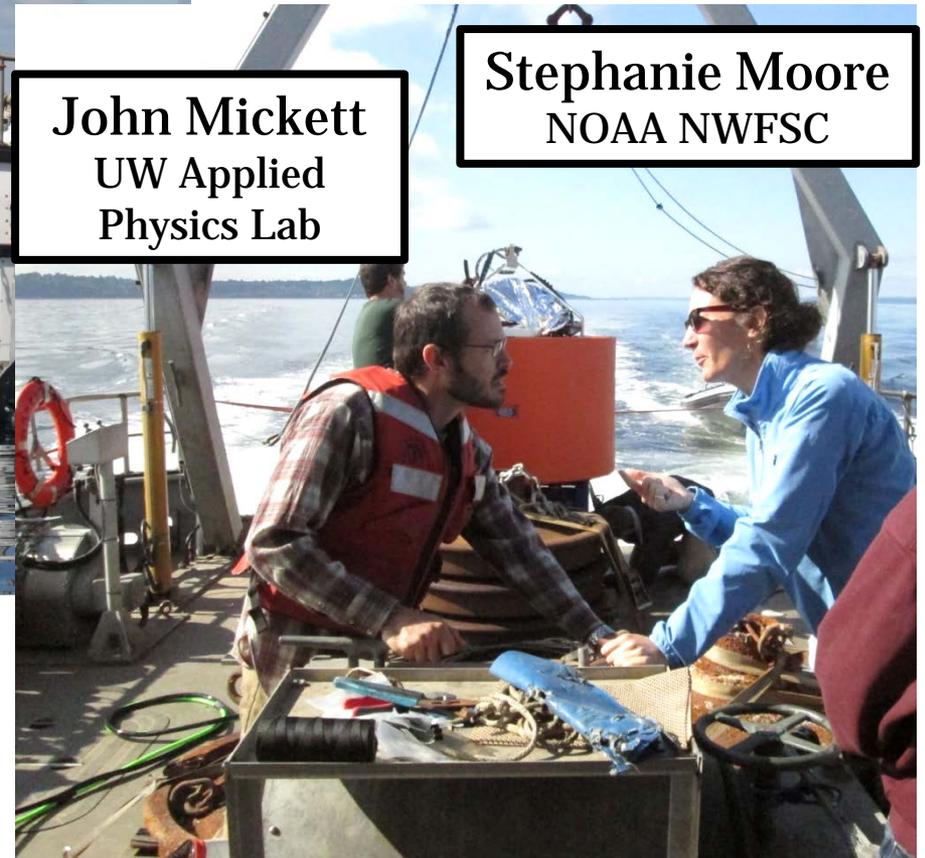
# Currently supported by IOOS



2014 – 2016  
IOOS Ocean Technology Transfer

**John Mickett**  
UW Applied  
Physics Lab

**Stephanie Moore**  
NOAA NWFSC



Keith Magness  
Chris Siani  
Nick Michele-Hart  
Linda Rhodes  
Nick Adams  
Bill Nilsson

Vera Trainer  
Greg Doucette  
Tina Mikulski  
Jim Birch  
Chris Scholin  
Roman Marin III

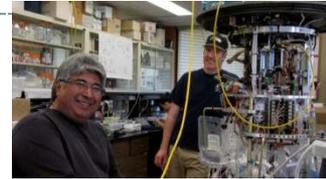
Brent Roman  
Jan Newton  
Emilio Mayorga  
Don Anderson  
Bruce Keafer

# Progression of ESP research at NOAA's NWFSC

19



- First ever deployment of an ESP in PNW
- Shore-based



- Archive deployment and technology transfer to NOAA FTEs
- Shore-based
- IOOS OTT award!!



