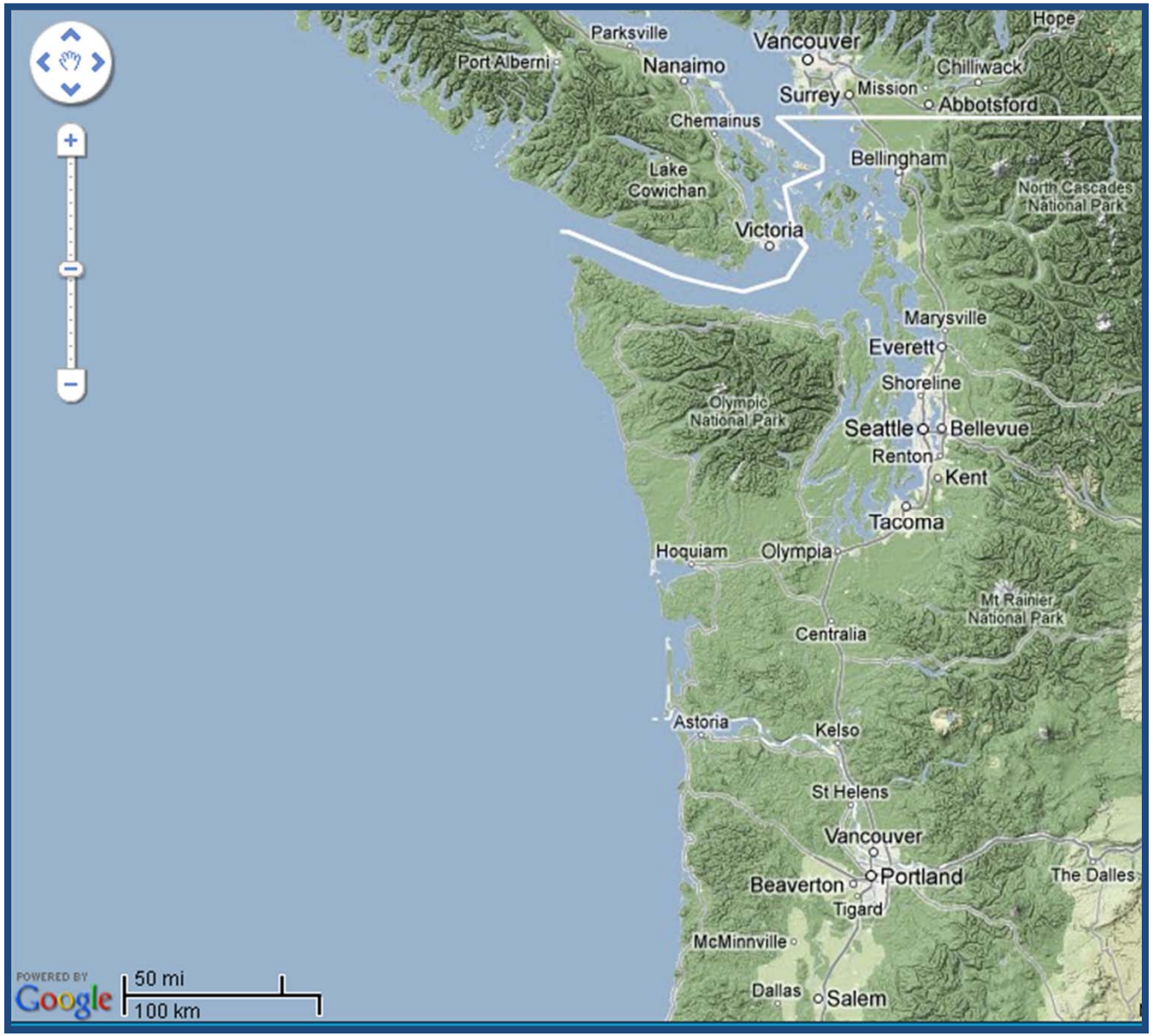
Draft Science Recommendations

For discussion by the Blue Ribbon
Panel on Ocean Acidification
on 20 June 2012

Science Recommendations

1. Understand the status, trends, and drivers of OA in Washington waters
2. Estimate the magnitude of human contributions to OA in Washington waters
3. Characterize biological responses among local species
4. Build capabilities for short-term forecasting and long-term prediction
5. Develop scientifically-based strategies to protect the shellfish industry
6. Integrate science into adaptation and mitigation strategies
7. Create mechanisms to advance OA science for the benefit of Washington State

Washington waters



1&2. Understand status, trends, and drivers

- Characterize:
  - the carbonate chemistry and pH of marine waters in WA
  - variation in chemistry over space and time
  - how the watershed, ocean, and atmosphere affect the status
  - how the status and trends in biological communities reflect the chemical conditions

- *To answer:*
  - *What are the status and trends of OA in WA waters?*
  - *Quantitatively, what factors drive these trends and variations?*
  - *What is the magnitude of human contributions to OA in WA waters?*
  - *How are the biology and chemistry linked?*

1&2. Understand status, trends, and drivers

- *<u>Approaches</u>:*
  - *CONSTRUCT OVERALL BUDGET: Conduct field sampling to construct carbon budget and quantify OA drivers*
  - *QUANTIFY KEY PROCESSES: Deploy/maintain moorings, gliders, shore stations to provide high temporal resolution data to discern OA drivers*
  - *ASSESS SPATIAL CONDITION: Conduct seasonal surveys to provide spatial definition of current conditions, vulnerable areas, data for predictive relation development*
  - *USE MODELS: Develop and/or utilize models of OA relevant processes*
  - *ESTABLISH INDEX STATIONS: Establish index stations to measure biology, chemistry, oceanography together*
  - *DEVELOP AND REFINE PREDICTIVE RELATIONSHIPS: Utilize high quality data to formulate spatially-defined equations to estimate carbon chemistry and pH from commonly made measurements*

