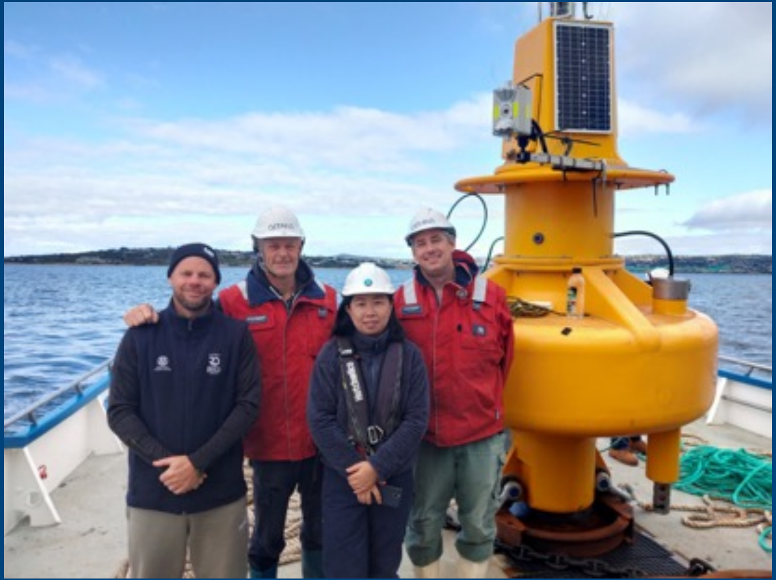
Development of a real-time HAB detection and forecasting system in South Australia's seafood capital



Government of South Australia

Department of Primary Industries and Regions

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

CSIRO

Mark Doubell, Paul Malthouse, Ian Moody (SARDI)
Hua Li (JFE Advantech), Xiubin Qi (CSIRO)

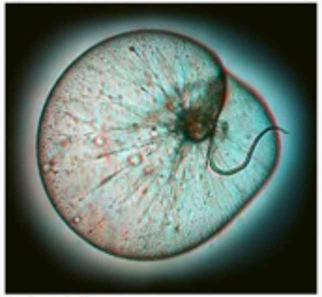
Forum for Operational Oceanography – November 2023

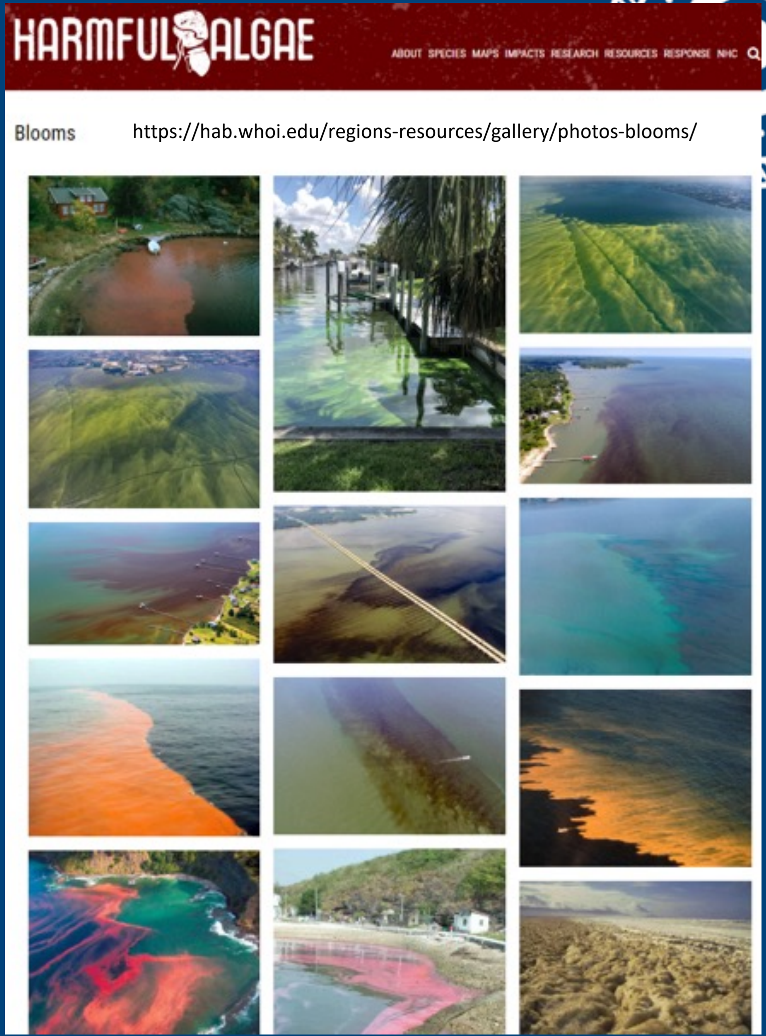
- Harmful algal blooms (HABs) occur when toxic or harmful microscopic algae bloom.