- Took delivery of ESPeddie [NOAA IOOS]

2011

2012

2013

2014

2015

2016

- Took delivery of ESPfriday [NOAA OHHI]



- Coordinated deployment of 4 ESPs [NOAA Office of Aquaculture]
- Expanded detection capability
- Shore-based with near-real time data dissemination

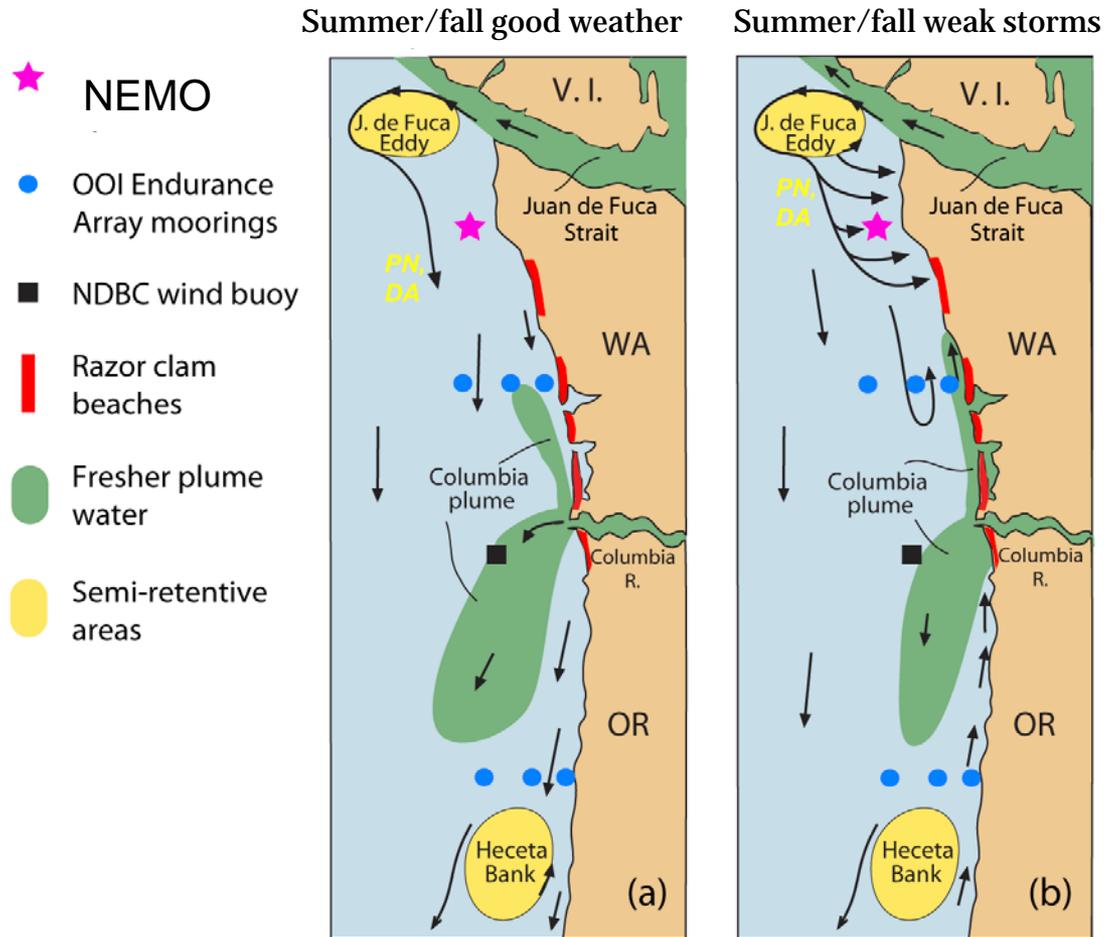


- Underwater deployment on a new mooring design
- Expanded detection capability (**domoic acid**)



# ESP deployed on existing moored observatory in transport pathway

20



[Modified from Hickey et al. 2013]

