Towards a social-ecological-environmental system approach for the coastal ocean

by **Emanuele Di Lorenzo, Alida Bundy & Keith Criddle**

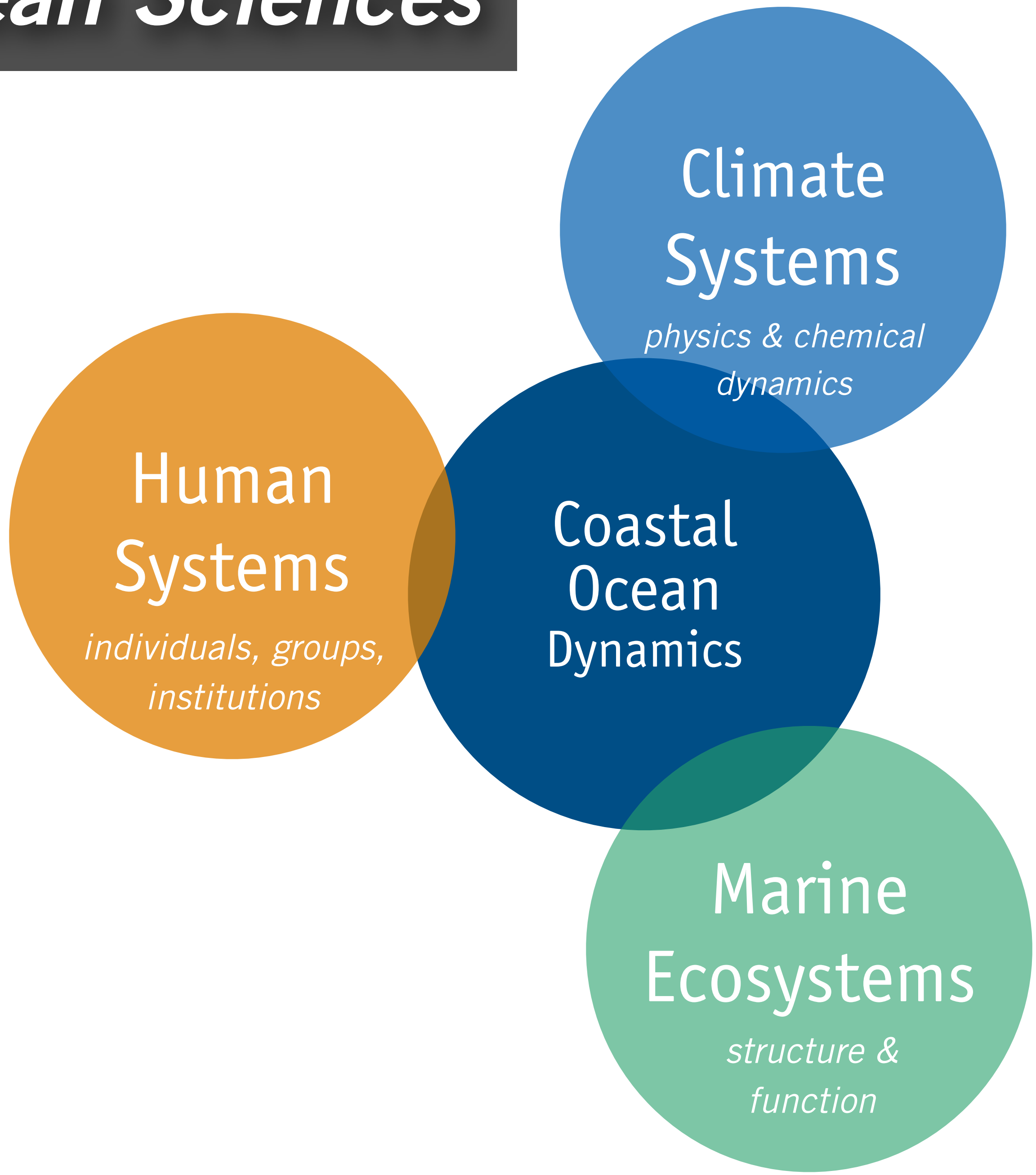
PICES Study Group
established in 2013

Georgia Institute of Technology

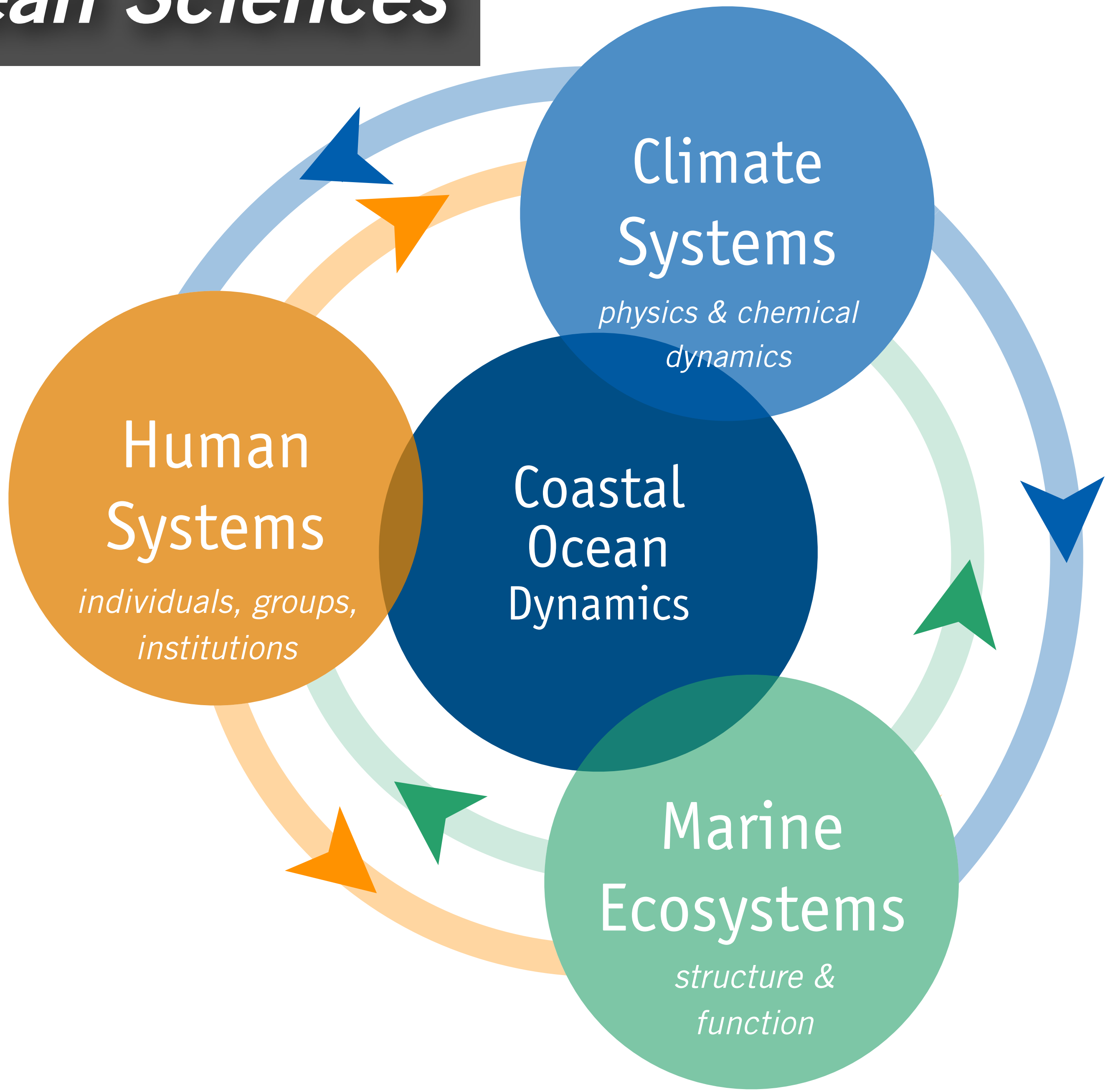
Coastal Ocean Sciences

Coastal
Ocean
Dynamics

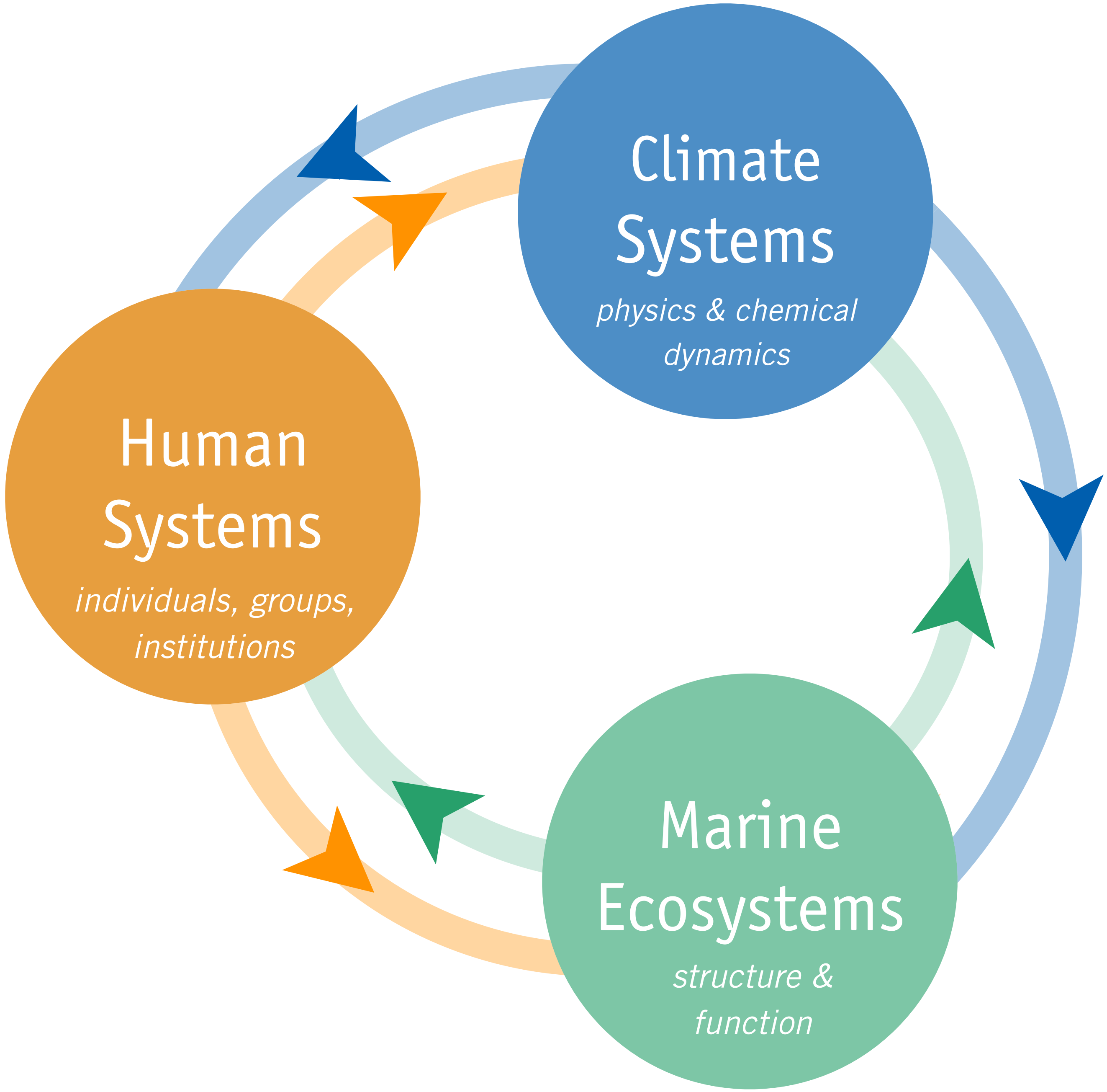
Coastal Ocean Sciences



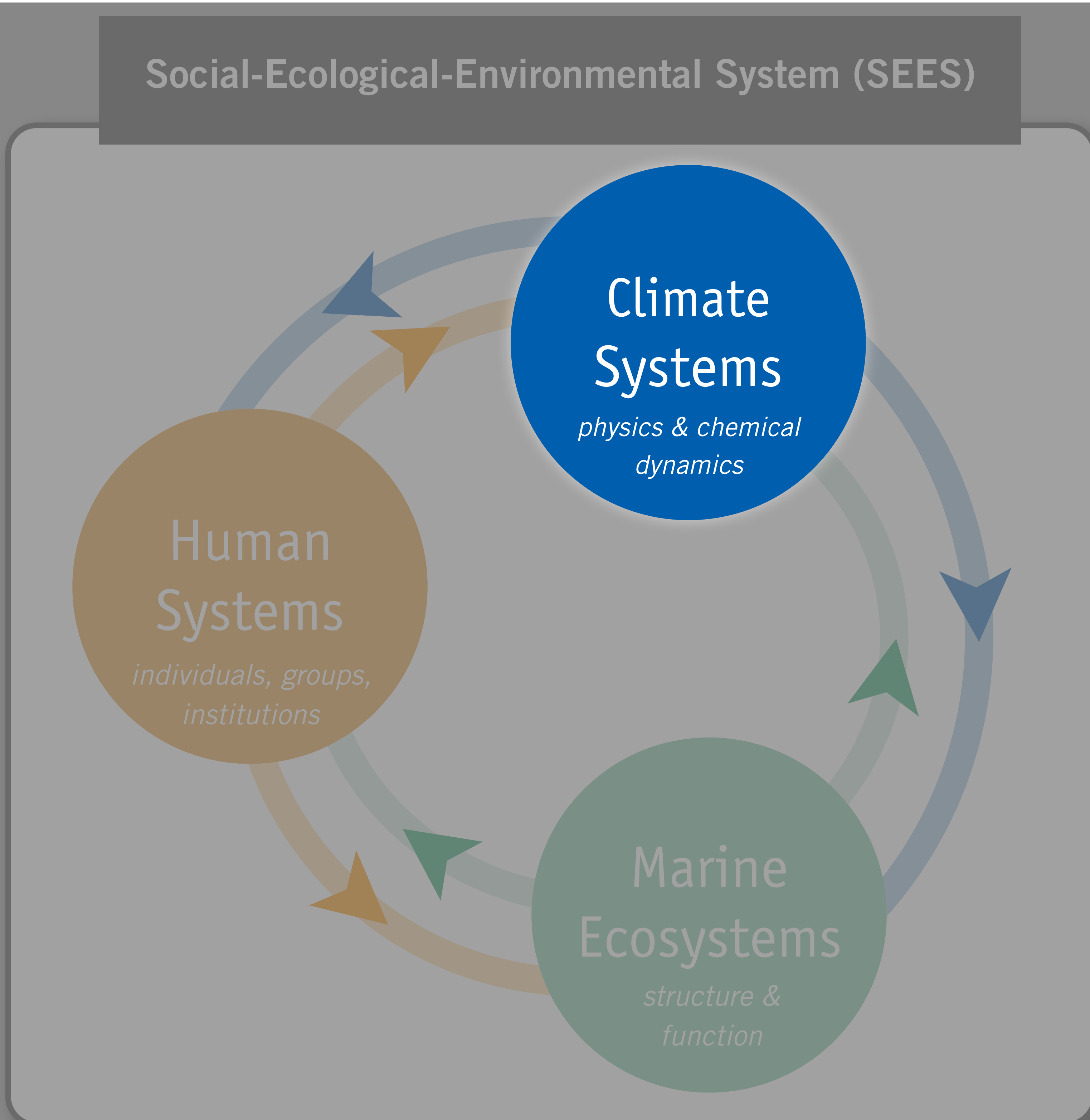
Coastal Ocean Sciences

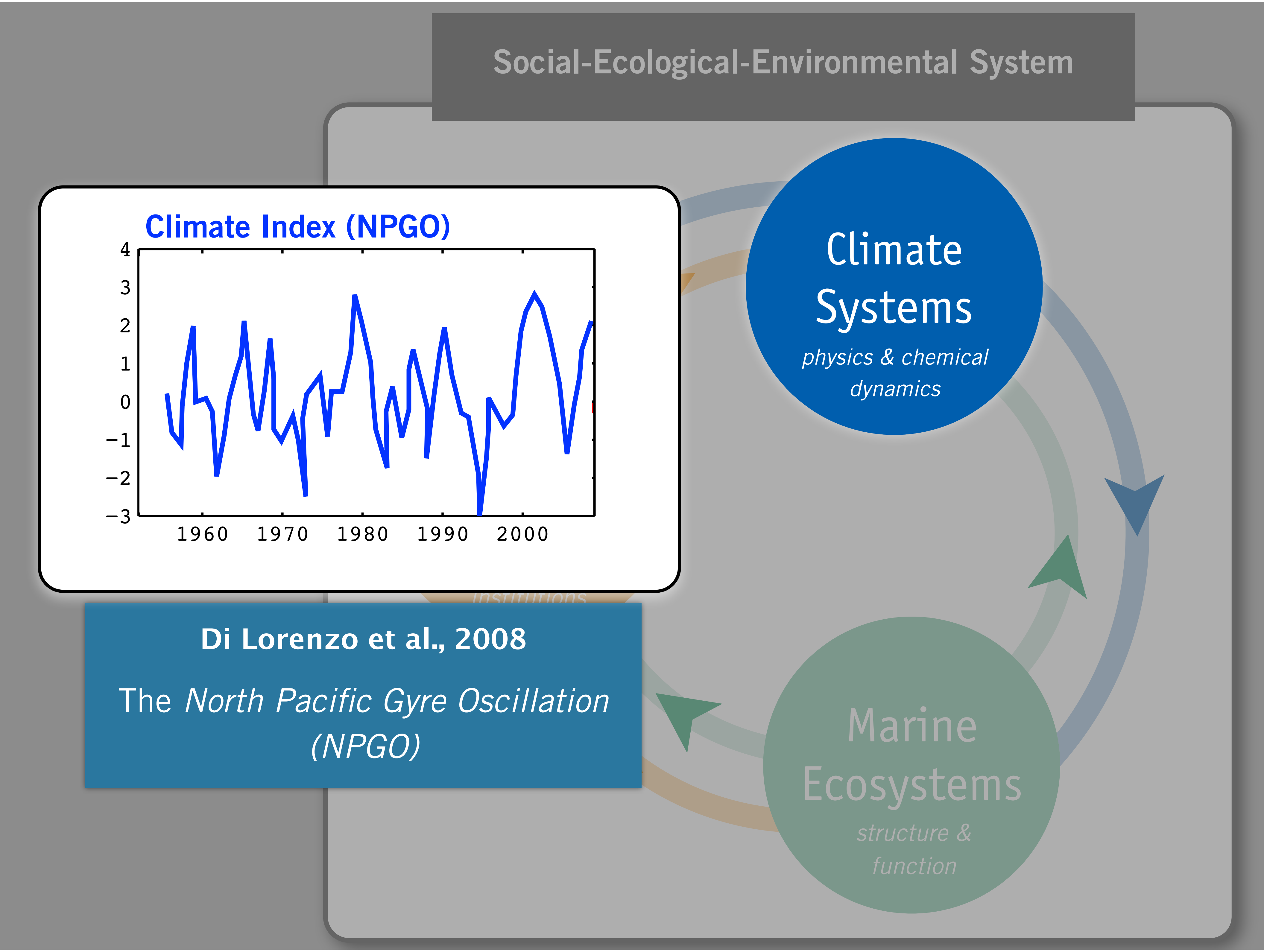


Social-Ecological-Environmental System (SEES)



Berkes and Folke 1998
Ostrom 2009
Perry et al 2010


Social-Ecological-Environmental System (SEES)
Climate Systems
physics & chemical dynamics
Human Systems
individuals, groups, institutions
Marine Ecosystems
structure & function


Social-Ecological-Environmental System
Climate Index (NPGO)
4
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1960
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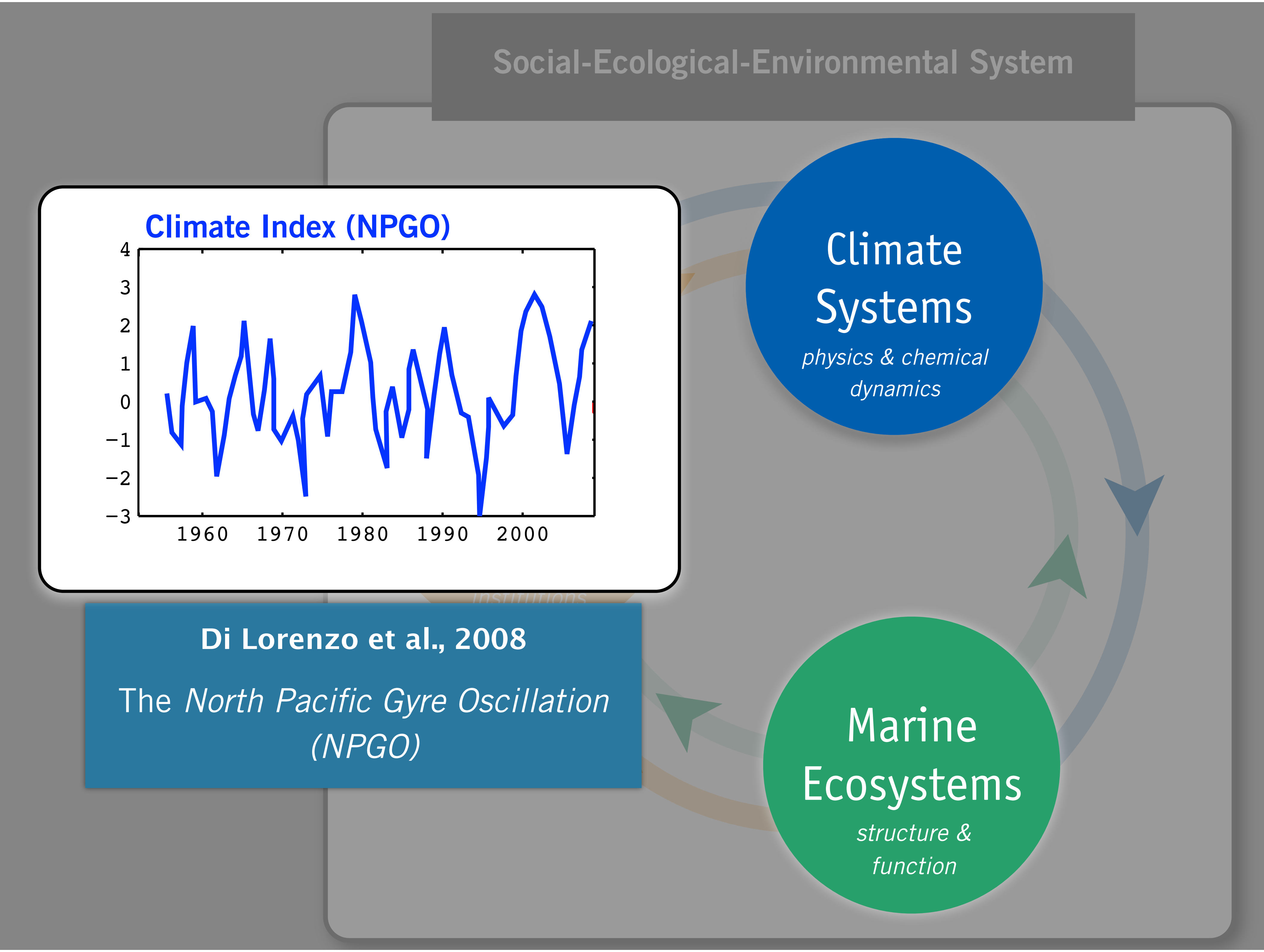
2000
Climate Systems
physics & chemical dynamics
Marine Ecosystems
structure & function
Di Lorenzo et al., 2008
The North Pacific Gyre Oscillation (NPGO)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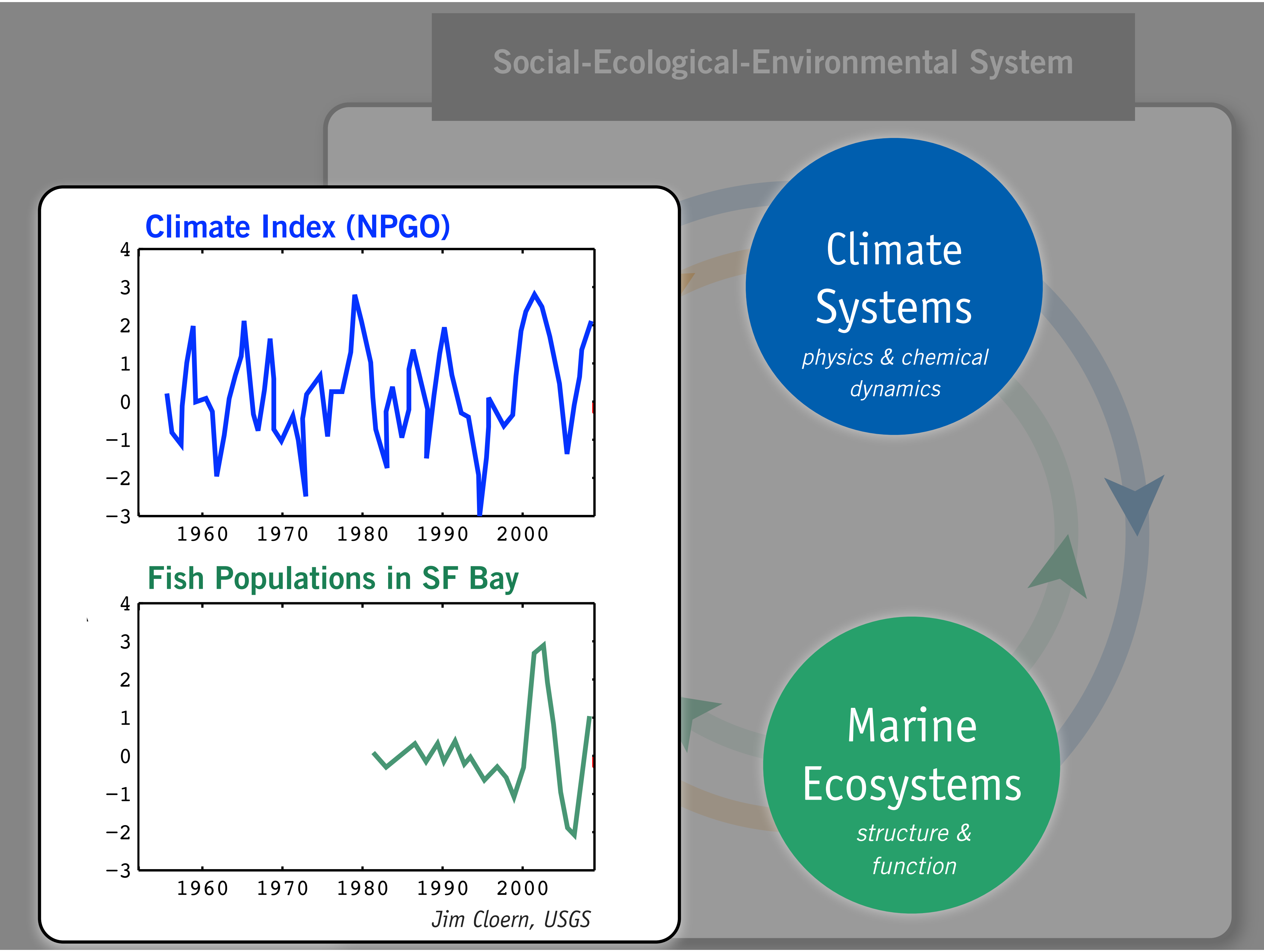
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Fish Populations in SF Bay
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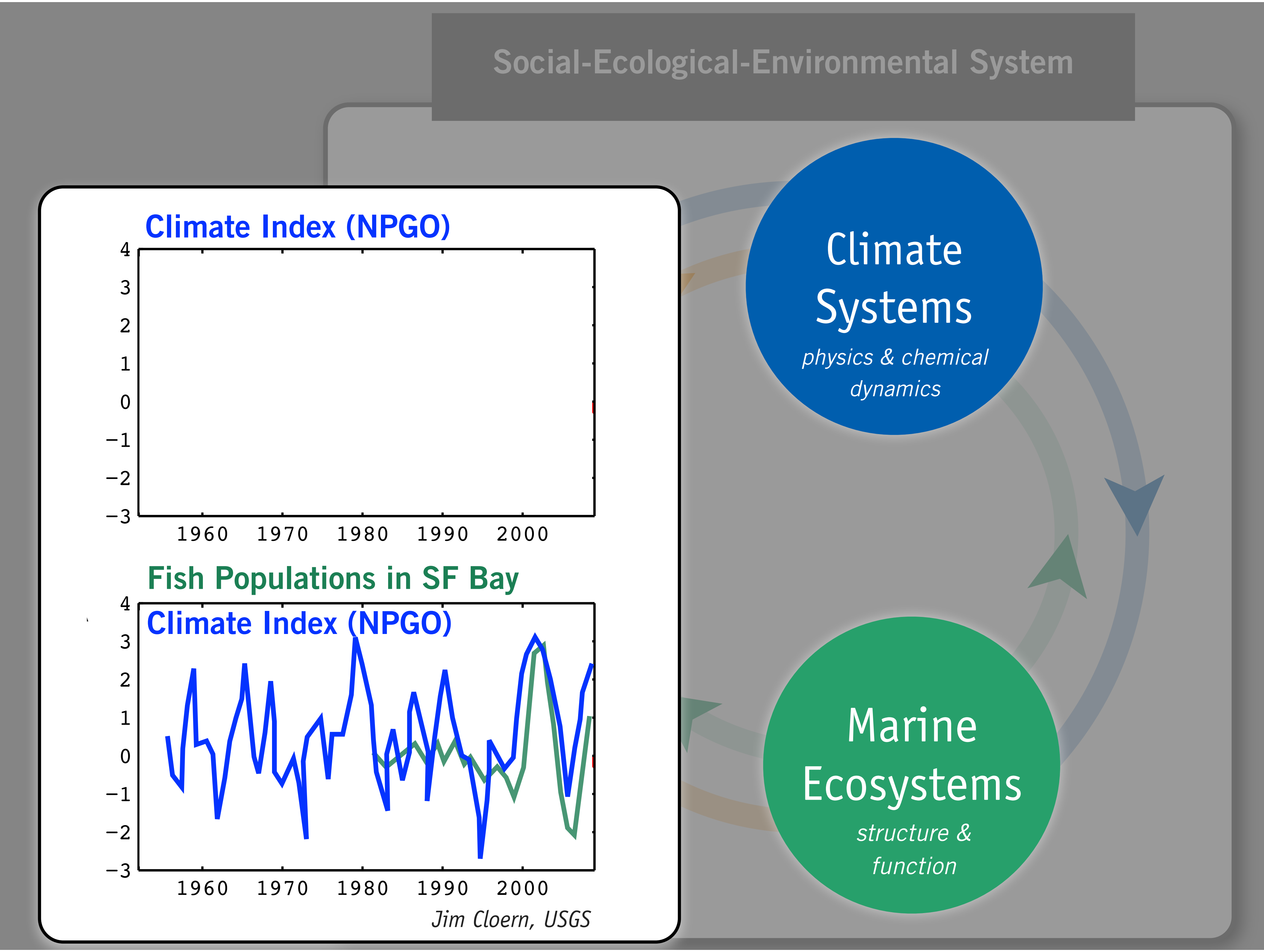
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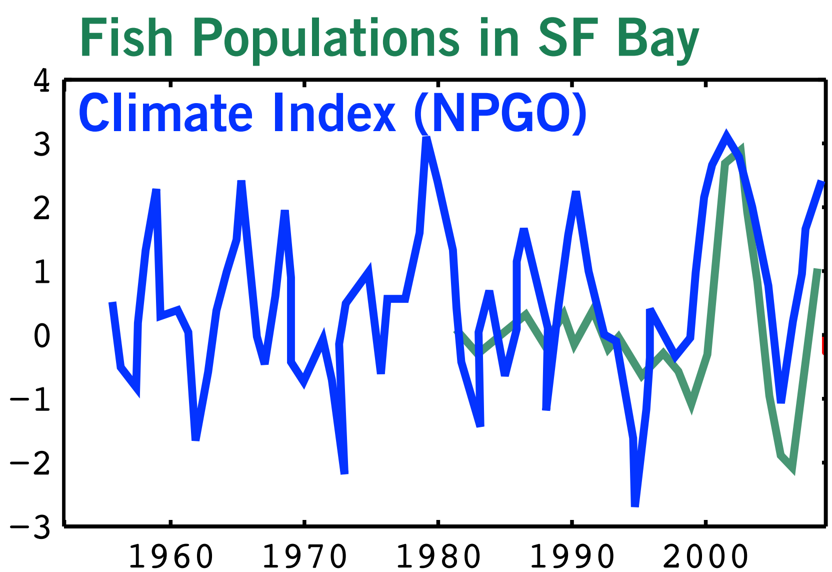
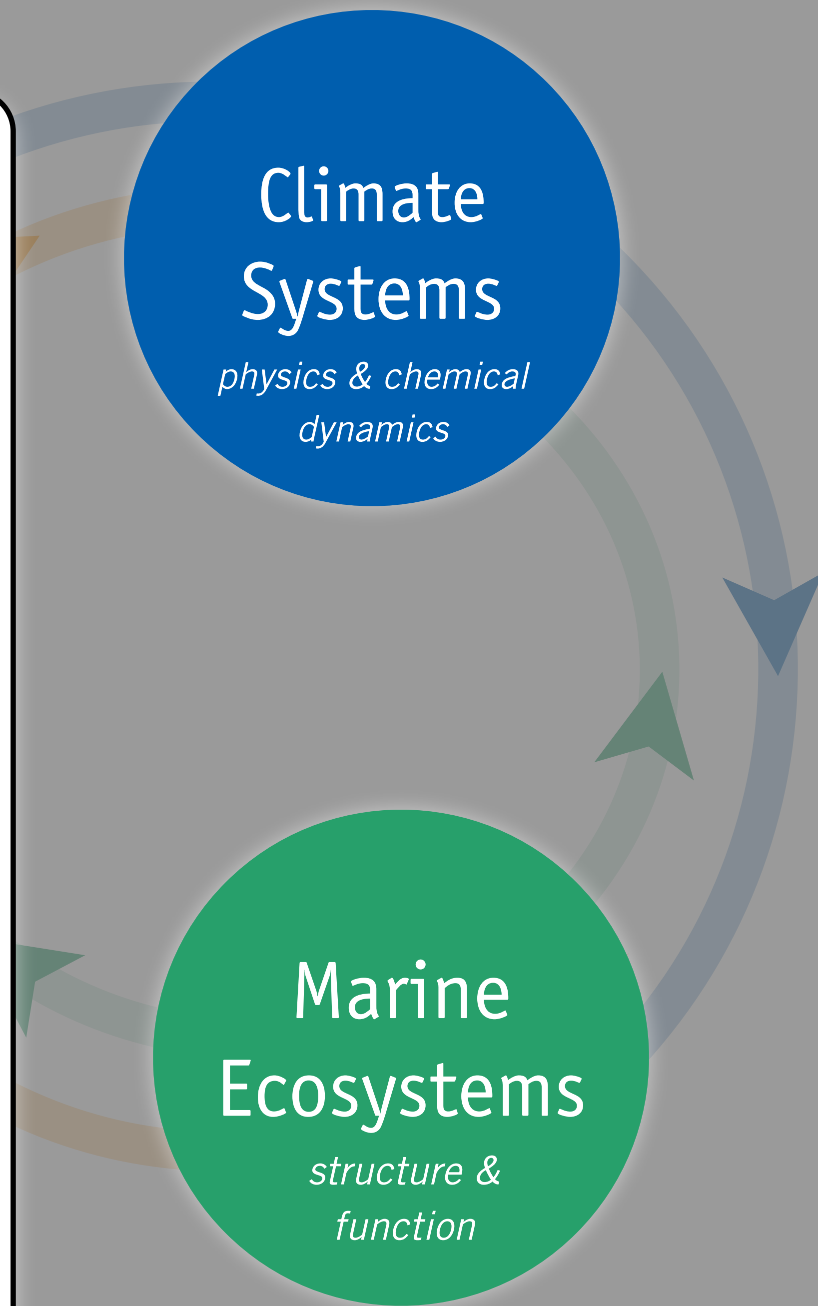
Social-Ecological-Environmental System

QUESTION:

Can we do better than this?