1&2. Understand status, trends, and drivers

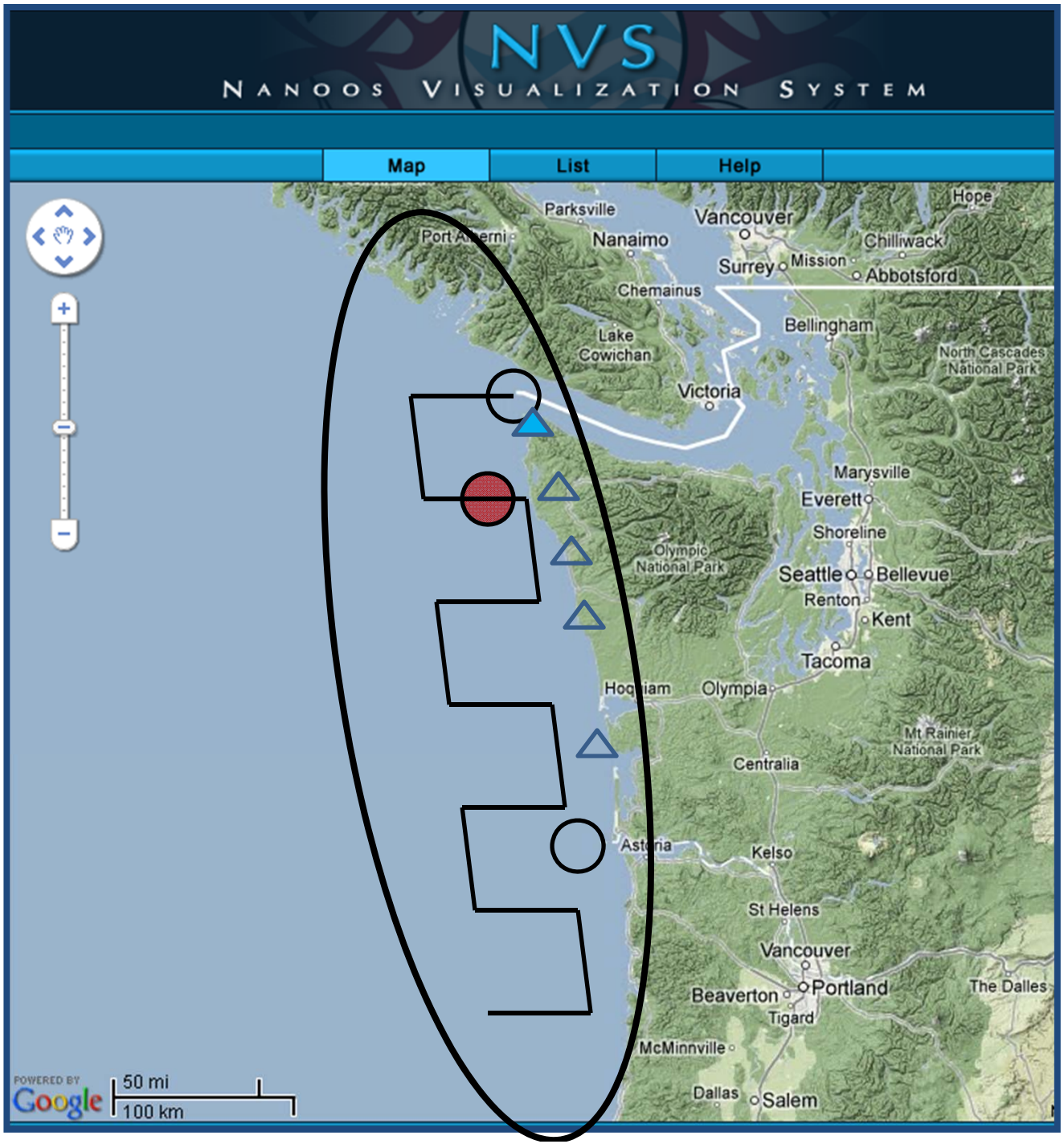
- *<u>Build upon</u>:*
  - *WA Coast: NOAA surveys, NANOOS buoy, OCNMS moorings, UW cruises*
    - *Wave Glider, La Push Cha'ba buoy, NOAA ship cruises and sensors*
  - *Puget Sound/Strait: NOAA sensors-UW moorings, PCSGA stations, JEMS*
    - *Dabob and Twanoh buoys, Taylor & Lummi hatcheries, timeseries at FHL and Strait*
  - *Columbia River: NSF Coastal Margin Observation & Prediction stations*
    - *Salinity gradient stations in Columbia River estuary*
  - *Shallow estuaries: WA Sea Grant and PS Partnership studies, PCSGA stations*
    - *Totten Inlet and Willapa Bay timeseries*
  - *Biological time-series: Research scientists, WDFW, ONP, OCNMS*
    - *Intertidal biodiversity time series on Tatoosh Island; Puget Sound cobble beaches;*
    - *Oyster and clam larval and recruitment time series from Willapa Bay and Hood Canal*
  - *Models: numerical modeling by Ecology, UW, NOAA, and others*
    - *Hydrodynamic, water quality, biological modeling*

Outer WA Coast specifics

Work to establish critical buoys off Strait and Columbia River

Use gliders to survey coast

Include nearshore observations



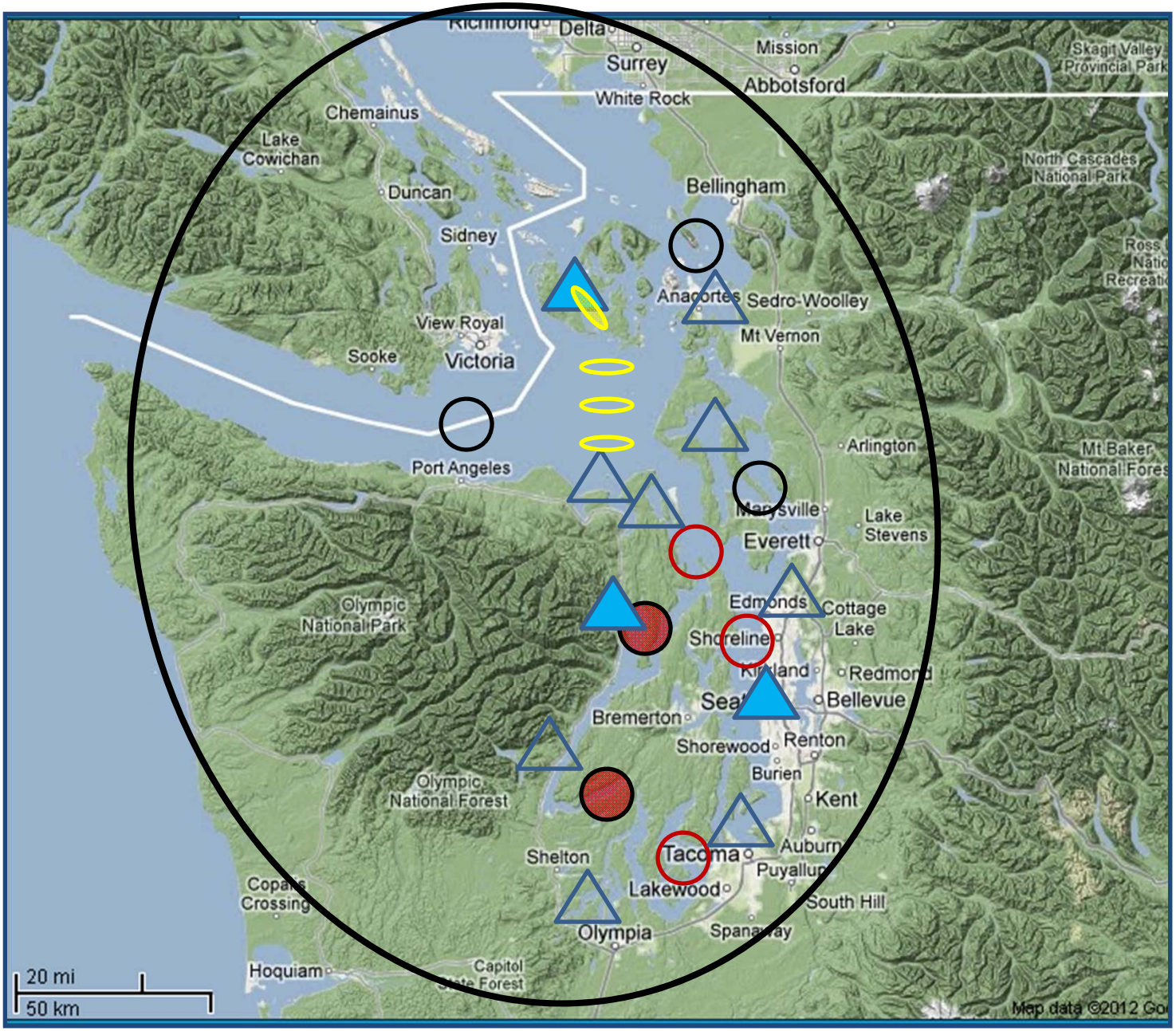
Puget Sound & Strait of Juan de Fuca specifics

Need moorings/ sensors in more basins (e.g., South Sound, Whidbey, Main Basin, Admiralty Inlet, Northern straits