# Next steps: 2016 offshore ESP deployments

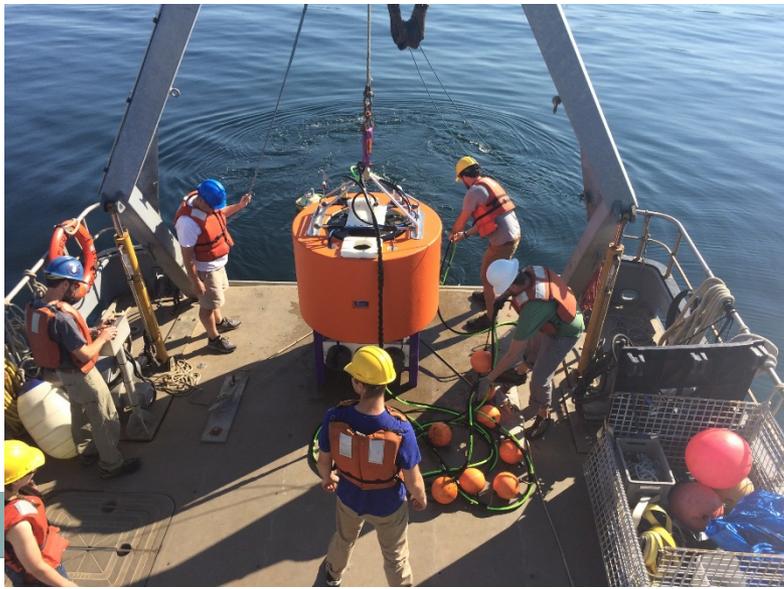
- Late spring/early summer deployment

- May 25 – July 11, 2016

- habda; 3×week

- Fall deployment

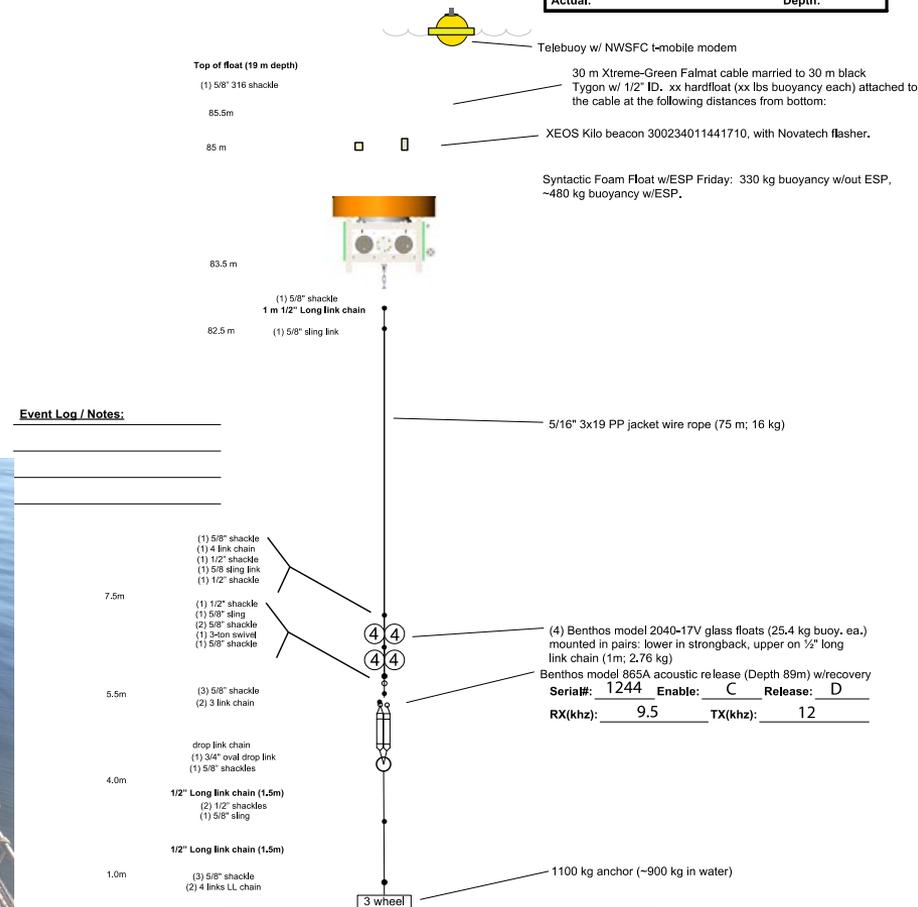
- Sep – Oct (TBD)