- Impacts can be significant & detrimental, or deadly, to people, fish, shellfish, marine mammals and birds & can have serious economic impacts for a range of coastal businesses and users.

~1000 B.C

. . . all the waters that were in the river were turned to blood. And the fish that was in the river died; and the river stank, and the Egyptians could not drink of the water of the river' (Exodus 7: 20–1).


Noctiluca scintillans
Source: NOAA



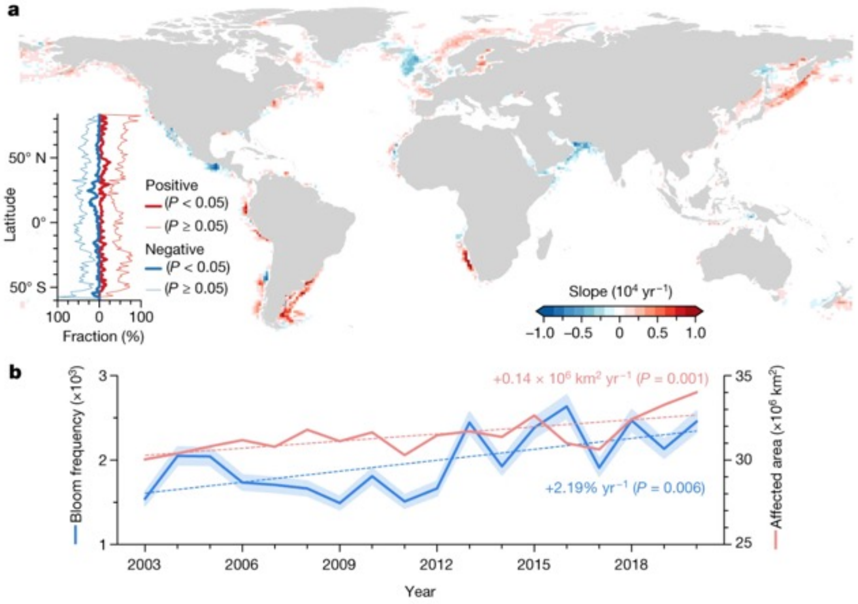
- Globally, the spatial extent (+13.2%) and frequency (+59.2%) of blooms has increased over the last ~20 years (Dai et al. (2023), Nature 615, 280–284).

- Multiple factors are known to contribute to HABs (e.g., increased nutrient loading, pollution, water flow modifications, climate change, extreme events, food web alterations, introduced species).

- How factors come together to create a bloom is not well understood, making HAB prediction difficult.

Fig. 2: Trends of global coastal phytoplankton blooms between 2003 and 2020.

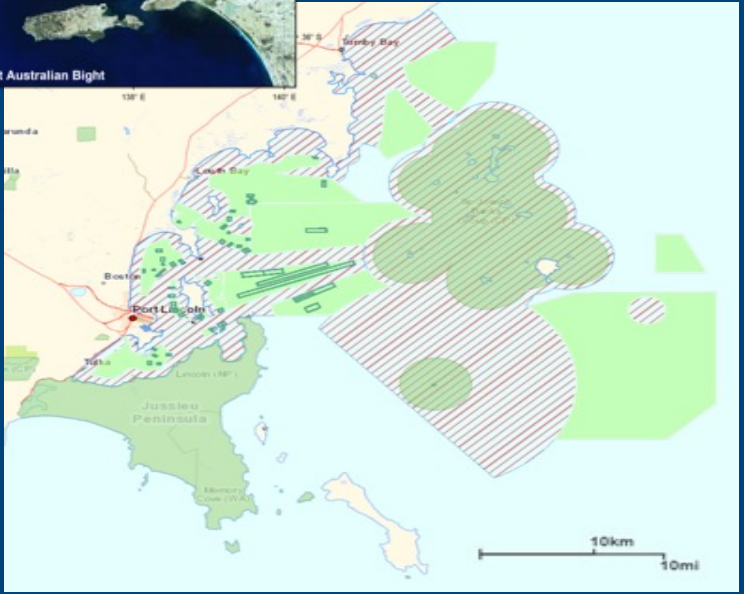
From: Coastal phytoplankton blooms expand and intensify in the 21st century



a, Spatial patterns of the trends in bloom frequency at a 1° × 1° grid scale. The latitudinal profiles show the fractions of grids with significant and insignificant trends (positive or negative) along the east–west direction. **b**, Interannual variability and trends in annual median bloom frequency and total global bloom-affected area. The linear slopes and *P*-value (two-sided *t*-test) are indicated. The shading associated with the bloom frequency data represents an uncertainty level of 5% in bloom detection. Map created using Python 3.8.