Need support for measurements in Strait

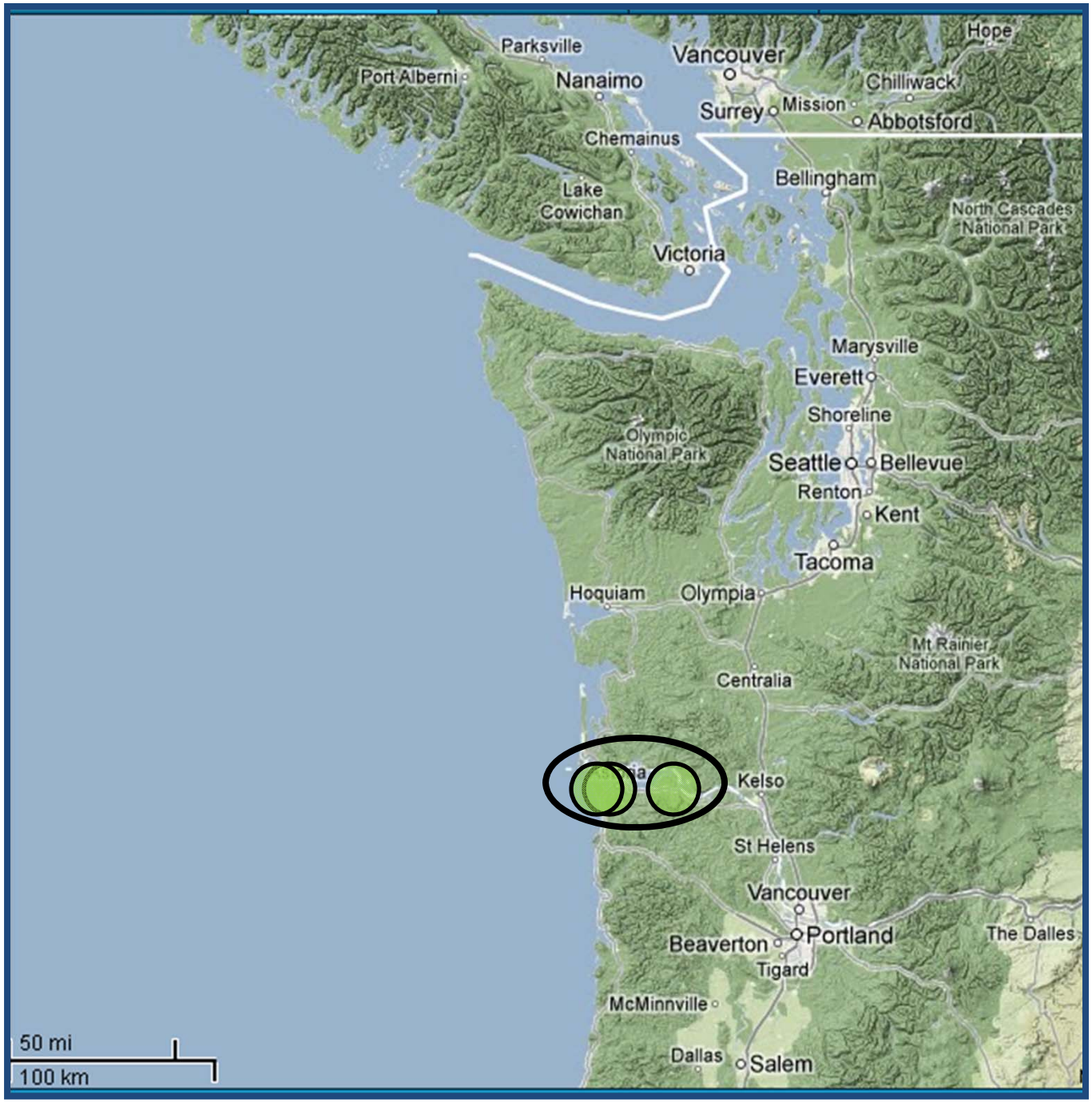
Need land-based index stations

Coordinate with Canada



Columbia River estuary specifics

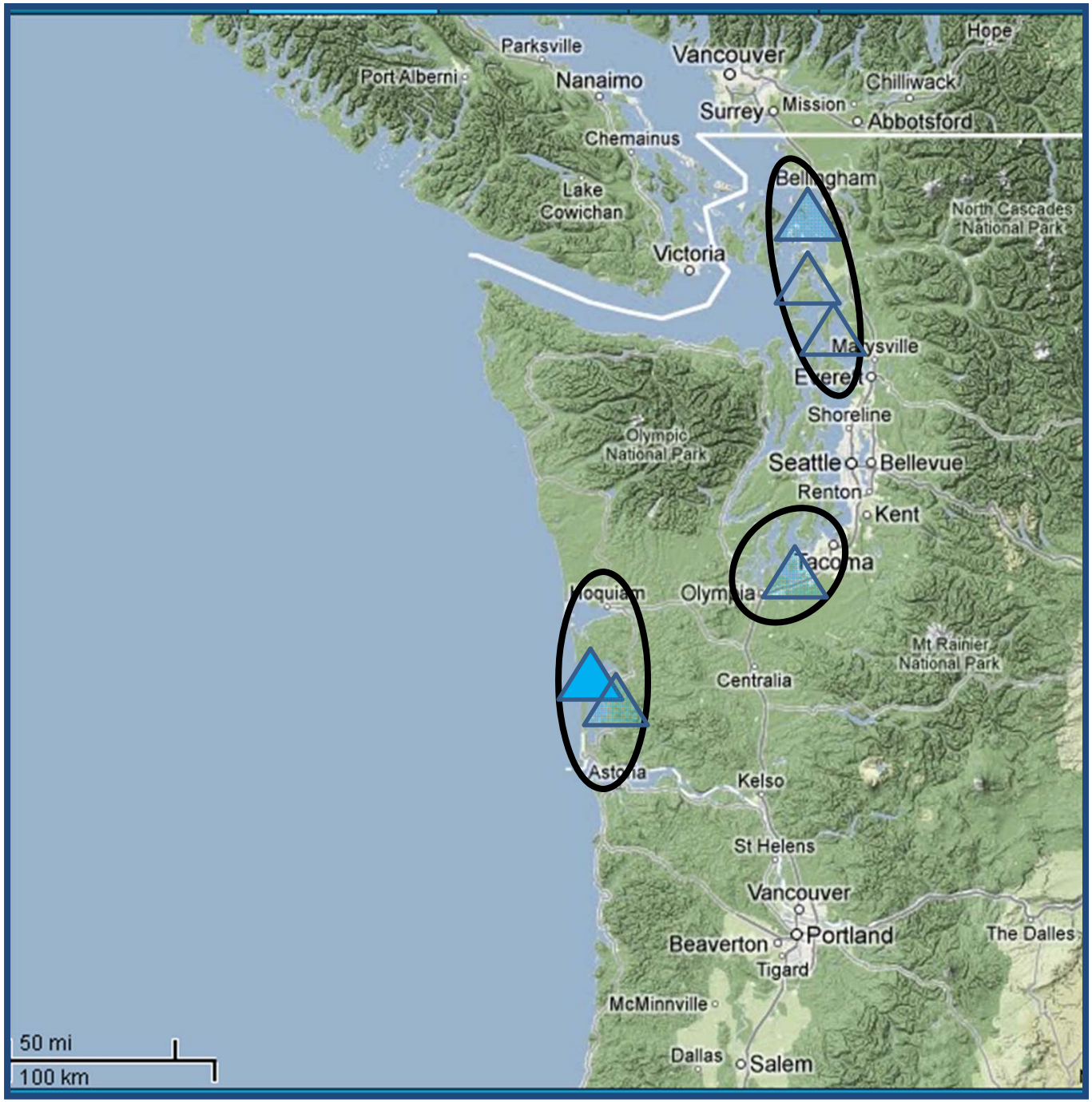
Leverage existing measurements from OHSU-CMOP



Shallow estuary specifics

Support continuation of chemistry/biology time-series index stations in Willapa, Totten, and Lummi

Establish new stations in N Puget Sound and Whidbey basins



3. Characterize Biological Responses

- Investigate:
  - The responses of local species and communities to changing carbonate chemistry and pH
  - The synergistic effects of multiple stressors

