ECOLOGICAL CONSIDERATIONS FOR CLIMATE INDICATORS

ANISSA FOSTER

AUGUST 16, 2021

CRWG MEETING

PHOTO CREDIT: MATT RATH, STEVE DROTER, ALICIA PIMENTAL

INTRODUCTION

- Climate Change Indicators Intern
- Stanford University
- Earth Systems – Oceans, Atmosphere, and Climate Major

PURPOSE

- Support the Chesapeake Bay Program in the development of the Bay Water Temperature Change indicator
  - Compile potential uses for a Bay Water Temperature Change Indicator related to fish impacts in Chesapeake Bay.
  - Review the literature to develop ideas for ecological impact indicators that connect water temperature change to fish habitat suitability.
  - Consider existing data for use with conceptual ideas related to ecological indicators.

PHOTO CREDIT: WILL PARSON

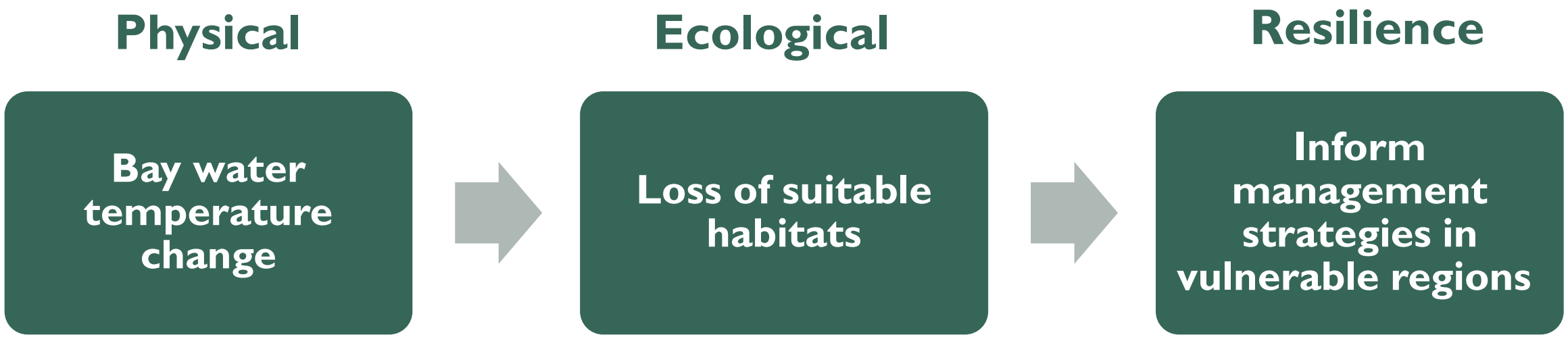
CLIMATE CONTEXT

Warmer water temperatures . . .

- Stress aquatic ecosystems by making them less hospitable for certain species or by upsetting the competitive balance between species.
- Lower the ability for water to carry dissolved oxygen, contributing to conditions that support harmful algal blooms.
- Decrease aragonite saturation, creating less suitable habitat for shellfish.
- The impacted ecosystems lead to economic impacts by influencing fishing/crabbing and recreation in the Bay.

CITATION: EASTERN RESEARCH GROUP, INC. 2018; PHOTO CREDIT: STEVE DROTER

CONNECTING THE INDICATOR TO ECOLOGICAL IMPACTS



Connecting physical change with ecological impact indicators can advise decisions for climate resilience

DEVELOPING A BAY WATER TEMPERATURE CHANGE INDICATOR

To develop a Bay Water Temperature Change Indicator, we must lay out

- Intended management applications of a tidal Bay temperature indicator
- Resultant characteristics of such an indicator
- Requisite spatial and the temporal data requirements for quantifying the indicator