- Port Lincoln is (South) Australia's seafood capital.

- Lower Eyre Peninsula Aquaculture Zone contains mussel, oyster, tuna and finfish aquaculture valued at ~$180 M per annum.



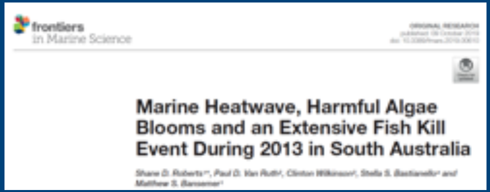
Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

- Between 2016-2022 39 HAB species identified with majority located inshore near aquaculture.

- History of HAB blooms, particularly ***Karenia mikimotoi***, in the region.

- May 2019: *Karenia mikimotoi bloom* observed in Boston Bay (200,000 cells/L PIRSA SASQAP). eSA-Marine forecasts used to monitor and advise Aquaculture industry.

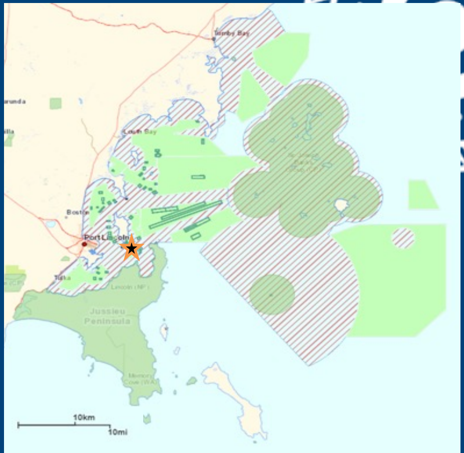

frontiers in Marine Science

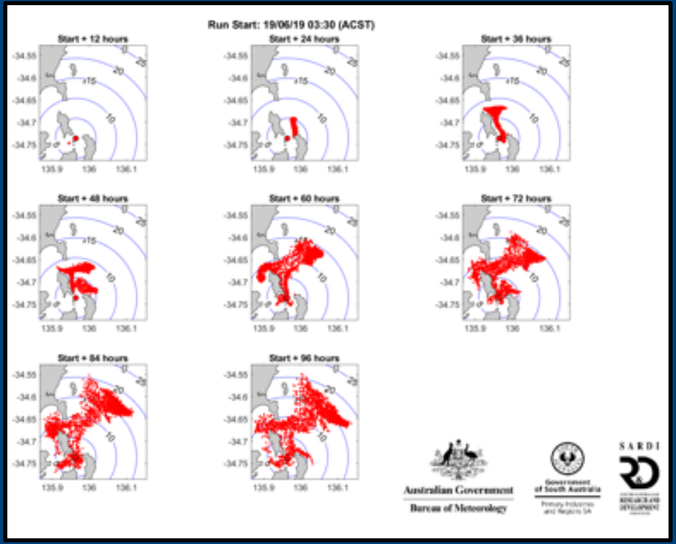
Marine Heatwave, Harmful Algae Blooms and an Extensive Fish Kill Event During 2013 in South Australia

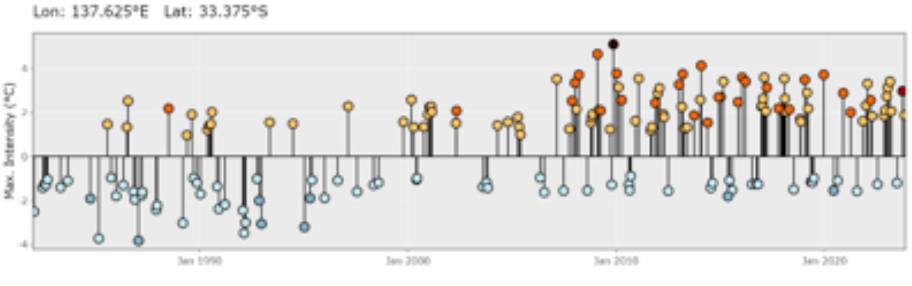

Fish kill investigation:

Coffin Bay harmful algal (Karenia mikimotoi) bloom February 2014

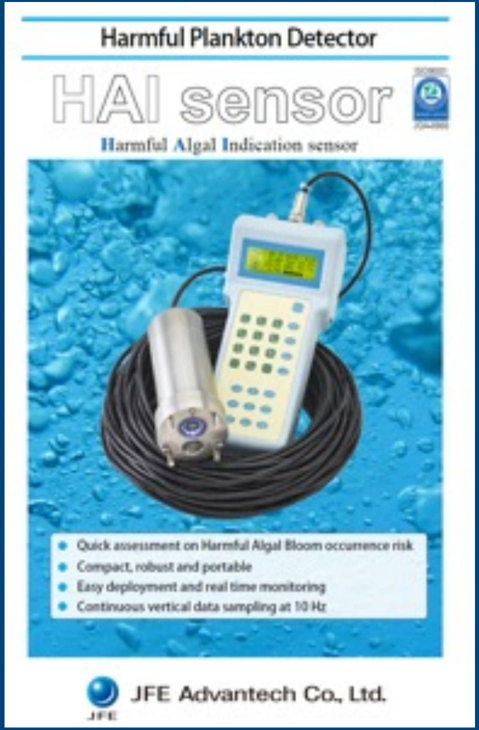
PIRSA Fisheries and Aquaculture Division

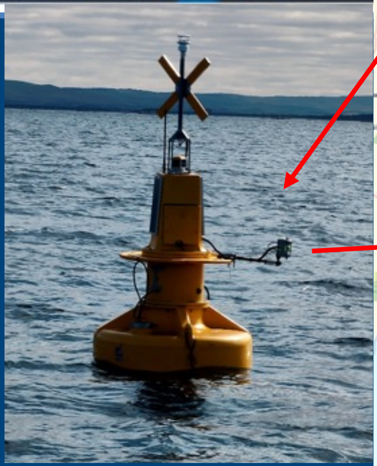


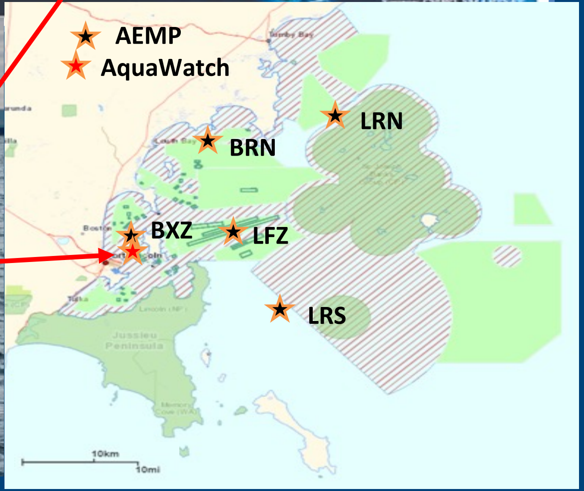




- AquaWatch real-time sensor platform provided a perfect platform to test a novel HAB sensor to provide an early warning system for aquaculture,







J. Fac. Agr., Kyushu Univ., **66** (1), 37–43 (2021)

A New Fluorometer to Detect Harmful Algal Bloom Species and its Application as a Long–Term HABs Monitoring Tool

Mitsuo YOSHIDA[1]*, Yohei SHIMASAKI, Daiki INOKUCHI[2], Ayahiro NAKAZATO[2], Shusaku OTAKE[3], Xuchun QIU[4], Koki MUKAI, Herminio FOLONI–NETO[1], Hiroharu KATO[1], Seiichiro HONDA[1] and Yuji OSHIMA

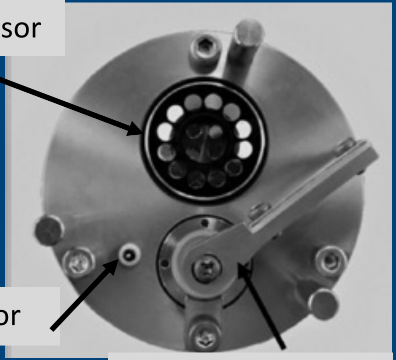
Laboratory of Marine Environmental Science, Faculty of Agriculture, Kyushu University, Fukuoka 819-0395, Japan

(Received October 30, 2020 and accepted November 4, 2020)