- *To answer:*
  - *How will local species and communities change under OA?*
  - *How will multiple stressors influence these changes?*
  - *Which species are at high risk of negative response?*
  - *Which species are likely to respond positively?*

3. Characterize Biological Responses

- *<u>Approaches</u>:*
  - *IDENTIFY DIRECT EFFECTS: Understand how pH, pCO_2, and other stressors affect species and populations*
  - *IDENTIFY INDIRECT EFFECTS: Understand how disruption of food webs, changes in habitats, etc. affect species and populations*
  - *PRIORITIZE: Species of ecological, economical, & cultural significance; species of conservation concern*

3. Characterize Biological Responses

- *<u>Build upon</u>:*
  - *Experimental studies conducted by NOAA, UW, WWU, Industry, and others*
  - *Field observations and biological monitoring conducted by state and federal agencies, universities, tribes, industry, and others*

4a. Build forecasts

- Develop:
  - **Short-term forecasts that:**
    - Use real-time and forecasted values of atmospheric and oceanographic variables to indicate risk of corrosive conditions

- *To answer:*
  - *Can forecasts of risk of corrosive conditions help the shellfish industry and tribal and state natural resource managers?*
  - *Can biological proxies be used in developing forecasts?*

4a. Build forecasts

- *<u>Approaches</u>:*
  - *DEVELOP FORECASTS FROM CORRELATIONS: Identify atmospheric, oceanographic, and biological variables that correlate with corrosive conditions; develop a suite of risk indicators*
  - *PROVIDE INDICATORS FROM NOW-CAST DATA: Maintain access to now-casts from the risk indicators*

4a. Build forecasts

- *Build upon:*
  - NOAA progress on predictive equations of chemistry for outer coast and associated data on atmospheric and oceanographic conditions from NOAA, UW, others
  - Regional availability of observational and modeling data for potential atmospheric and oceanographic indicators from Climate Impacts Group, UW, NOAA, others
  - NANOOS capability for real-time data display for adaptation to risk forecasting
  - Regional biological time-series by UW, WDFW, OCNMS, others for assessing biological proxies

4b. Build predictive capability

- Develop:
  - **Long-term predictions of:**
    - How watershed, oceanic, and atmospheric drivers of OA will affect future status; natural and human-caused
    - How the carbonate chemistry and pH of WA marine waters will respond to future changes in OA drivers, over space and time
    - How organisms and biological communities will respond to the chemical changes

- *To answer:*
  - *What are future predictions of OA status in WA?*
  - *What biological scenarios are possible?*

4b. Build predictive capability

- *<u>Approaches</u>:*
  - *USE ANALYTICAL TOOLS: to develop predictions about the progression of OA and about the response of food webs to changes in carbonate chemistry*
  - *DEVELOP PREDICTIVE MODELS: to determine chemical changes and biological community responses*

4b. Build predictive capability

- *<u>Build upon</u>:*
  - *Atmospheric and oceanographic models by NOAA, UW, others*
  - *Local circulation models by UW, NOAA, PNNL, others*
  - *Nutrient loading model by Washington Ecology & PNNL*
  - *Biological modeling by NOAA, UW, others*
  - *Experimental studies by NOAA, UW, others*

5. Protect Shellfish Production

- Investigate:
  - The impacts of OA on shellfish production and ways to mitigate these impacts

- *To Answer:*
  - *What actions can we take to protect the shellfish industry from adverse effects of OA?*
    - *Can we select for strains of shellfish that show greater resistance to OA?*
    - *Can culture practices be further modified?*

5. Protect Shellfish Production

- *<u>Approaches</u>:*
  - *Use hatcheries and farms as experimental sites and sources of data*
  - *Test mitigation potential in hatcheries, on farms, and in laboratories*
  - *Develop resistant strains*
  - *Promote collaboration across agencies, tribes, universities, industry, and others*

5. Protect Shellfish Production

- *<u>Build upon</u>:*
  - *Existing programs within hatcheries (e.g., Taylor, Whiskey Creek) and on farms*
  - *Existing collaborations between agencies, industry, tribes, researchers, and others*

6. Integrate science into adaptation and mitigation strategies

- *<u>Approach</u>:*
  - *Create partnerships between scientists and others to promote the integration of science into adaptation and mitigation strategies*
- *<u>Build upon</u>:*
  - *Existing relationships to establish necessary capacity and new partnerships for innovation*
  - *New knowledge and emerging scientific understanding*

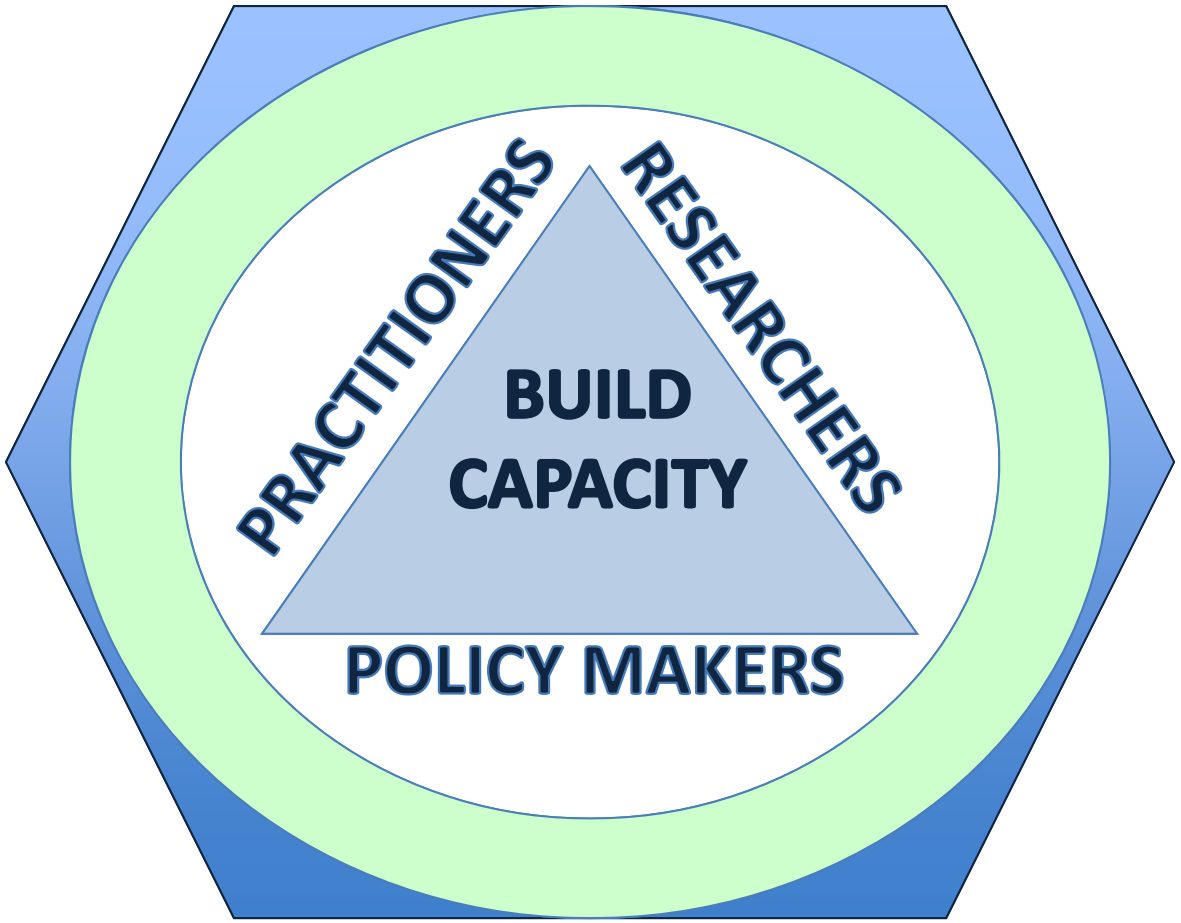
7. Create mechanisms to advance OA science for the benefit of Washington State