PHOTO CREDIT: WILL PARSON

METHODS

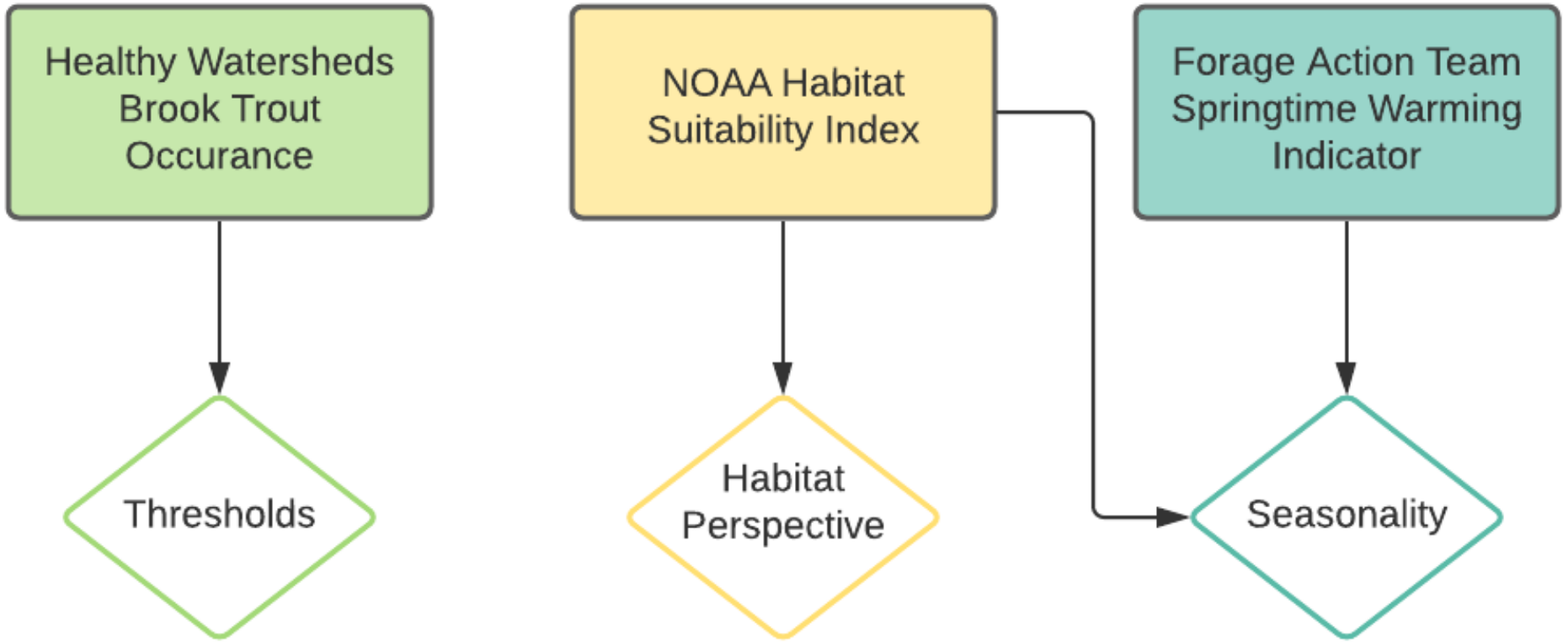
- Literature Review
  - Documented ecological indicators
  - Vulnerability assessments
  - EPA Indicators
  - Forage Indicators (Forage Action Team)
- Meetings
  - Rising Water Temperatures STAC Workshop Effort
  - Sustainable Fisheries Summer Goal Team Meeting

RISING WATER TEMPERATURE STAC WORKSHOP EFFORT

- Participated in developing a pre-workshop synthesis paper on indicator considerations for bay water temperature change related to natural resource management responses
- Findings include:
  - Working towards an ecological impact indicator needs to consider potential management applications to eventually connect with resilience progress
  - Given data limitations, a multi-data approach could allow for a more robust indicator