Improving technology for monitoring of harmful algal species is an important issue in fisheries industries, coastal management, and public health agencies. We have studied the possibility of monitoring harmful algal species using specificity of chlorophyll fluorescence spectrum obtained through the investigation of fluorescence properties of various species. We found that the peak wavelengths of the chlorophyll fluorescence spectra of *Karenia mikimotoi* and *Chattonella marina* var. *antiqua* slightly shift towards longer wavelengths compared to other species. Based on these findings, we have developed an *in situ* Harmful Algal Indication sensor (HAI sensor), which measures the Fluorescence spectral Shift Index (FSI), which is defined as the ratio of fluorescence intensities at two different wavelengths (670 and 690 nm) for representing the degree of fluorescence spectrum shifts, from the fluorescence intensities excited by blue light. The performance evaluation of HAI sensor for algal strains showed that FSI of *Karenia mikimotoi* and *Chattonella marina* var. *antiqua* were higher than those of other species. These results indicate that HAI sensor is able to detect these harmful algae. The field studies, conducted in Saiki Bay, Oita Japan in 2017, compared vertical profiles of FSI measured by HAI sensor with the species composition estimated by microscopic analysis. In these observations, HAI sensor successfully detected vertical distributions of *Karenia mikimotoi*. Furthermore, we have conducted long–term mooring observation using two units of HAI sensor, which were placed at mid and near-bottom layers and connected to a telemeter system in Saiki bay, Oita Japan in 2019. In this observation, HAI sensor detected the presence of *Karenia mikimotoi* at concentrations as low as 27 cells ml^{-1}, suggesting that HAI sensor is useful for harmful algal blooms (HABs) monitoring and early warning systems.

Key words: *Karenia mikimotoi*, *Chattonella marina*, Fluorescence, Early warning system, HABs monitoring system

JFE Advantech Co., Ltd.



SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

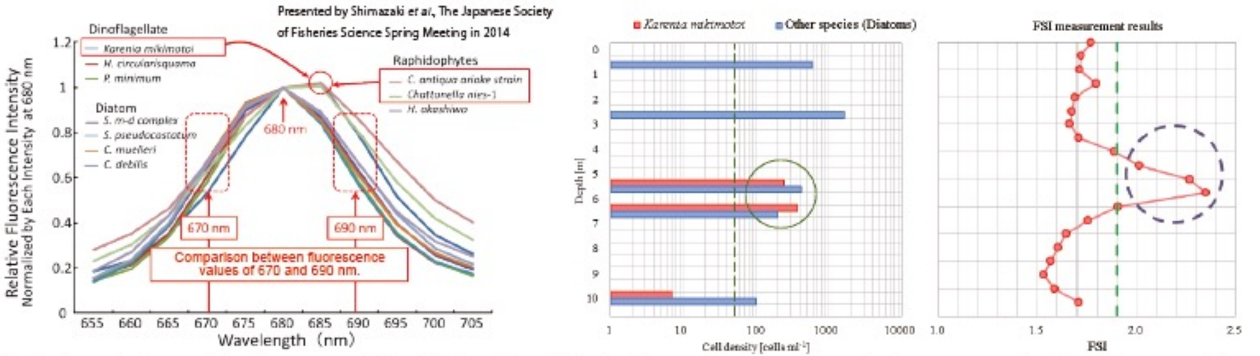
CSIRO

- Designed to identify two HAB phytoplankton species; *Karenia mikimotoi* & *Chattonella marina.*

- Uses the Fluorescence Spectral Shift Index (FSI) method to identify the species (Yoshida et al. 2021)

$$\text{FSI} = \frac{\text{Fluorescence intensity at 690 nm}}{\text{Fluorescence intensity at 670 nm}}$$