<u>Approach:</u>

- ***Establish and fund a consortium*** *made up of Washington State policy makers, scientists, tribes, business leaders, and others whose mission is to advance knowledge, mitigation, and adaptation with respect to OA in Washington State*


PRACTITIONERS
RESEARCHERS
BUILD
CAPACITY
POLICY MAKERS

UNDERSTAND STATUS, TRENDS, DRIVERS



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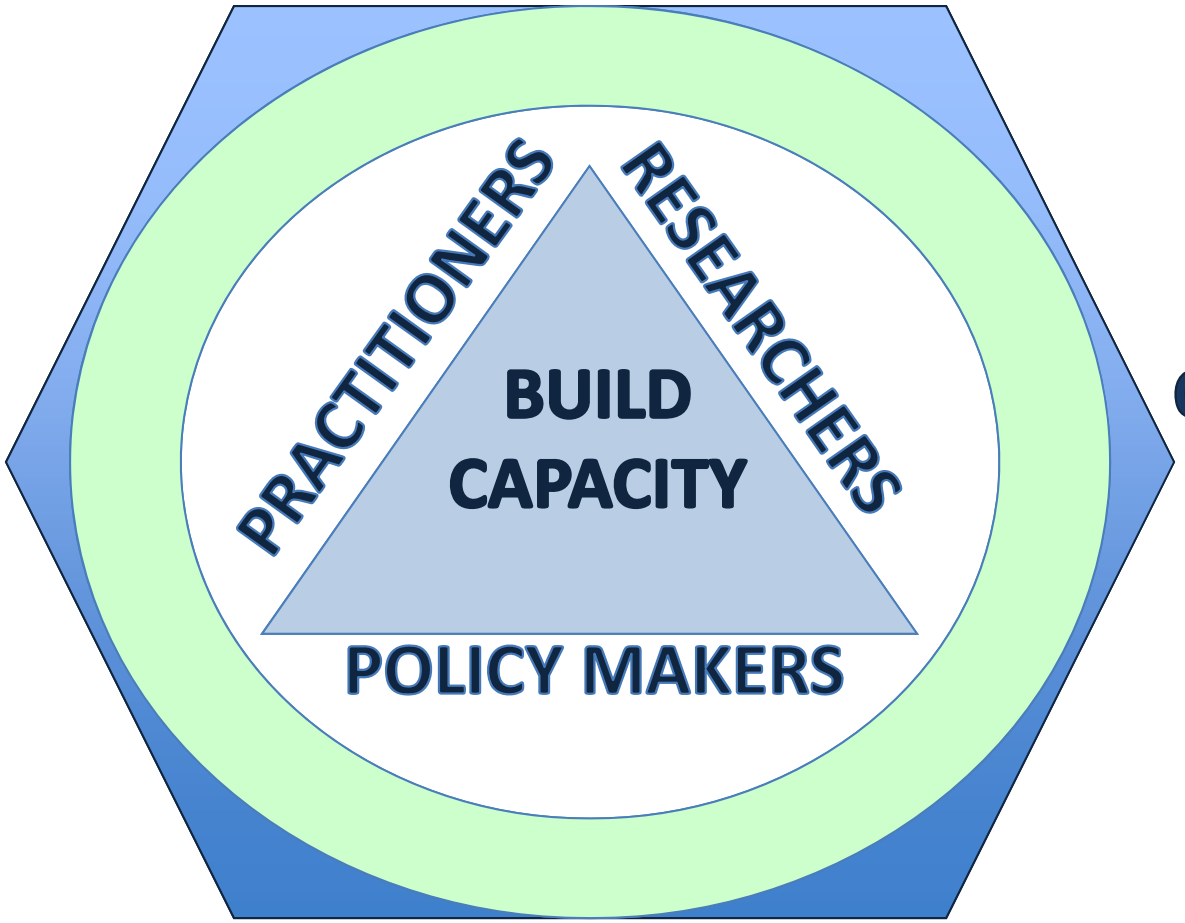

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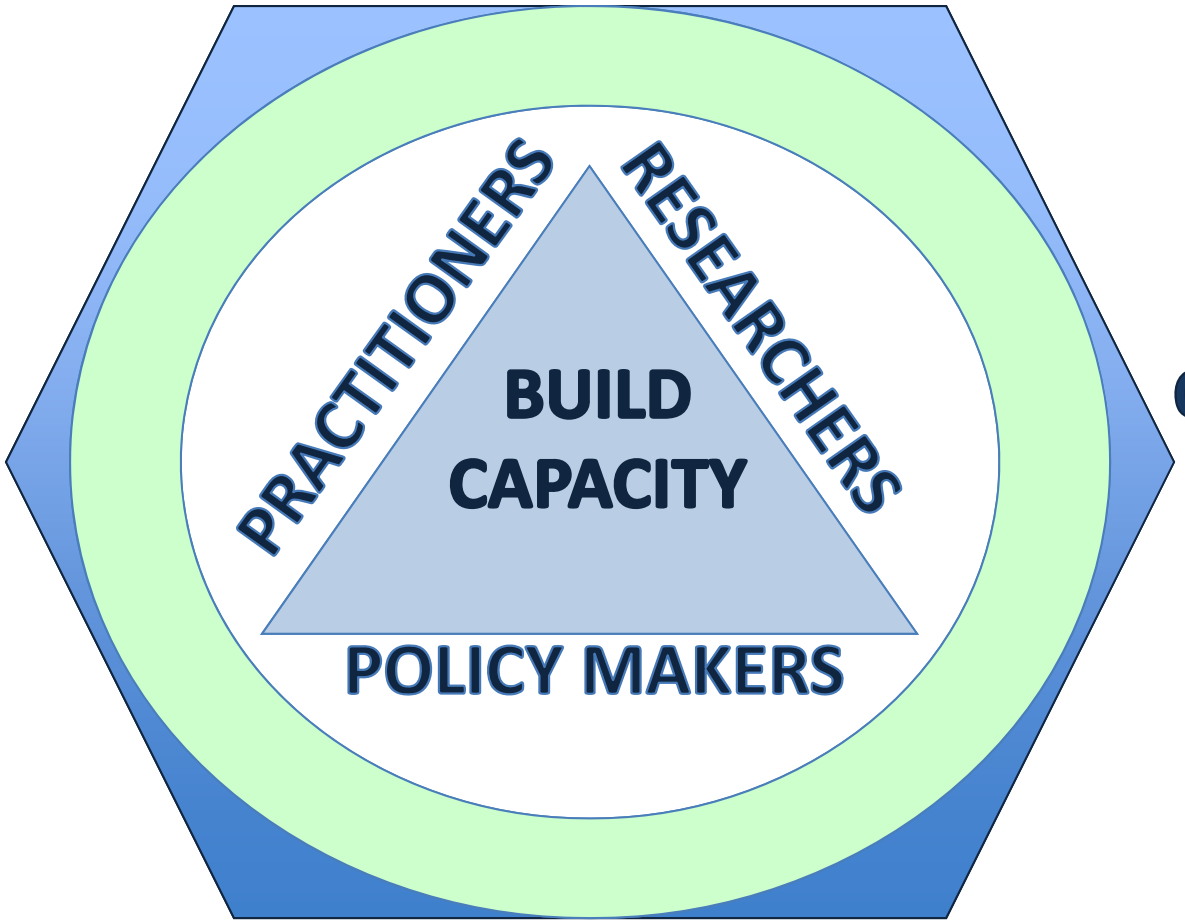
UNDERSTAND STATUS, TRENDS, DRIVERS