## NEMO ESP SUBSURFACE TEST MOORING

Version: Aug 6th, 2015 deploy

Target: 47°-45.27' N, 122°-23.68' W	Depth: 105 m
Actual:	Depth:



**Event Log / Notes:**

---

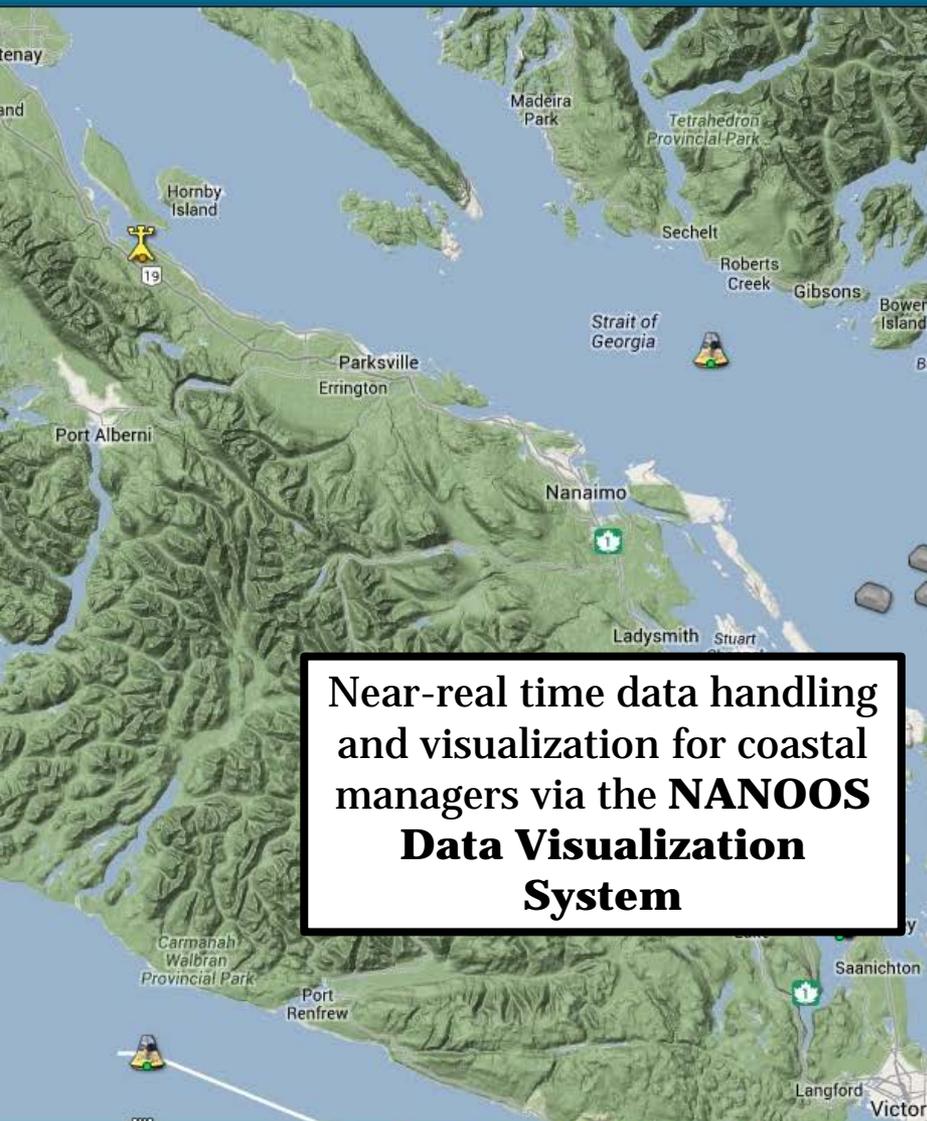


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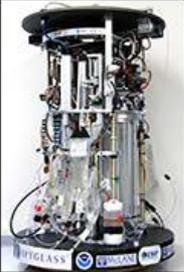
**Start Deploy:** Date: \_\_\_\_\_ Time: \_\_\_\_\_ Wind Dir / Spd: \_\_\_\_\_ Lat: \_\_\_\_\_ Long: \_\_\_\_\_  
**Drop Anchor:** Date: \_\_\_\_\_ Time: \_\_\_\_\_ Hdg / Spd: \_\_\_\_\_ Lat: \_\_\_\_\_ Long: \_\_\_\_\_



Near-real time data handling and visualization for coastal managers via the **NANOOS Data Visualization System**

**Samish Bay Biosensor, Taylor Shellfish Farms**

Observations	Details	History	Credits
Latitude: 48.6101		Longitude: -122.4372	
Type: Fixed Shore Platform			
Region: Puget Sound			
State(s): Washington			
Provider: NWFSC-NOAA			
Data Source: NWFSC-NOAA			
Asset Class: SISO		Asset ID: NWFSC_ESPSamish	



The NWFSC Environmental Sample Processor (ESP) is an advanced biosensor for micro-organisms, including those responsible for harmful algal blooms. It remotely and autonomously samples the water, conducts molecular analyses for target organisms, and telemeters the results to