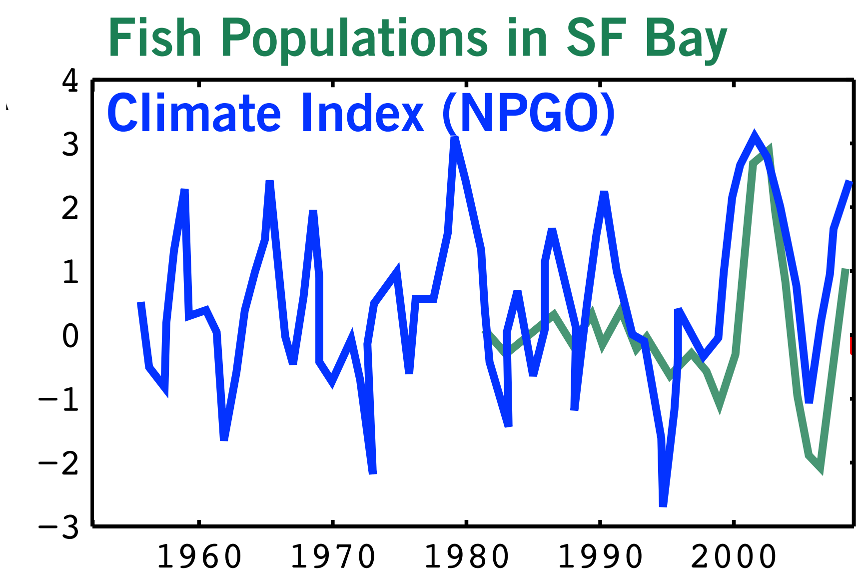
Jim Cloern, USGS



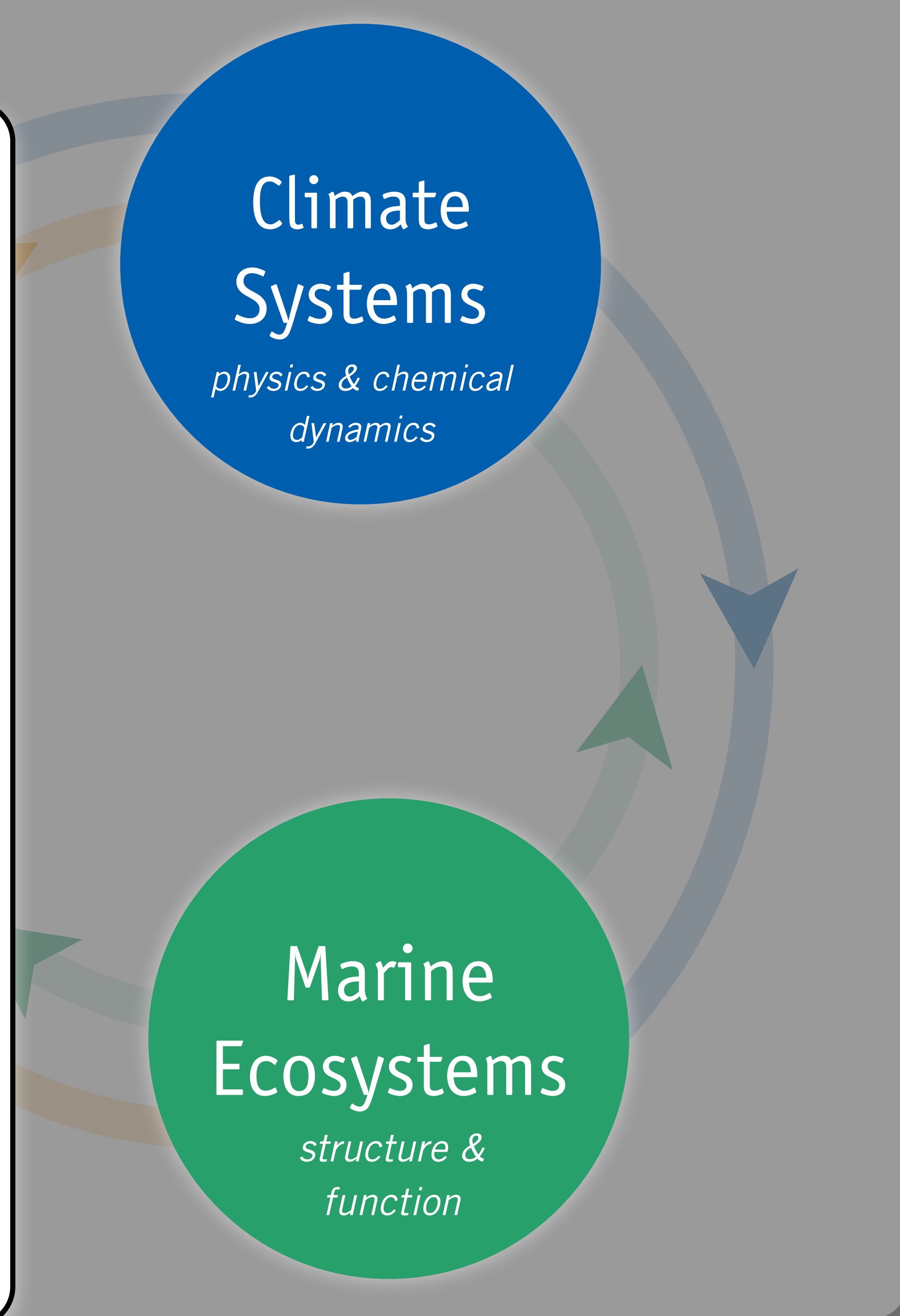
QUESTION:

Can we do better than this?

Simple Process Model



Social-Ecological-Environmental System



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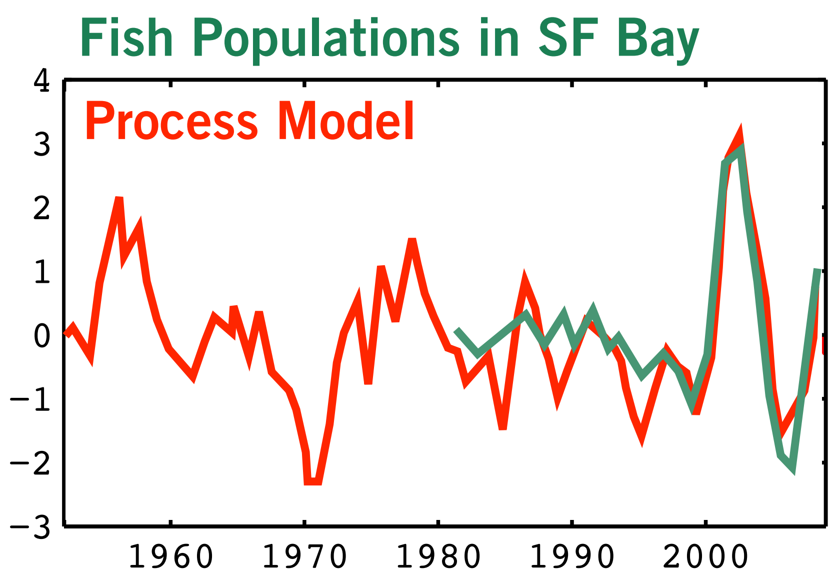

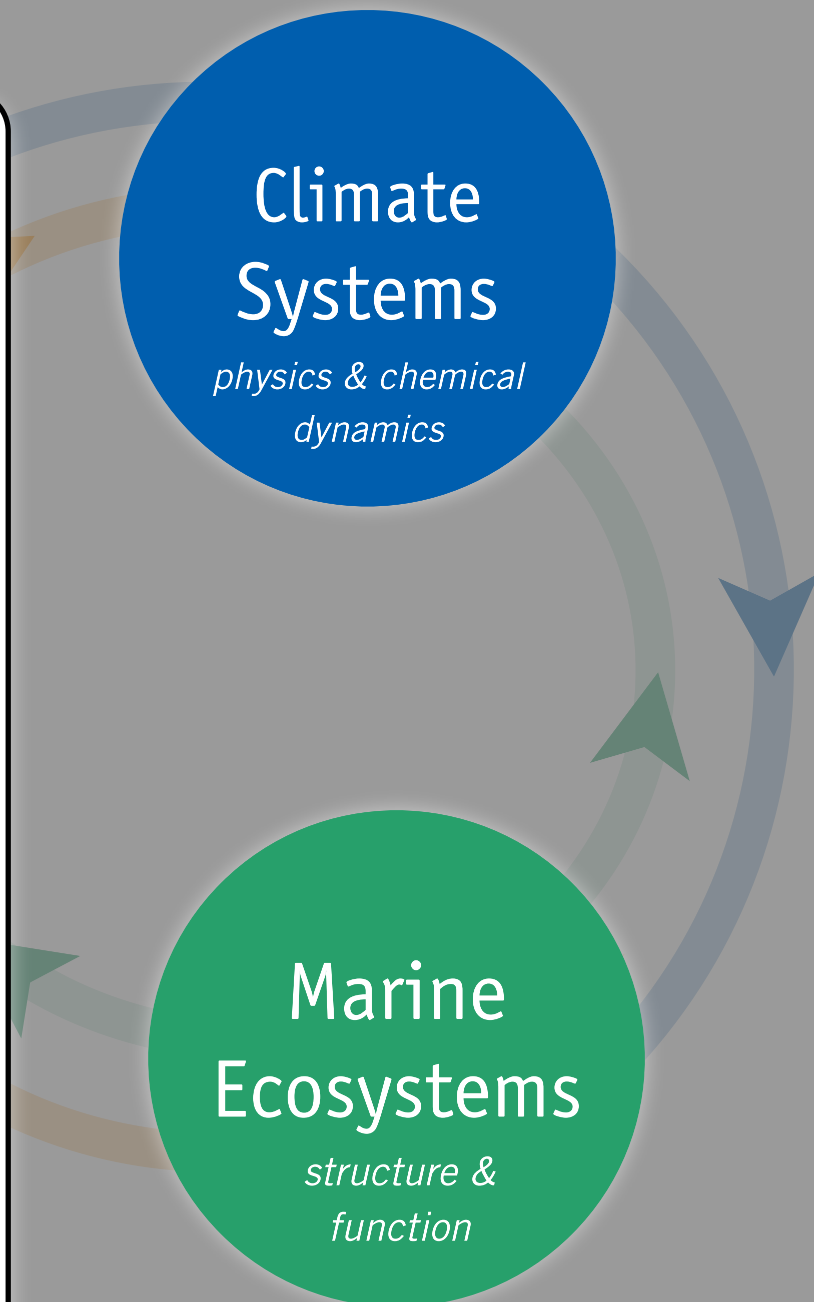

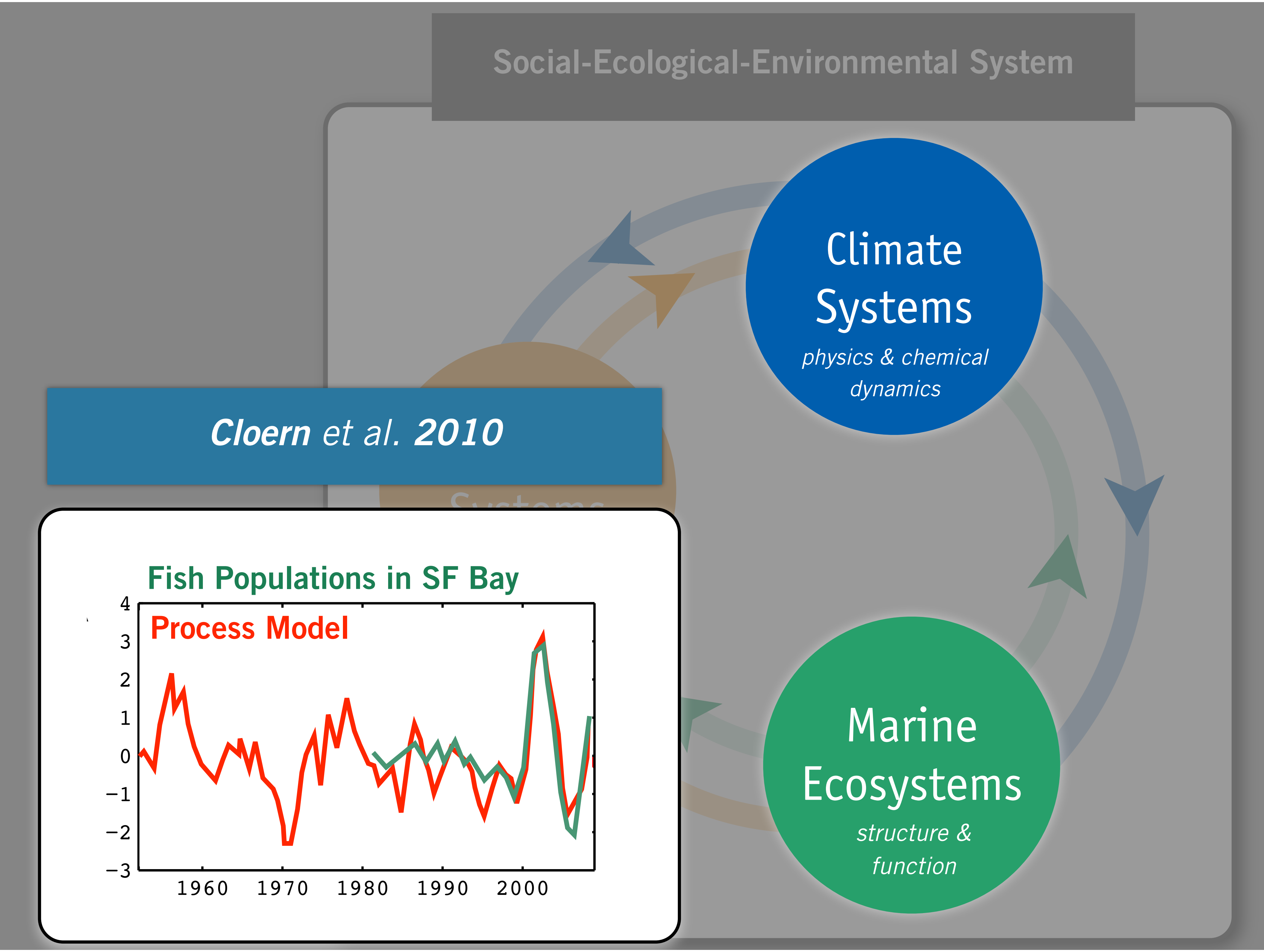
Social-Ecological-Environmental System
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physics & chemical dynamics
Marine Ecosystems
structure & function
Systems
Cloern et al. 2010
Fish Populations in SF Bay
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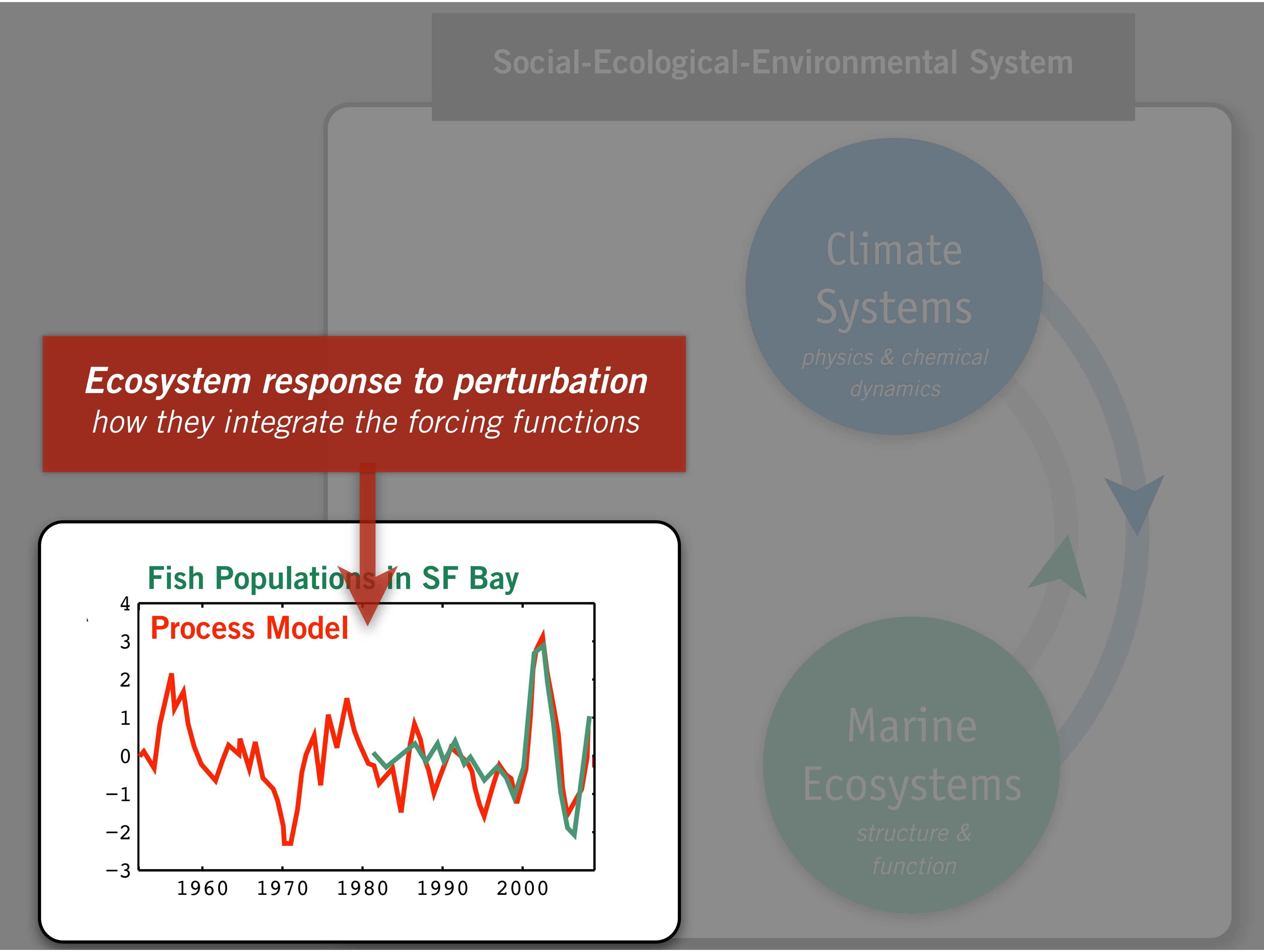

Social-Ecological-Environmental System
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physics & chemical dynamics
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Ecosystem response to perturbation
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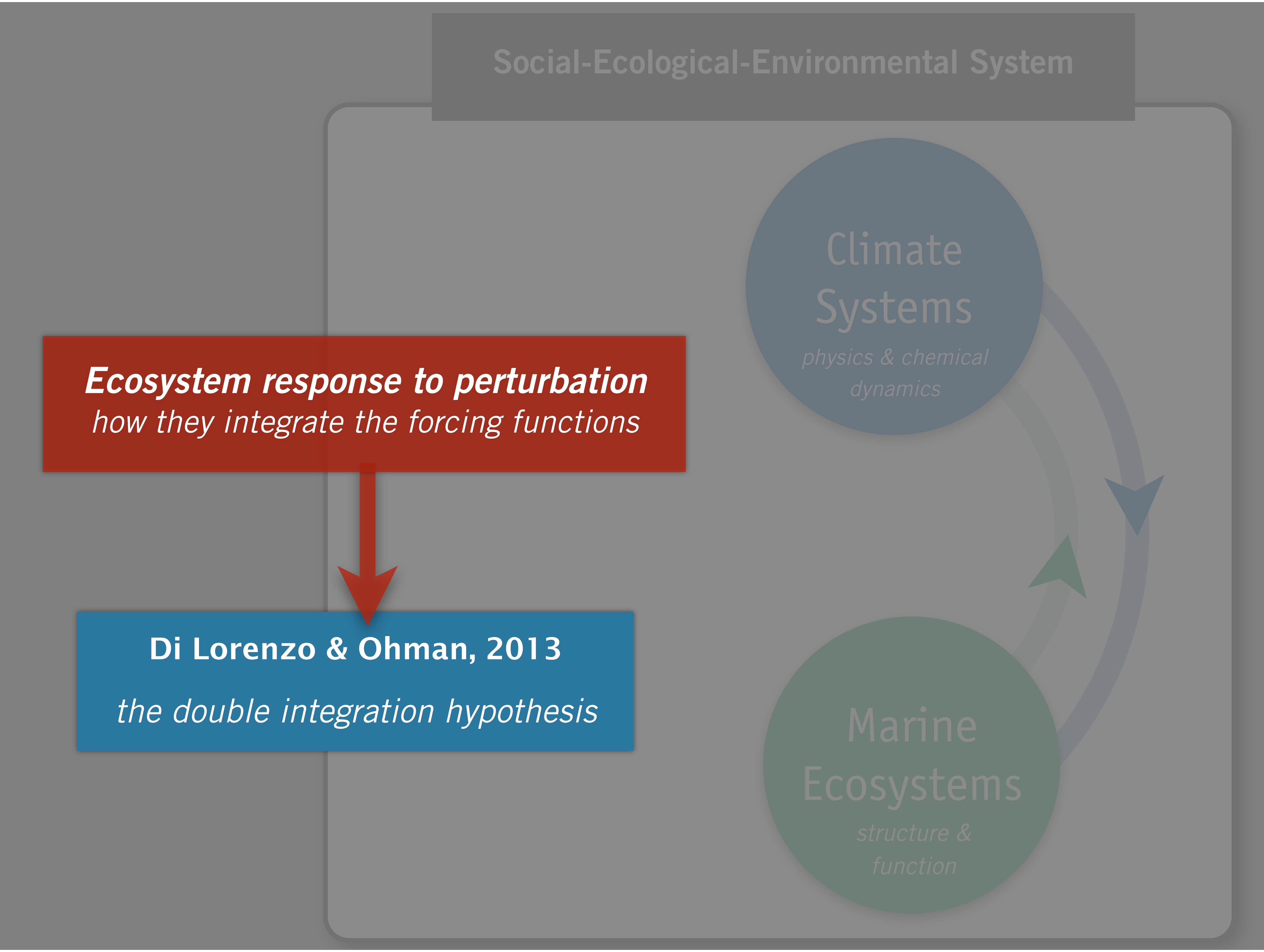
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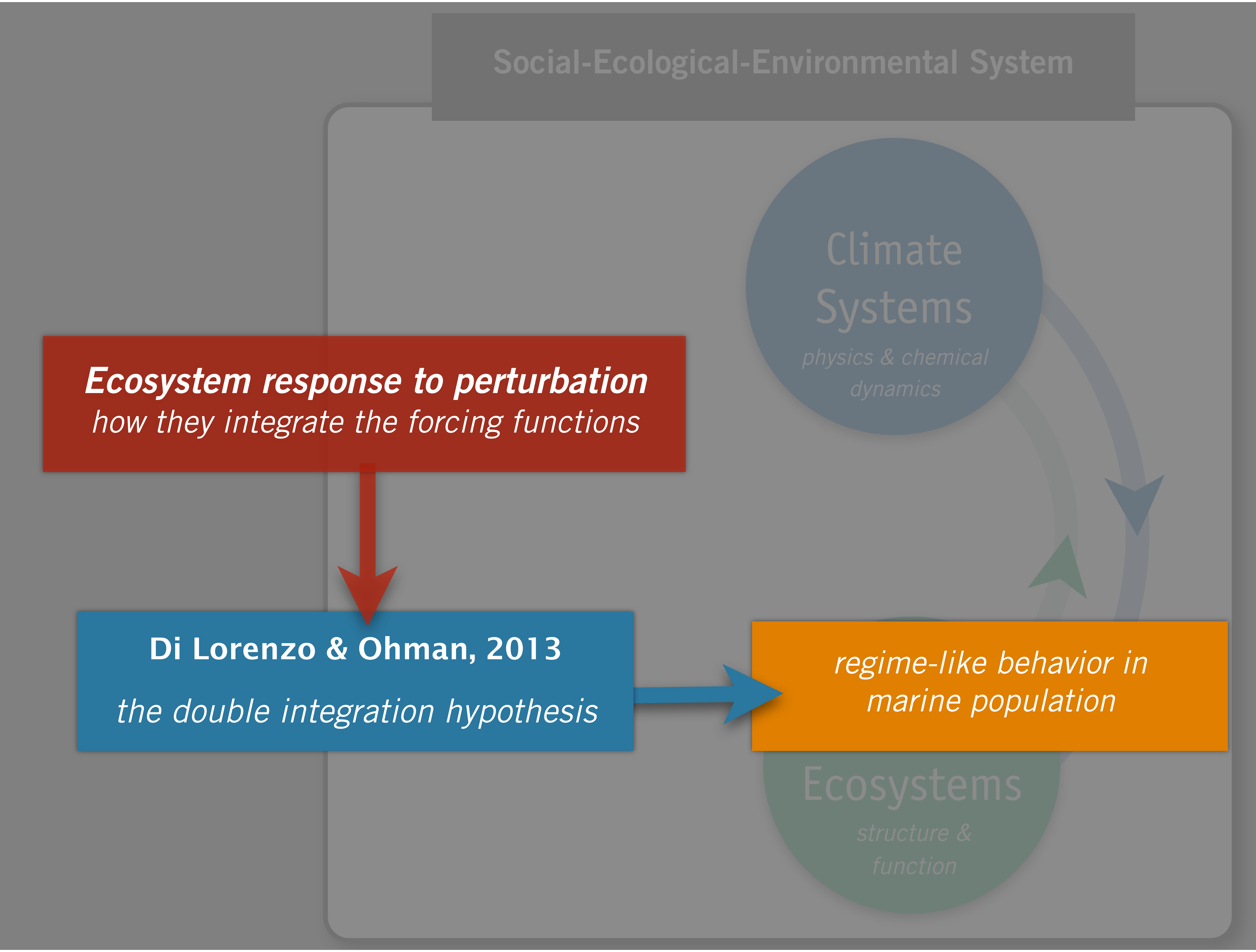
Di Lorenzo & Ohman, 2013
the double integration hypothesis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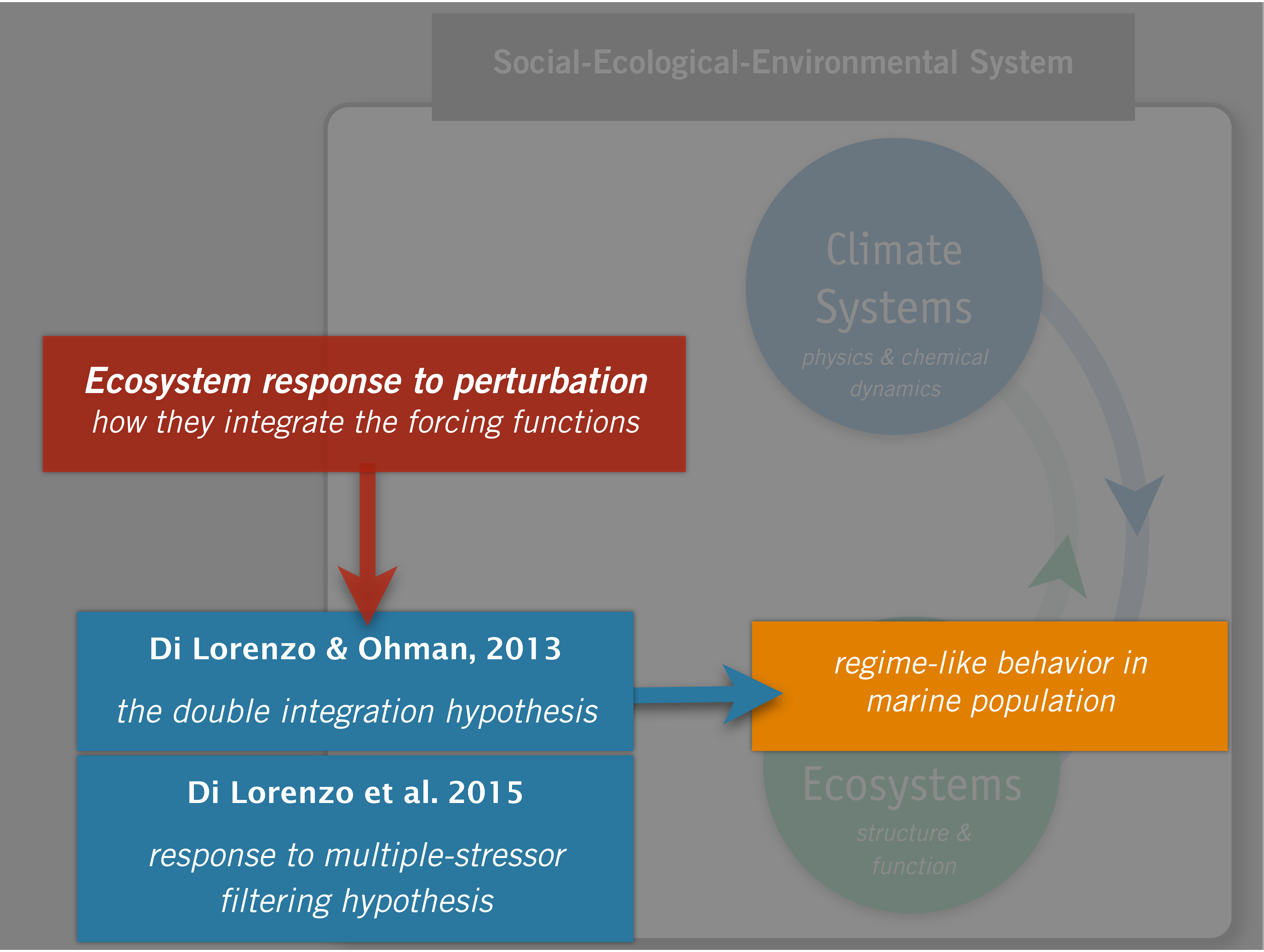
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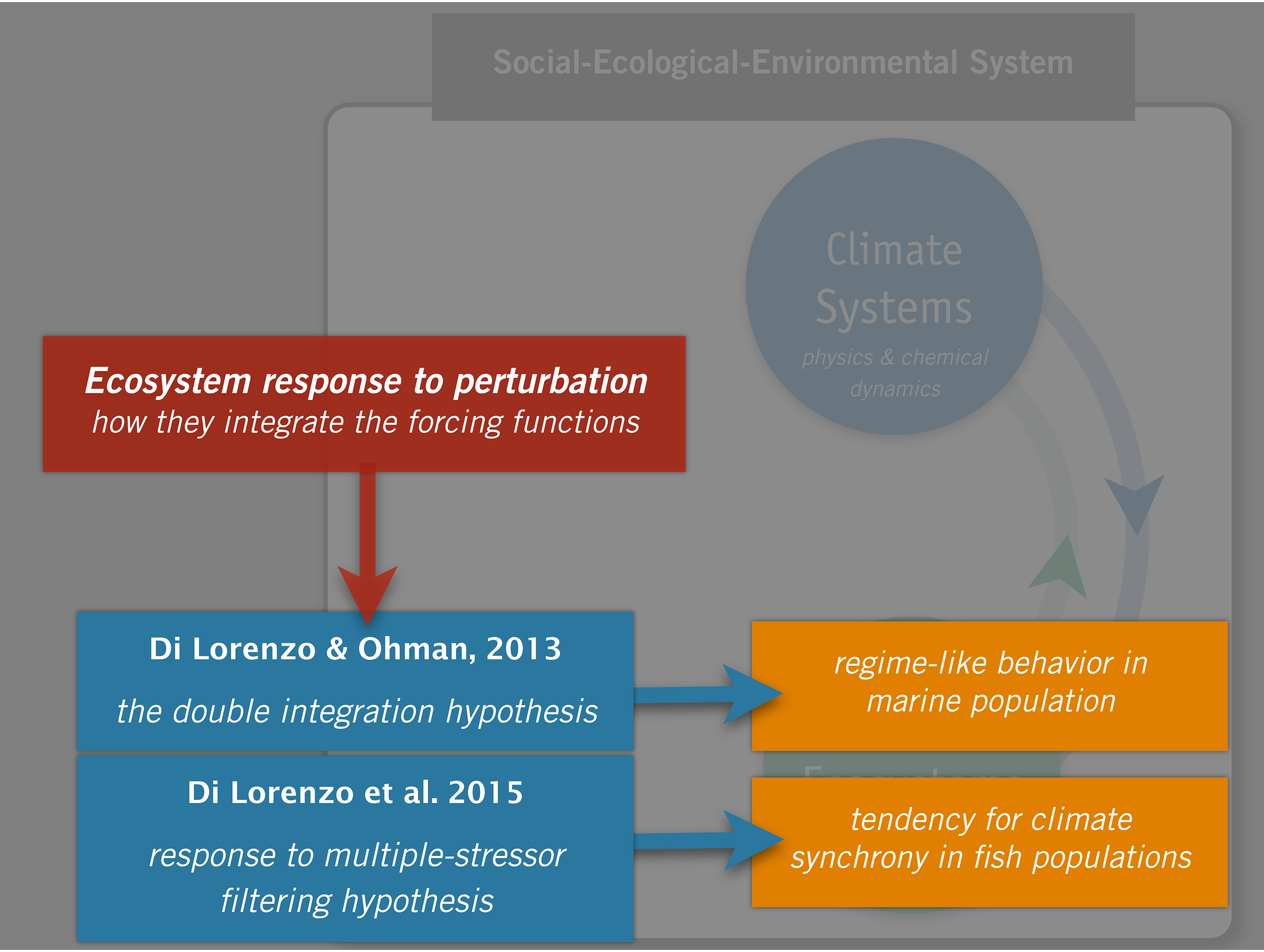
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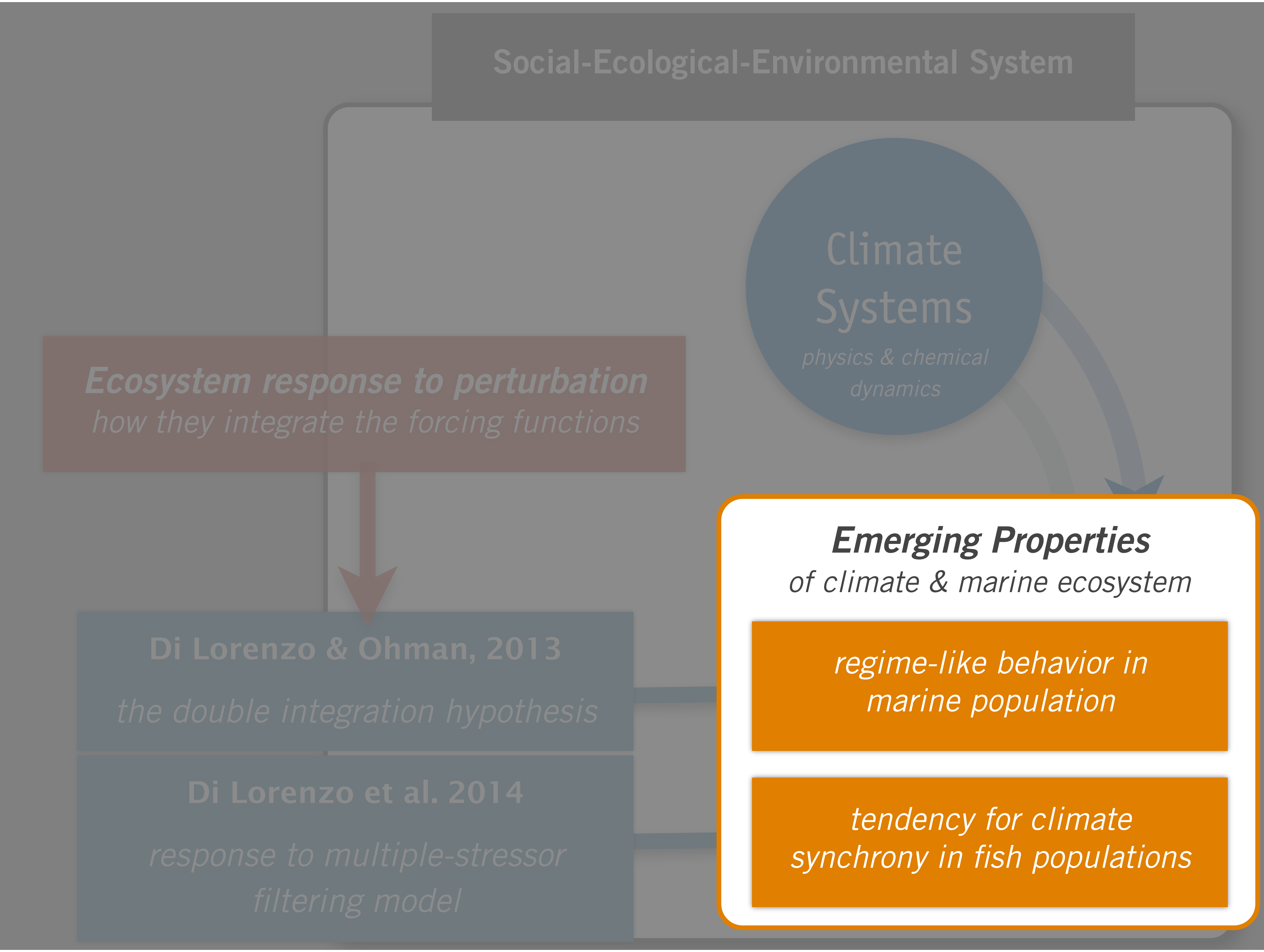
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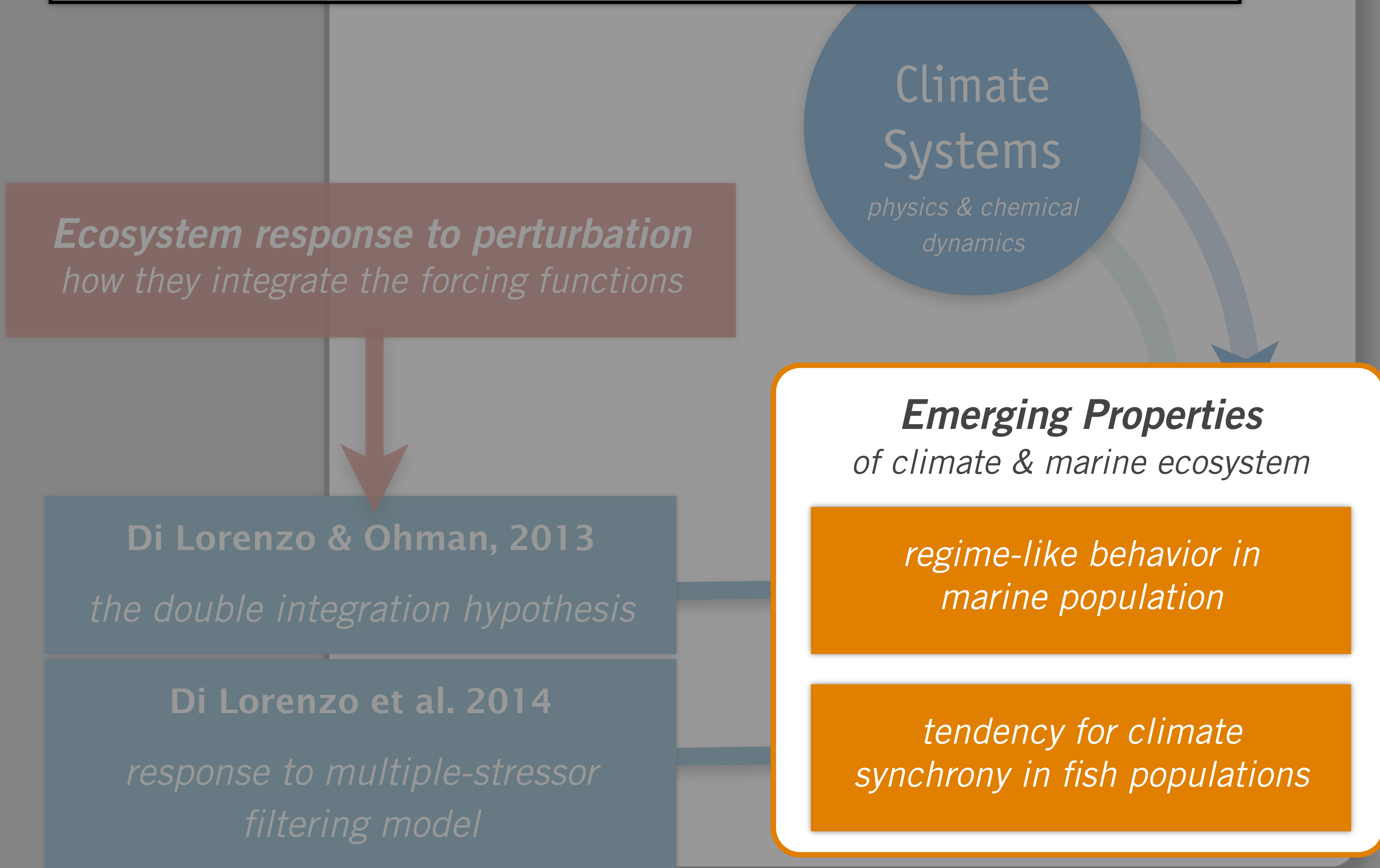
Emerging Properties
of climate & marine ecosystem
regime-like behavior in marine population
tendency for climate synchrony in fish populations

EXAMPLES: move beyond science at the interface between systems to true ***integrative science*** across the interface.