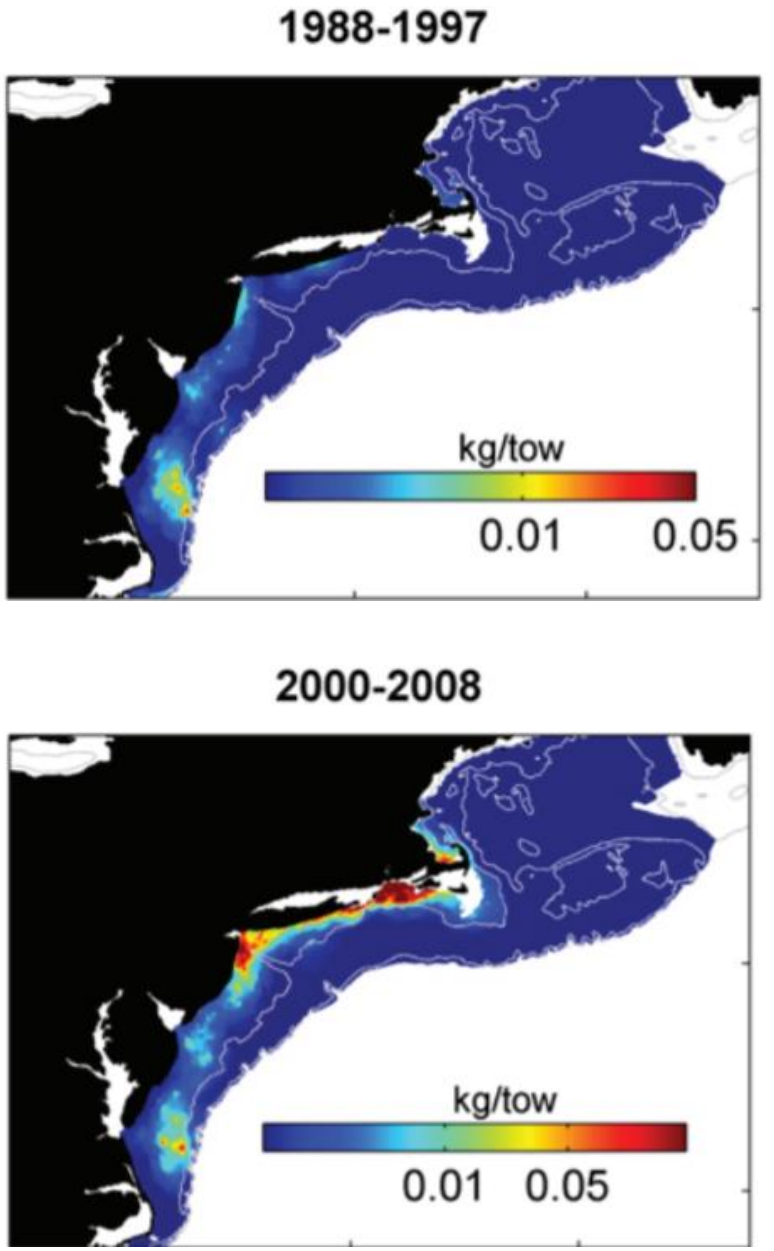
INDICATOR-RELATED EFFORTS

RELATED TO HABITAT AND LIVING RESOURCES



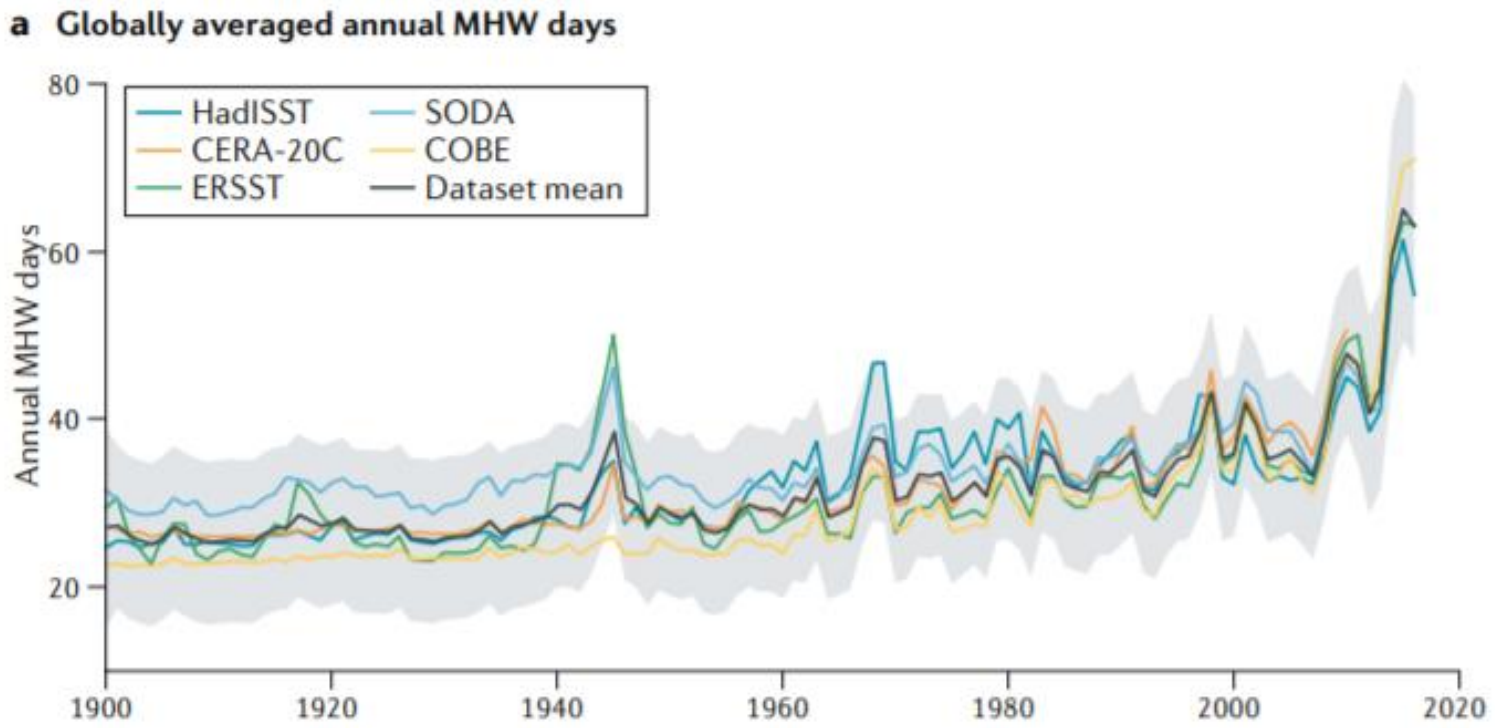
LITERATURE REVIEW –
DISTRIBUTION CHANGE

- Climate-forced changes in species distributions are causing changes in both fishery operations and fisheries management.
- Fisheries along the Northeast United States serve as an example of reactions to climate change: fish and shellfish populations are shifting predominantly northward or to deeper waters.