scientists at their desks in near real-time approximately once a day. This state-of-the-art instrument is being tested for its ability to provide early warning of harmful algae and pathogens that can affect shellfish growers, fish farmers and water enthusiasts.

[Link](#)

long-term

RESILIENT COASTAL COMMUNITIES AND ECONOMIES

Coastal and Great Lakes communities are environmentally and economically sustainable

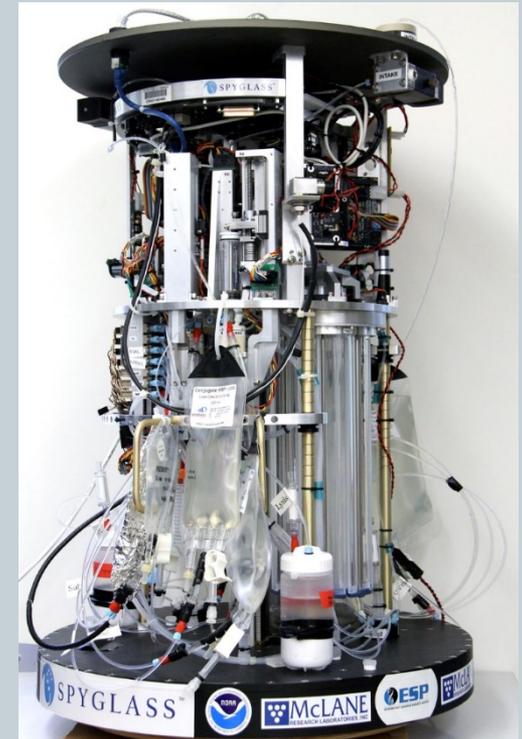
## **NOAA's Vision of the Future: *Resilient Ecosystems, Communities, and Economies***

*“To achieve this vision we must **understand** current Earth system conditions, project future changes, and **help people make informed decisions** that **reduce their vulnerability** to environmental hazards...”*

# How does ESP increase resiliency?

24

- Improved understanding of the roles of climate, OA, nutrients, and other drivers of HABs
  - Co-located sensors operated by UW and NANOOS
- Informed fisheries management decisions
  - Enhanced decision-making for harvesting opportunities and closures
- Improved communication
  - Near-real time data dissemination to coastal decision-makers
- Reduce risk of exposure to toxins
- Optimize economic opportunities