EXAMPLES: move beyond science at the interface between systems to true ***integrative science*** across the interface.

APPROACH: use ***team of experts*** and ***observations*** to develop ecological-environmental ***quantitative models***

Climate Systems

Di Lorenzo & Ohman, 2013

the double integration hypothesis

Di Lorenzo et al. 2014

response to multiple-stressor filtering model

Emerging Properties

of climate & marine ecosystem

regime-like behavior in marine population

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Di Lorenzo & Ohman, 20

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Di Lorenzo et al. 2014

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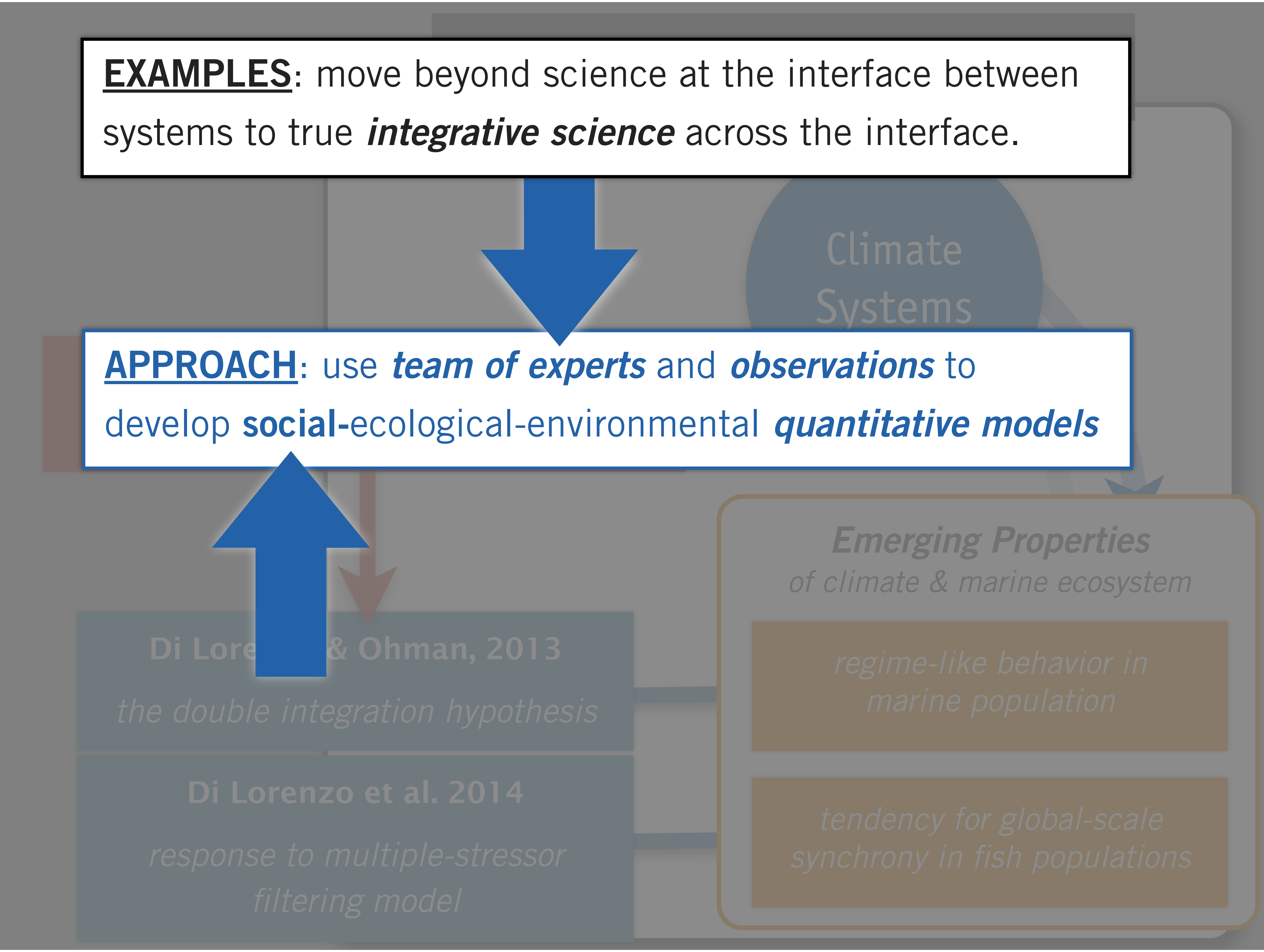
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Climate Systems

Di Lorenzo & Ohman, 20

the double integration hypoth

Di Lorenzo et al. 2014

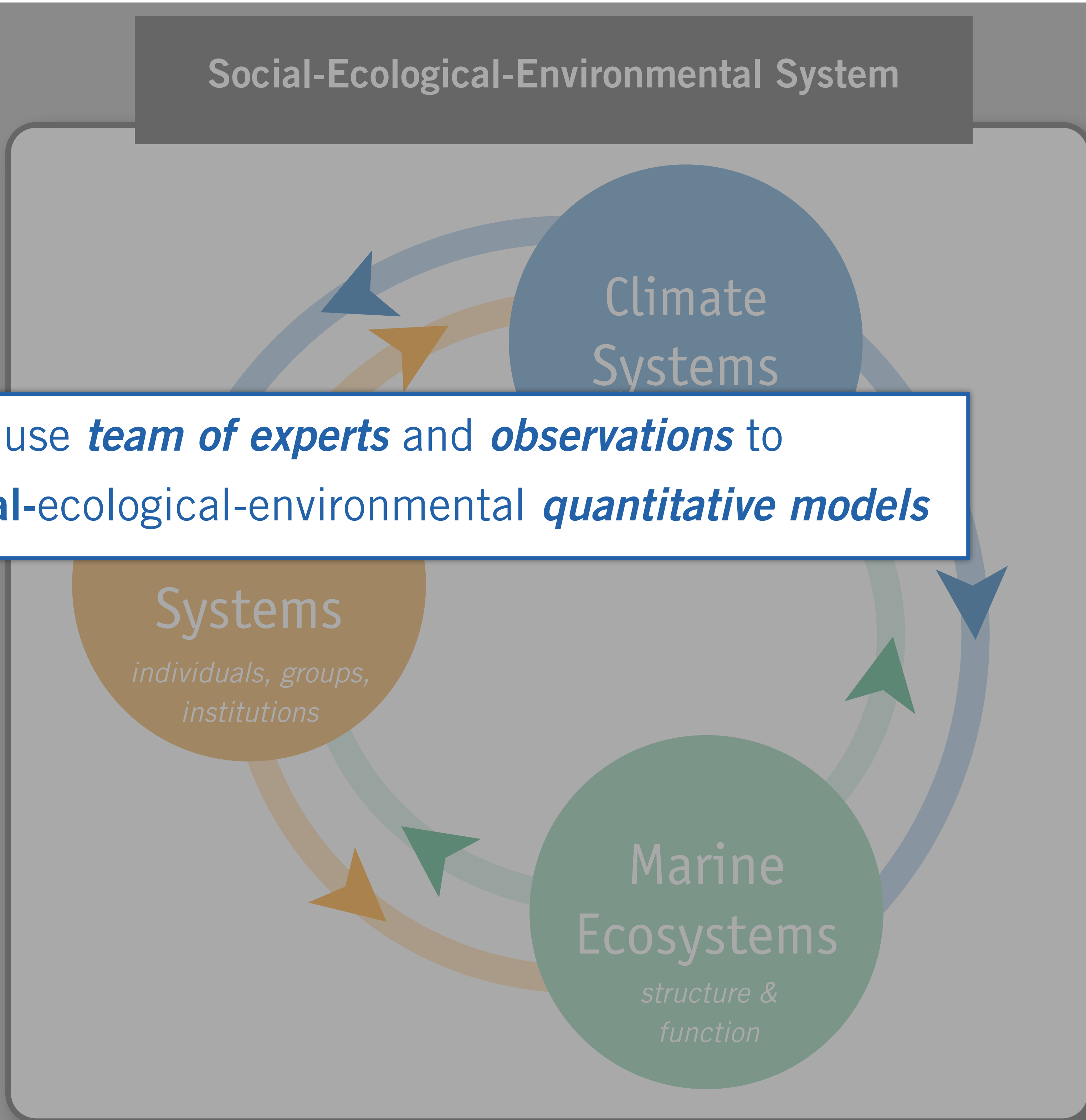
response to multiple-stressor filtering model

Emerging Properties

of complex SEES

guiding principles ?

guiding principles ?

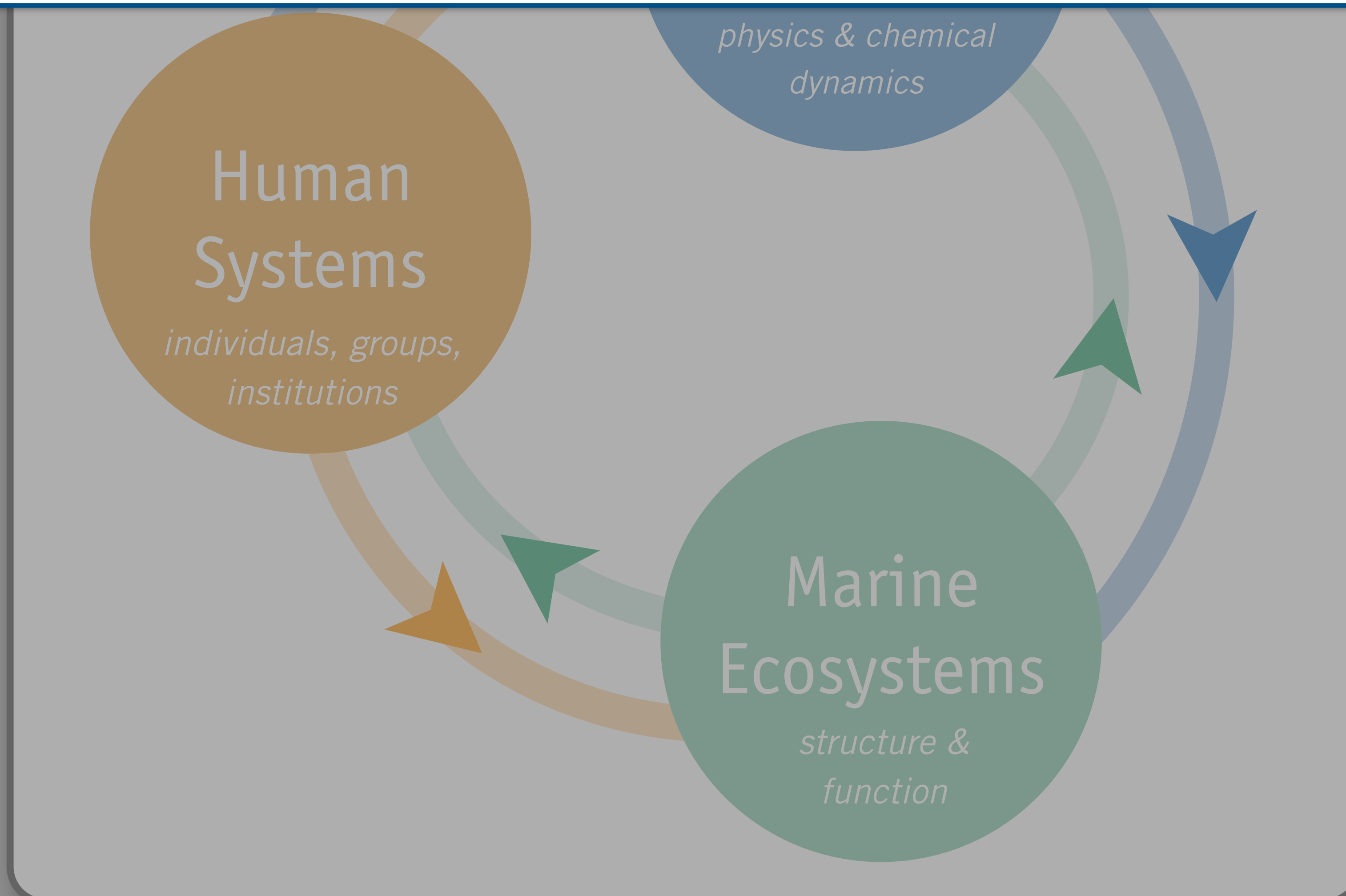


APPROACH: use ***team of experts*** and ***observations*** to develop **social-**ecological-environmental ***quantitative models***

Study group in **PICES** on

Social-Ecological-Environmental Systems (SG-SEES)

proposed and formally established in 2013



Members

Prof. Rosemary E. Ommer,
*Depts. of **History** and Geography*
University of Victoria, **Canada**

Dr. Naesun Park
***International Affairs** Section*
KIOST, **Korea**

Prof. Derek Kellenberg
*Chair, Department of **Economics***
University of Montana, **USA**

Dr. Juri Hori
*Department of **Psychology***
Rikkyo University, **Japan**

Dr. Ian Perry
*Head of **Ecosystem Approaches** Program*
Fisheries and Oceans, **Canada**

Dr. Jeffrey M. Dambacher
Computational Informatics
CSIRO, **Australia**

Dr. Alida Bundy (SG-SEES)
*Chair IMBER **Human Dimension***
Fisheries and Oceans, **Canada**

Dr. Mitsutaku Makino (S-HD)
*Head of the **Fisheries Management** Group*
Fisheries Research Agency, **Japan**

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*School of **Marine & Environmental Affairs** &*
Jackson School of International Studies
University of Washington, **USA**

Dr. Beth Fulton
*Head of **Social-Ecological Modeling** Group*
CSIRO, **Australia**

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*School for **Conflict Analysis and Resolution***
George Mason University, **USA**

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WHOI, **USA**

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*Department of **Math. Methods in Economy***
Far Eastern Federal University, **Russia**

Dr. Frank Schwing
Ecosystem Management
Office of Management and Budget, NOAA, **USA**

Dr. Nathan Mantua (SG-SEES)
*Southwest **Fisheries** Science Center*
NOAA, **USA**

International study group in **PICES** on

Social-Ecological-Environmental Systems (SG-SEES)

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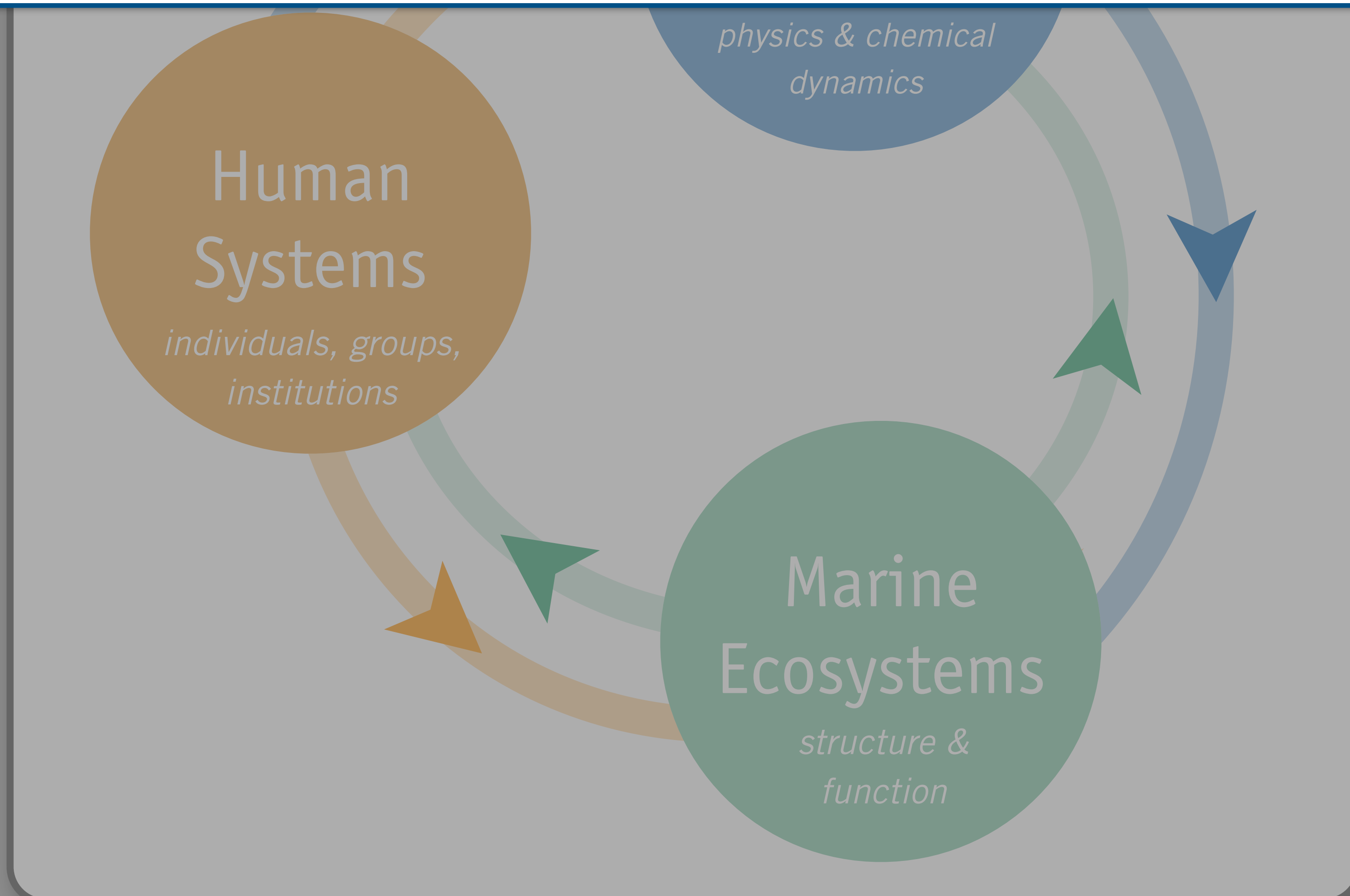

International study group in **PICES** on

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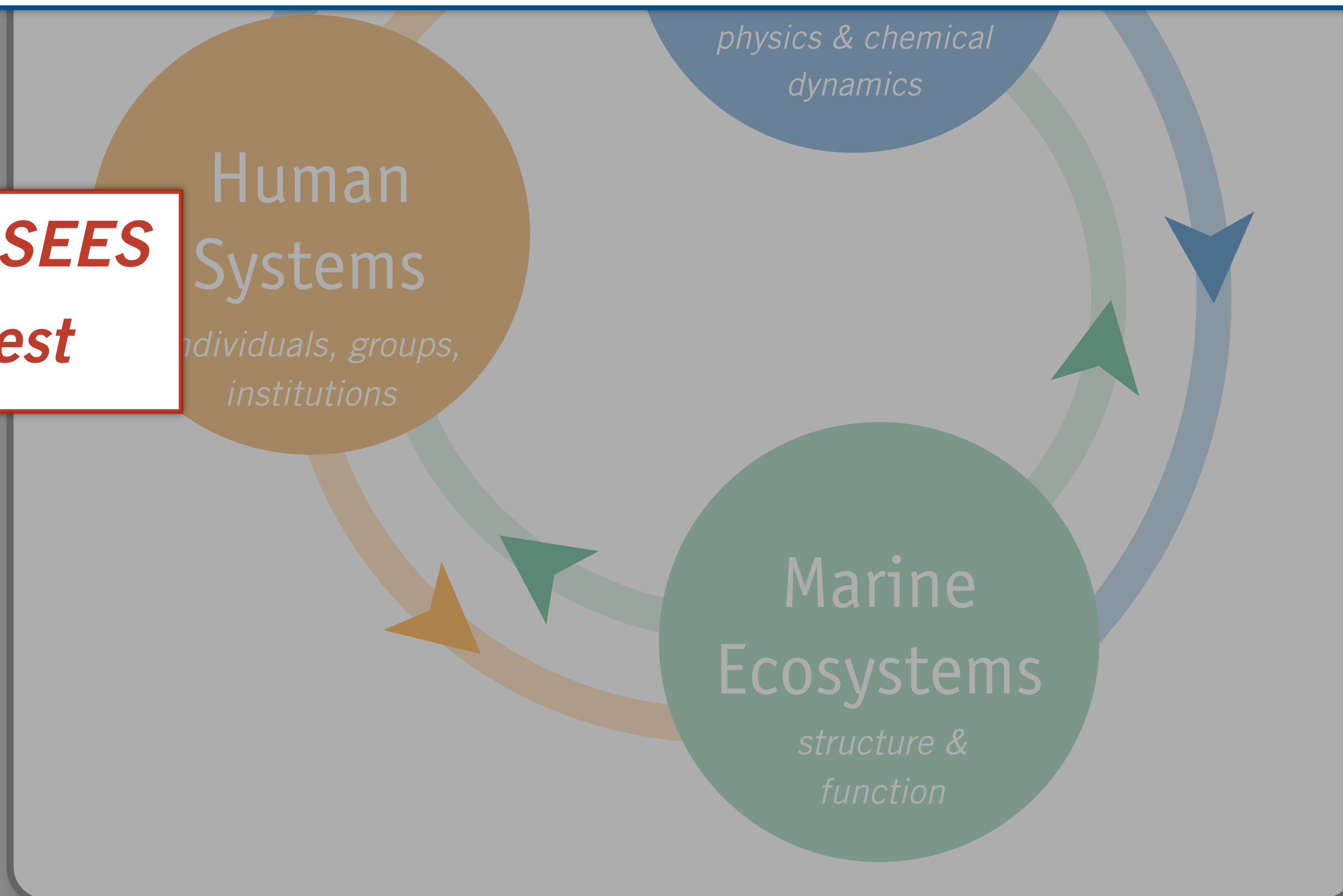
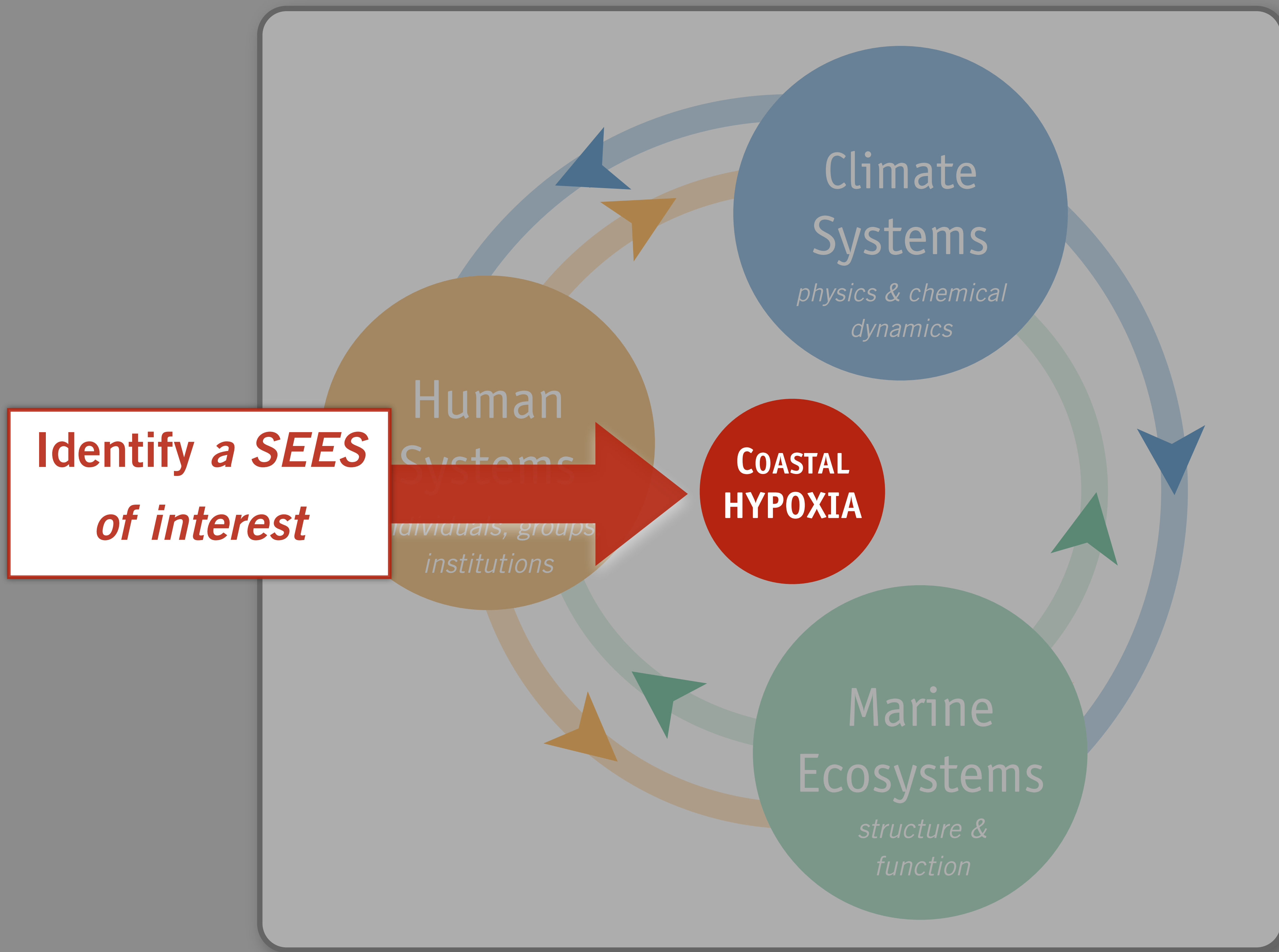
Identify *a SEES of interest*





Identify a SEES of interest
Climate Systems
physics & chemical dynamics
Human
institutions
COASTAL HYPOXIA
Marine Ecosystems
structure & function

Identify *a SEES of interest*

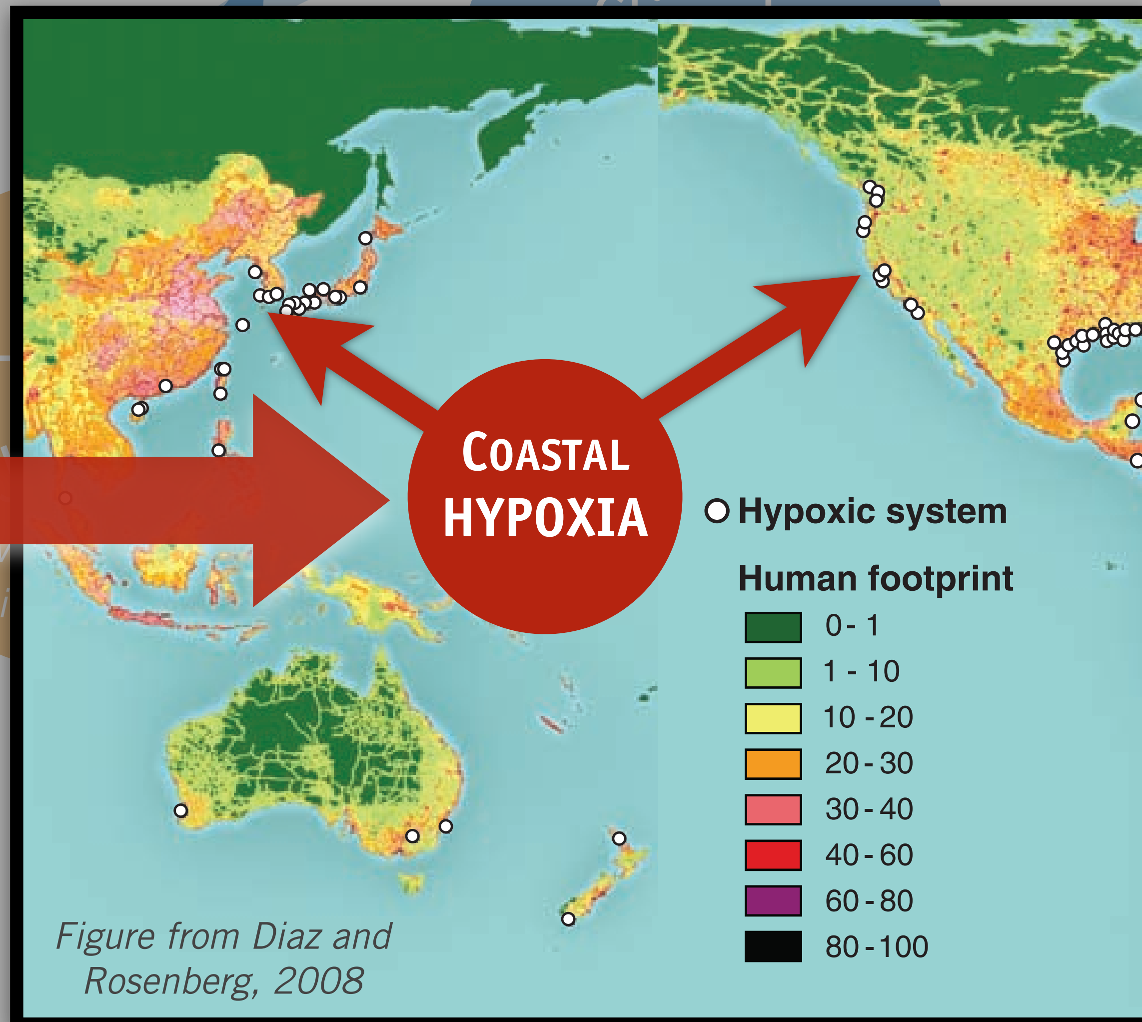
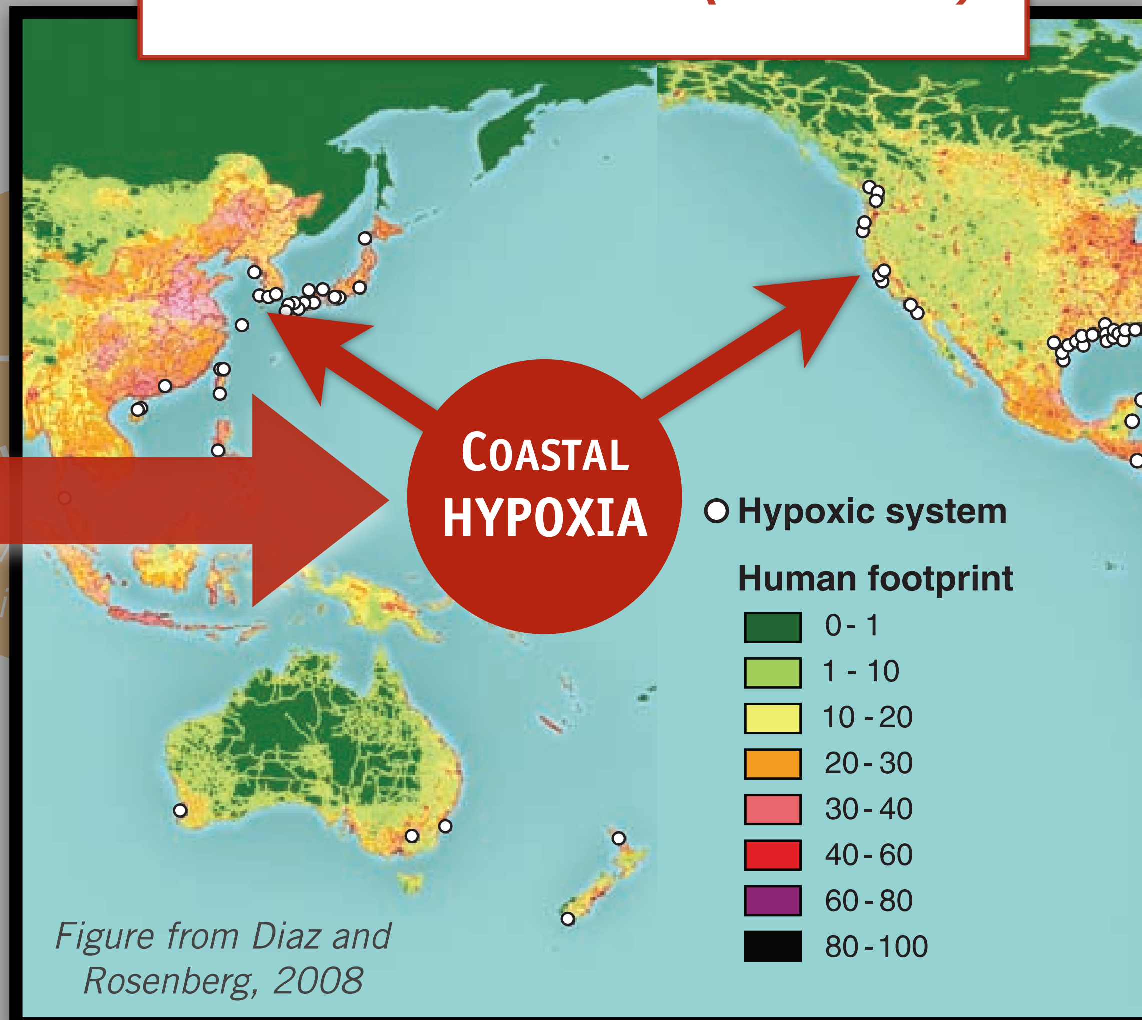