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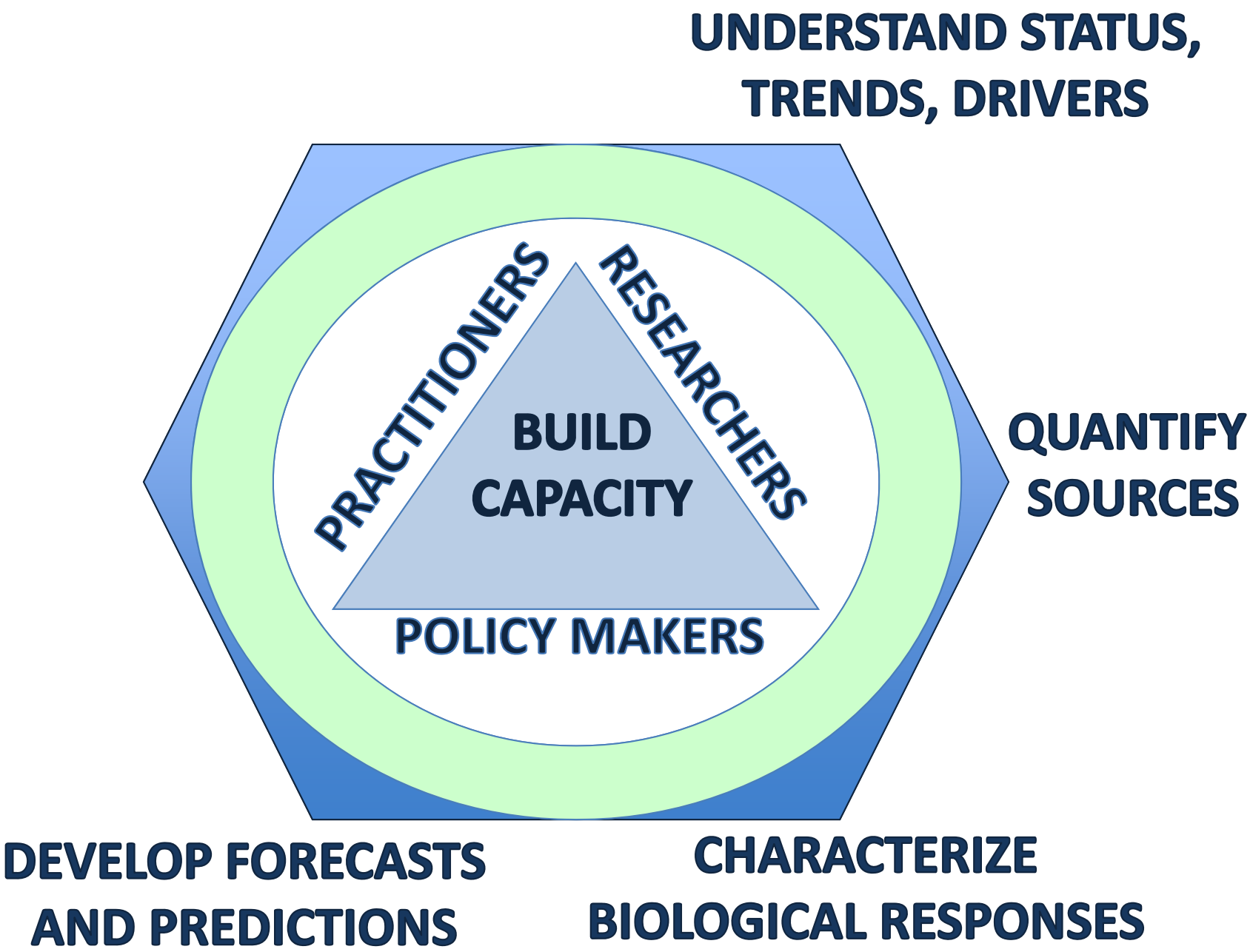
CHARACTERIZE BIOLOGICAL RESPONSES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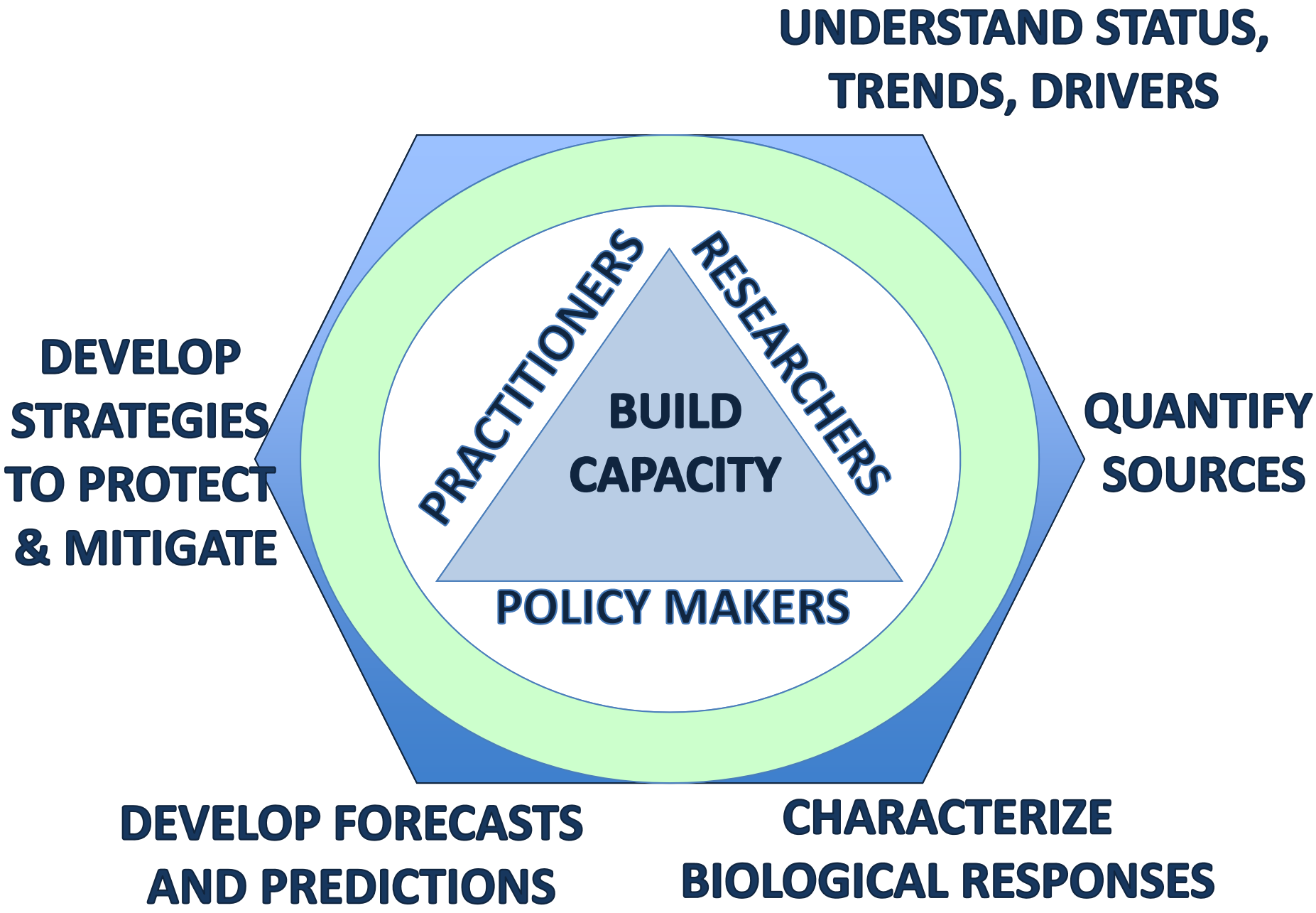