CREDIT: JASON S. LINK, ROGER GRIFFIS, SHALLIN BUSCH (EDITORS). 2015. NOAA FISHERIES CLIMATE SCIENCE STRATEGY. U.S. DEPT. OF COMMERCE, NOAA TECHNICAL MEMORANDUM NMFS-F/SPO-155, 70P

LITERATURE REVIEW –
HEAT WAVE EVENTS



CITATION: HOLBROOK ET AL. 2020. KEEPING PACE WITH MARINE HEATWAVES. NATURE REVIEWS EARTH & ENVIRONMENT

INDICATOR CONCEPTS

PHOTO CREDIT: WILL PARSON

IMPORTANT SPECIES FOR THE CHESAPEAKE BAY

Representative Predators

Five predator species were selected by the Steering Committee of the 2014 Forage Workshop to serve as representative indicator species for the range of predators and lifestyle types in the Chesapeake Bay. The selected species included:

Striped Bass
anadromous, piscivore

Summer Flounder
mesohaline-polyhaline, piscivore

Atlantic Croaker
oligohaline-polyhaline, omnivore

Clearnose Skate
polyhaline, omnivore

White Perch
oligohaline, omnivore

To identify important forage in the Chesapeake Bay ecosystem, an analysis of a long term, fishery-independent survey (ChesMMAP) was conducted to quantify the gut contents of five representative predator species.

Forage species were considered important if the forage taxon or group composed at least 5% by wet weight of a predator's diet in at least one of the five ChesMMAP seasonal sampling cruises taken during any year of the study (on right).

Forage species are critical to sustaining production of economically and ecologically valuable fish species in the Chesapeake Bay.

Key Forage*

Bay Anchovy

Polychaetes

Mysids

Amphipods and isopods

Weakfish (juveniles)

Spot (juveniles)

Mantis shrimp

Razor clams

Sand shrimp

Atlantic croaker (juveniles)

Macoma clams

* Based on wet weight of prey in stomach analysis of 5 representative predators in the Chesapeake Bay (ChesMAPP)

Additional Important Forage

Managed forage species

Atlantic menhaden

Blue crab

Historically important

Shad & river herrings

Forage of Upriver Predators

Small bivalves

Atlantic Silverside

Mummichog

Additional species were added to the list of important forage by the participants of the Forage Workshop to include forage of under-represented freshwater predators, historically important forage, and managed forage (additional important forage above).

For more details on this analysis, please view the Scientific and Technical Advisory Committee's 2014 Forage Workshop Report.

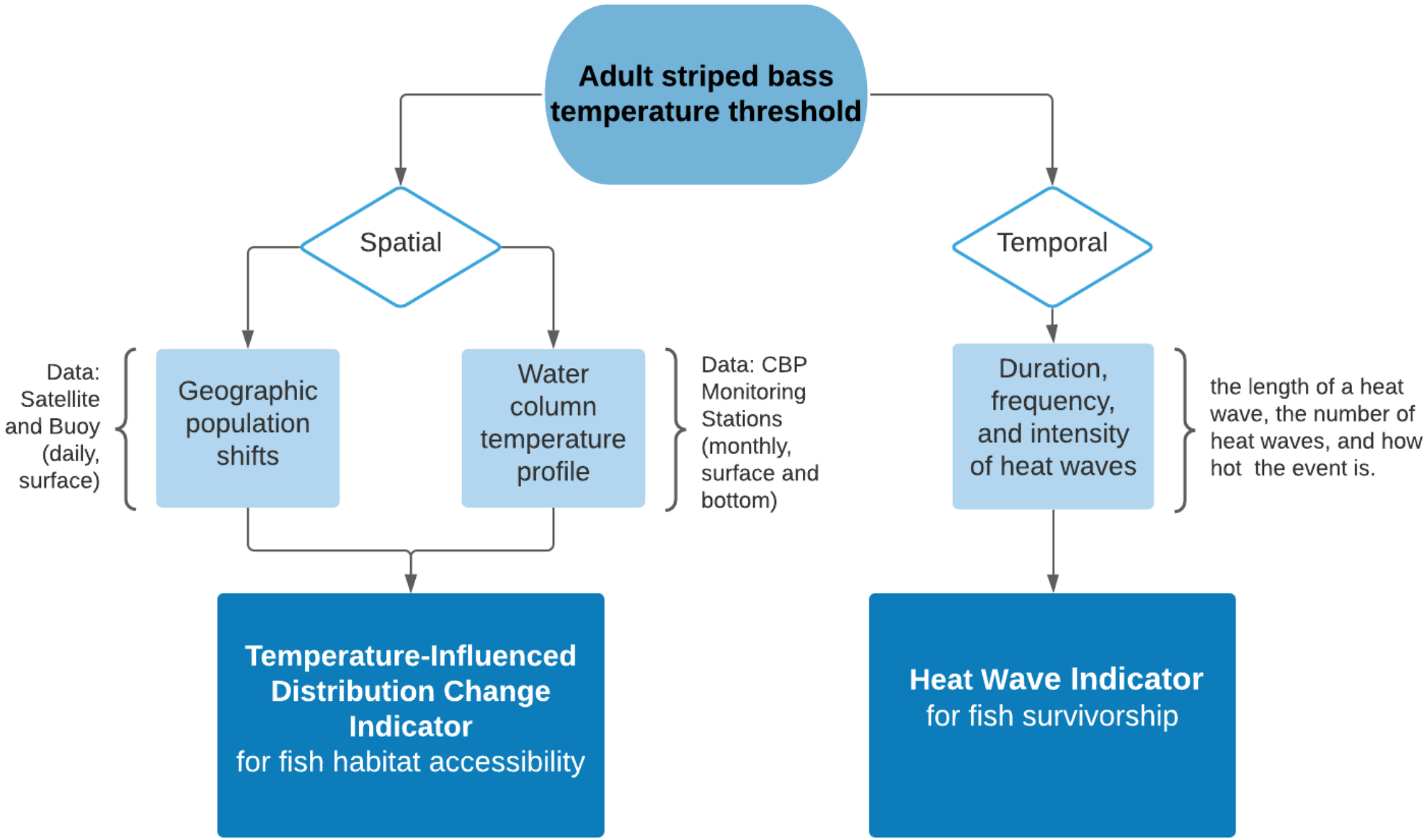
Above data is based on the 2014 Scientific and Technical Advisory Committee Forage Workshop