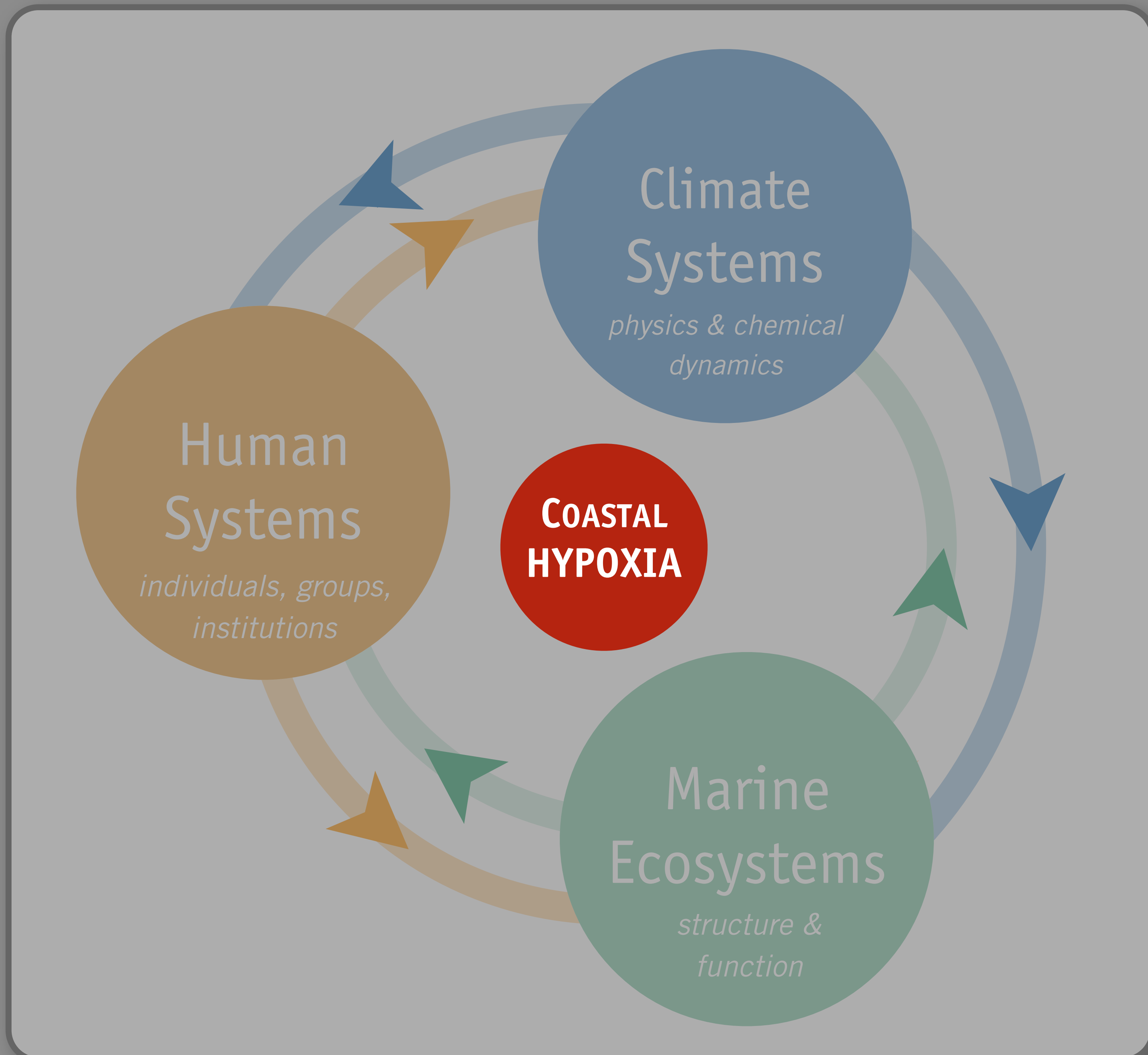
Figure from Diaz and Rosenberg, 2008

Model and Compare

2 CASE STUDIES (locations)

Identify *a SEES of interest*

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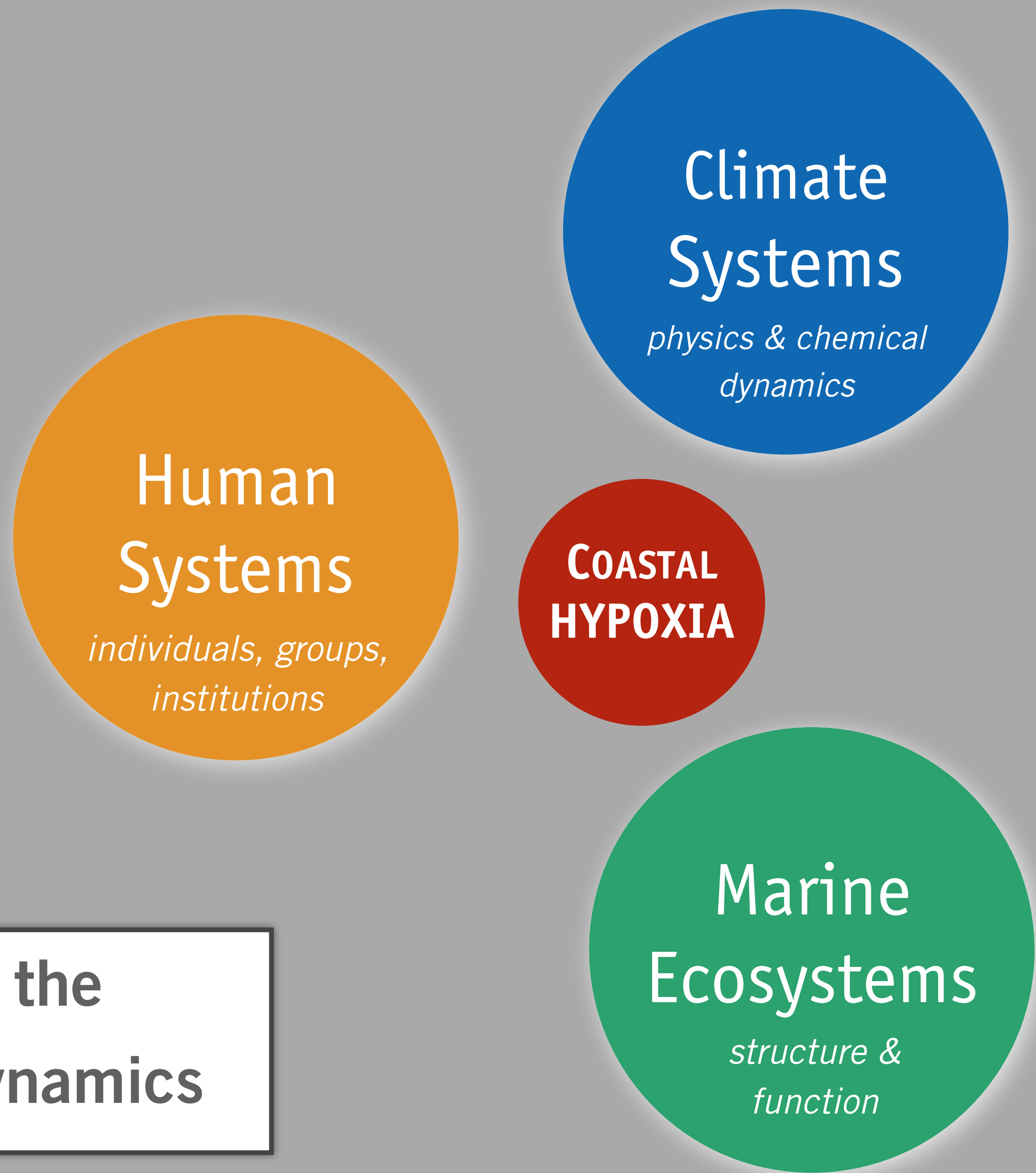
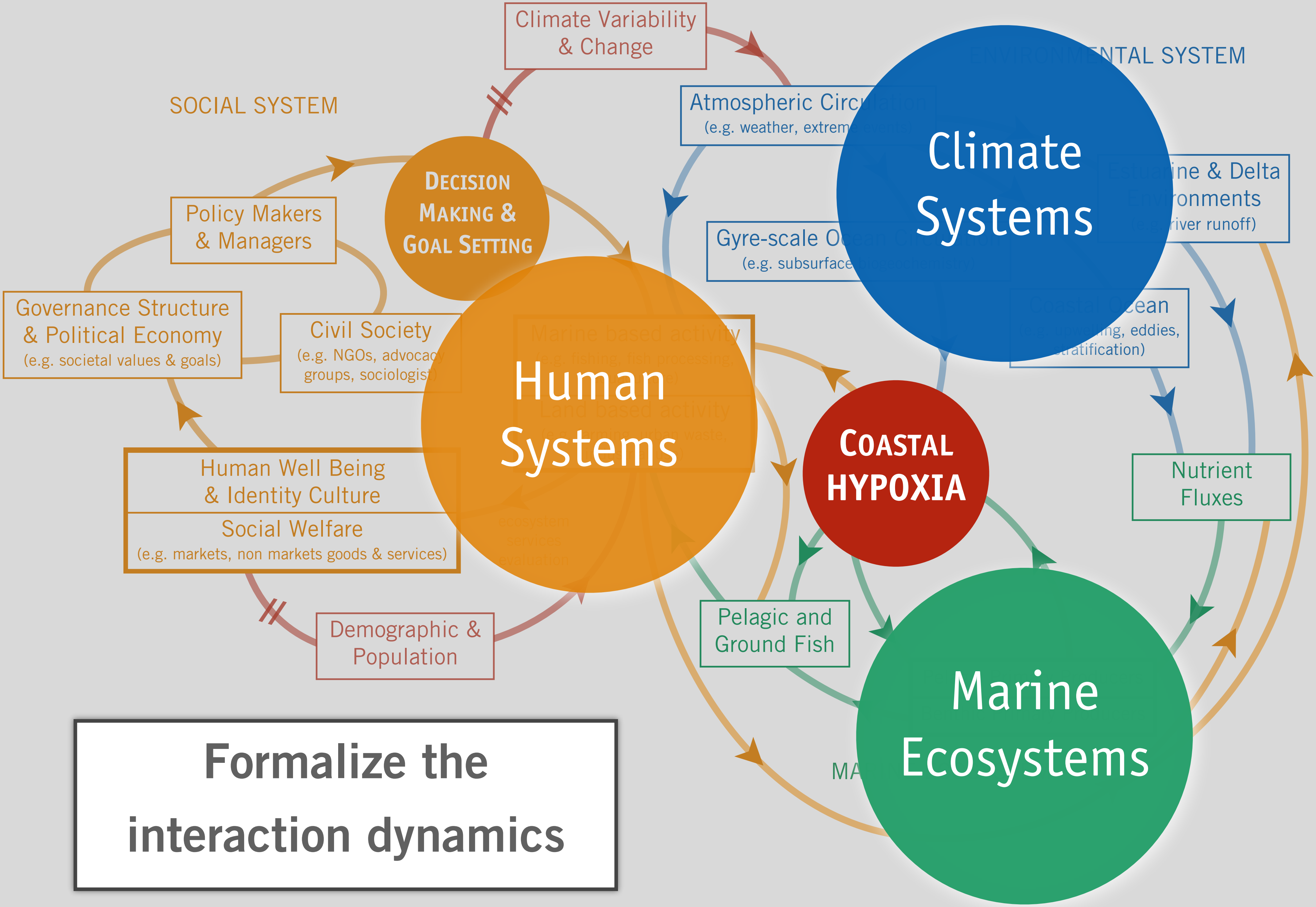
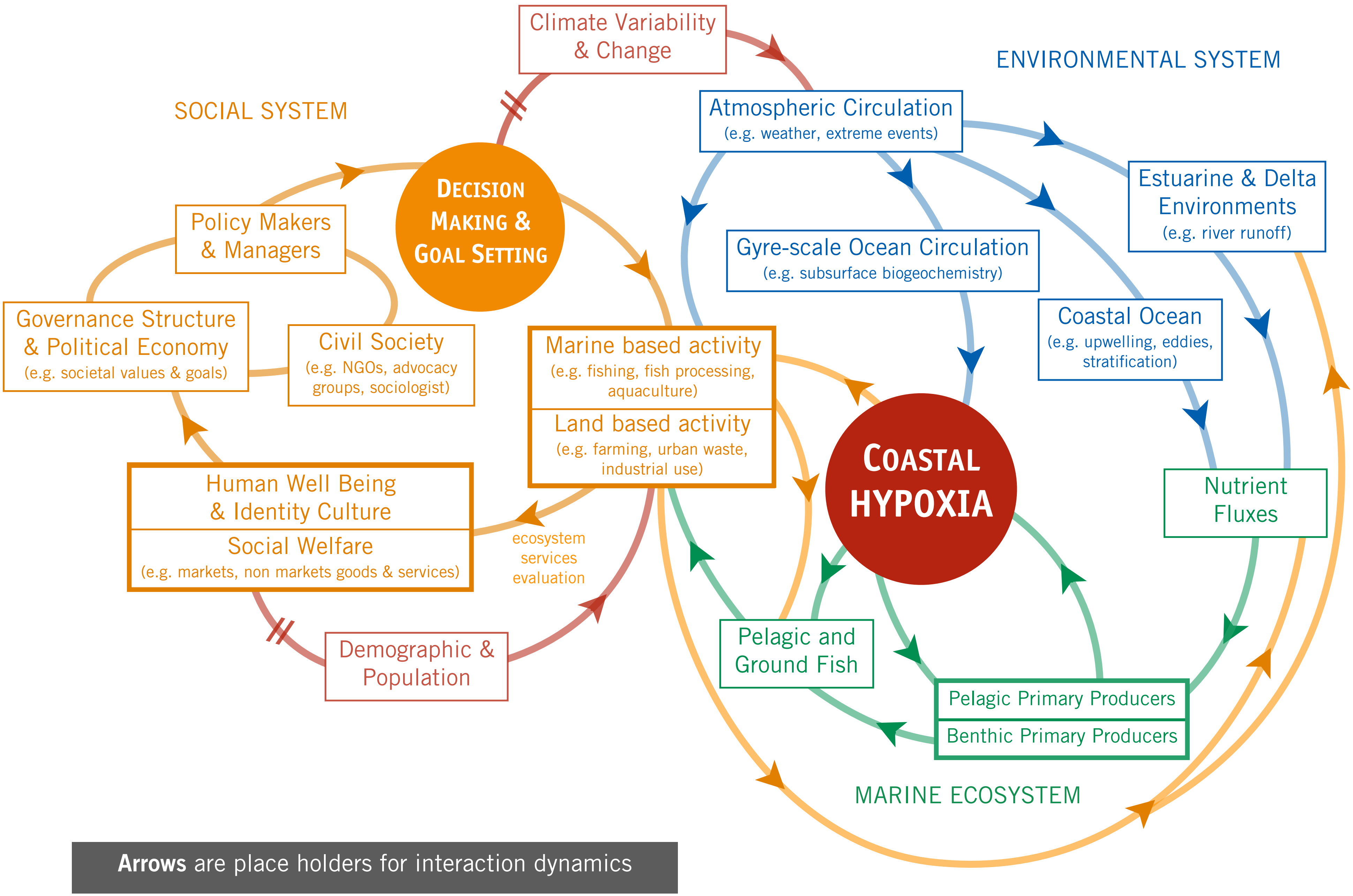
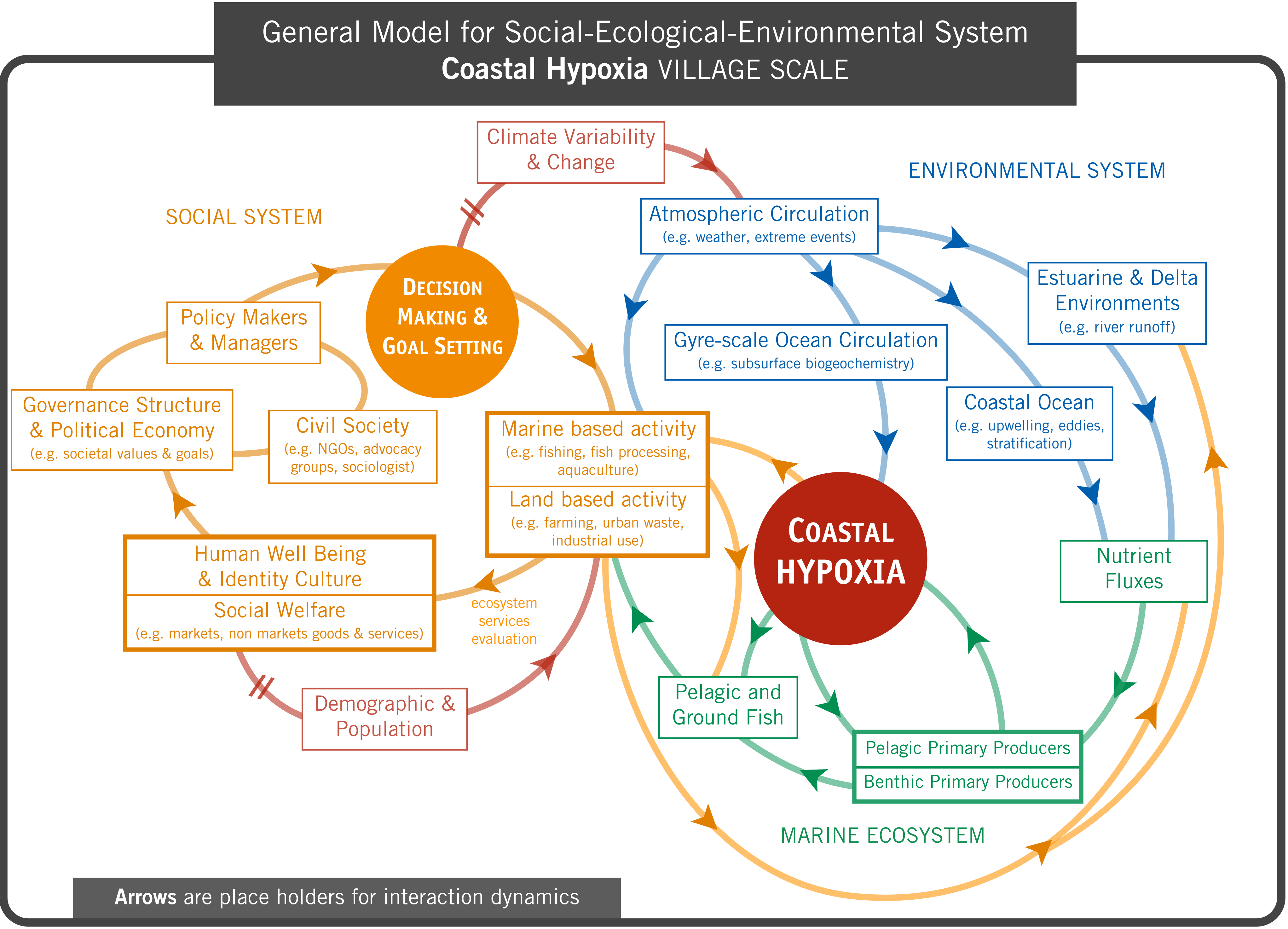


Formalize the interaction dynamics



Formalize the interaction dynamics


Climate Variability & Change
ENVIRONMENTAL SYSTEM
SOCIAL SYSTEM
Atmospheric Circulation
(e.g. weather, extreme events)
Estuarine & Delta Environments
(e.g. river runoff)
Decision Making & Goal Setting
Policy Makers & Managers
Gyre-scale Ocean Circulation
(e.g. subsurface biogeochemistry)
Coastal Ocean
(e.g. upwelling, eddies, stratification)
Governance Structure & Political Economy
(e.g. societal values & goals)
Civil Society
(e.g. NGOs, advocacy groups, sociologist)
Marine based activity
(e.g. fishing, fish processing, aquaculture)
Land based activity
(e.g. farming, urban waste, industrial use)
Coastal Hypoxia
Nutrient Fluxes
Human Well Being & Identity Culture
Social Welfare
(e.g. markets, non markets goods & services)
ecosystem services evaluation
Pelagic and Ground Fish
Demographic & Population
Pelagic Primary Producers
Benthic Primary Producers
MARINE ECOSYSTEM
Arrows are place holders for interaction dynamics


General Model for Social-Ecological-Environmental System
Coastal Hypoxia VILLAGE SCALE
Climate Variability & Change
ENVIRONMENTAL SYSTEM
SOCIAL SYSTEM
Atmospheric Circulation (e.g. weather, extreme events)
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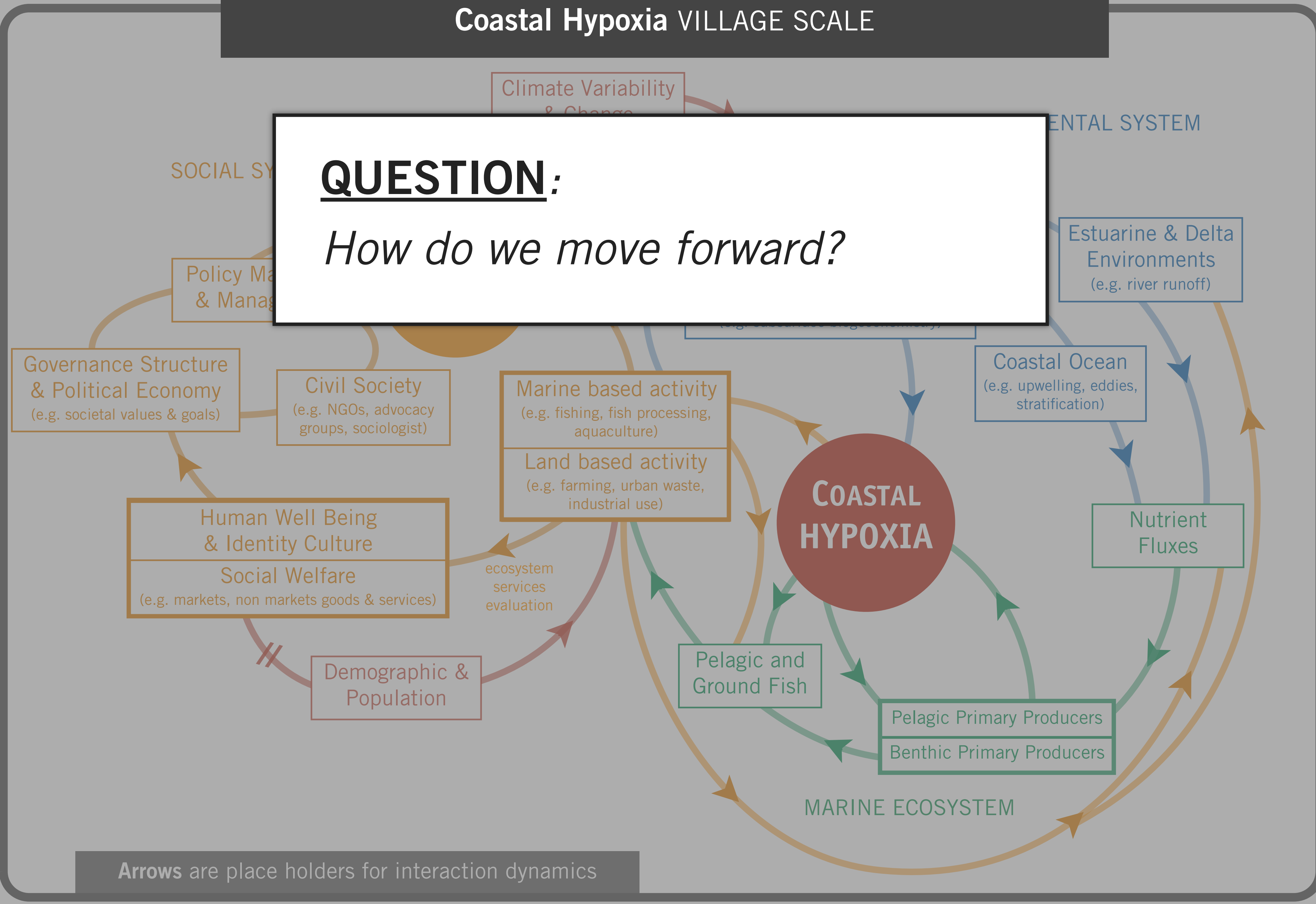
MARINE ECOSYSTEM
Arrows are place holders for interaction dynamics

General Model for Social-Ecological-Environmental System

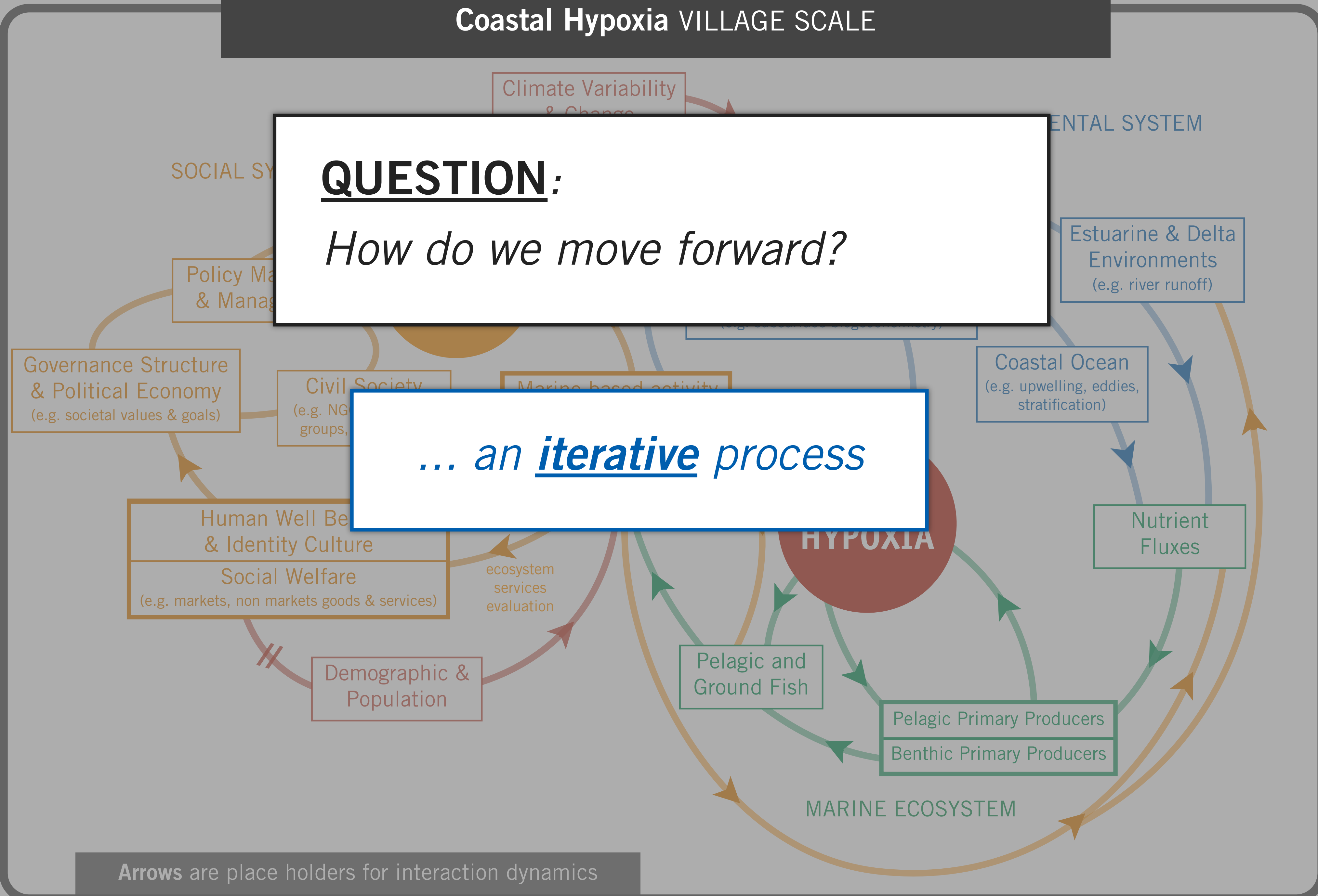
Coastal Hypoxia VILLAGE SCALE



QUESTION:

How do we move forward?

General Model for Social-Ecological-Environmental System
Coastal Hypoxia VILLAGE SCALE

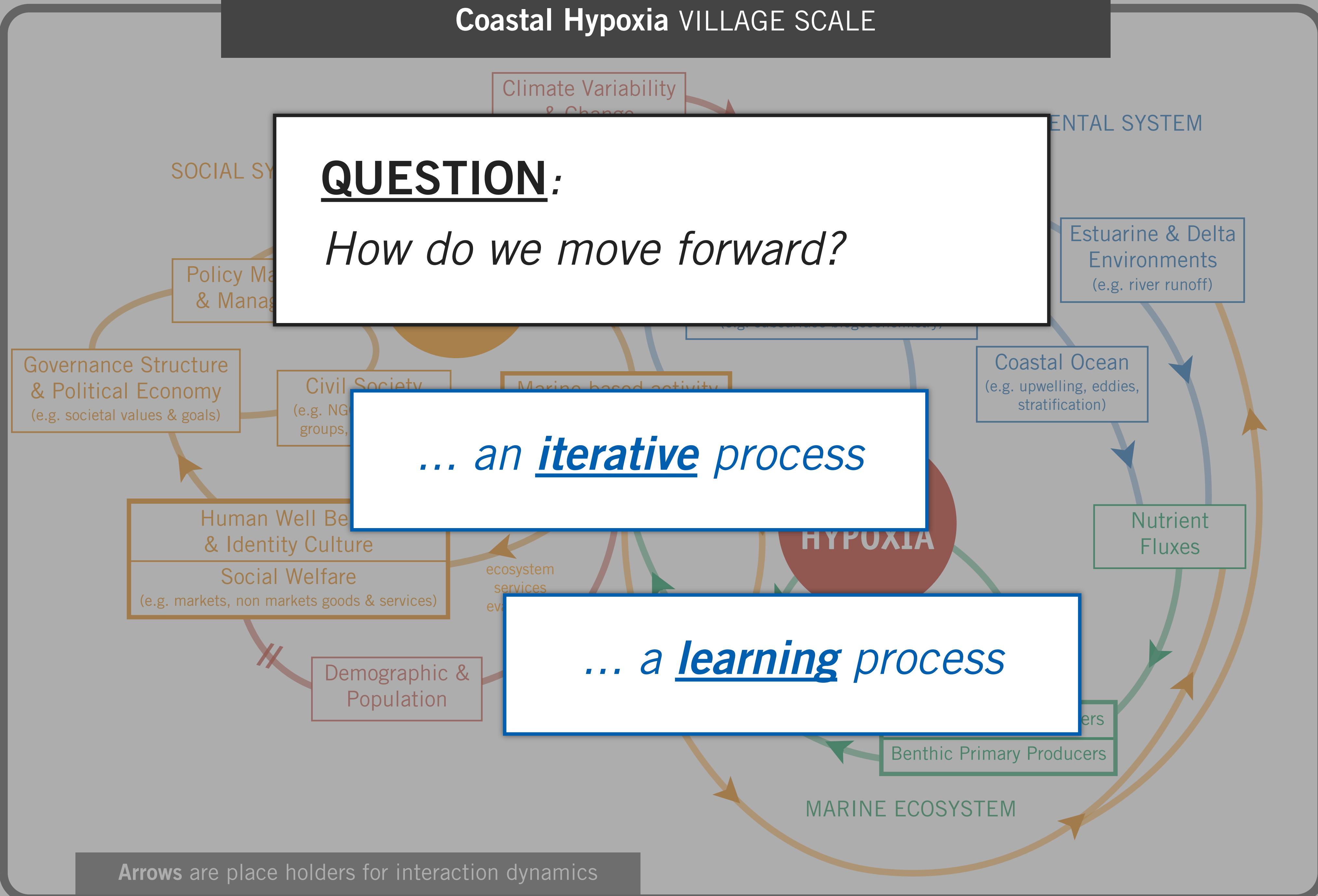


QUESTION:

How do we move forward?

*… an **iterative** process*

General Model for Social-Ecological-Environmental System
Coastal Hypoxia VILLAGE SCALE



QUESTION:

How do we move forward?