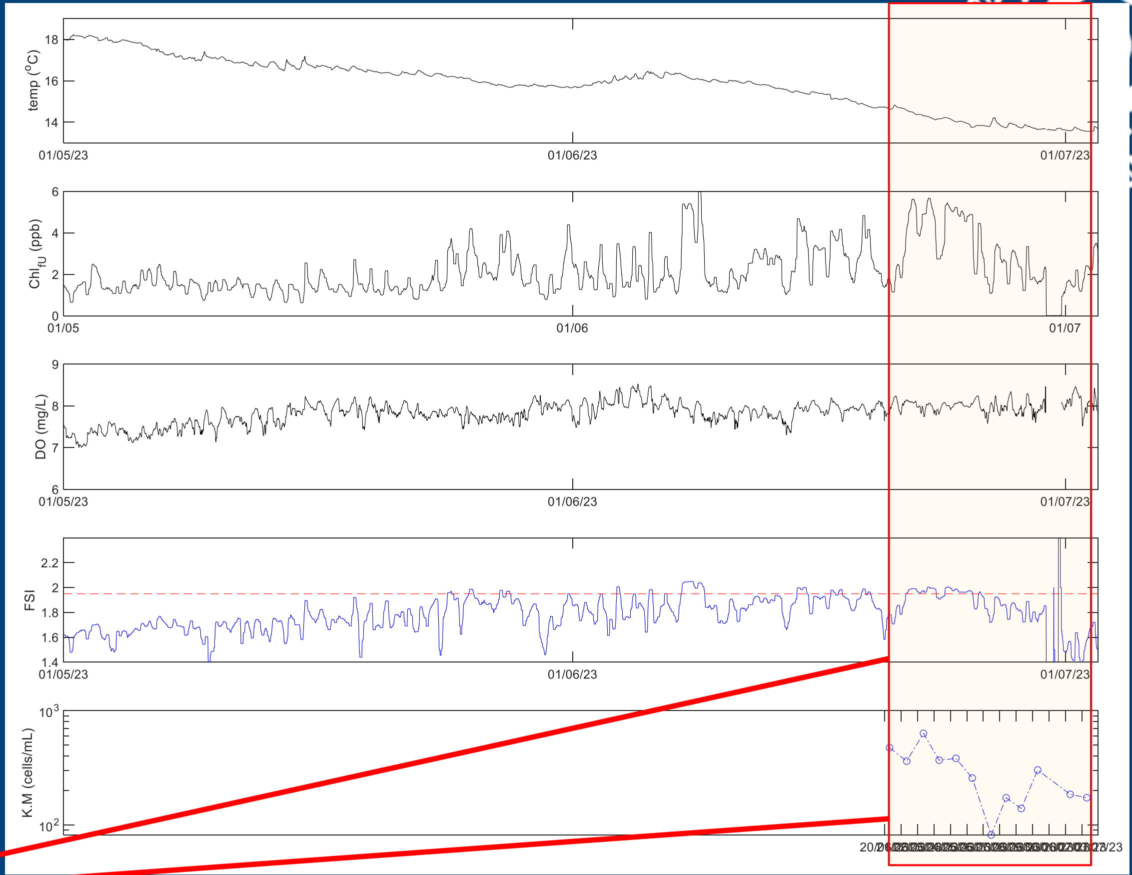
- FSI>1.95 indicative of HAB species presence at concentrations as low as ~5000 cells/L

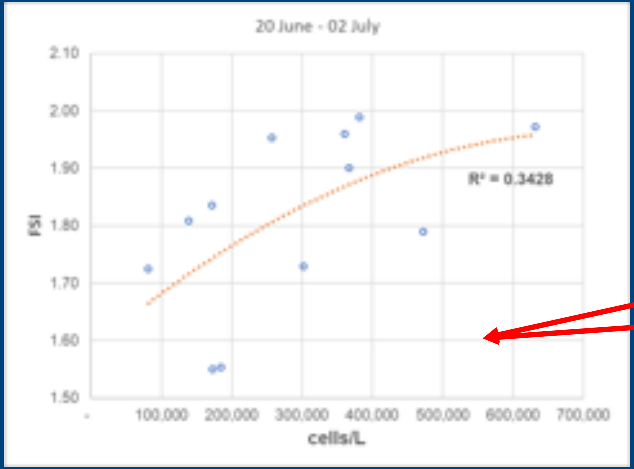


The left panel shows relative fluorescence intensity for various phytoplankton species. The mid panel shows an example of species composition estimated by water sampling and microscope analysis: a bloom of *Karenia mikimotoi* in the mid water column (green circle), where the dark green dashed line denotes 50 cells/ml threshold. The right panel shows the FSI estimated using HAI sensor for the same period. The light green dashed line enotes the FSI threshold of approximately 1.9 and the purple dashed circle denotes the FSI estimated when concentration of *Karenia mikimotoi* surpasses 50 cells/ml indicating a possible harmful algal bloom is on its way.

***Depending on conditions such as density of other dominant species, the fluorescence spectral characteristics may not be detected well due to the influence of other species.*

- In mid-June 2023 *Karenia mikimotoi* bloom in Boston Bay
- PIRSA SASQAP & Cleanseas Seafood assisted in collecting & analysing water samples from Aquawatch buoy daily for 12 days (632,000 cells/L, 22-June)
- FSI >1.95