STRIPED BASS

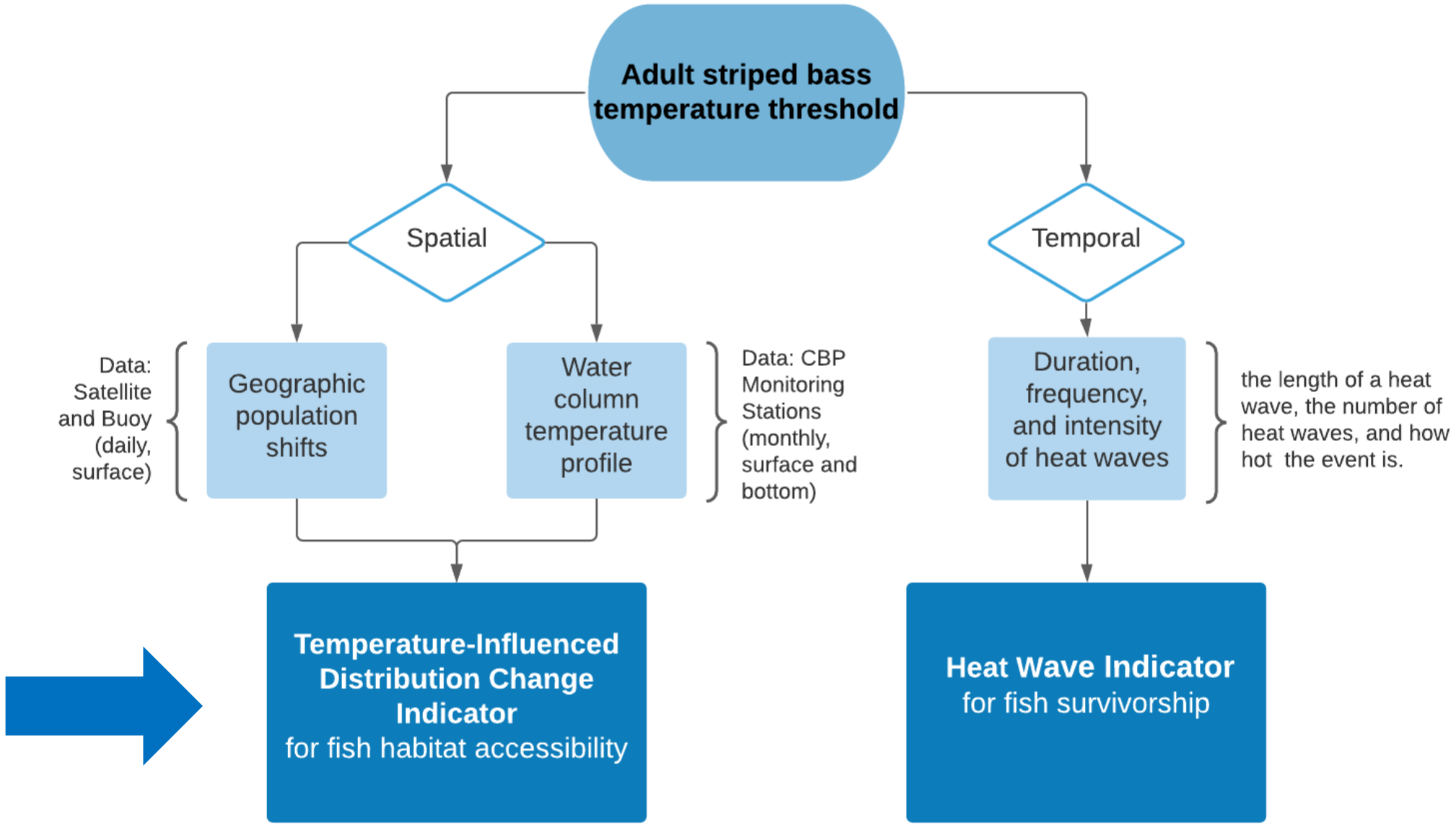
- Focused on indicator concepts related to fish habitat
- Important to the Chesapeake Bay because they support one of the most important commercial and recreational fisheries on the Atlantic Coast,
- The Bay provides these fish with critical spawning and nursery grounds