… an ***iterative*** *process*

… a ***learning*** *process*

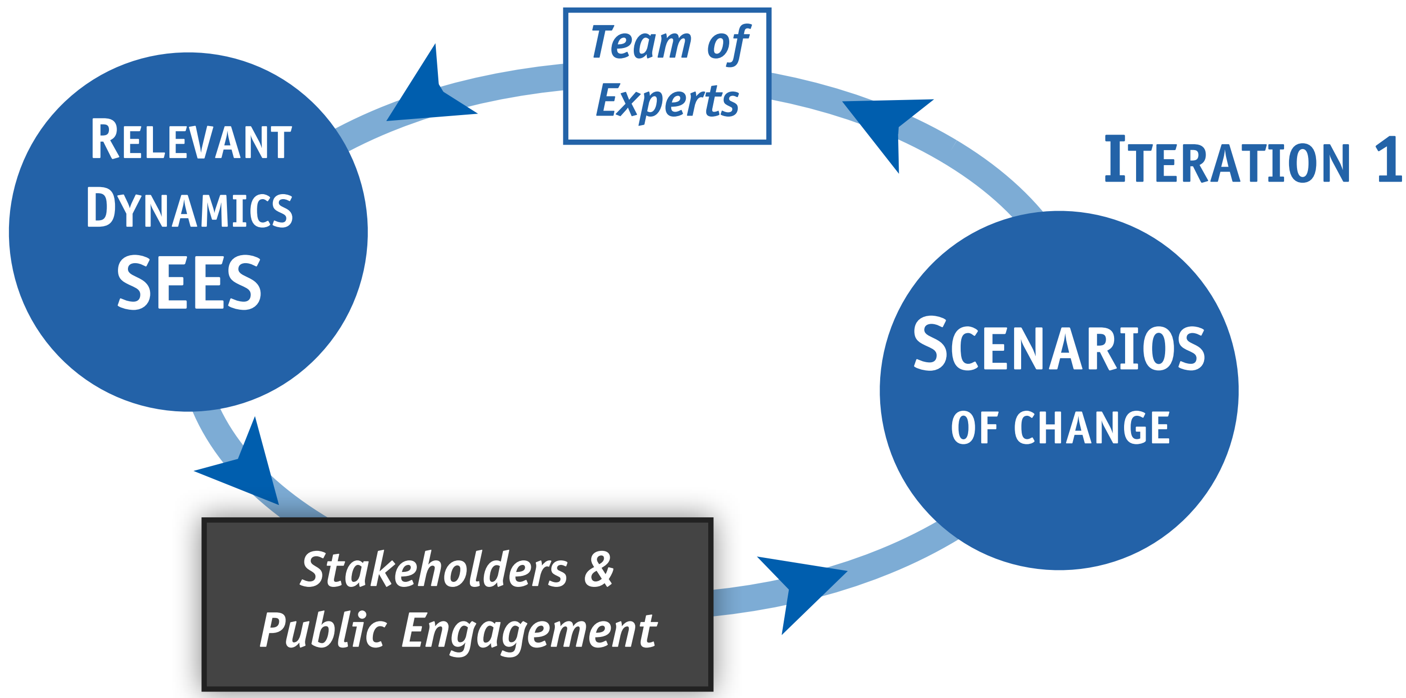
Team of Experts

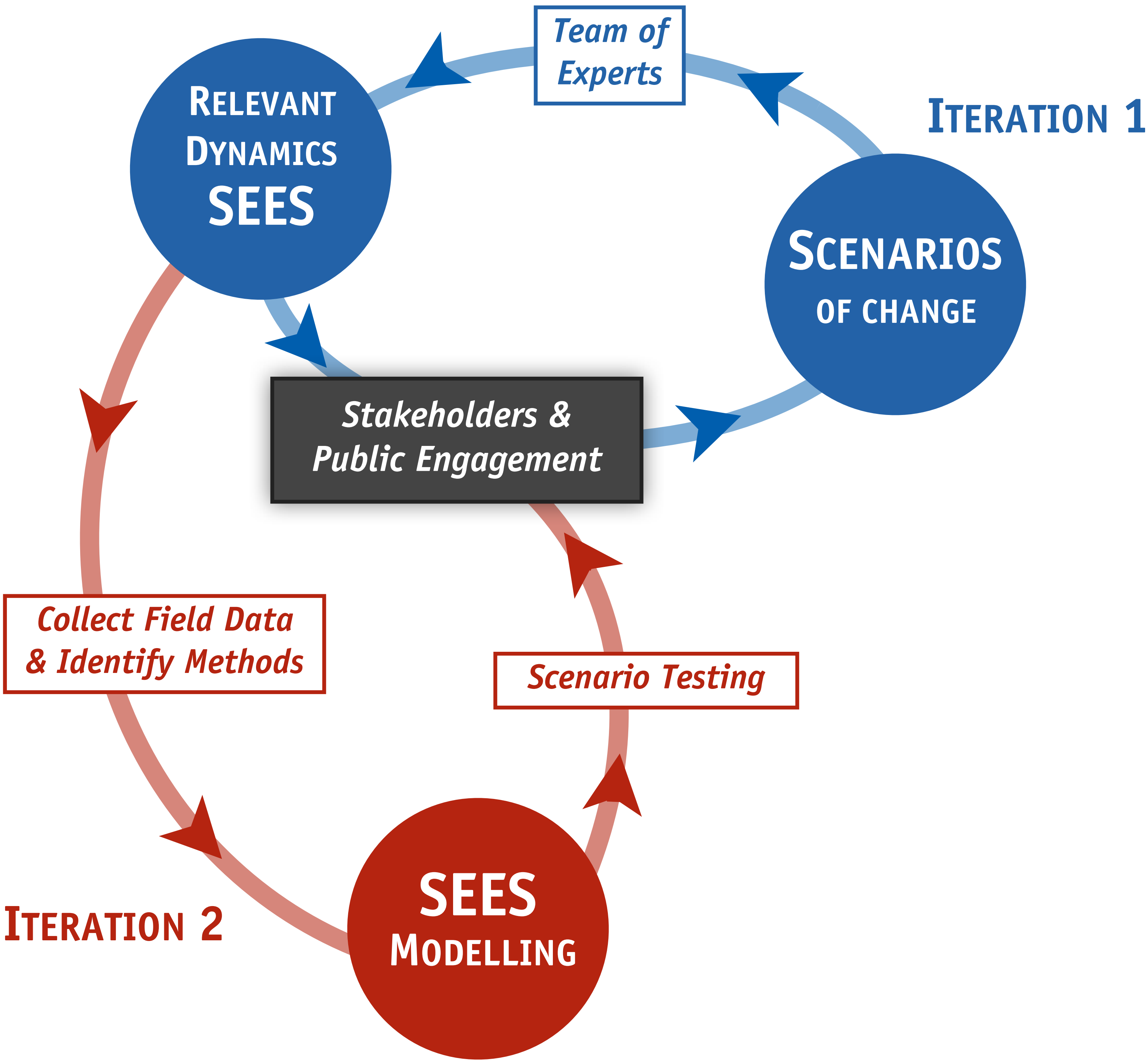
RELEVANT DYNAMICS SEES

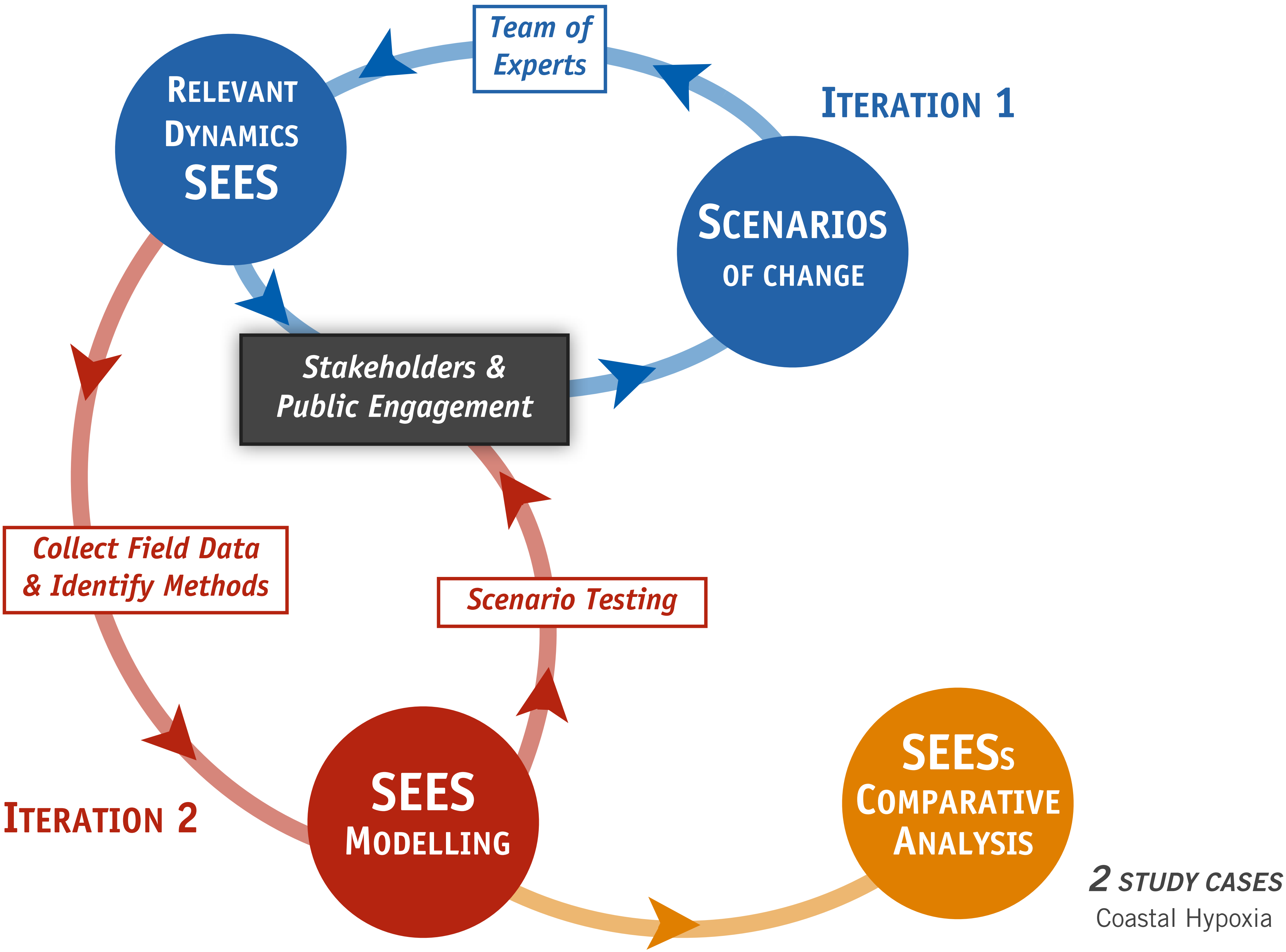
Isolate specific dynamics of ***2 CASE STUDIES***

Specify the scales of interaction

… an ***iterative*** *process*


Team of Experts
RELEVANT DYNAMICS SEES
ITERATION 1
SCENARIOS OF CHANGE
Stakeholders & Public Engagement


Team of Experts
Iteration 1
Relevant Dynamics SEES
Scenarios of change
Stakeholders & Public Engagement
Collect Field Data & Identify Methods
Scenario Testing
SEES Modelling
Iteration 2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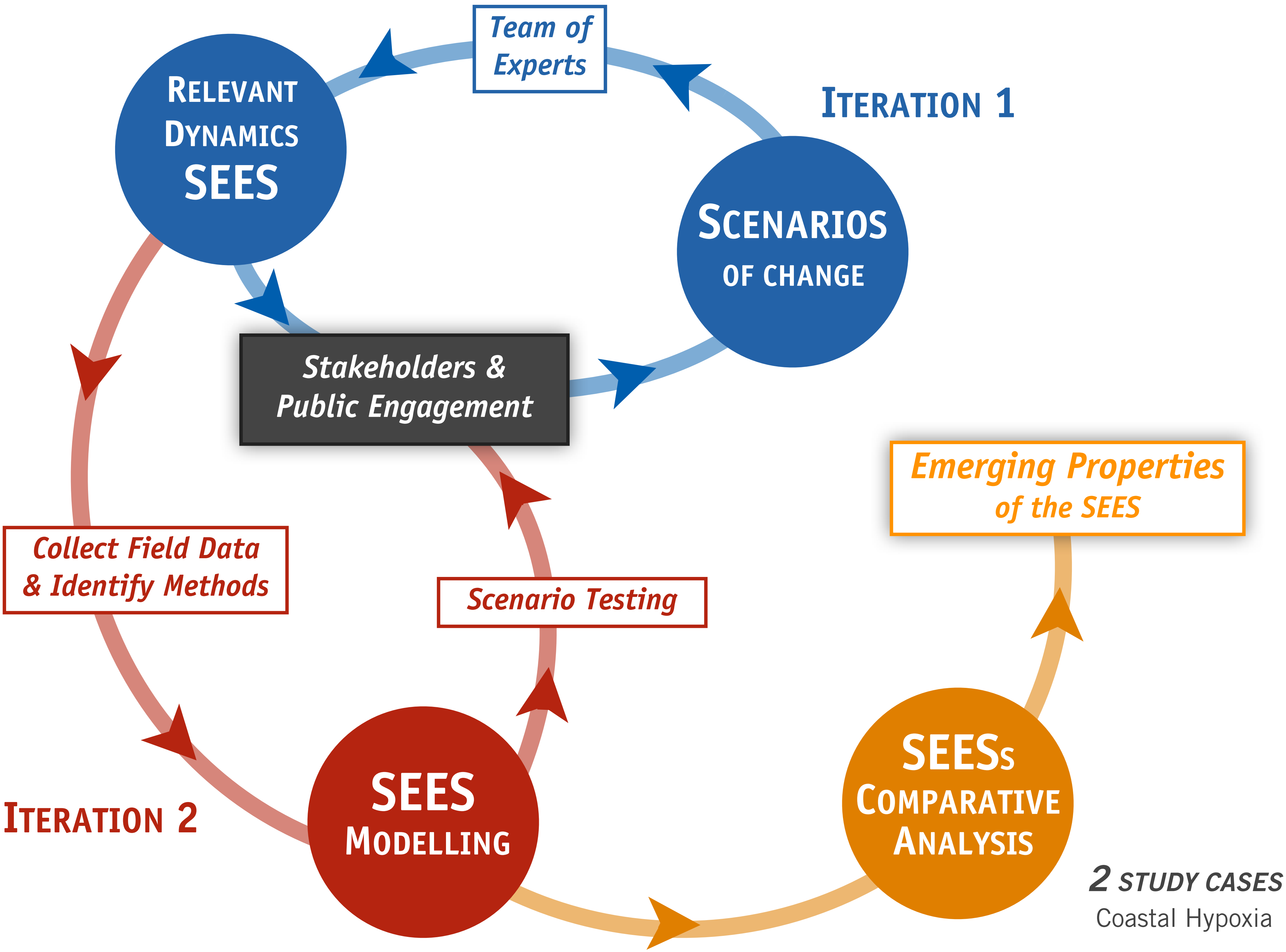
Iteration 2
SEESs Comparative Analysis
2 study cases
Coastal Hypoxia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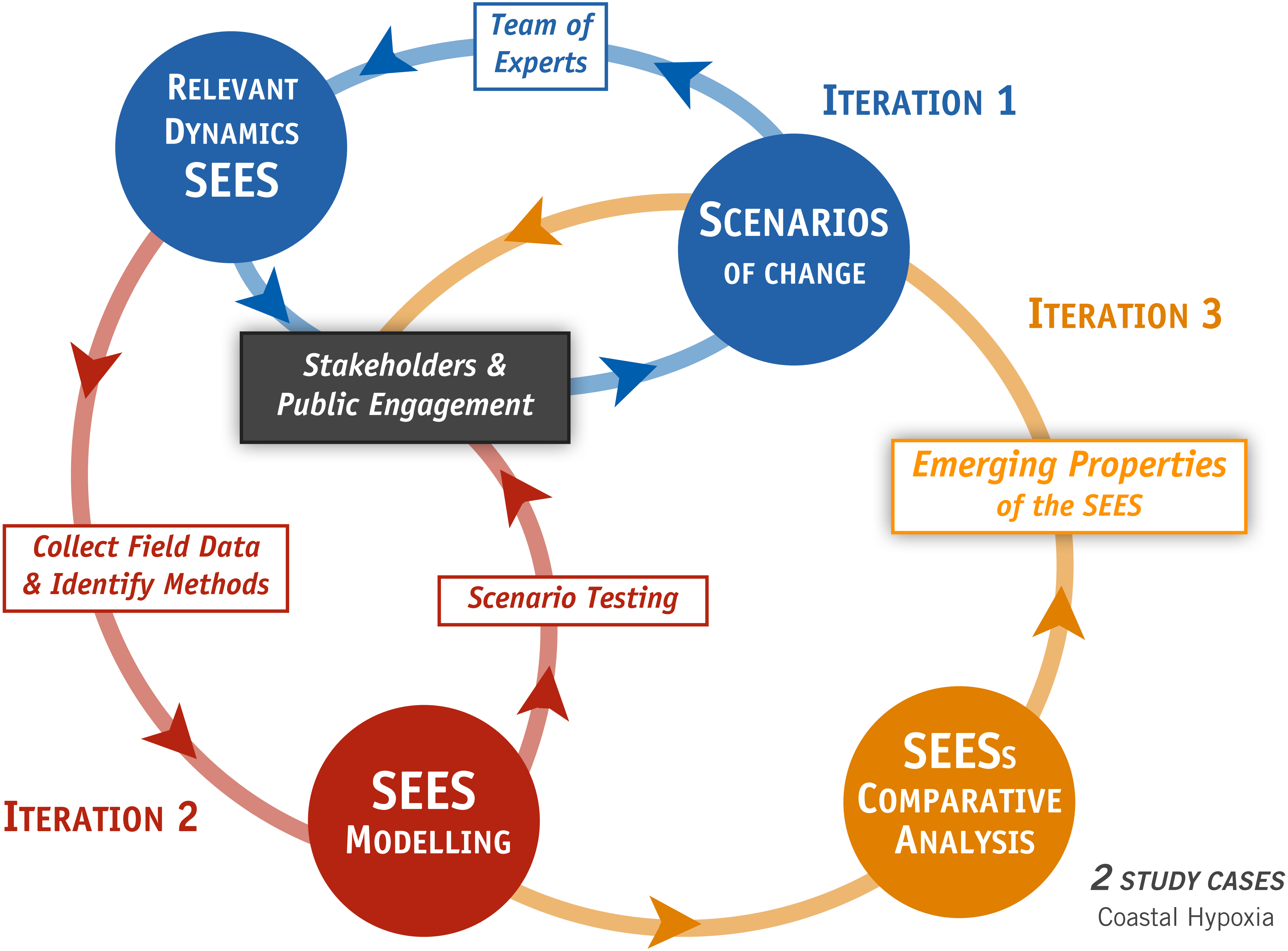
SEESs Comparative Analysis
Iteration 2
SEES Modelling
2 study cases
Coastal Hypoxia



Team of Experts
Iteration 1
Relevant Dynamics SEES
Scenarios of change
Iteration 3
Stakeholders & Public Engagement
Emerging Properties of the SEES
Collect Field Data & Identify Methods
Scenario Testing
Iteration 2
SEES Modelling
SEESs Comparative Analysis
2 study cases
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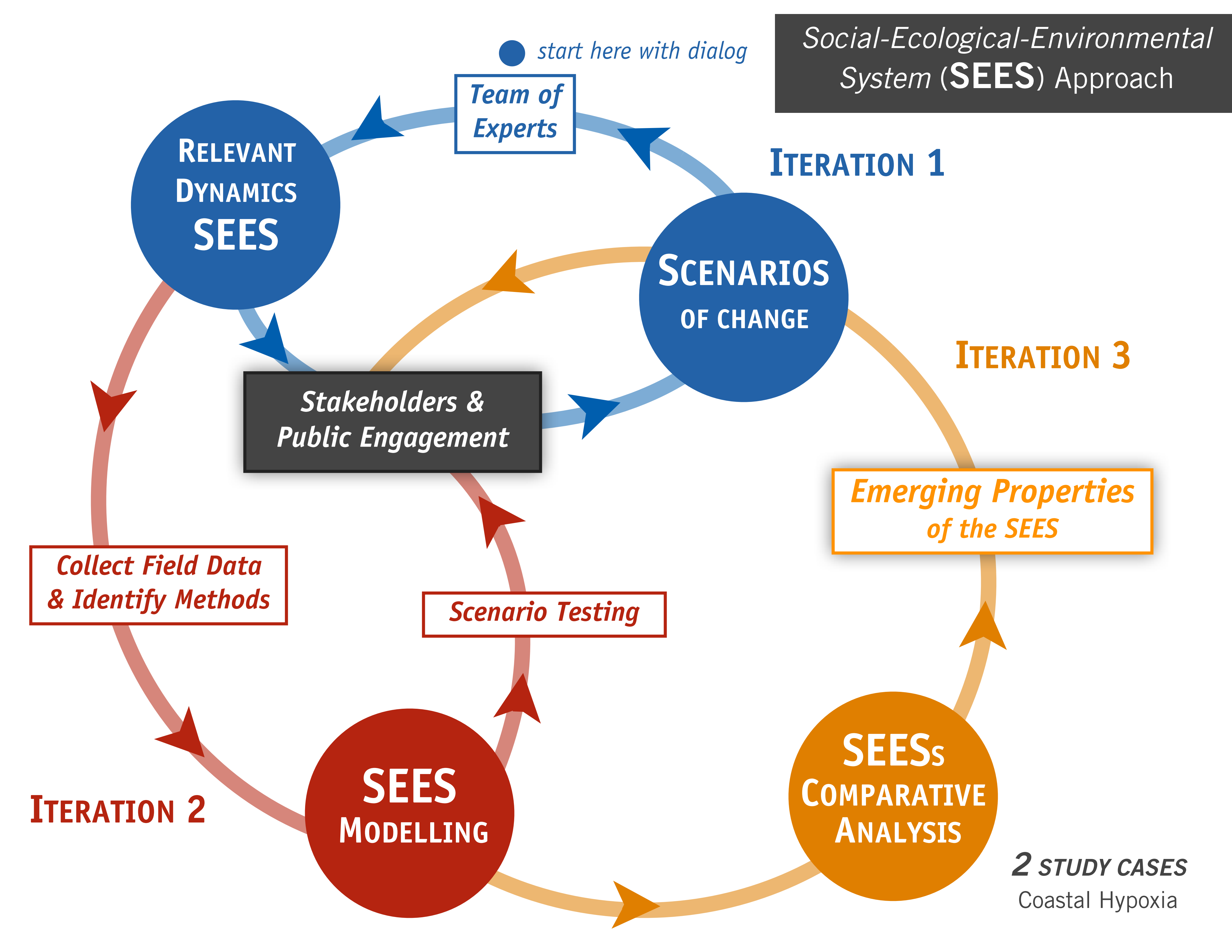
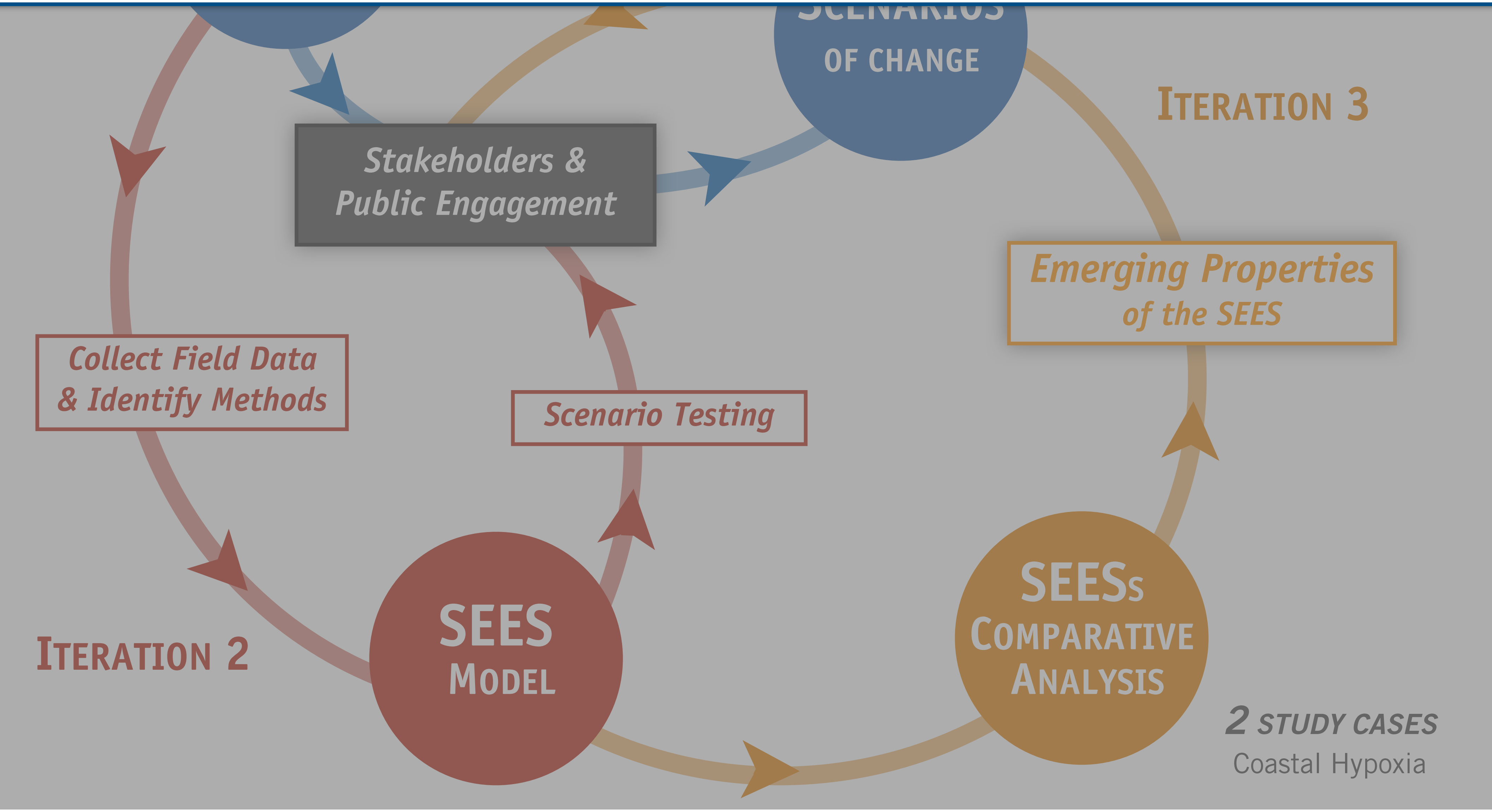
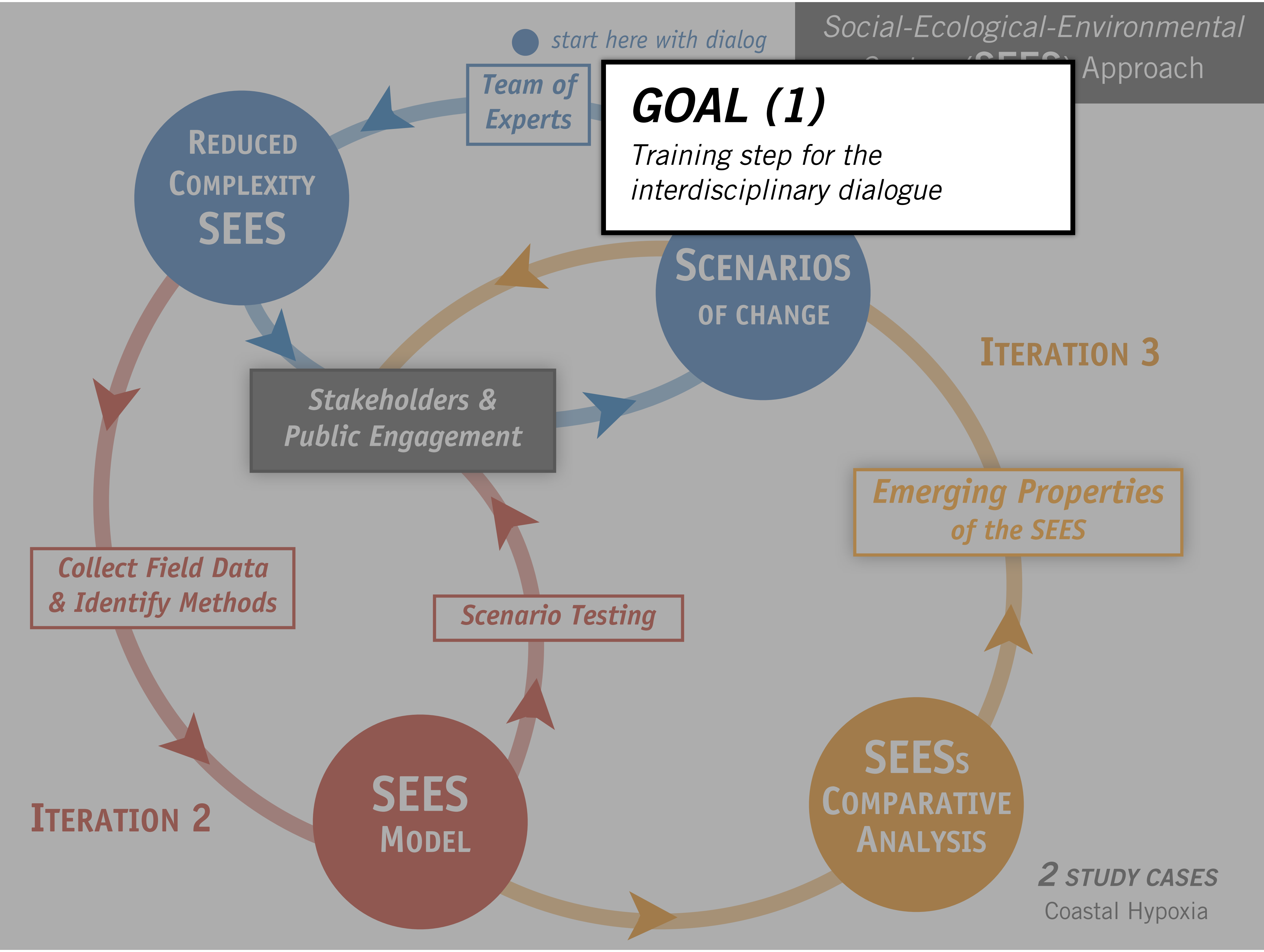


Social-Ecological-Environmental System (SEES) Approach
start here with dialog
Team of Experts
RELEVANT DYNAMICS SEES
ITERATION 1
SCENARIOS OF CHANGE
Stakeholders & Public Engagement
ITERATION 3
Emerging Properties of the SEES
Collect Field Data & Identify Methods
Scenario Testing
SEES MODELLING
ITERATION 2
SEESs COMPARATIVE ANALYSIS
2 STUDY CASES
Coastal Hypoxia

What is the study group accomplishing?





Social-Ecological-Environmental
Approach
start here with dialog
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GOAL (1)
Training step for the interdisciplinary dialogue
Reduced Complexity SEES
Scenarios of Change
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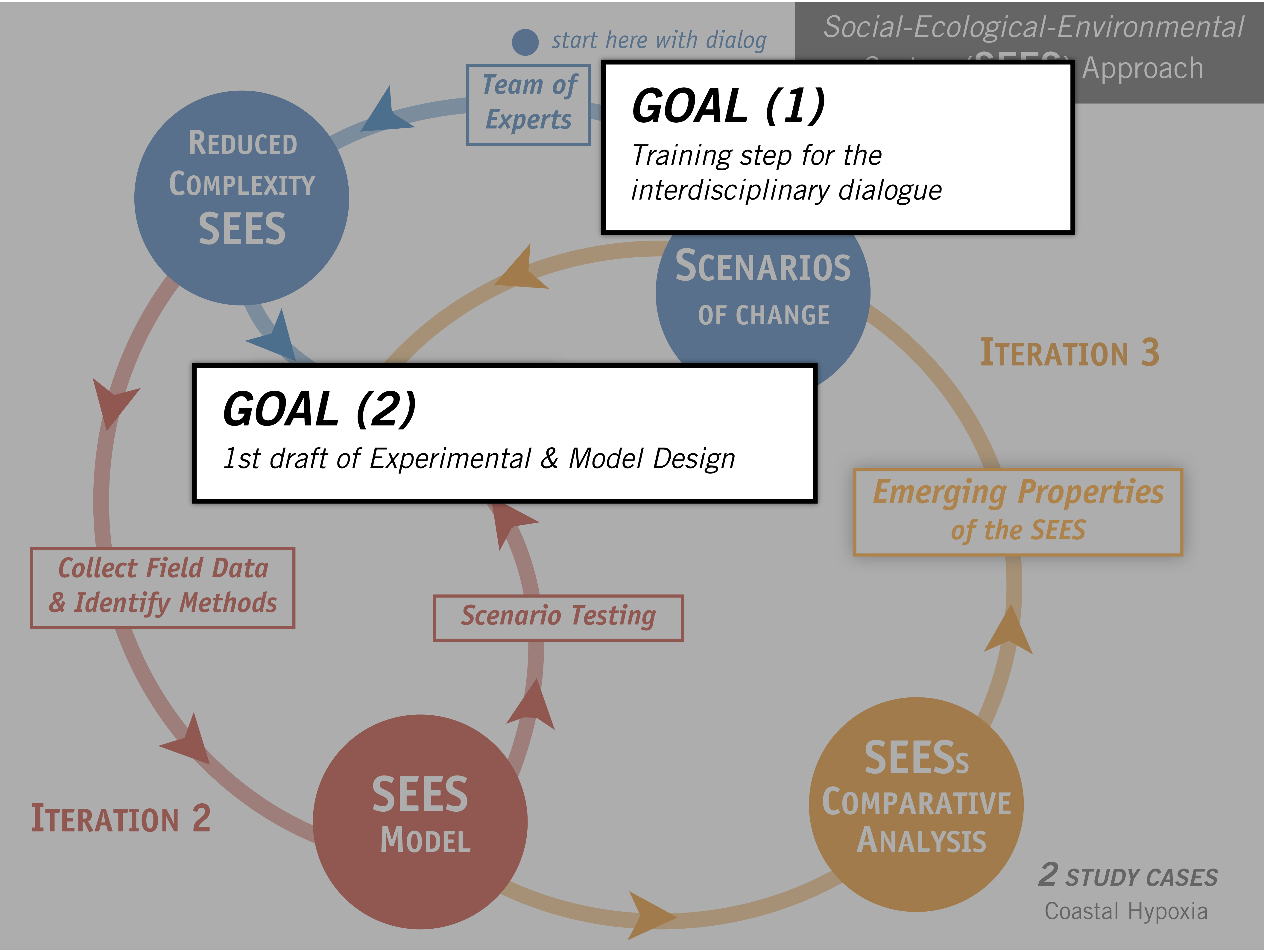
Social-Ecological-Environmental
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Training step for the interdisciplinary dialogue
REDUCED COMPLEXITY SEES
SCENARIOS OF CHANGE
ITERATION 3
GOAL (2)
1st draft of Experimental & Model Design
Emerging Properties of the SEES
Collect Field Data & Identify Methods
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SEES MODEL
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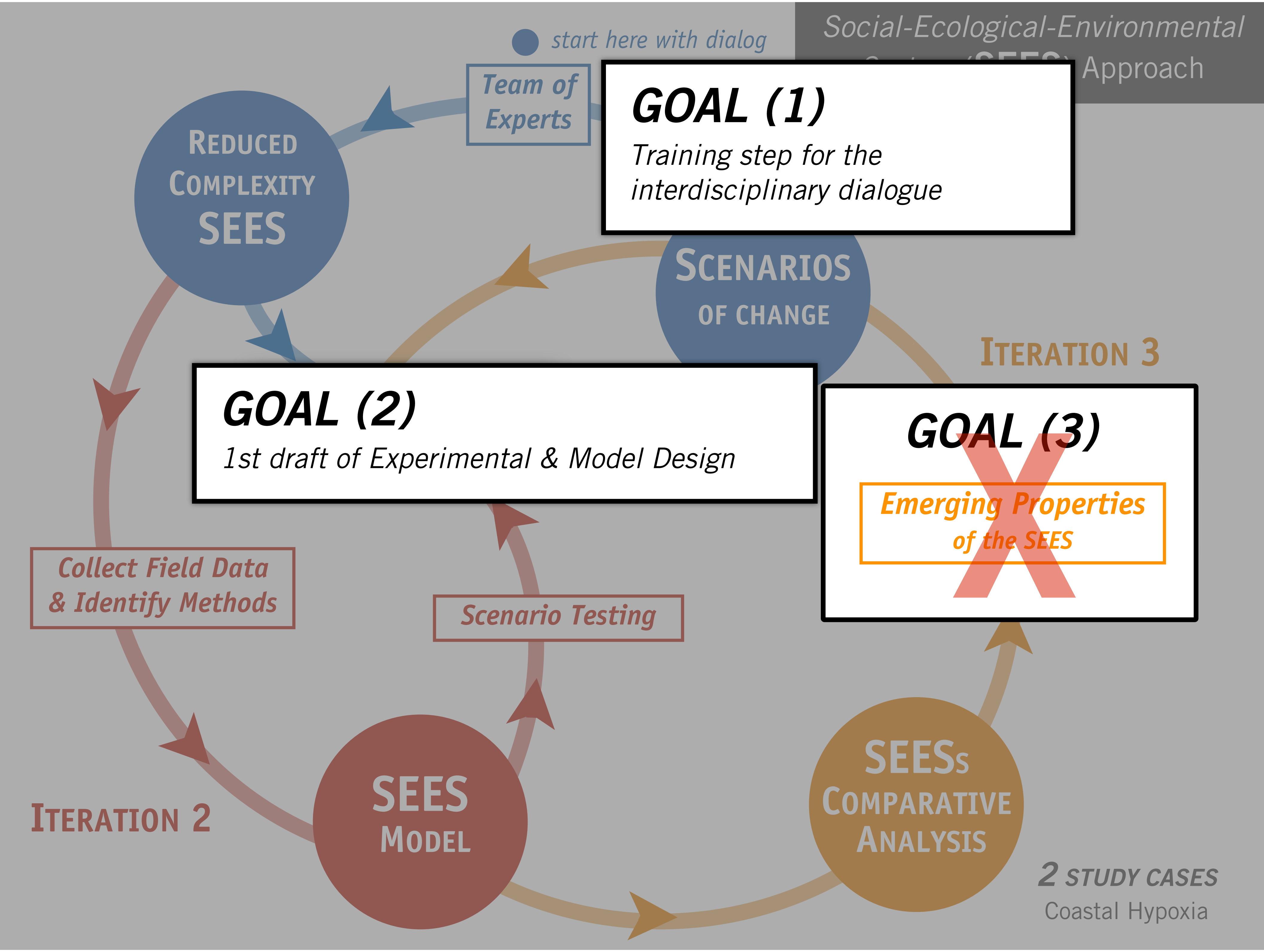

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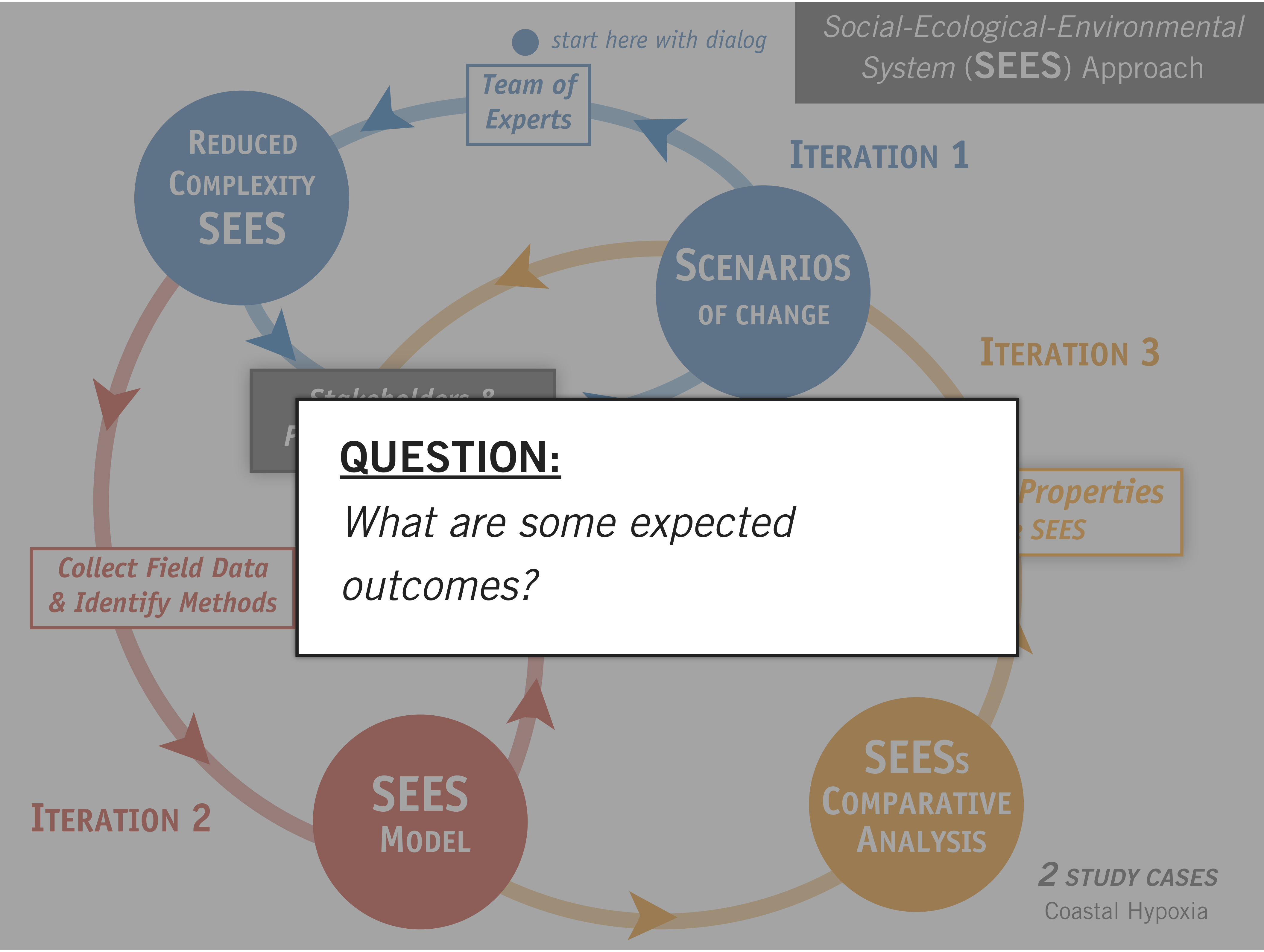


QUESTION:

What are some expected outcomes?