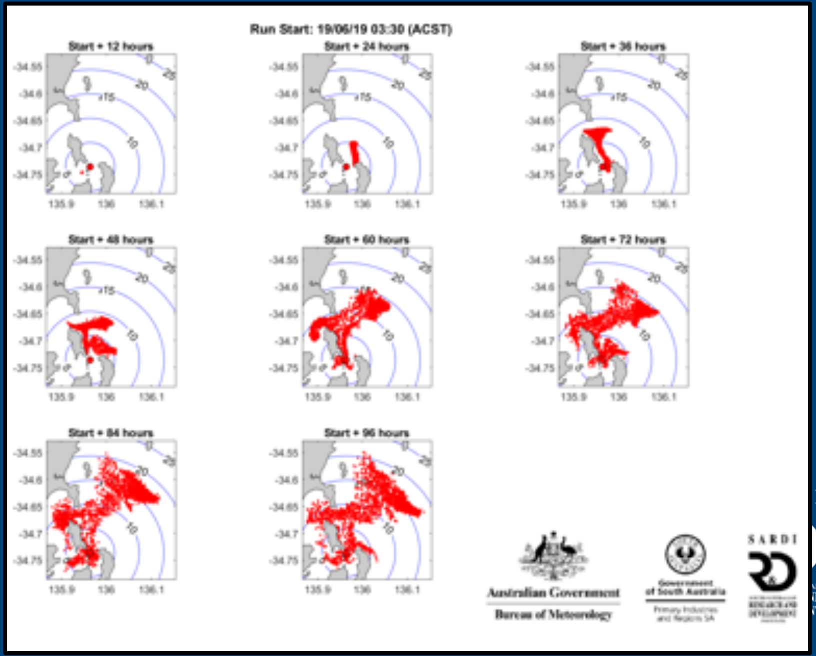




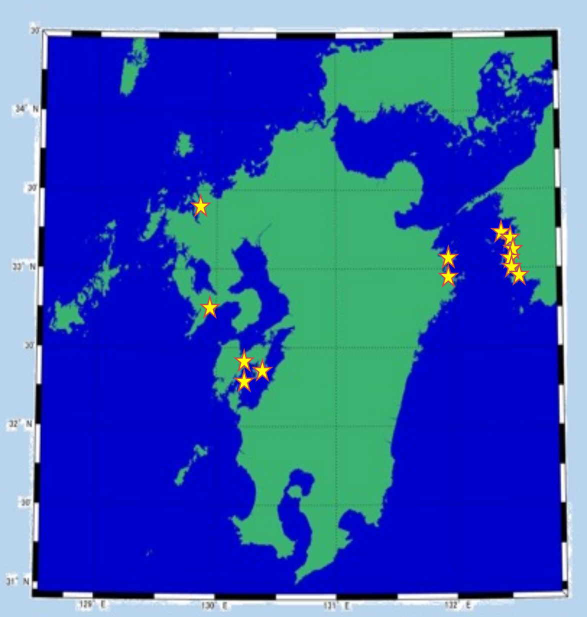
Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

- Next steps:
- Work with manufacturers to validate & improve performance & understanding of the sensor to provide reliable estimates of cell abundances,
- Integrate with eSA-Marine hydrodynamic model to provide forecasts of bloom trajectories to help mitigate HAB bloom impacts,
- Use FSI and other measured variables to better understand drivers of HAB blooms in the region.
- establish as an early detection system network,



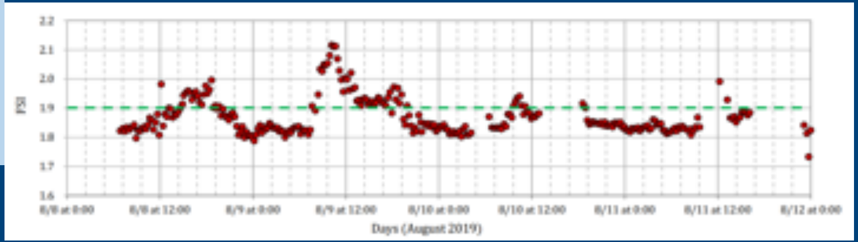
HABs Monitoring System Network



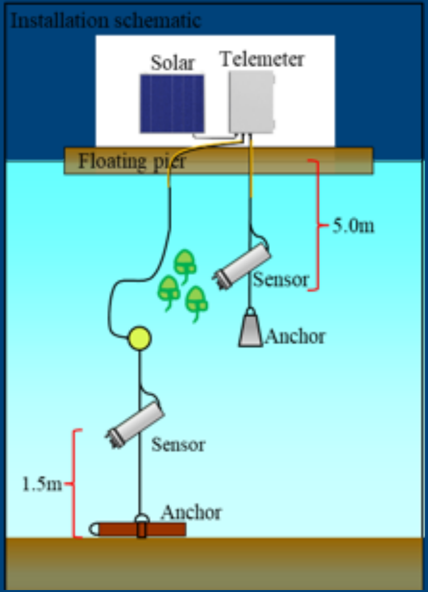
Location of systems currently in operation (Japan)