PHOTO CREDIT: WILL PARSON

Fish Habitat Suitability



Fish Habitat Suitability

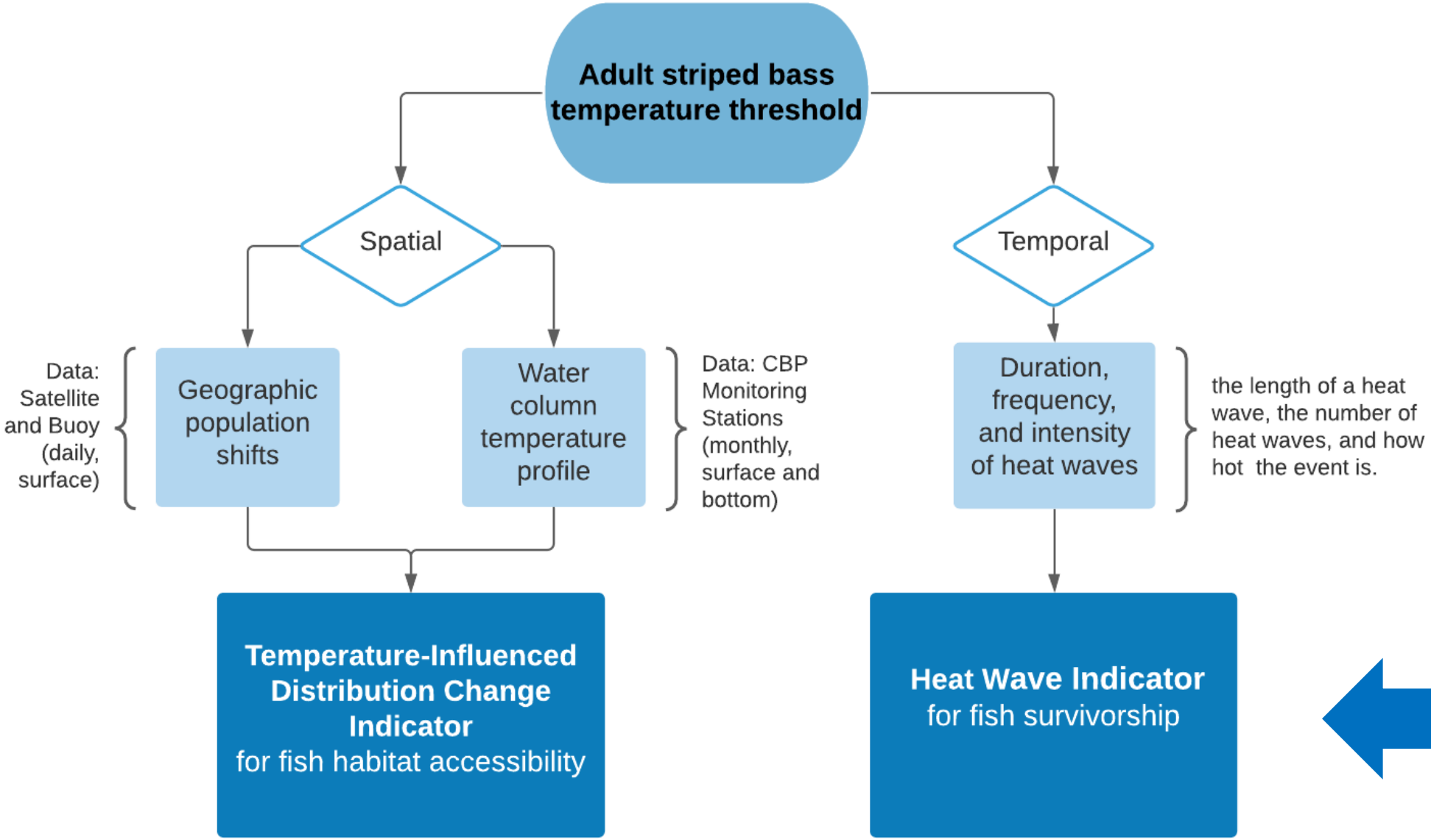


TEMPERATURE AND DISSOLVED OXYGEN: STRIPED BASS EXAMPLE

- Habitat requirements for inland striped bass include dissolved oxygen levels above 2–3 mg/L and temperatures below 25°C to thrive.
- As summer stratification develops striped bass selected preferred temperatures of 20–23°C if the DO was at least 2 mg/L.
- Striped bass remained at the top of the oxycline into the fall, even after deeper water with preferred temperatures became available.

THOMPSON, J. S., RICE, J. A., & WATERS, D. S. (2010). STRIPED BASS HABITAT SELECTION RULES IN RESERVOIRS WITHOUT SUITABLE SUMMER HABITAT OFFER INSIGHT INTO CONSEQUENCES FOR GROWTH. TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY, 139(5), 1450-1464.

Fish Habitat Suitability



HEAT WAVE INDICATOR CHARACTERISTICS

Frequency
the number of heat waves that occur every year.

Duration
the length of each individual heat wave, in days.

Season length
the number of days between the first heat wave of the year and the last.

Intensity
how hot it is during the heat wave.