COASTAL OCEAN SEES
Ningaloo Coral Reef

DR. BETH FULTON
CSIRO, AUSTRIALIA

TERRESTRIAL SEES
Massachusetts Forest

DR. KATHY FALLON LAMBERT
HARVARD, USA

QUESTION:

What are some expected outcomes?

Coastal Ocean SEES
Ningaloo Coral Reaf

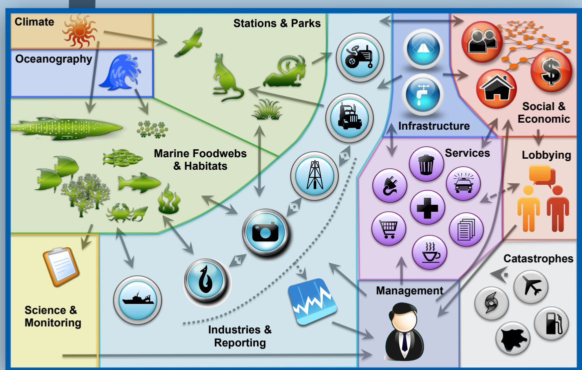
Dr. Beth Fulton
CSIRO, Austrialia

Terrestrial SEES
Massachusetts Forest

Dr. Kathy Fallon Lambert
Harvard, USA

COASTAL OCEAN SEES
Ningaloo Coral Reaf

Stakeholders & Public Engagement

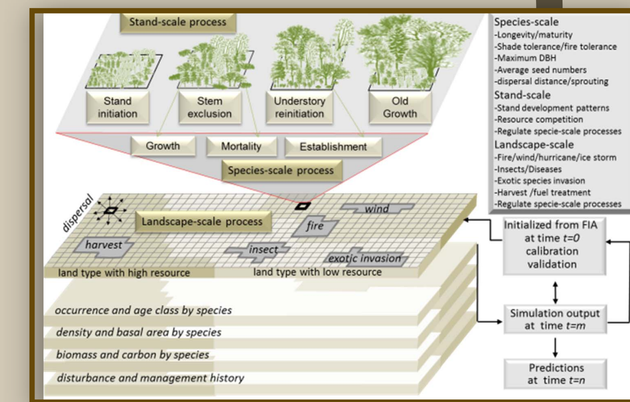


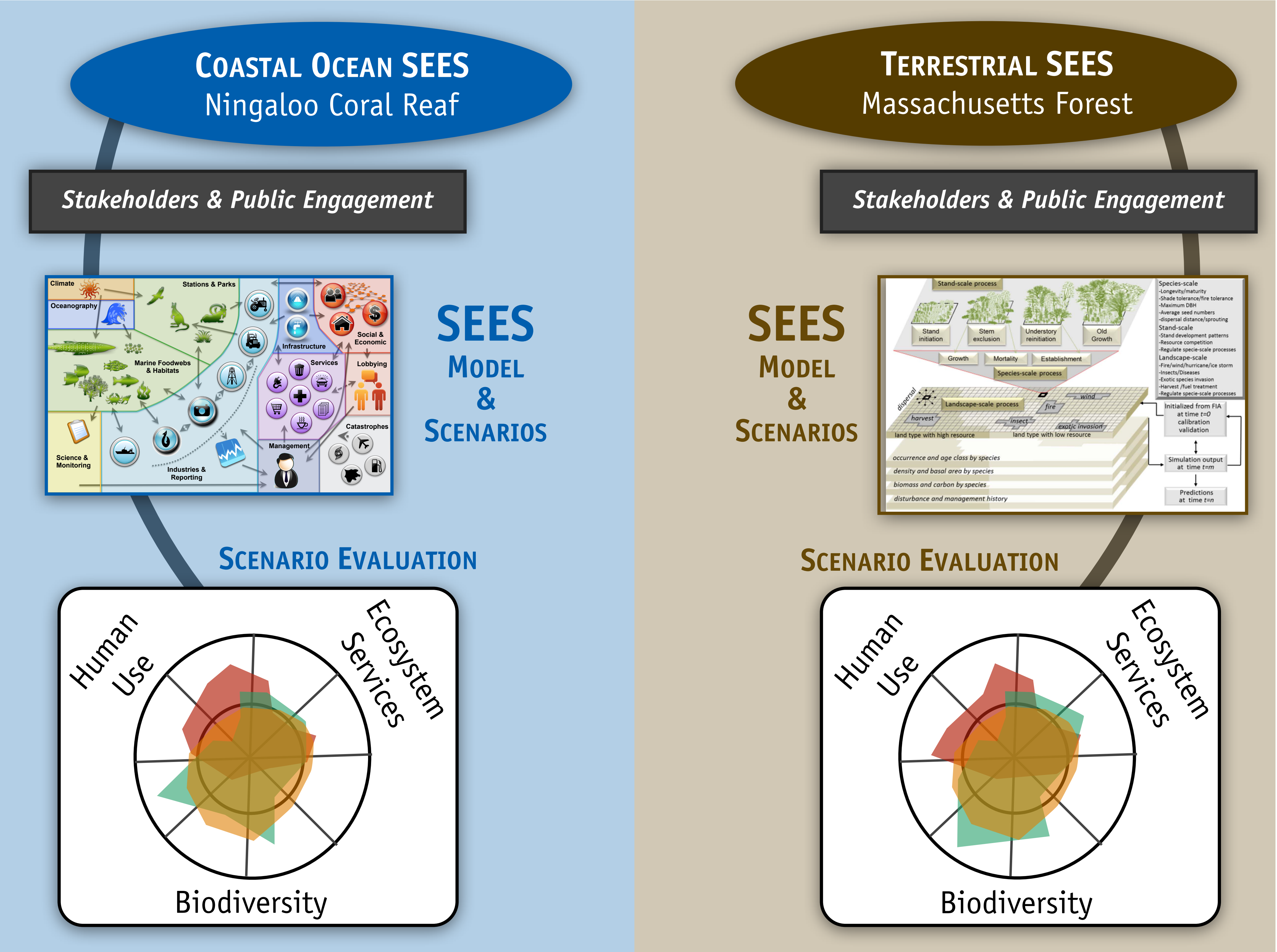
SEES
MODEL
&
SCENARIOS

TERRESTRIAL SEES
Massachusetts Forest

Stakeholders & Public Engagement

SEES
MODEL
&
SCENARIOS





Coastal Ocean SEES
Ningaloo Coral Reef
Stakeholders & Public Engagement
Climate
Oceanography
Stations & Parks
Infrastructure
Social & Economic
Marine Foodwebs & Habitats
Services
Lobbying
Catastrophes
Management
Science & Monitoring
Industries & Reporting
SEES
Model
&
Scenarios
Scenario Evaluation
Human Use
Ecosystem Services
Biodiversity
Terrestrial SEES
Massachusetts Forest
Stakeholders & Public Engagement
Stand-scale process
Stand initiation
Stem exclusion
Understory reinitiation
Old Growth
Growth
Mortality
Establishment
Species-scale process
Landscape-scale process
dispersal
harvest
fire
wind
insect
exotic invasion
land type with high resource
land type with low resource
occurrence and age class by species
density and basal area by species
biomass and carbon by species
disturbance and management history
Species-scale
-Longevity/maturity
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-Maximum DBH
-Average seed numbers
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Stand-scale
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-Resource competition
-Regulate specie-scale processes
Landscape-scale
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-Regulate specie-scale processes
Initialized from FIA at time t=0 calibration validation
Simulation output at time t=m
Predictions at time t=n
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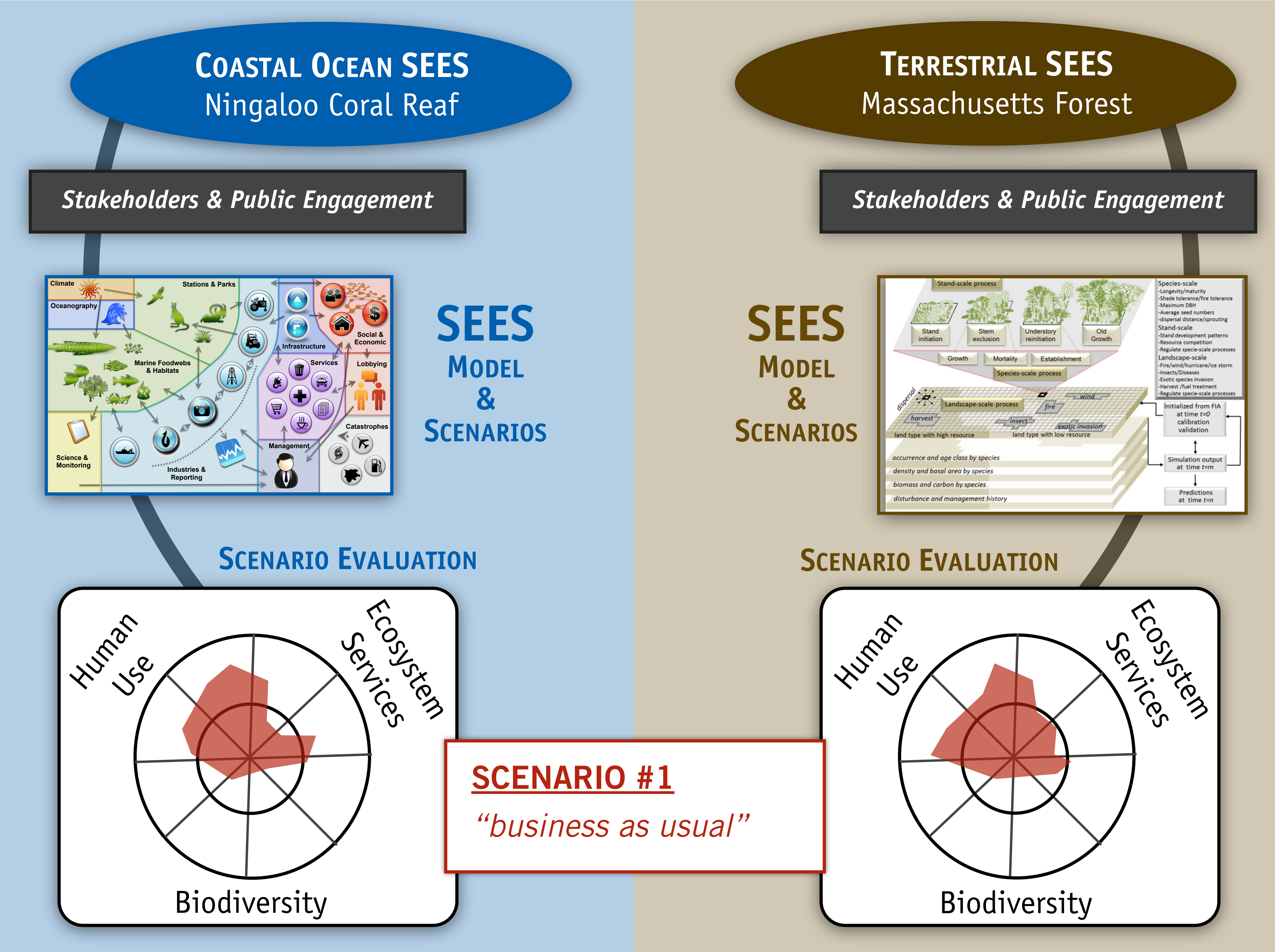

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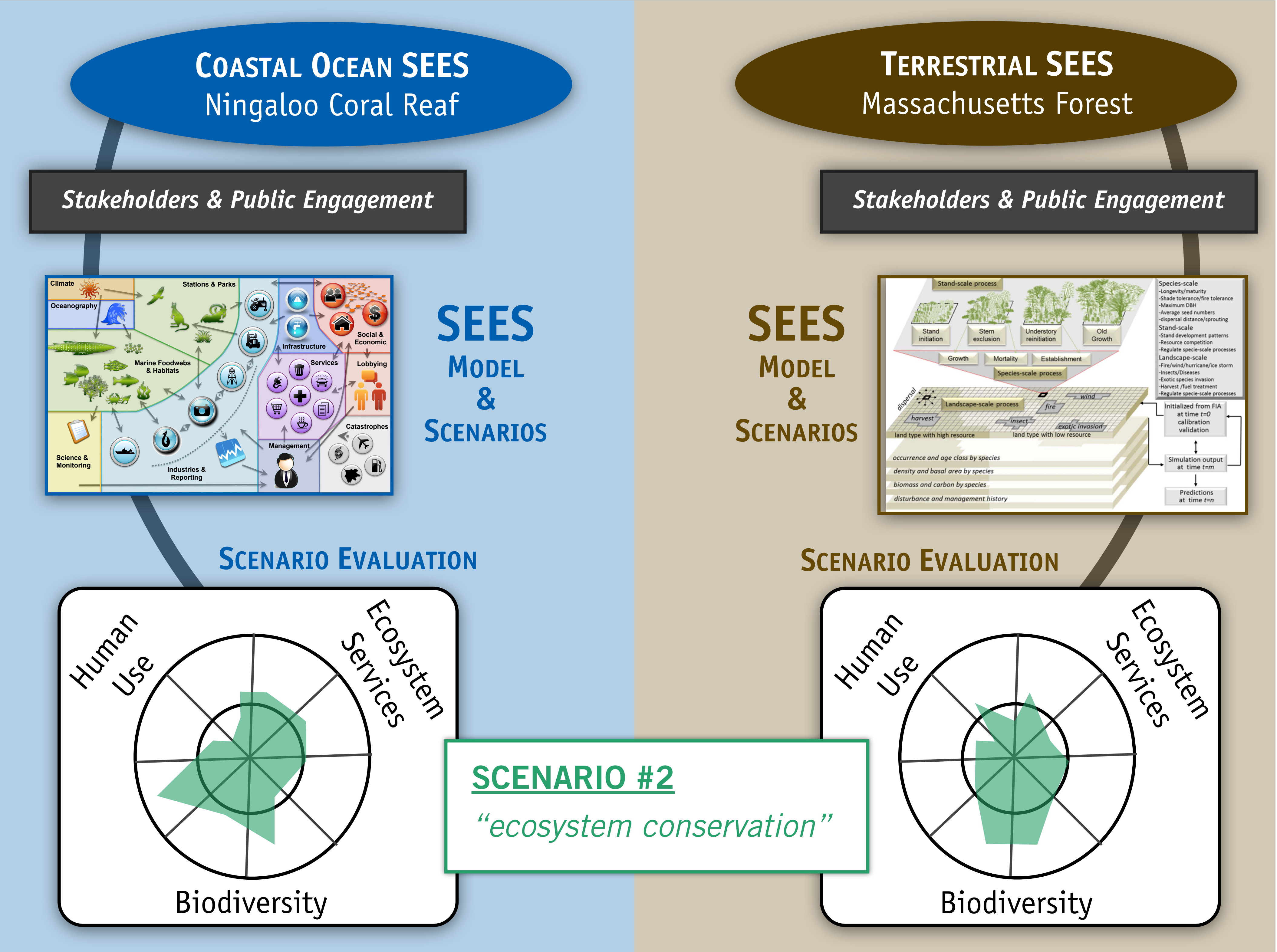
SCENARIO #1
"business as usual"



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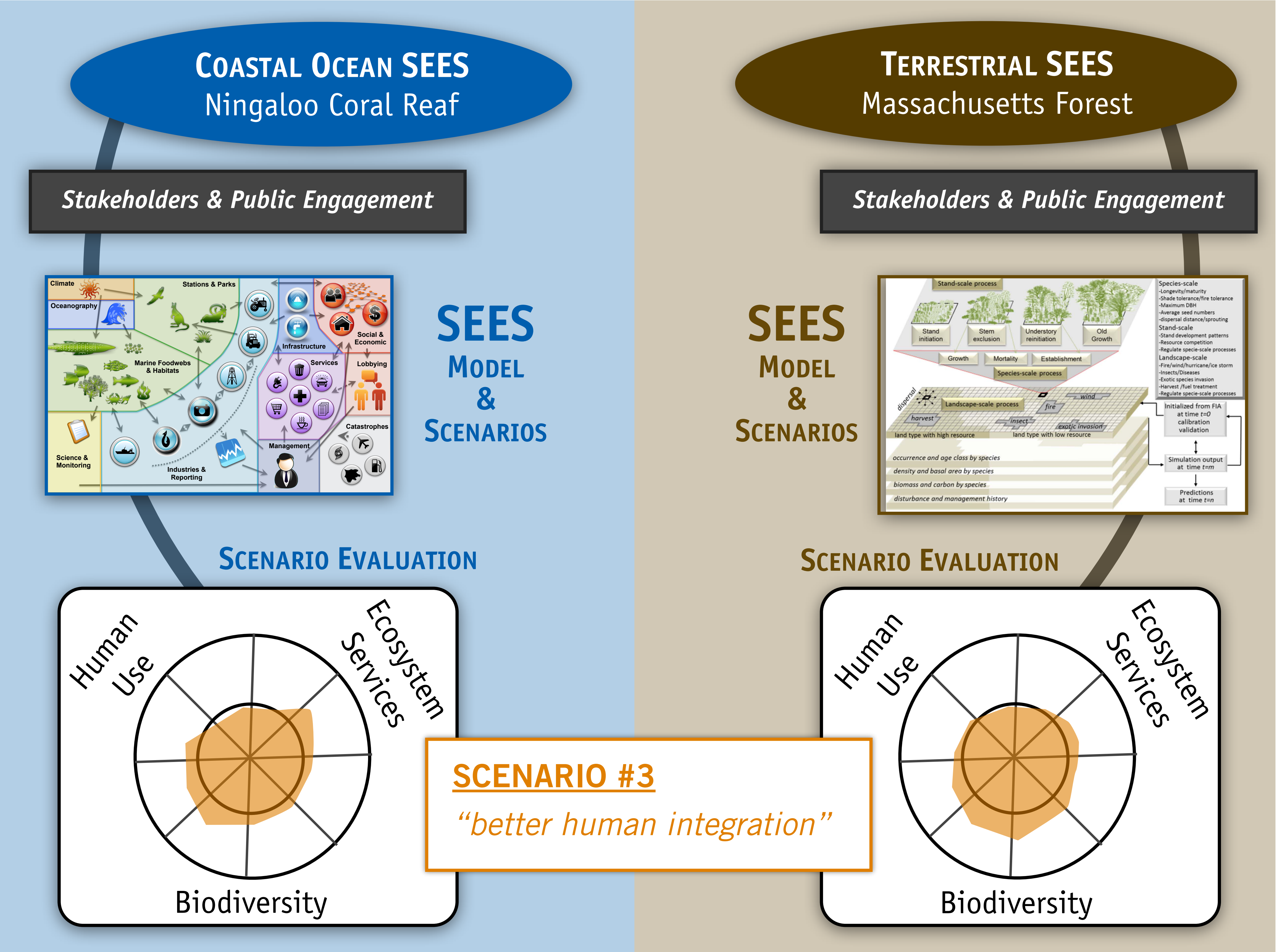
Ecosystem Services
Biodiversity
Human Use
Ecosystem Services
Biodiversity
SCENARIO #2
“ecosystem conservation”



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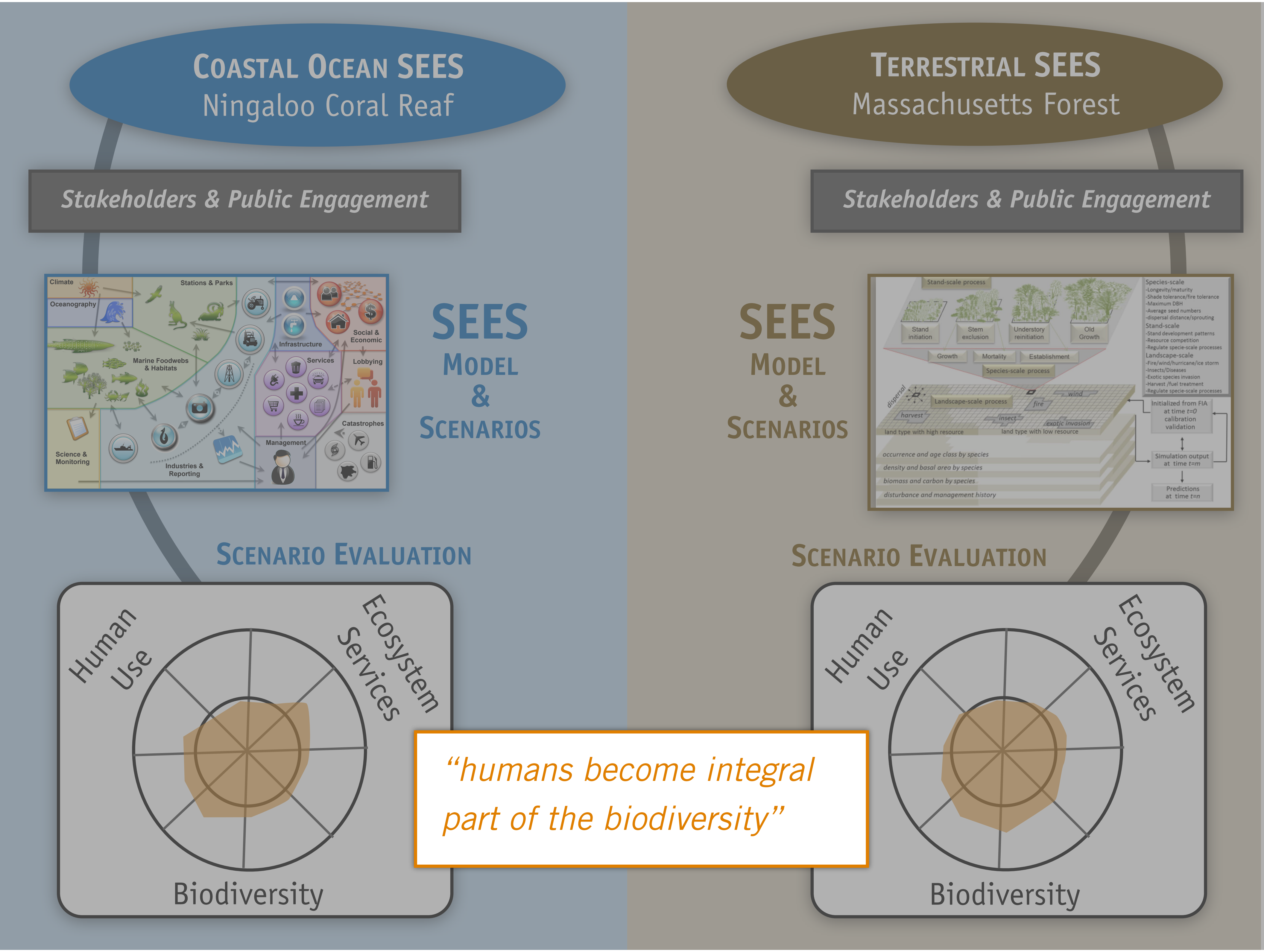
Biodiversity
Human Use
Ecosystem Services
Biodiversity
SCENARIO #3
"better human integration"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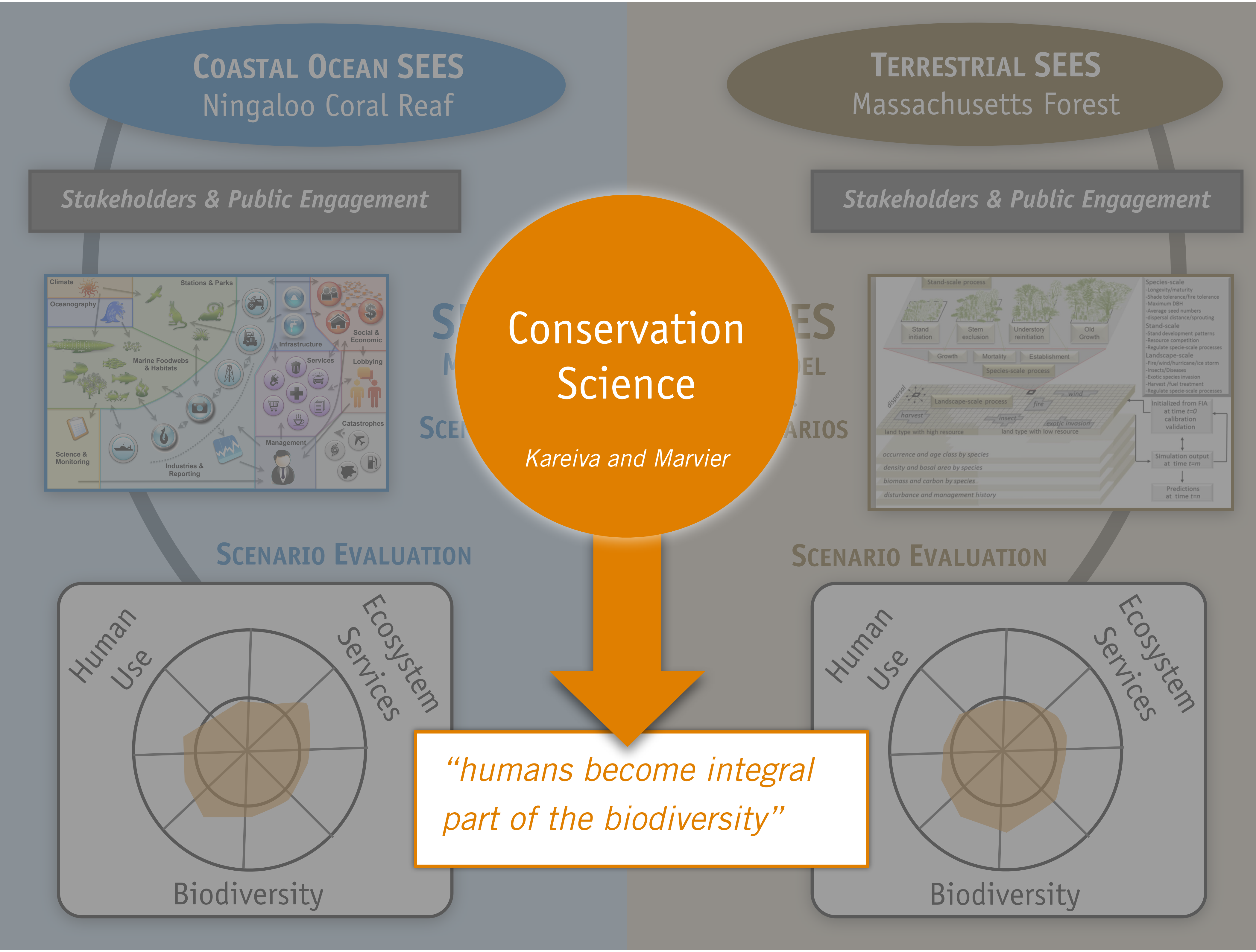
"humans become integral part of the biodiversity"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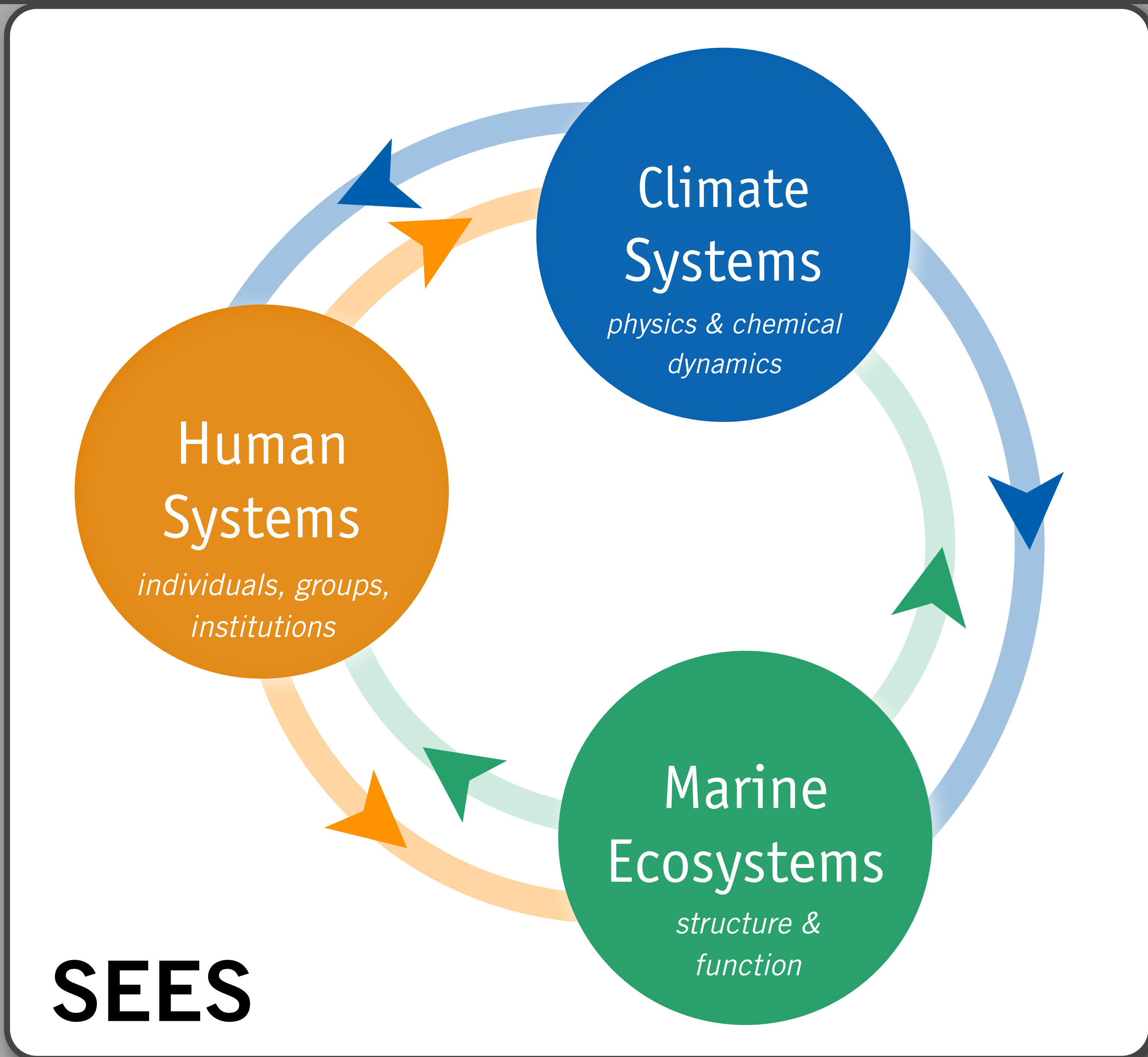
Towards Social-Ecological-Environmental System *Approach & Modeling*



QUESTION:

How is the this important for PICES

***FUTURE** ?*

Elements of **FUTURE**

SCIENCE PROGRAM FOR 2020

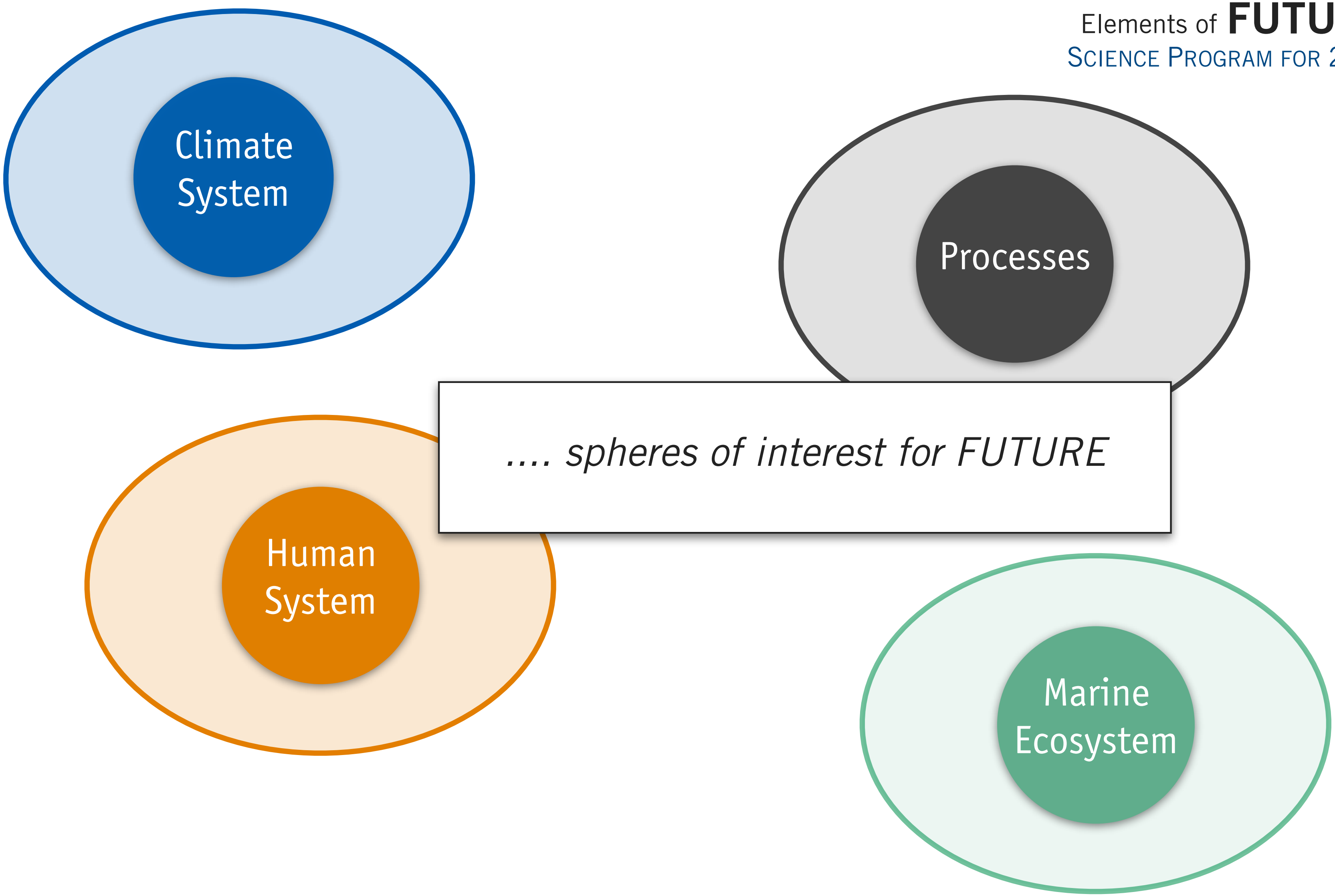
PICES

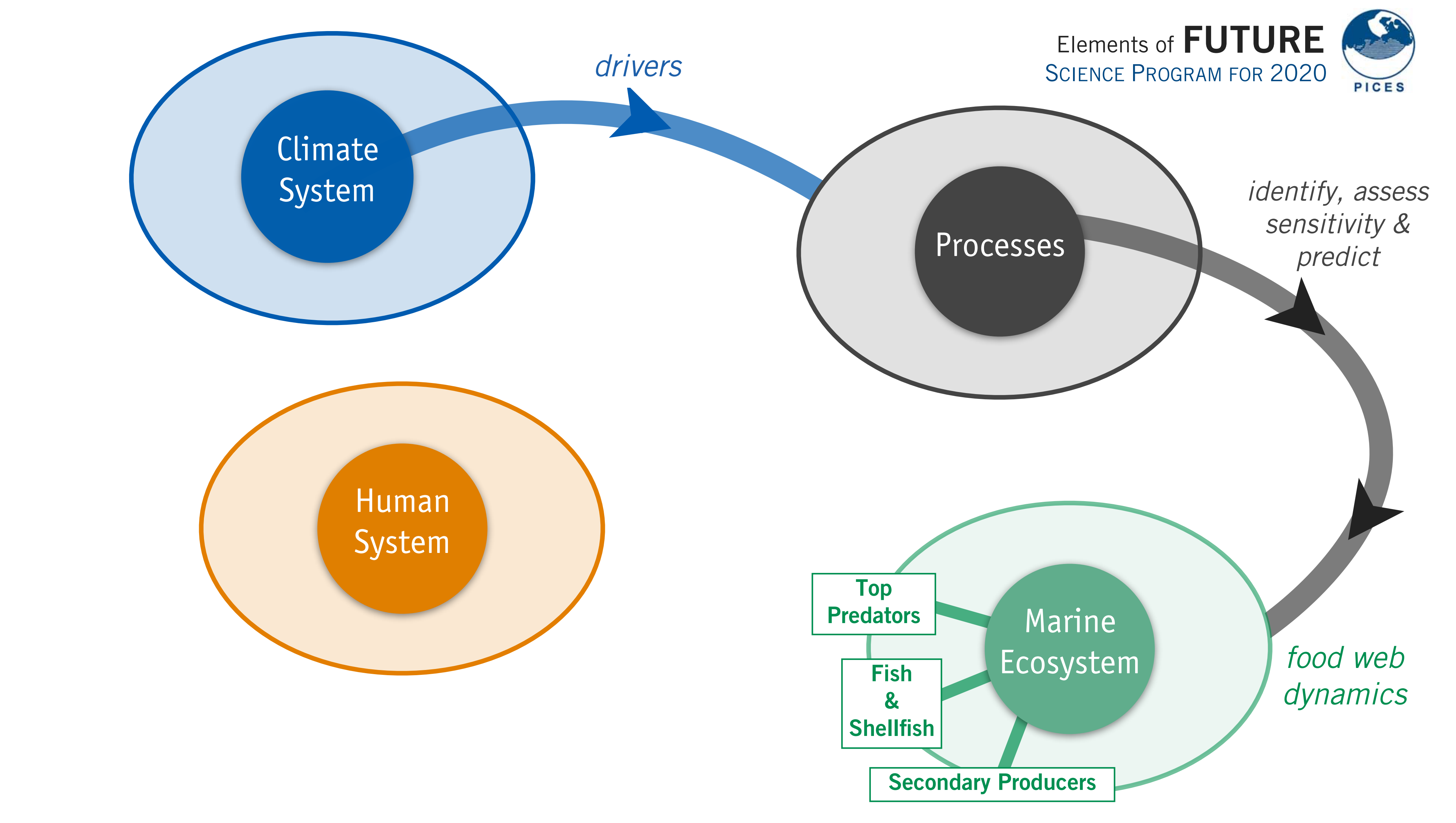
Elements of **FUTURE**

SCIENCE PROGRAM FOR 2020

PICES

.... spheres of interest for FUTURE


Climate System
Processes
.... spheres of interest for FUTURE
Human System
Marine Ecosystem