Anti biofouling wiper

Monitoring System

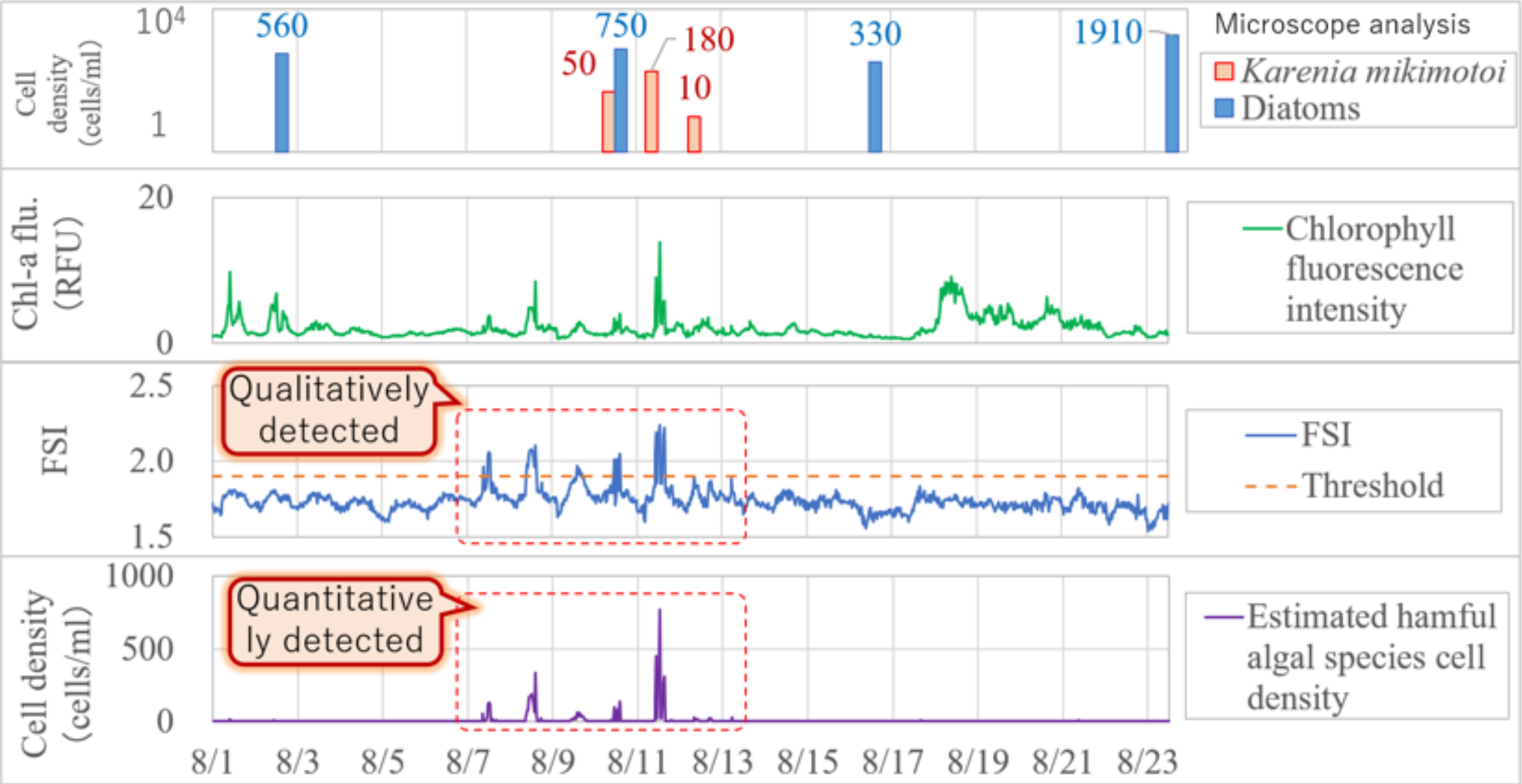


FSI continuous telemetered monitoring



Long-term monitoring results

- Ago-bay Mie Japan in 2021 (depth 5 m)



Thank you for listening
& to our partners…

Government of South Australia
Department of Primary Industries and Regions

SARDI
South Australian Research and Development Institute

CSIRO

SA Shellfish Quality Assurance Program

JFE Advantech Co., Ltd.

Australian Government
Bureau of Meteorology

xylem
Let's Solve Water

CLEANSEAS
SUSTAINABLE SEAFOOD

Government of South Australia
Department of Primary Industries and Regions
SARDI
South Australian Research and Development Institute