NEXT STEPS

CONSULTATION WITH FISH EXPERTS IMPORTANT IN DEFINING INDICATORS TO DEVELOP

PRESENT WORK AT RISING WATER TEMPERATURE STAC WORKSHOP

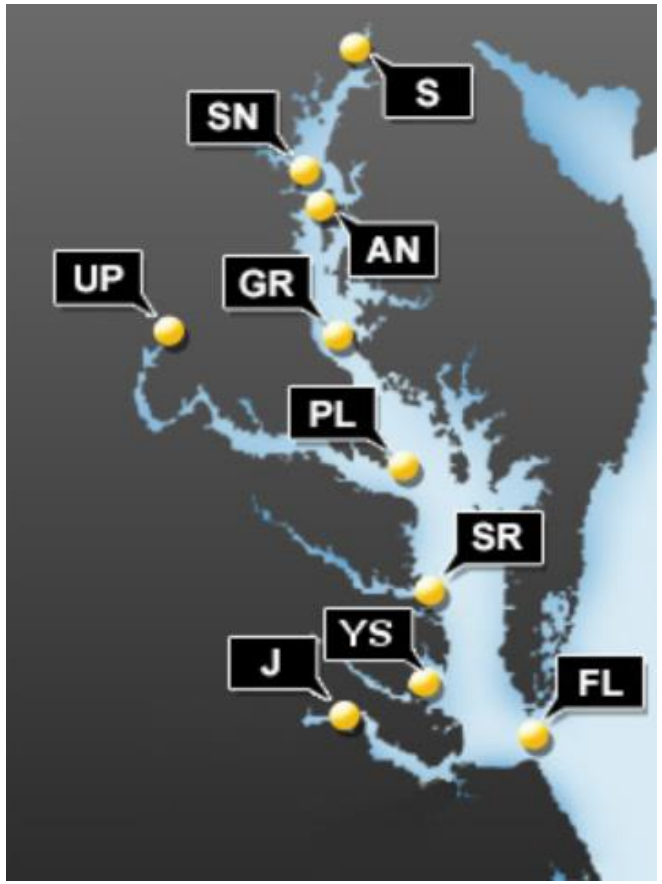
CONSIDER A MULTI-DATA APPROACH TO ADDRESS DATA GAPS

MAIN DATA SOURCES

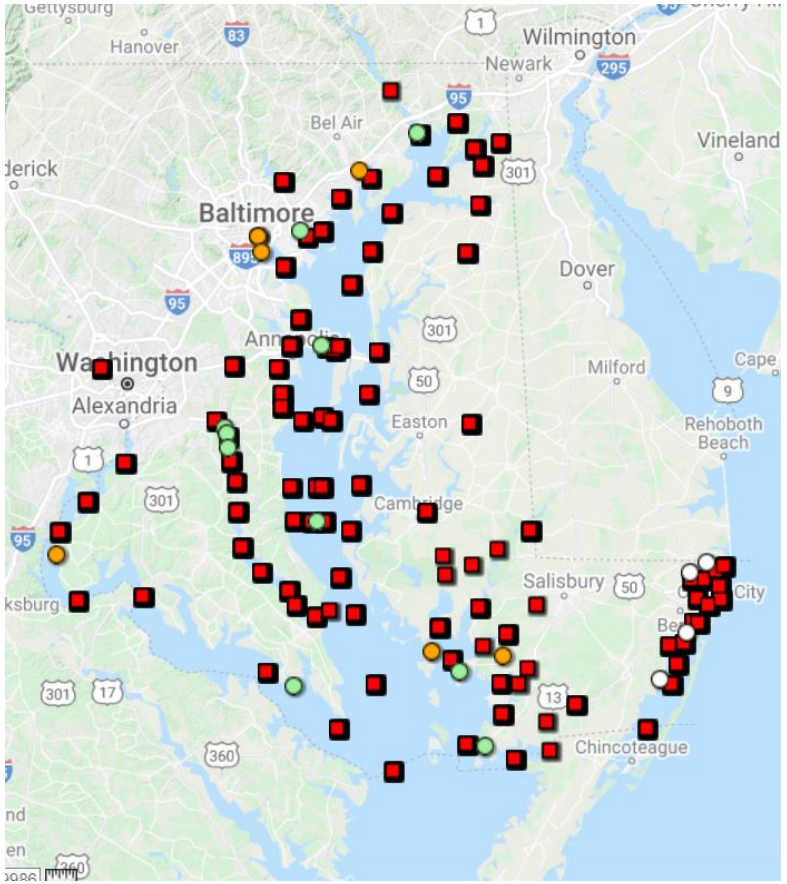
Data Source	Reading Depth	Reading Date	Gaps	Sampling Frequency
CBP Data Hub	Surface, Bottom	1984 – present	Varies with data source	Monthly
Eyes on the Bay	Shallows	1985 – present	Varies with station (3-year rotation)	15 min
NOAA CBIBS	0.5 meters below surface	2008 – present	Varies with buoy	10 – 60 min
NOAA Satellite Data	Surface	2002 – present	2002 – 2006	Daily
National Data Buoy Center	0.5 – 2 meters below MLLW	1985 – present	Some stations with no data for 8 hrs. or more	6 – 10 min