Elements of FUTURE
SCIENCE PROGRAM FOR 2020
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drivers
Climate System
Processes
identify, assess sensitivity & predict
Human System
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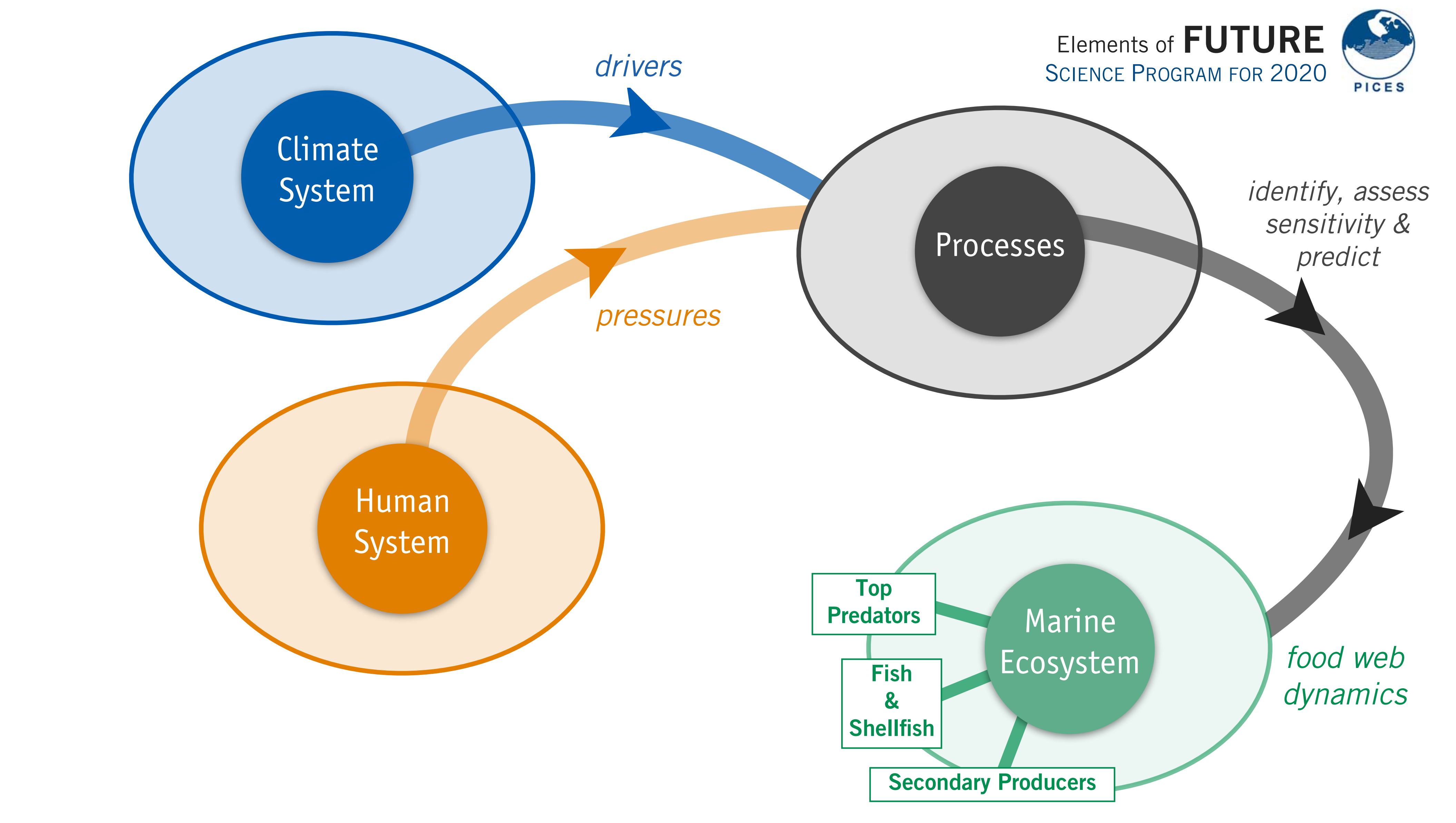
Fish & Shellfish
Marine Ecosystem
Secondary Producers
food web dynamics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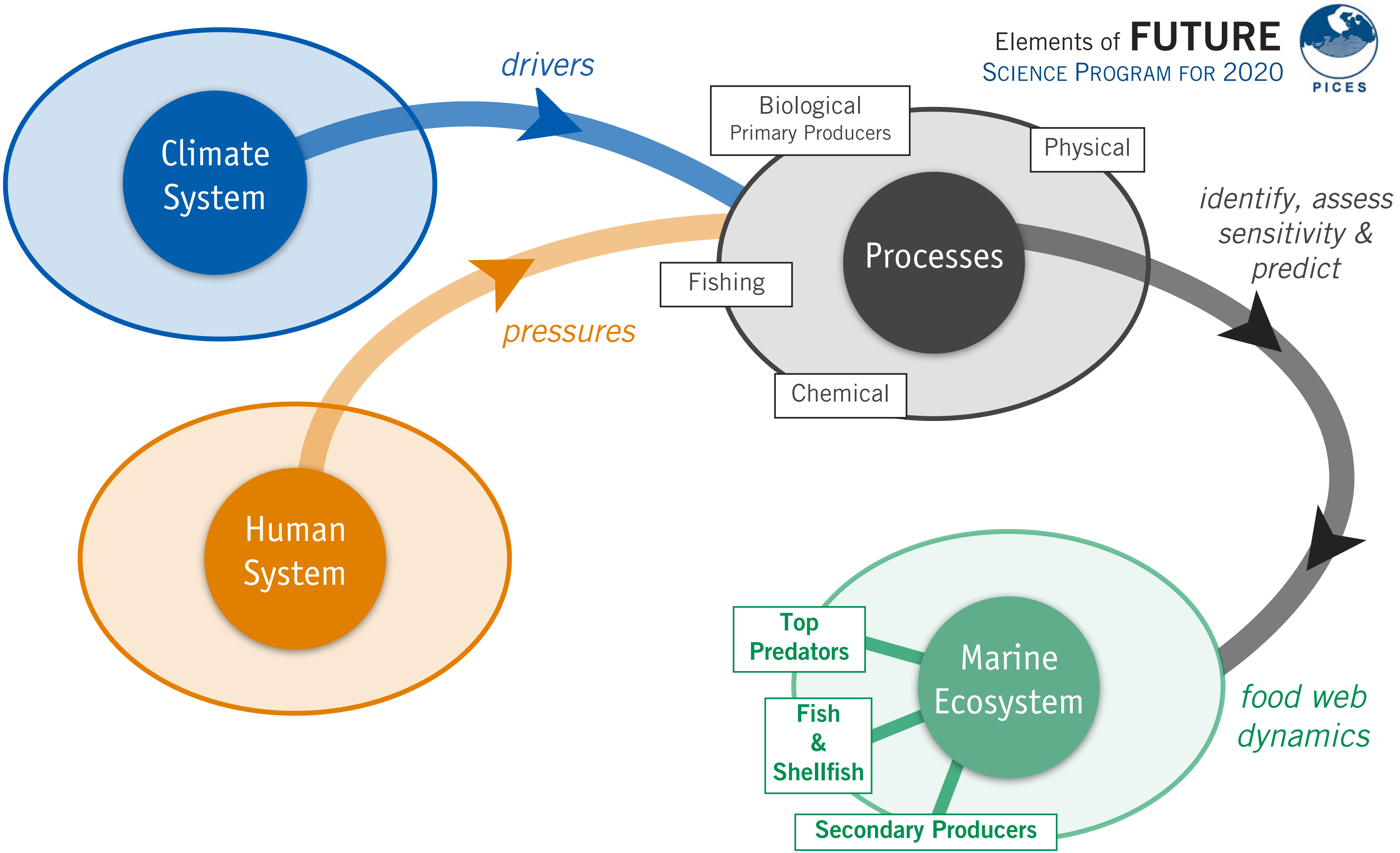

Elements of FUTURE
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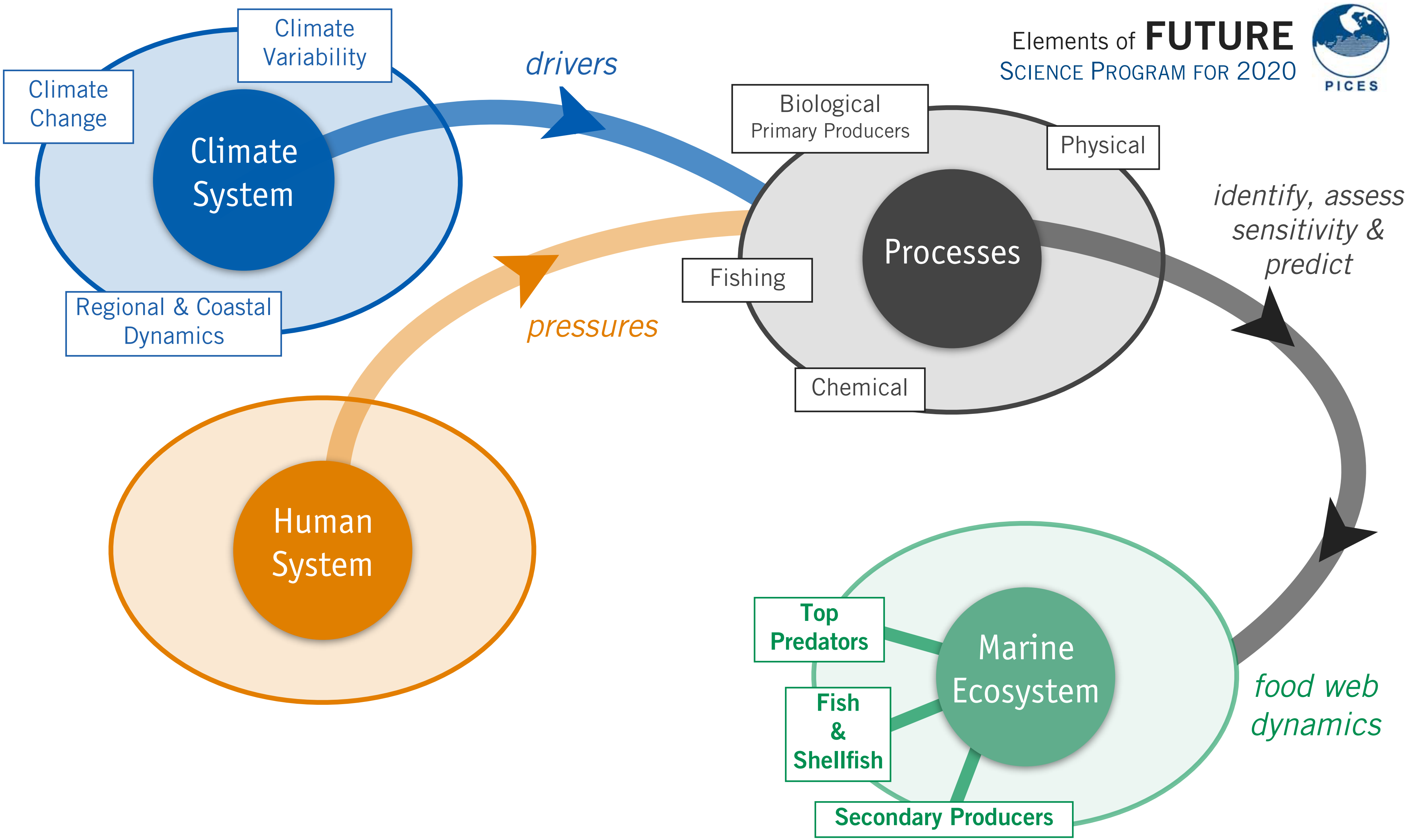
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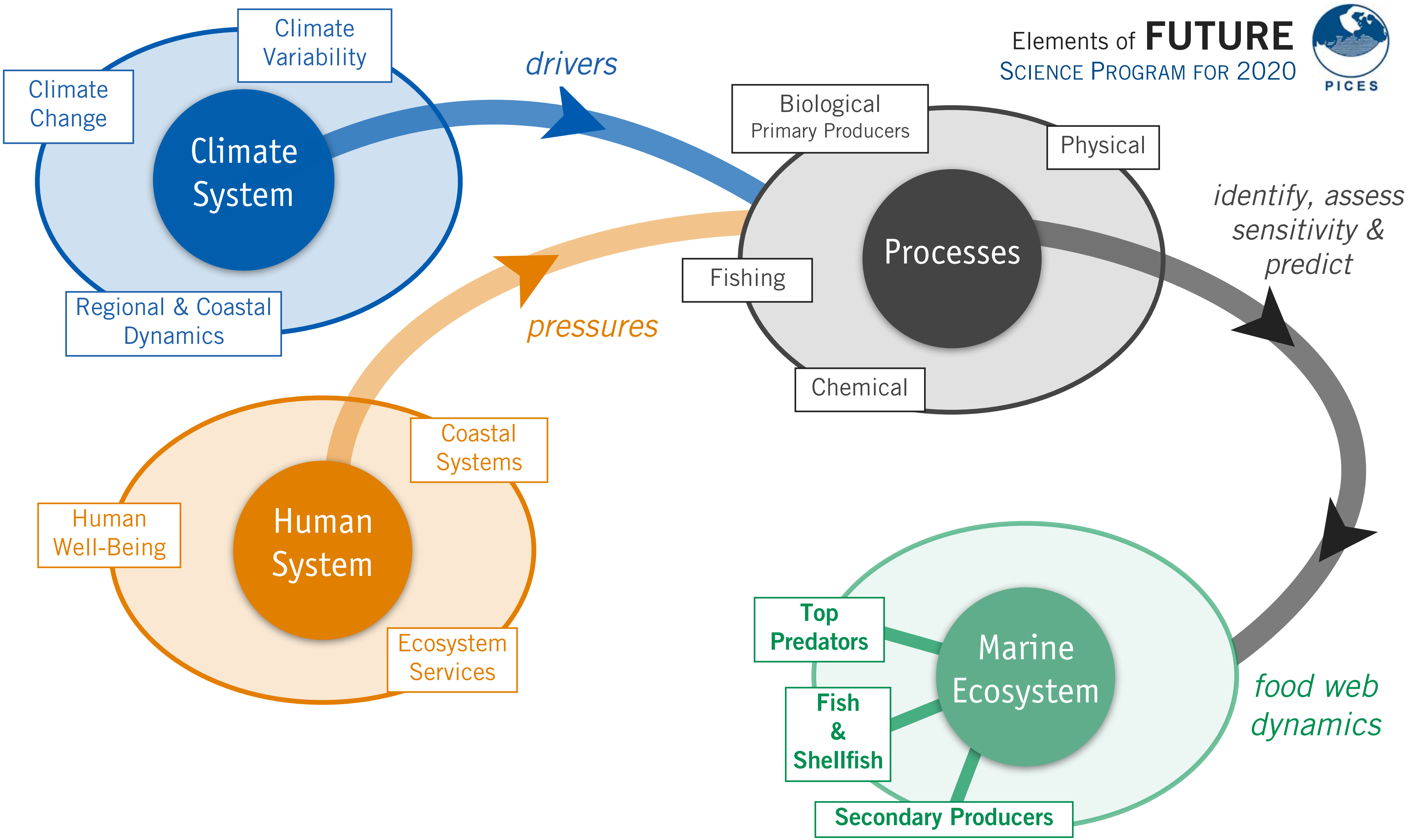

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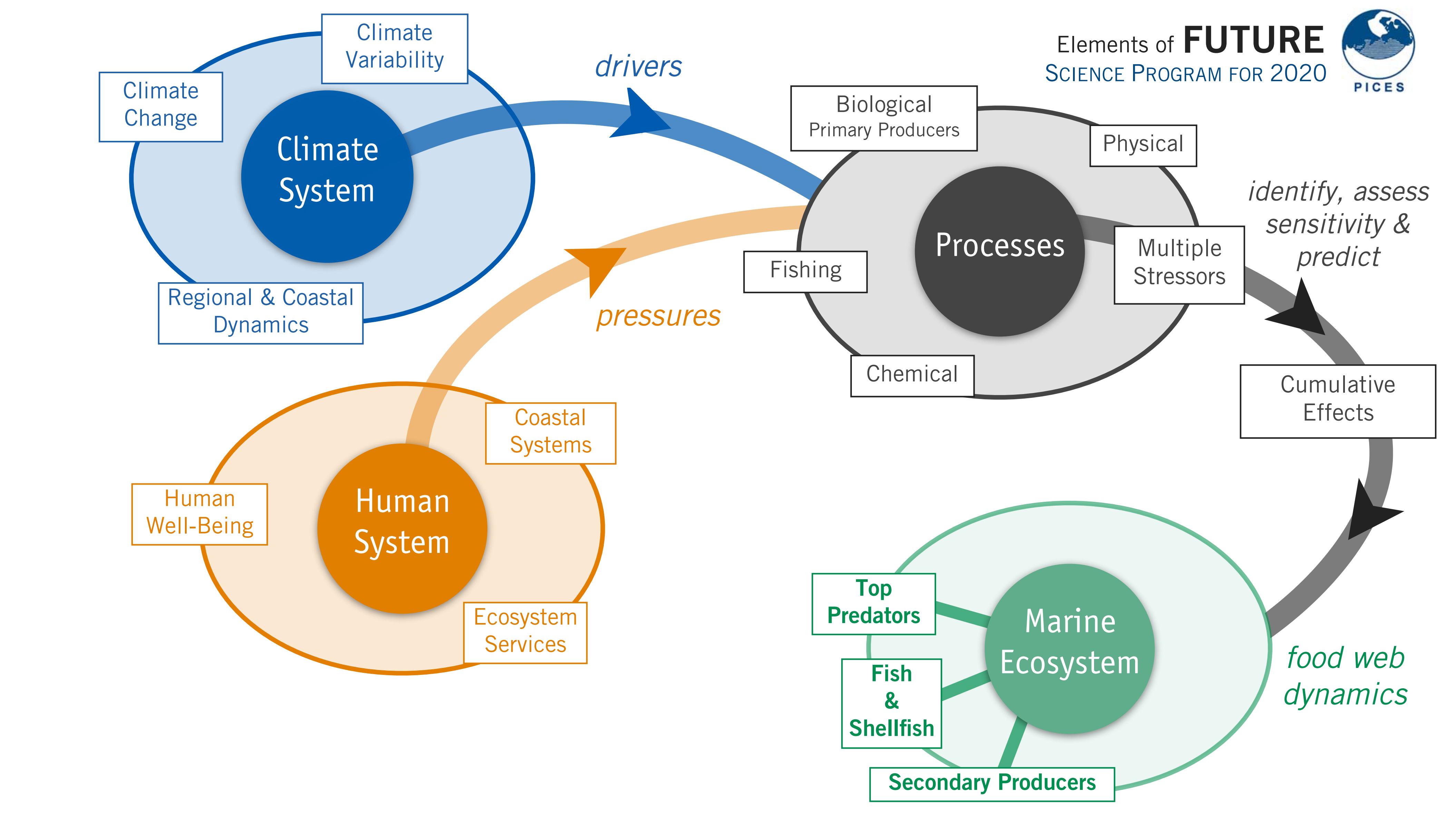
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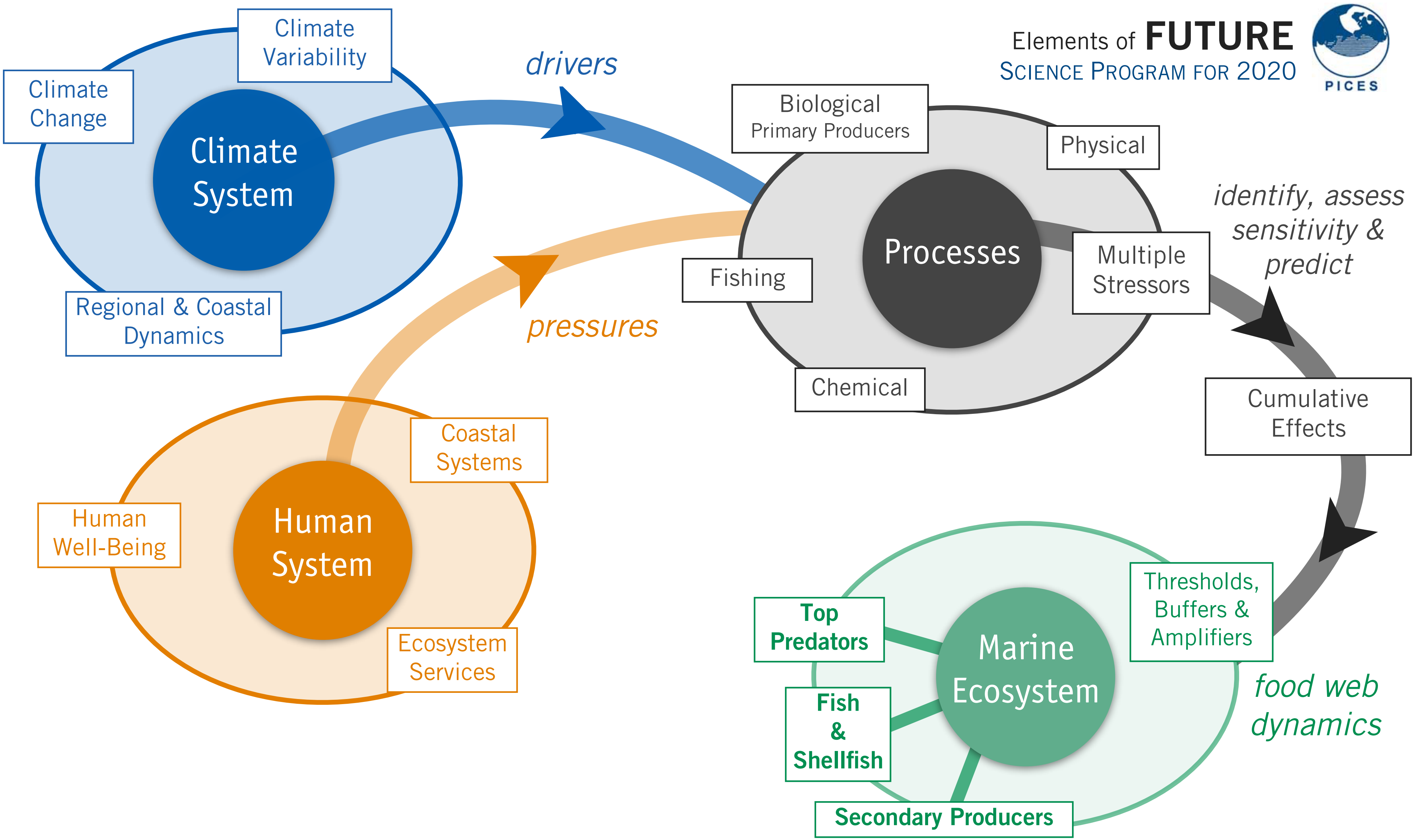

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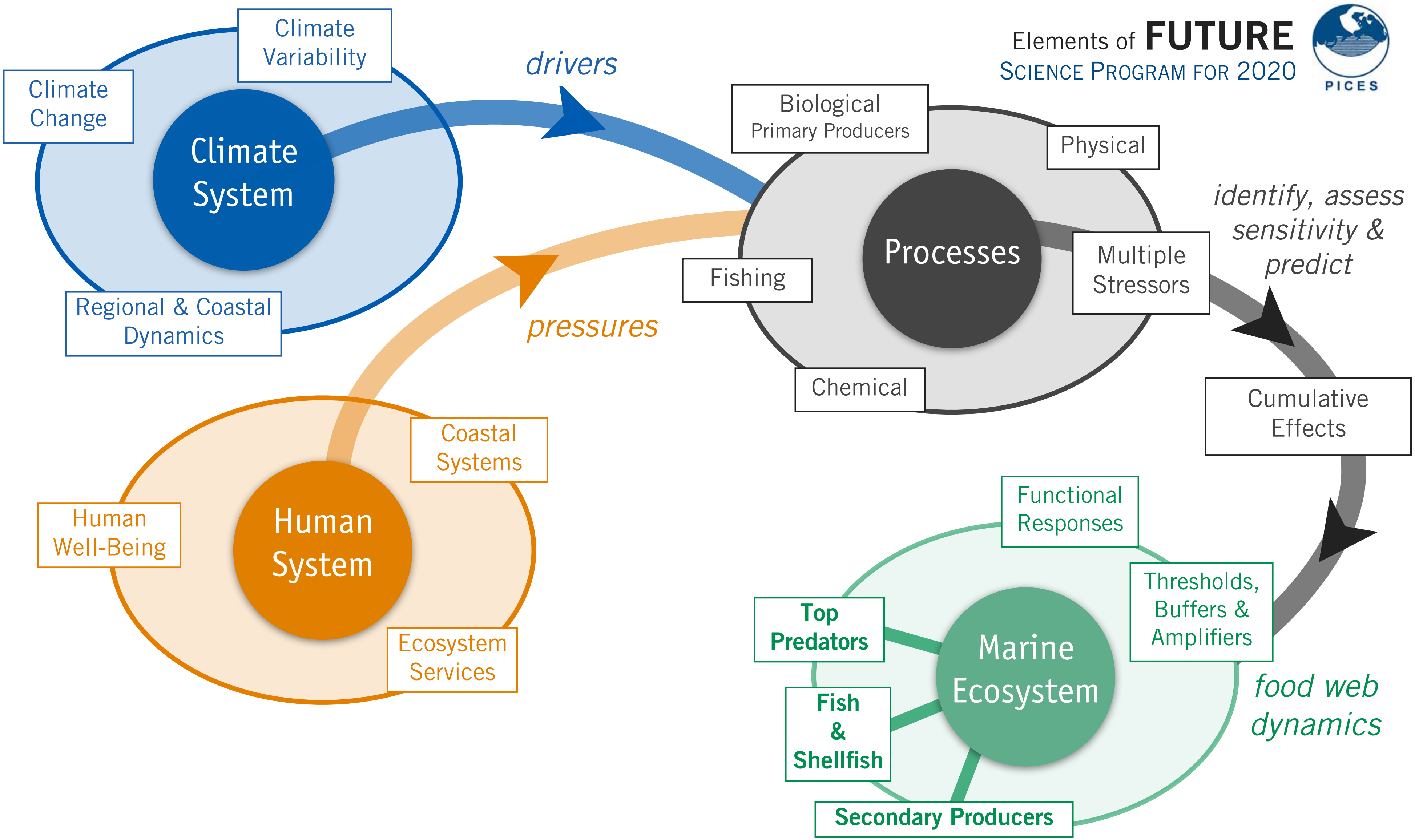
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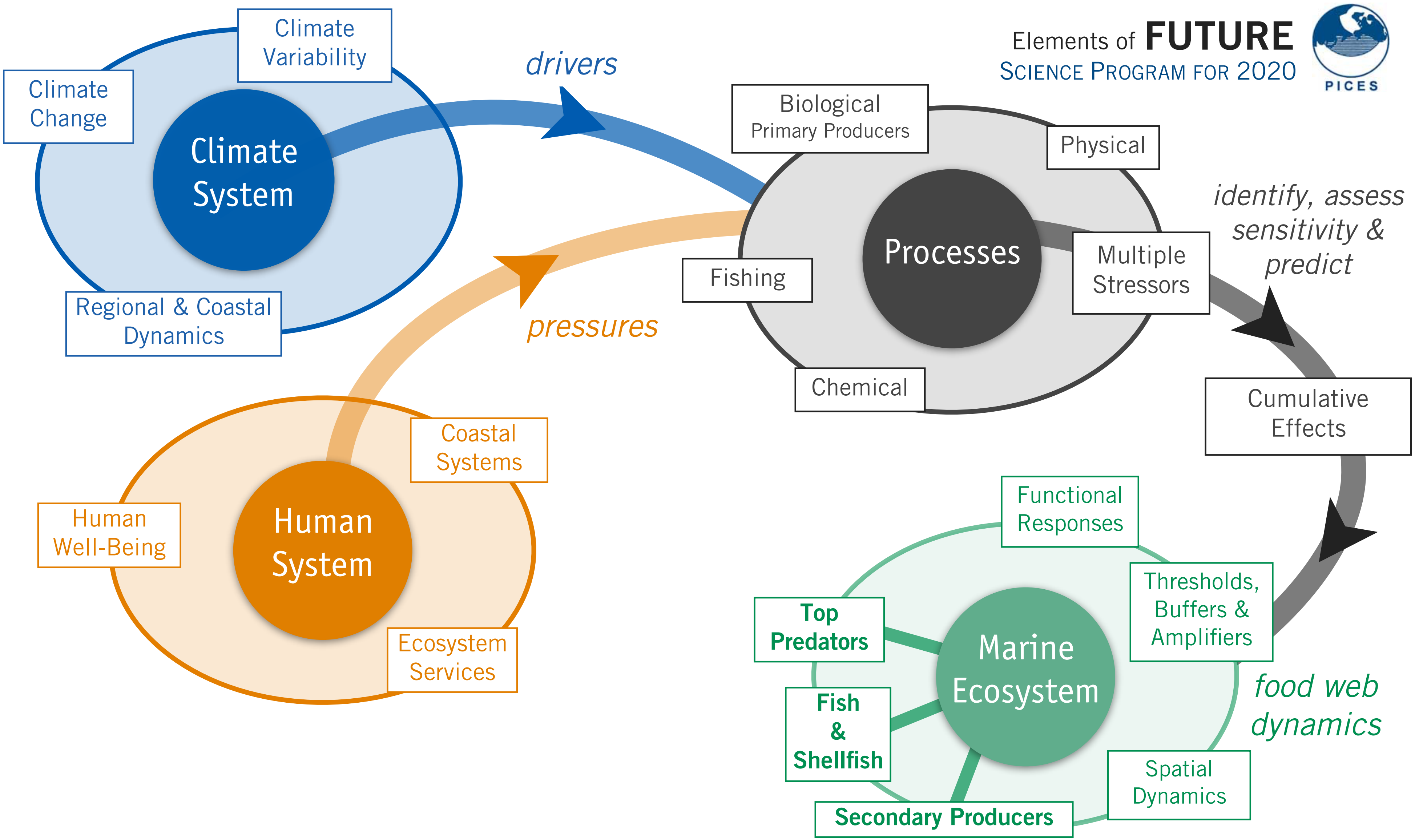
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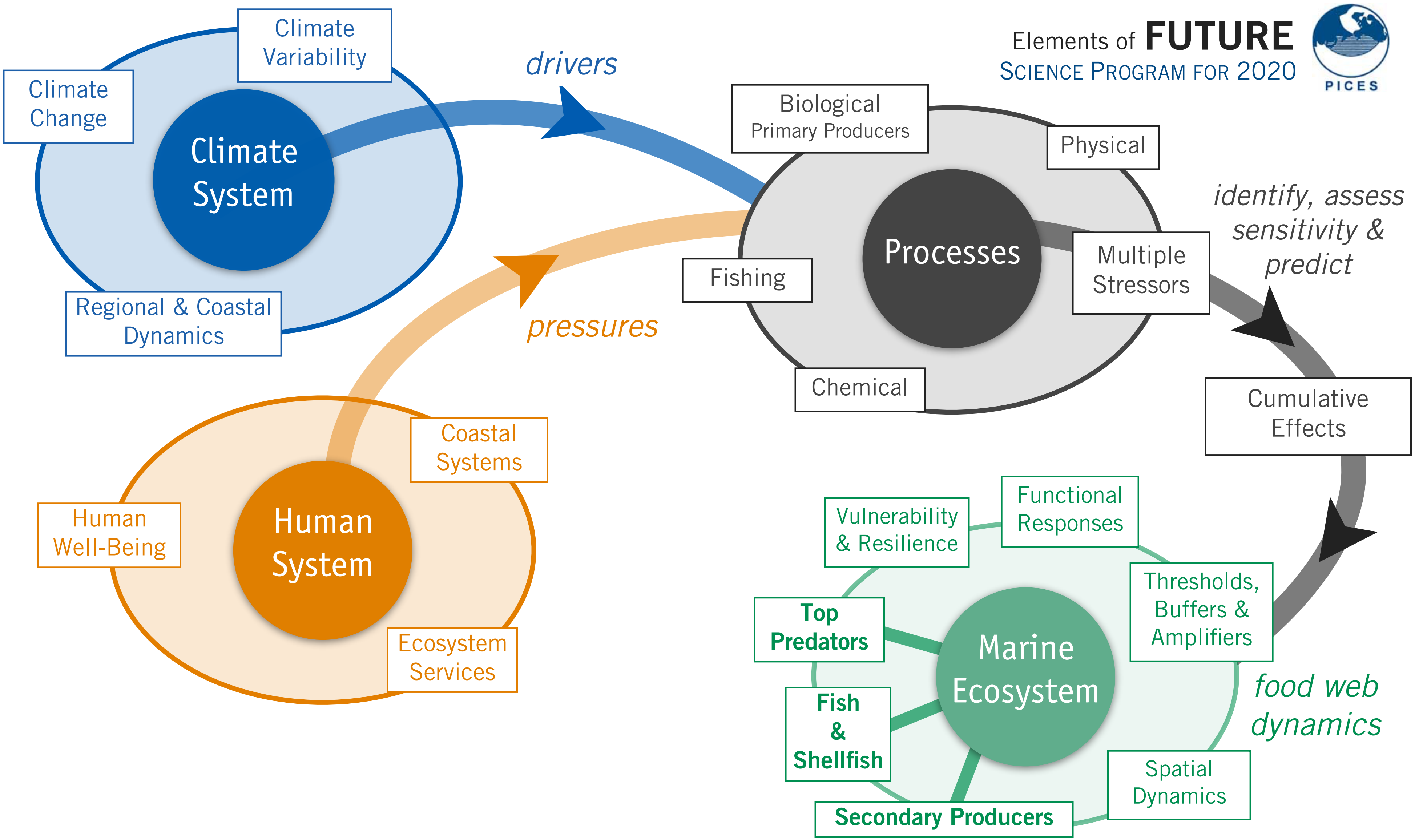
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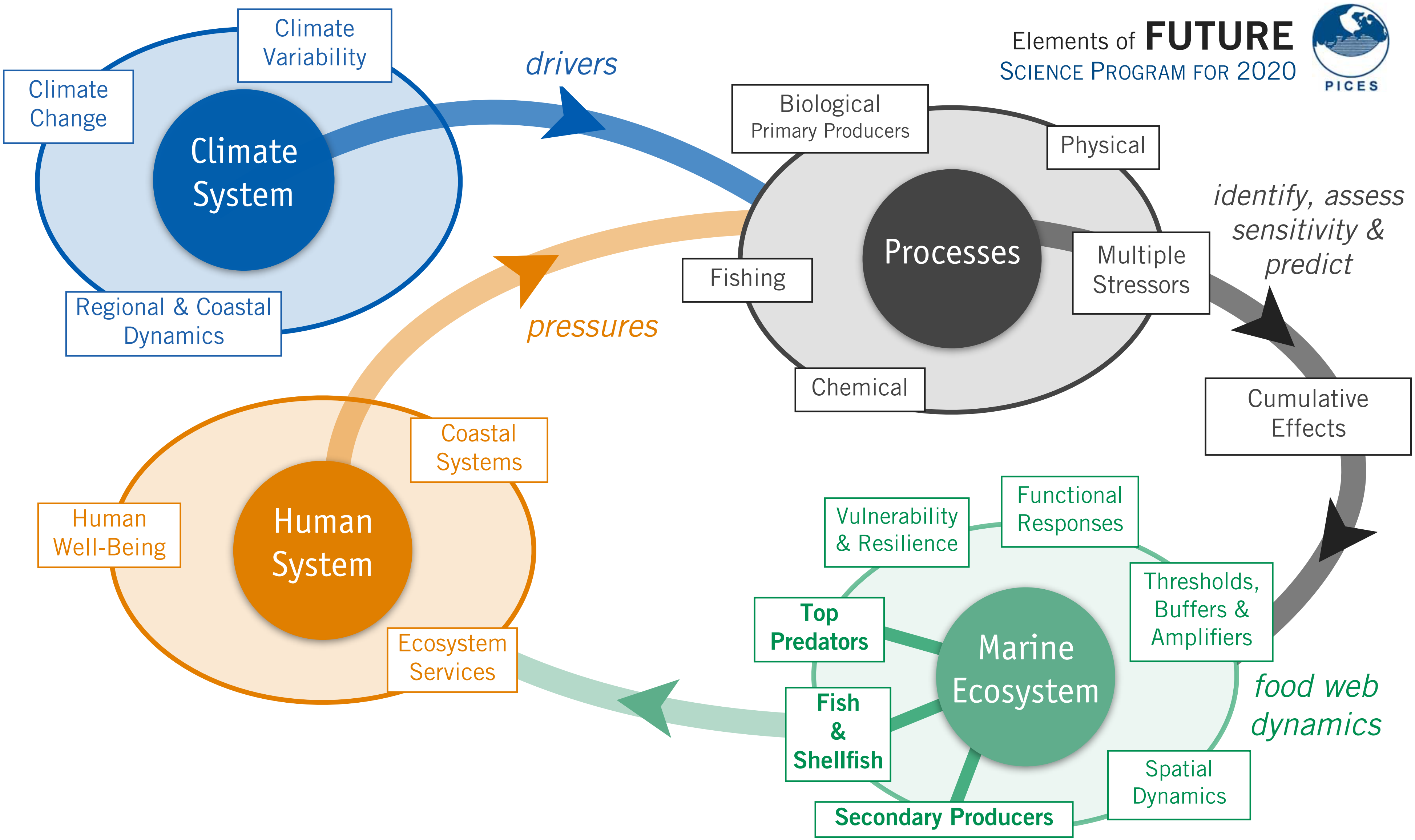
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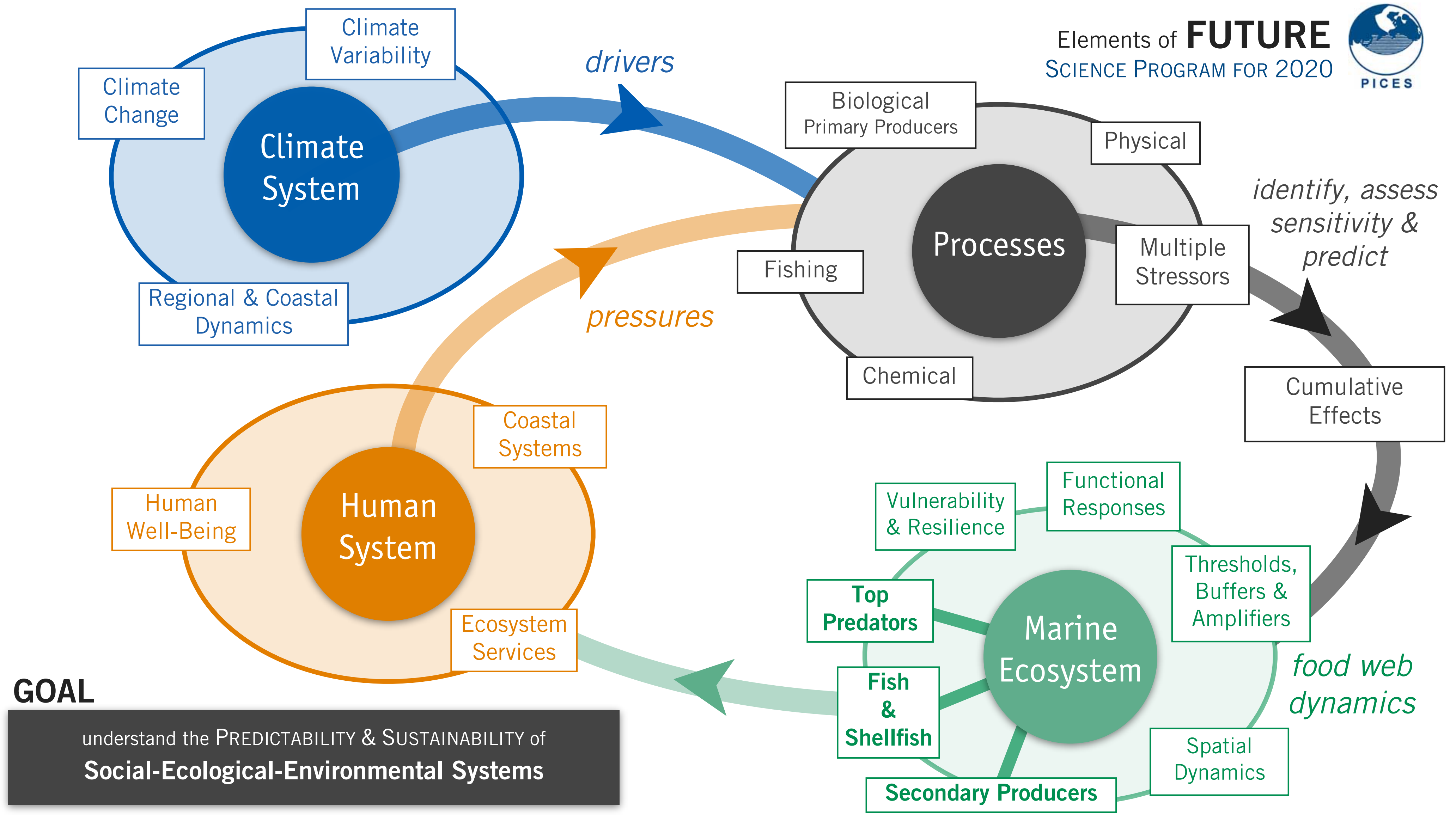
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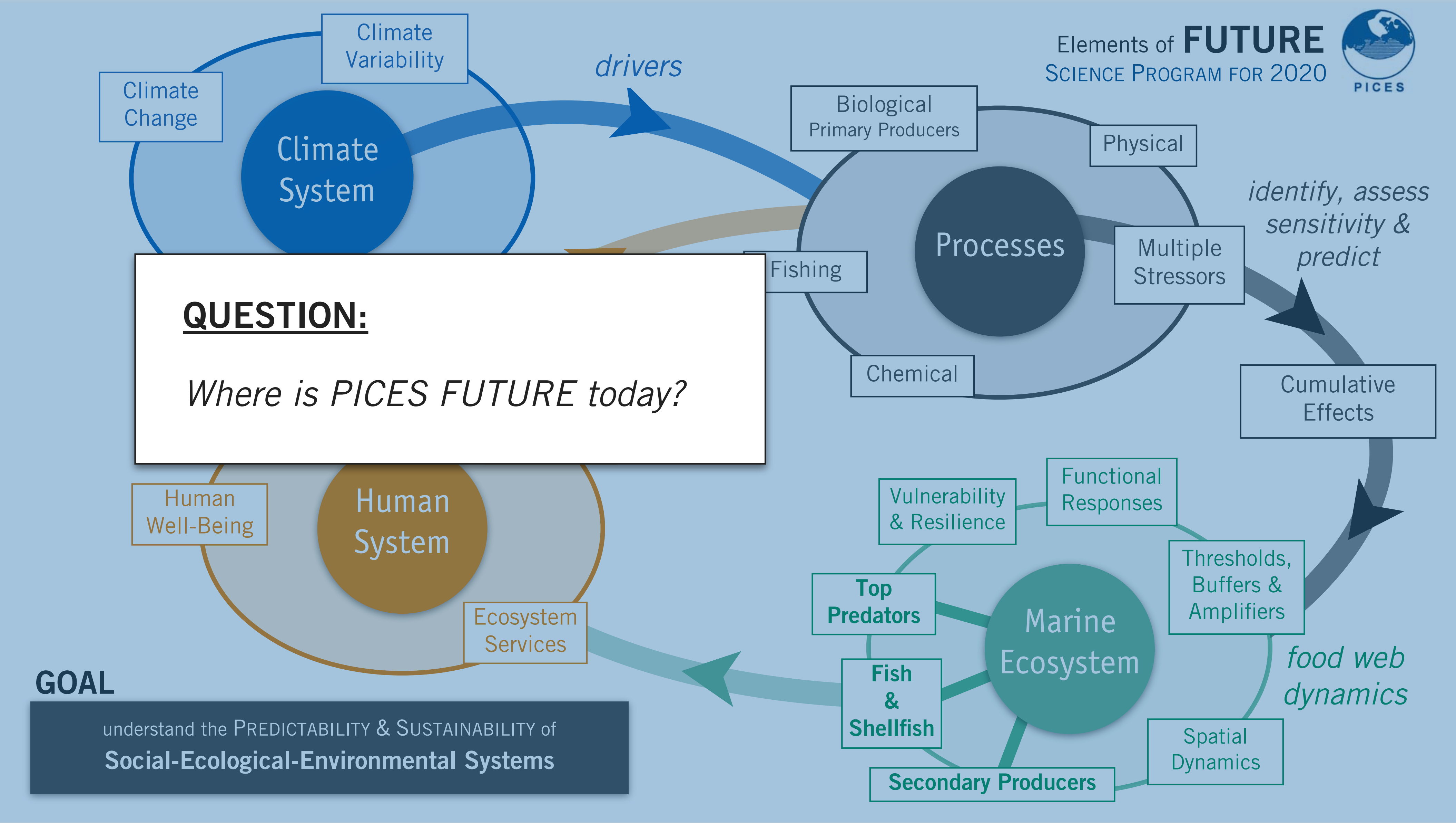
GOAL
understand the Predictability & Sustainability of
Social-Ecological-Environmental Systems