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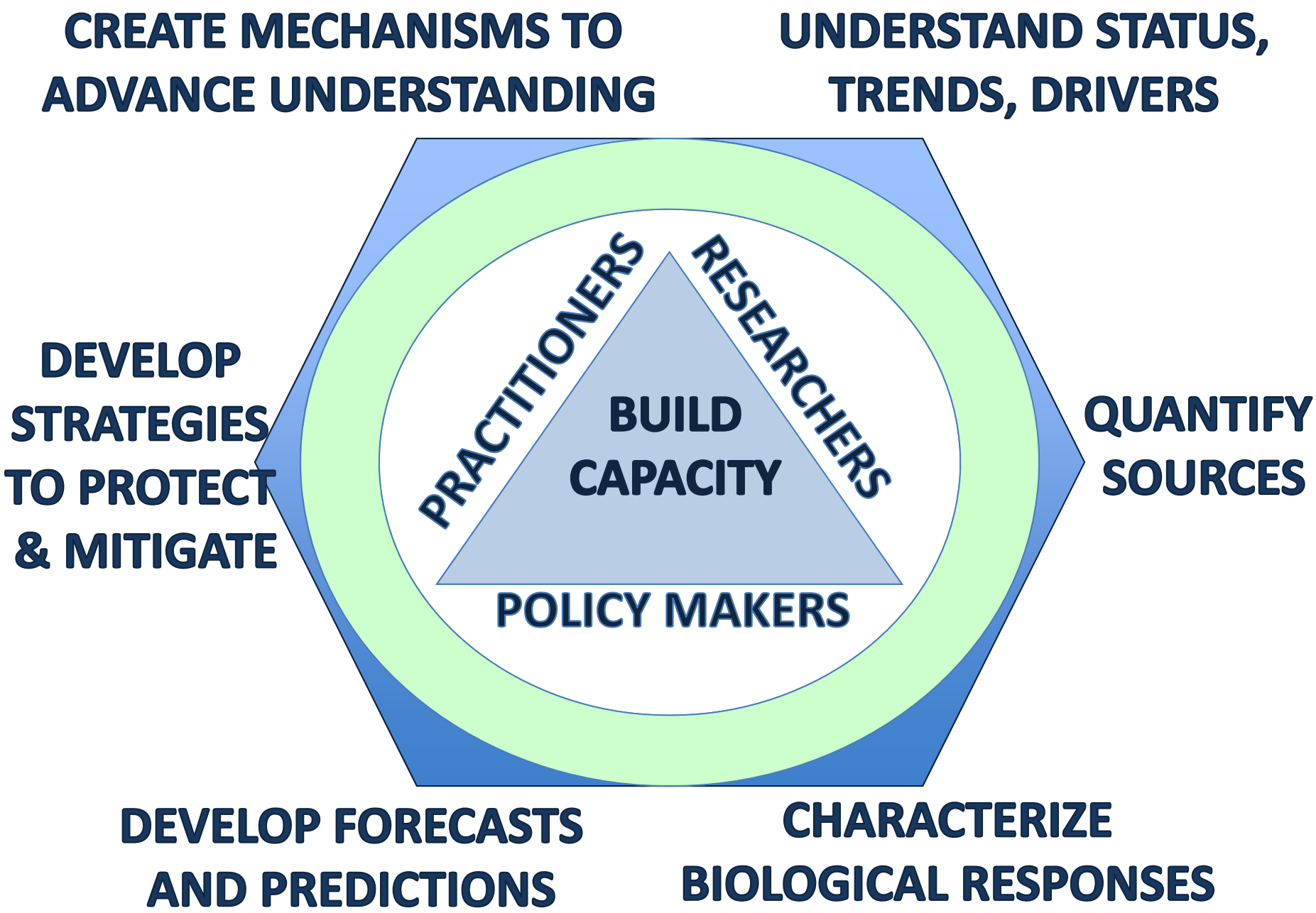
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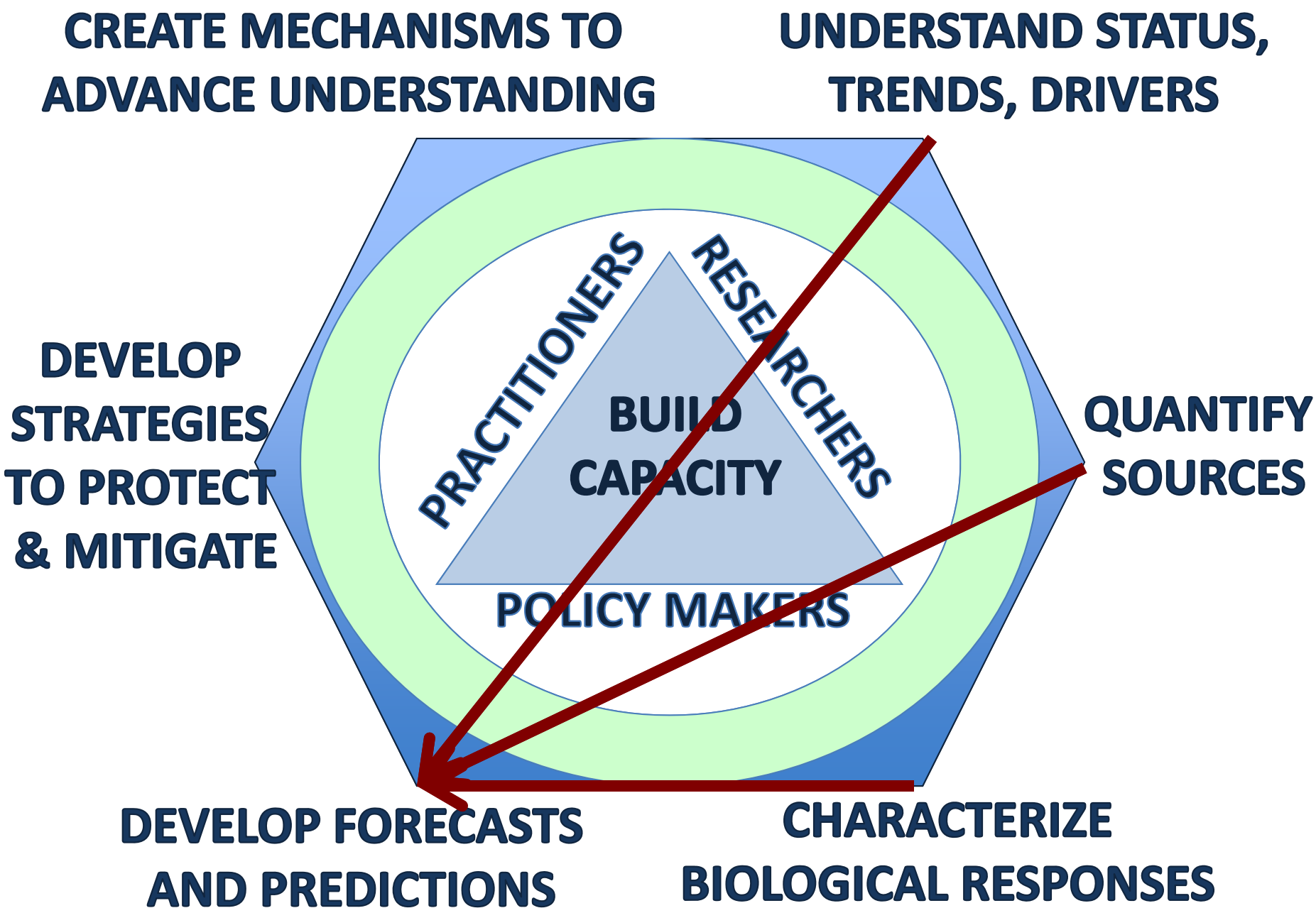