# ESP data alone does not predict shellfish toxicity at coastal beaches

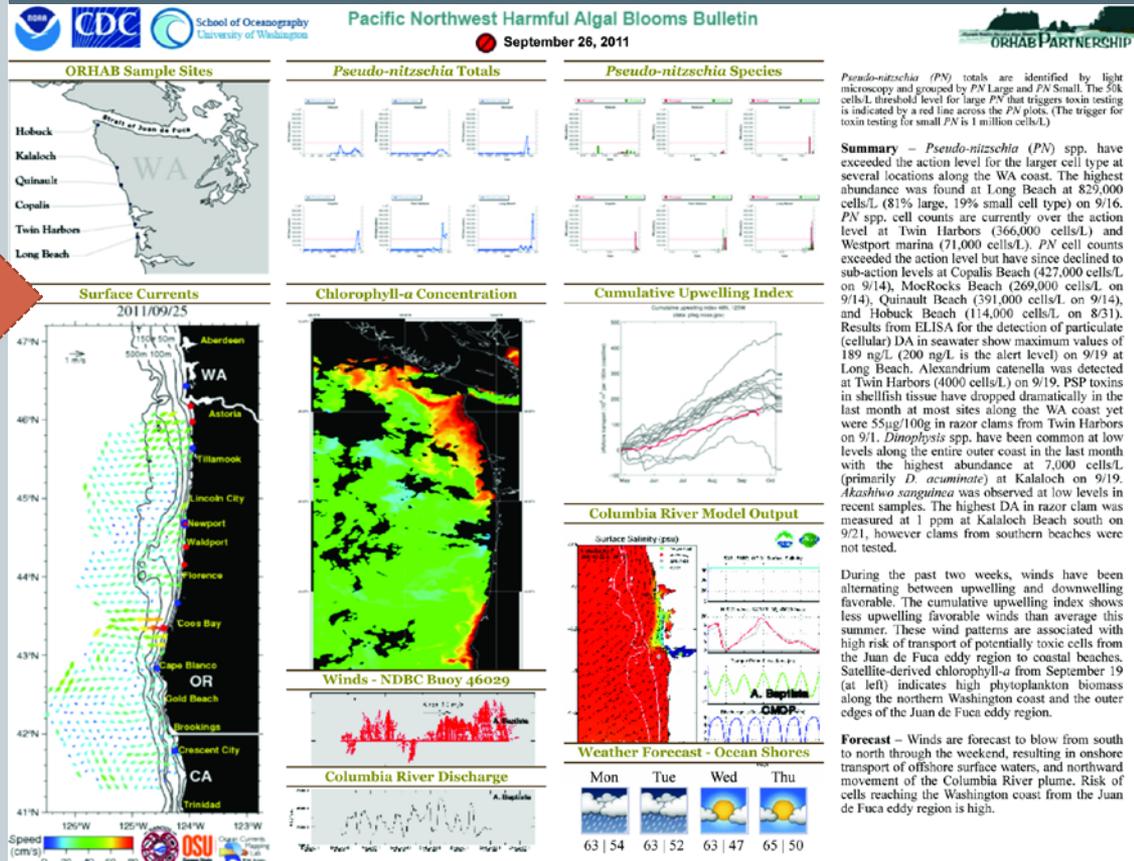
25

- Must be combined with models, beach monitoring of HABs, weather data, and more

...an integrated forecast system!

- Bulletin partially supported by NOAA MERHAB (under negotiation)
- Transition to operations for ESP and bulletin currently not funded