CREDIT: SHALOM FADULLON

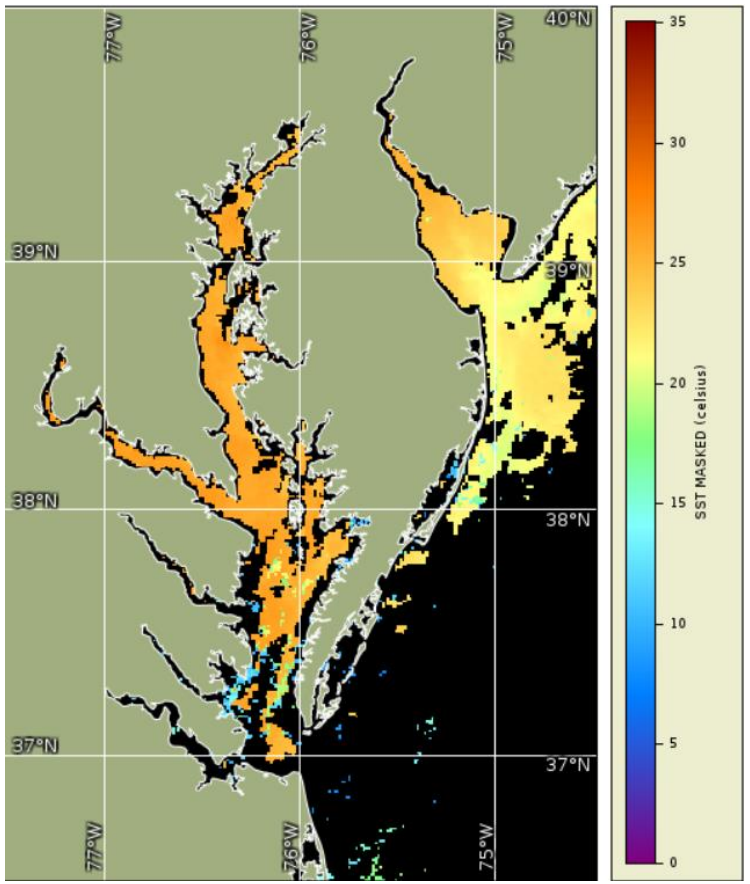
NOAA CBIBS



EYES ON THE BAY



NOAA SATELLITE



CHALLENGES

- How and who will compile data from multiple sources in format that can be applied towards indicator development for the management temporal and spatial scales of interest?
- How and who will maintain and update the indicators after they have been developed?

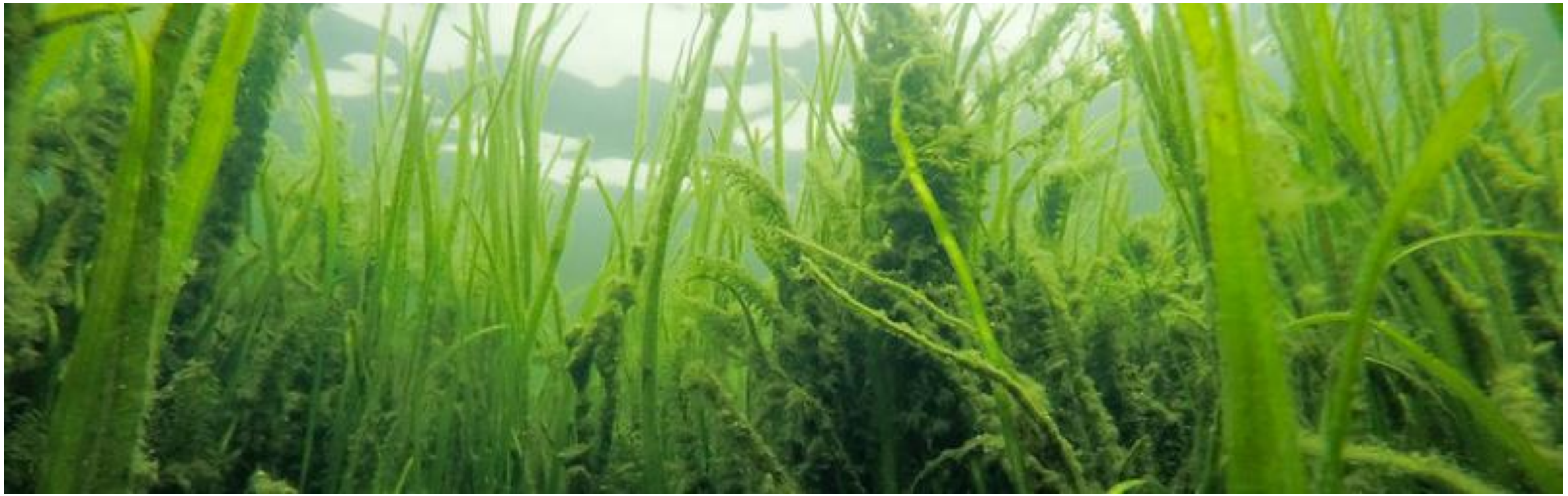


PHOTO CREDIT: WILL PARSON

THANK YOU TO MY WONDERFUL MENTORS JULIE REICHERT-NGUYEN AND BRECK SULLIVAN!

DISCUSSION

- Do you know of similar research connecting climate change to ecological impacts?
- Are there any recommendations for indicator concepts?
- Are there other species of interest for this work?

CREDIT: WILL PARSON