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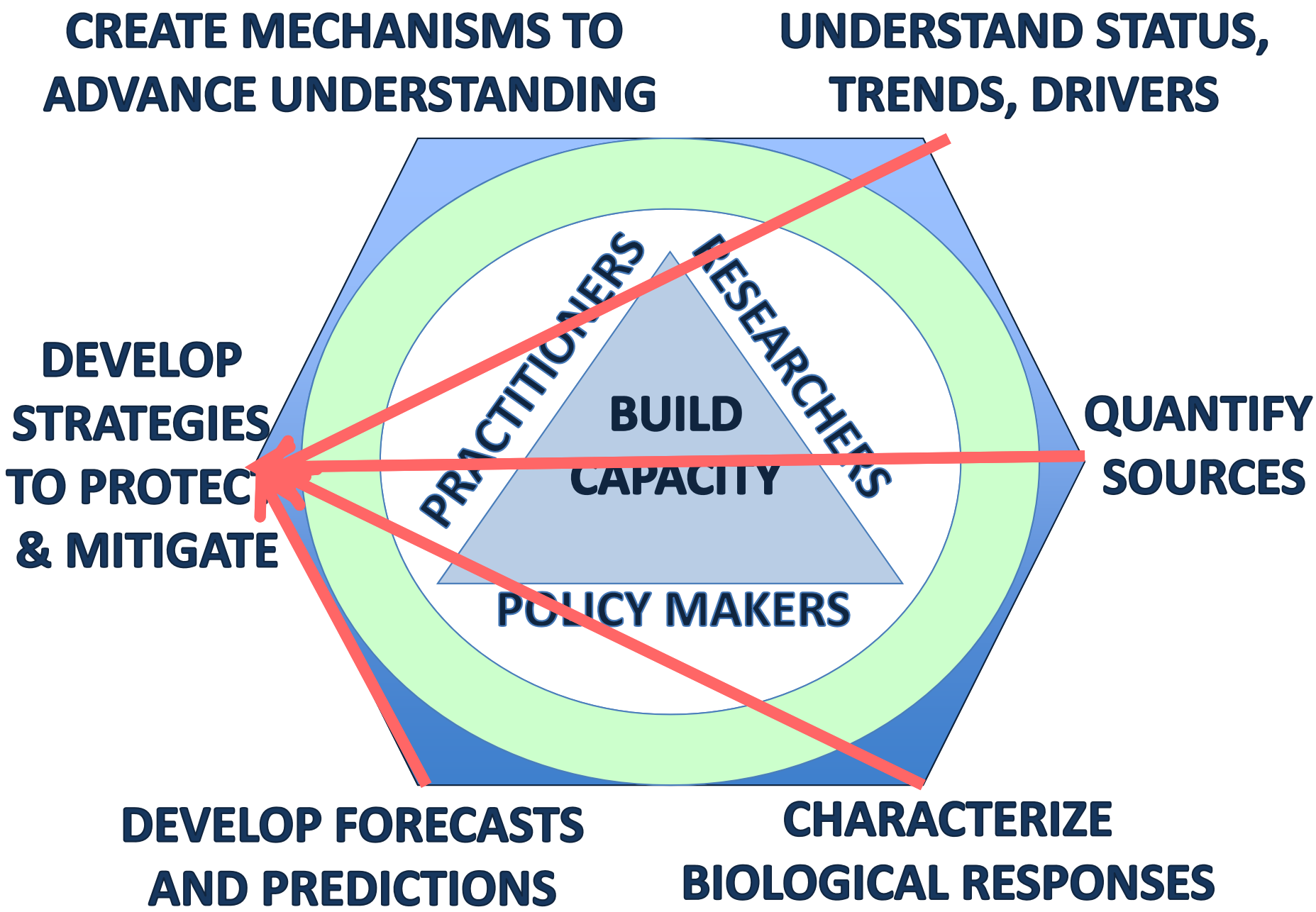
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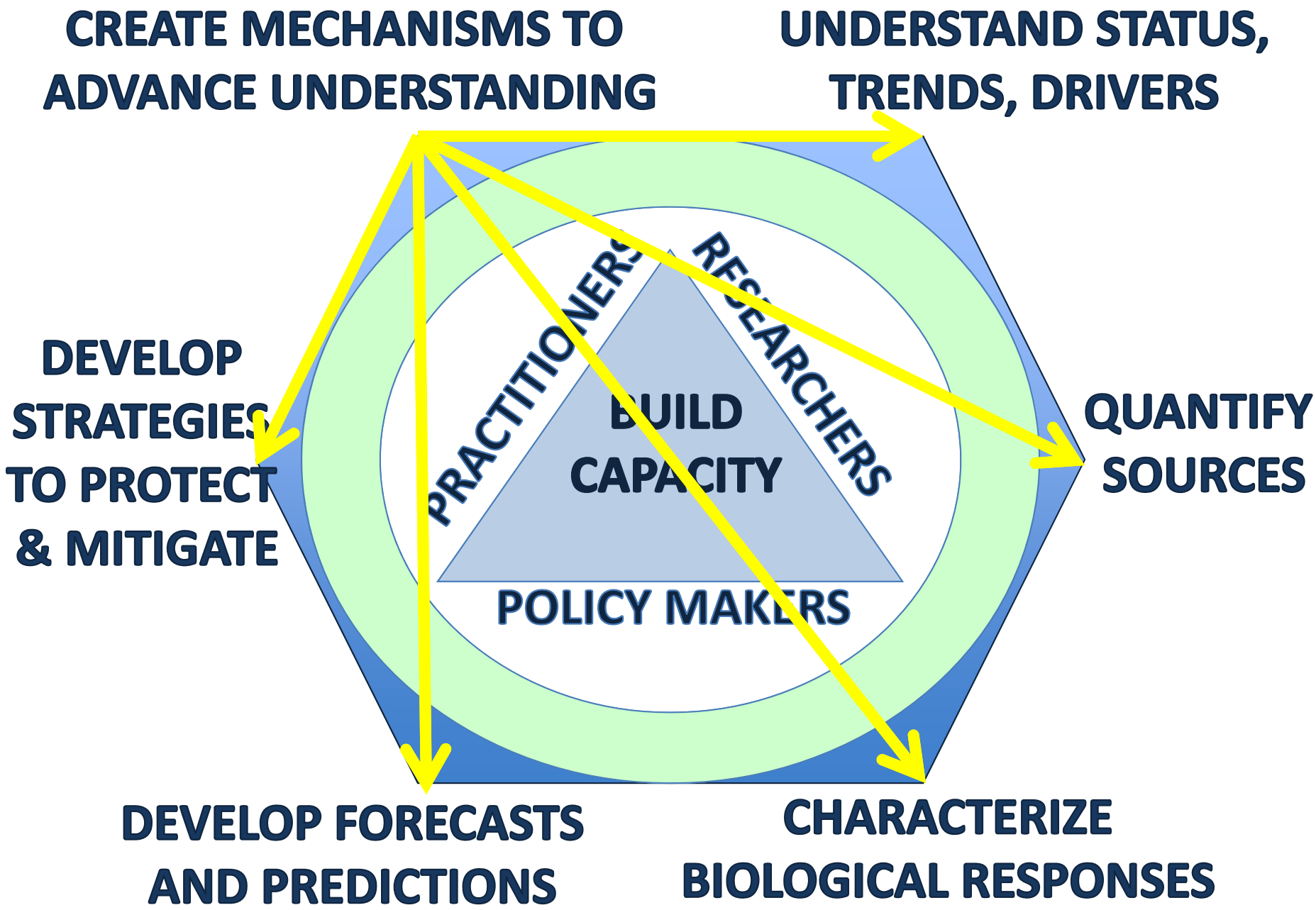
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