## Pacific Northwest HAB Bulletin



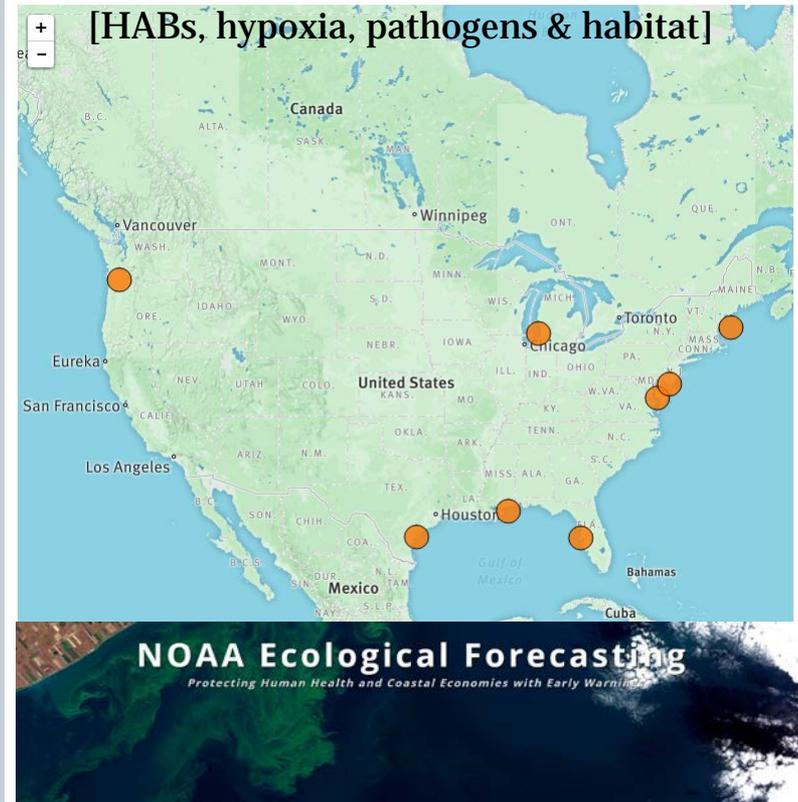
# Looking forward: **opportunities**

26

## **Pacific Northwest HAB forecast is ripe for transition to operations!**

- **Socio-economic impacts known**
- **Coastal managers demanding early warning**
- **Partnerships exist**

### Ecoforecasting hotspots



# Could improved HAB forecasting increase resilience?

27



*The Clam Diggers*  
The Clam Diggers. REPRODUCED FROM THE COLLECTIONS OF THE LIBRARY OF CONGRESS

- Proactive shellfish toxicity testing to avoid costly recalls
  - Recall of razor clams harvested for sale barely avoided in 2015
- Integrated HAB forecasting to allow early harvest and selective closure of beaches
  - Minimize economic losses
- Reduce risk for illness

# Acknowledgments

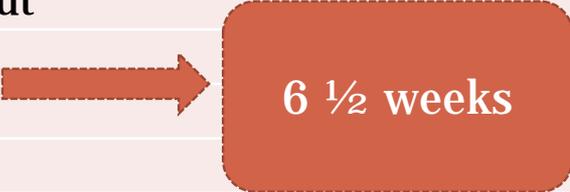
28

- **UW APL**
  - John Mickett
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  - Jan Newton
  - Emilio Mayorga
- **UW Oceanography**
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  - Barbara Hickey
- **NOAA CCEHBR**
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  - Marco Hatch
- **ORHAB**
- **Quinault Indian Nation**
- **Quileute Nation**
- **OCNMS**
- **WDOH**
- **WDFW**
- **U.S. IOOS**
- **NOAA OHHI**
- **NOAA Office of Aquaculture**
- **NANOOS**
- **Spyglass Technologies**

# Spring deployment timeline

29

<b>DATE</b>	<b>ACTIVITY</b>
January	Grow up Pn cultures for standard curves
February	Establish communications & data handling system
Week of March 21	Prepare ESPfriday
Week of March 27	Load reagents
Week of April 4	Create standard curves
Week of April 11	Create standard curves
Week of April 18	Create standard curves
Week of April 25	Create standard curve
Week of May 2	Build pucks
9-11 May	3-peat test (habda)
12-13 May	Load pucks
16 May	Can ESP
17 May	Post-can QC
23 May	Load ship and ESP checkout
25 May	Deploy (TGT May 24-26)
Week of July 11 or 18	Retrieve
Week of July 18 or 25	Post-deployment QC



6 ½ weeks