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Human Well-Being
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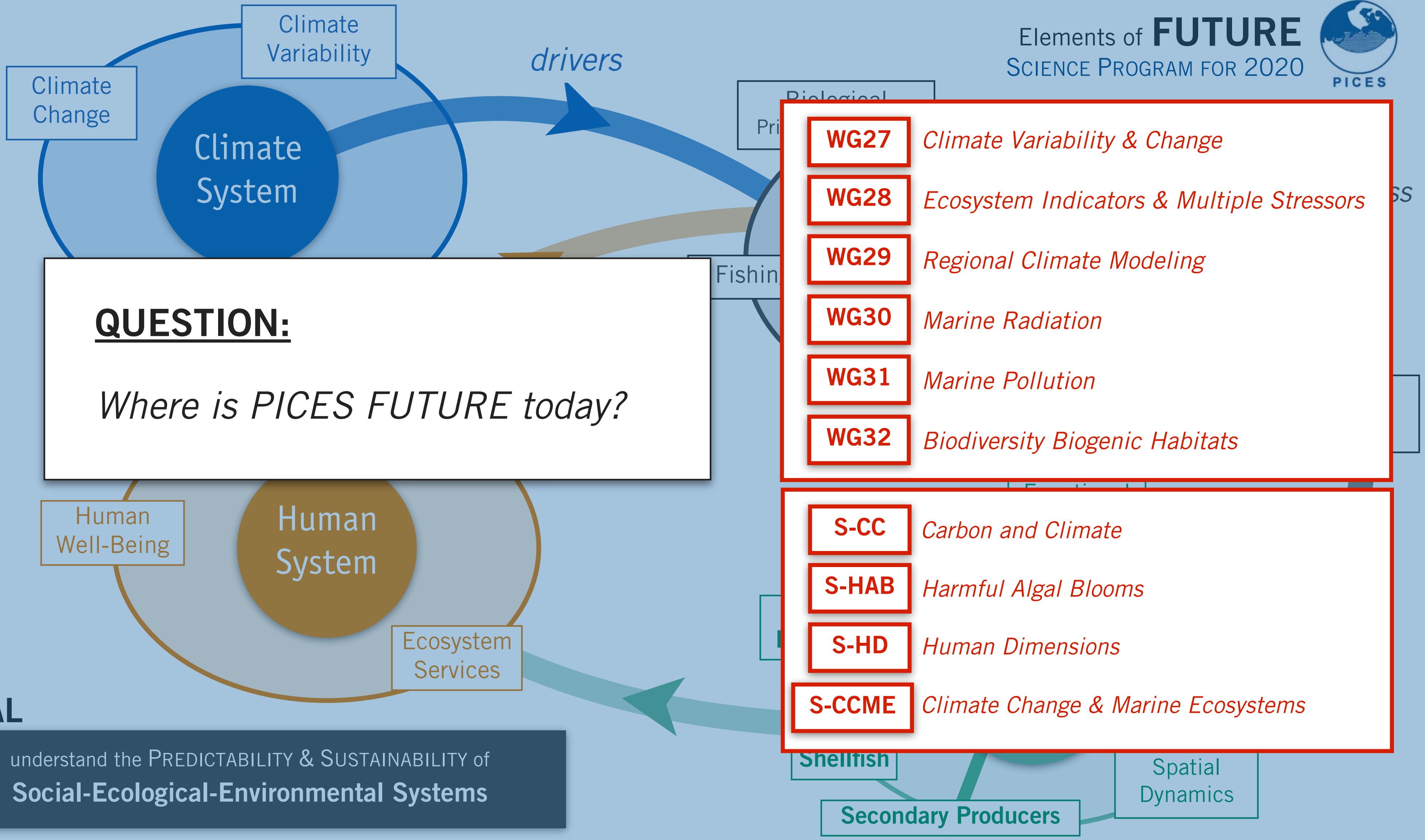
Vulnerability & Resilience
Functional Responses
Thresholds, Buffers & Amplifiers
Top Predators
Marine Ecosystem
Fish & Shellfish
food web dynamics
Spatial Dynamics
Secondary Producers
GOAL
understand the Predictability & Sustainability of
Social-Ecological-Environmental Systems

Elements of **FUTURE**
SCIENCE PROGRAM FOR 2020

PICES



QUESTION:

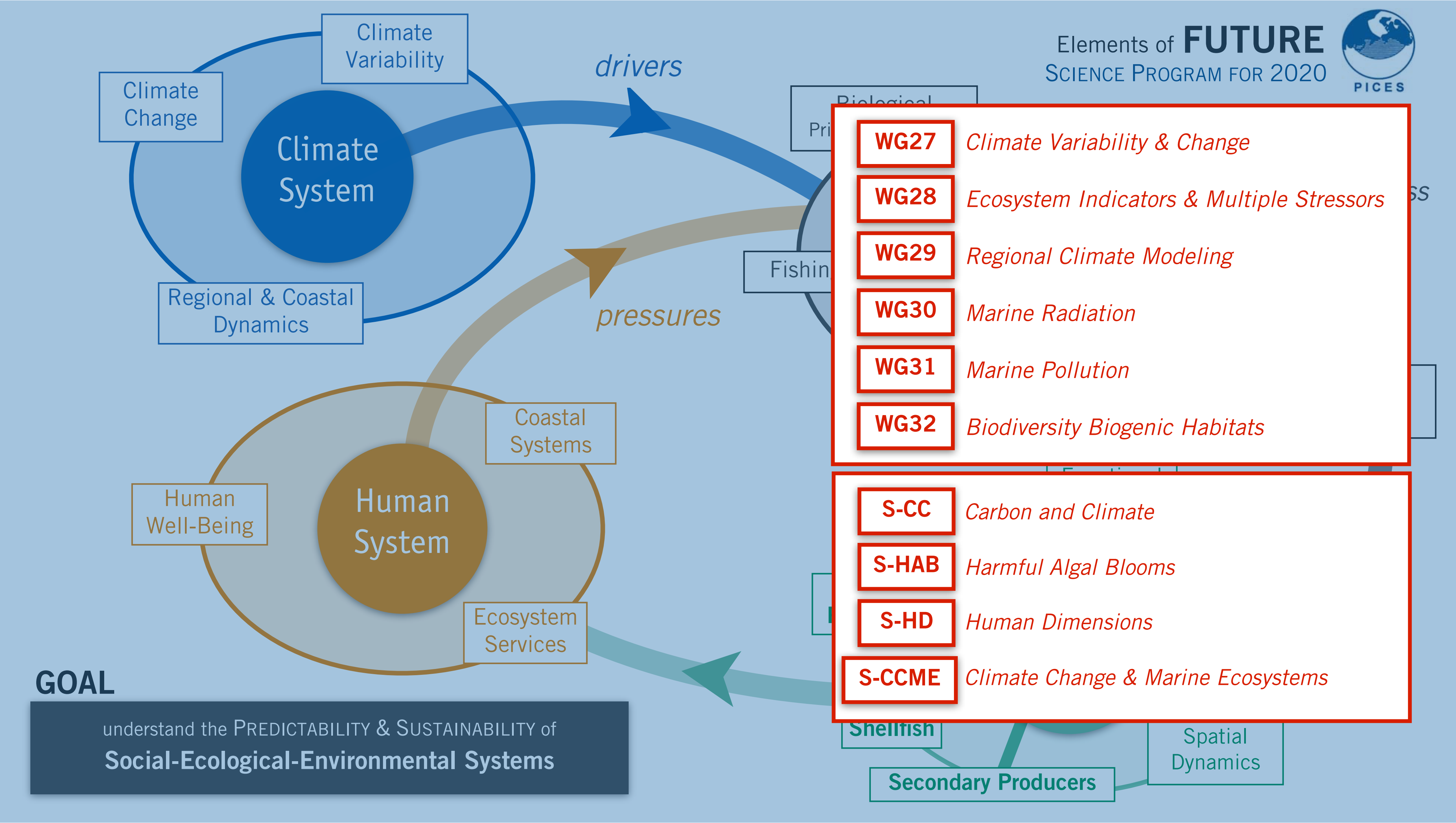
Where is PICES FUTURE today?

WG27	*Climate Variability & Change*
WG28	*Ecosystem Indicators & Multiple Stressors*
WG29	*Regional Climate Modeling*
WG30	*Marine Radiation*
WG31	*Marine Pollution*
WG32	*Biodiversity Biogenic Habitats*

S-CC	*Carbon and Climate*
S-HAB	*Harmful Algal Blooms*
S-HD	*Human Dimensions*
S-CCME	*Climate Change & Marine Ecosystems*

GOAL

understand the PREDICTABILITY & SUSTAINABILITY of
Social-Ecological-Environmental Systems



Elements of FUTURE
SCIENCE PROGRAM FOR 2020
PICES
Climate Variability
Climate Change
Climate System
Regional & Coastal Dynamics
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pressures
Coastal Systems
Human Well-Being
Human System
Ecosystem Services
WG27 Climate Variability & Change
WG28 Ecosystem Indicators & Multiple Stressors
WG29 Regional Climate Modeling
WG30 Marine Radiation
WG31 Marine Pollution
WG32 Biodiversity Biogenic Habitats
S-CC Carbon and Climate
S-HAB Harmful Algal Blooms
S-HD Human Dimensions
S-CCME Climate Change & Marine Ecosystems
Shellfish
Secondary Producers
Spatial Dynamics
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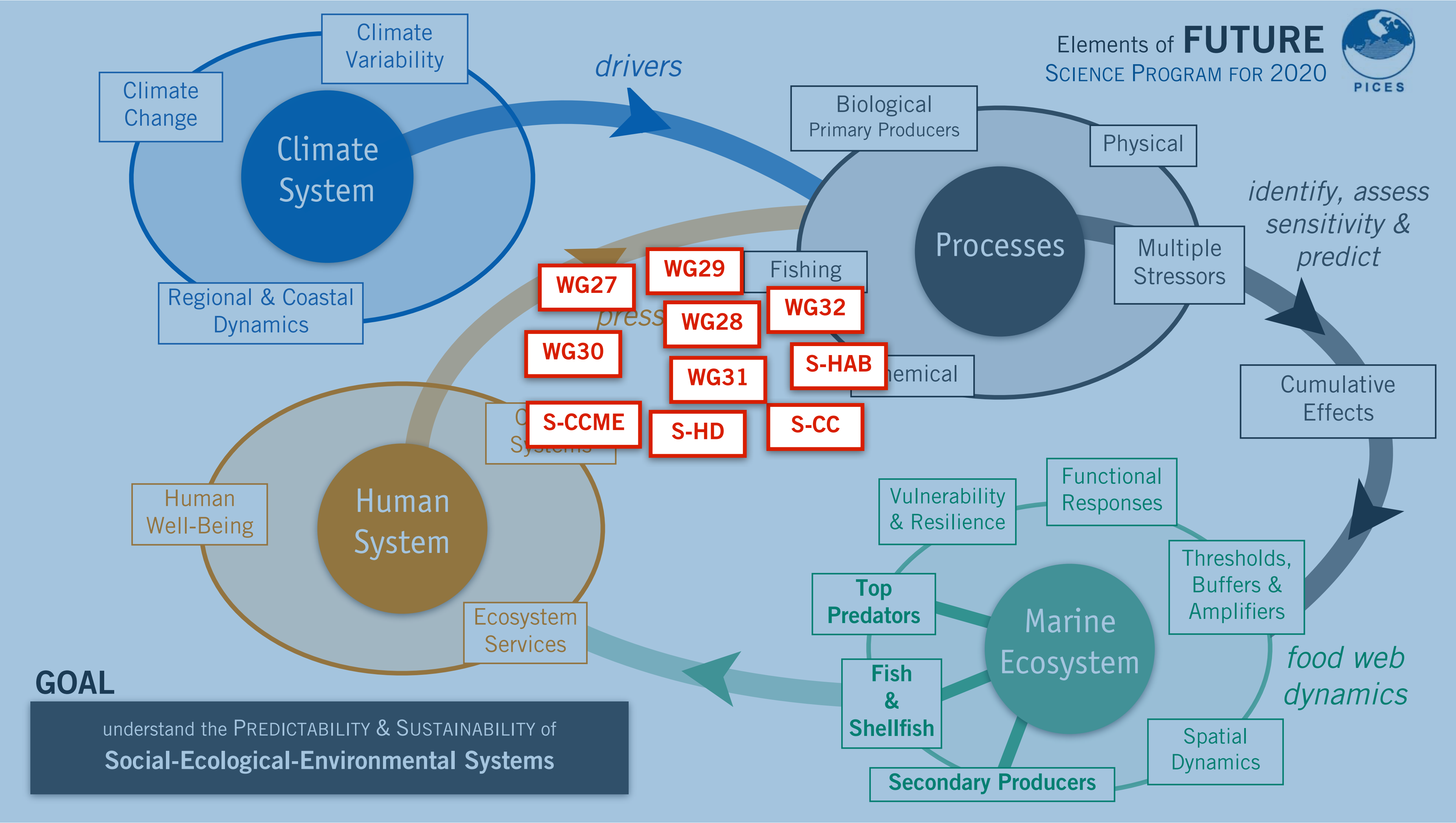
Elements of FUTURE
Science Program for 2020
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Biological Primary Producers
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Processes
Multiple Stressors
Fishing
hemical
identify, assess sensitivity & predict
Cumulative Effects
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WG29
WG28
WG32
WG30
WG31
S-HAB
S-CCME
S-HD
S-CC
press
Human Well-Being
Human System
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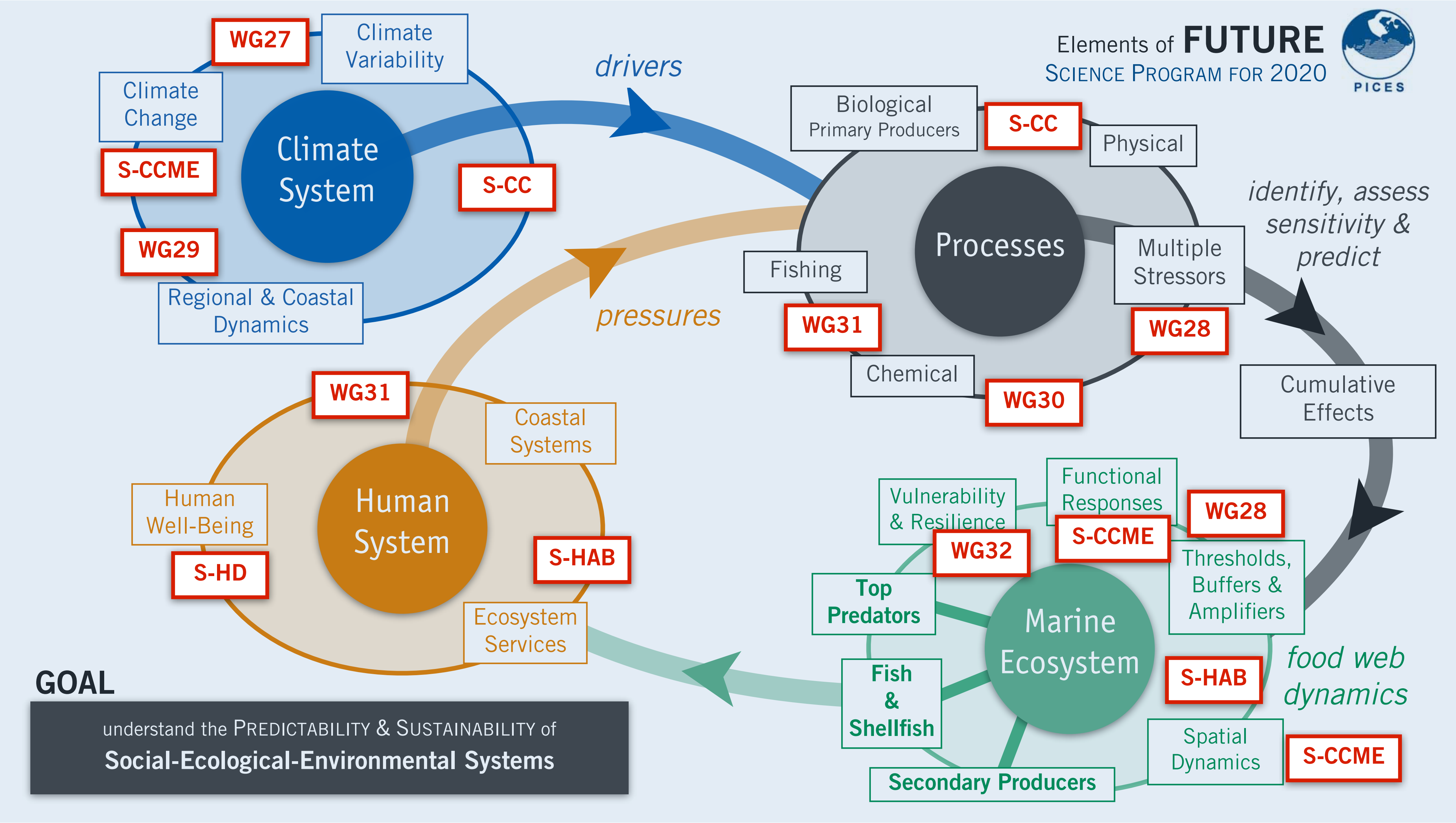
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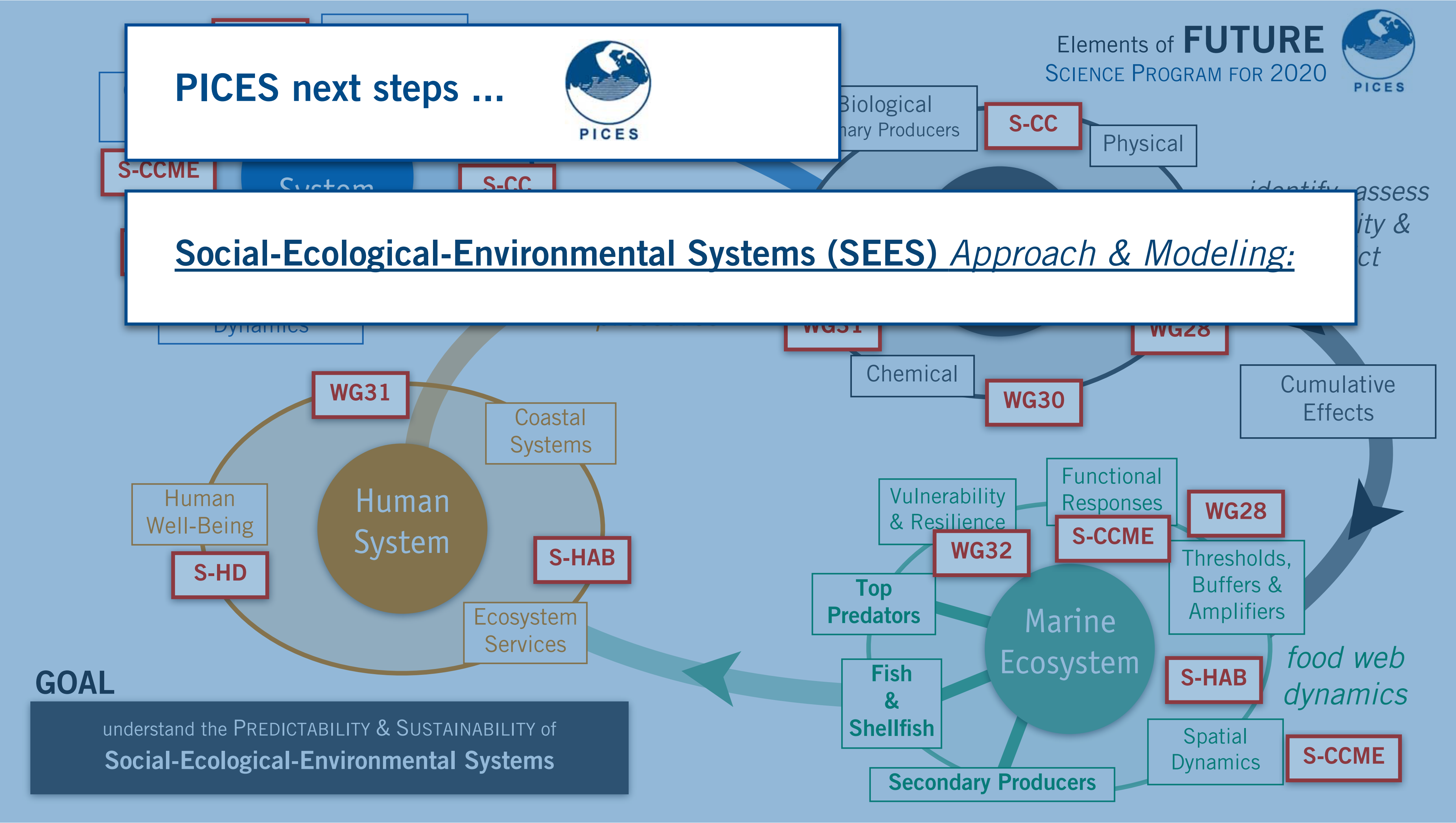
PICES next steps ...

PICES

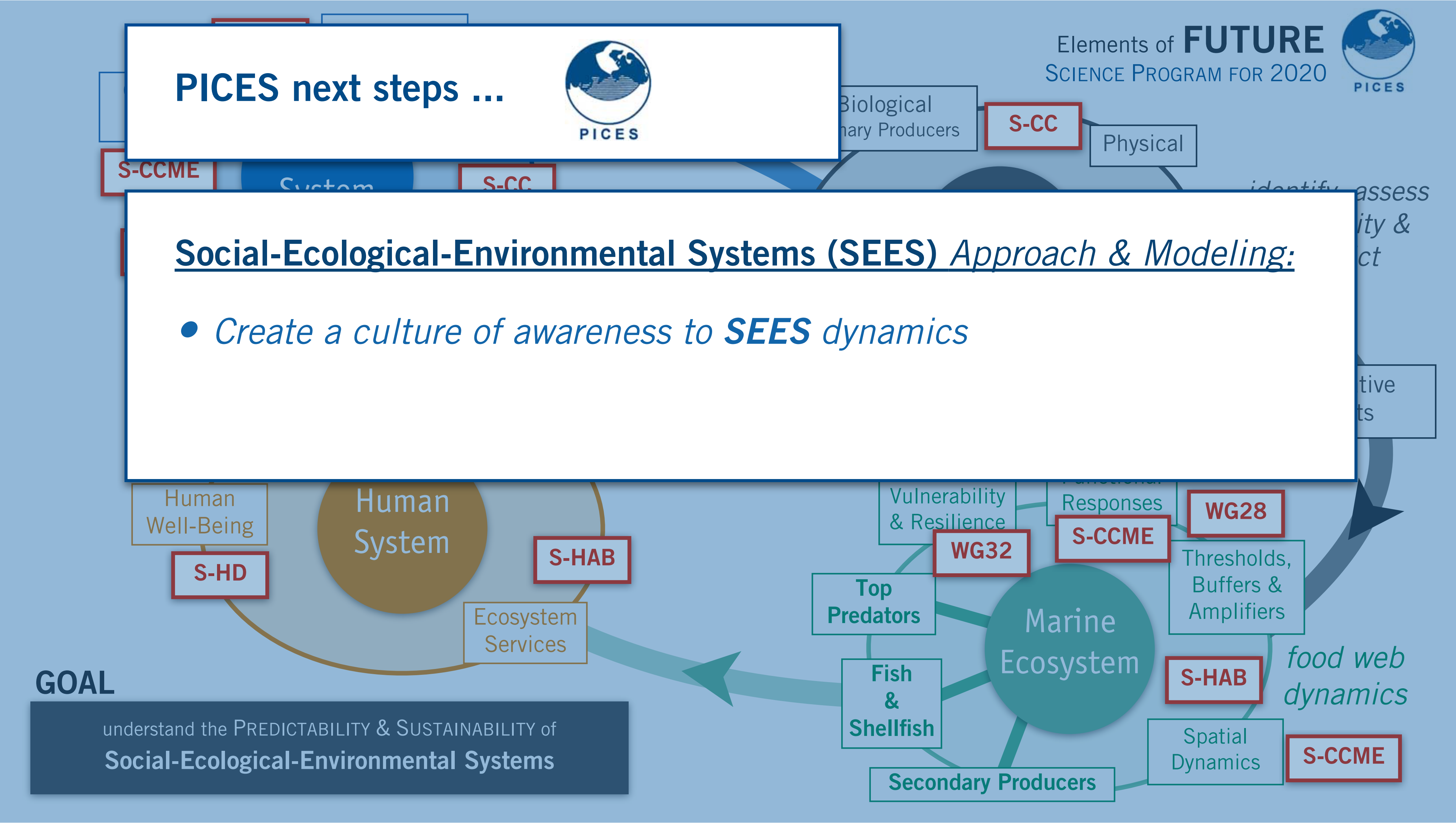
<u>Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*</u>



PICES next steps ...

<u>Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*</u>

- *Create a culture of awareness to **SEES** dynamics*



Elements of **FUTURE**
SCIENCE PROGRAM FOR 2020

PICES next steps ...

Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*

- *Create a culture of awareness to **SEES** dynamics*
- *Train scientist in the practice of a trans-disciplinary **SEES** dialogue*

GOAL

understand the PREDICTABILITY & SUSTAINABILITY of
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Elements of FUTURE
SCIENCE PROGRAM FOR 2020

PICES next steps ...

<u>Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*</u>

- *Create a culture of awareness to **SEES** dynamics*
- *Train scientist in the practice of a **trans-disciplinary SEES dialogue***

- no a priori questions and model
- questions and model are developed from the exchange
- **requires a substantial level of interaction**

GOAL

understand the PREDICTABILITY & SUSTAINABILITY of
Social-Ecological-Environmental Systems

PICES next steps ...

<u>Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*</u>

- *Create a culture of awareness to **SEES** dynamics*
- *Train scientist in the practice of a trans-disciplinary **SEES** dialogue*
- *Engage multiple “non-science” actors*

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Biological
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S-CC
Physical
S-CCME
S-CC
Services
Ecosystem
Fish & Shellfish
Secondary Producers
S-HAB
food web dynamics
Spatial Dynamics
S-CCME

GOAL

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PICES next steps …

<u>Social-Ecological-Environmental Systems (SEES)</u> ***<u>Approach & Modeling:</u>***

- *Create a culture of awareness to **SEES** dynamics*
- *Train scientist in the practice of a trans-disciplinary **SEES** dialogue*
- *Engage multiple "non-science" actors*
- *Identify issues that are prime for implementing a **SEES** approach*

Elements of **FUTURE**
SCIENCE PROGRAM FOR 2020

GOAL
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PICES next steps ...

<u>Social-Ecological-Environmental Systems (SEES) *Approach & Modeling:*</u>

- *Create a culture of awareness to **SEES** dynamics*
- *Train scientist in the practice of a trans-disciplinary **SEES** dialogue*
- *Engage multiple "non-science" actors*
- *Identify issues that are prime for implementing a **SEES** approach*
- *Find proper sources of funding and coordination*

Elements of **FUTURE**
Science Program for 2020

GOAL

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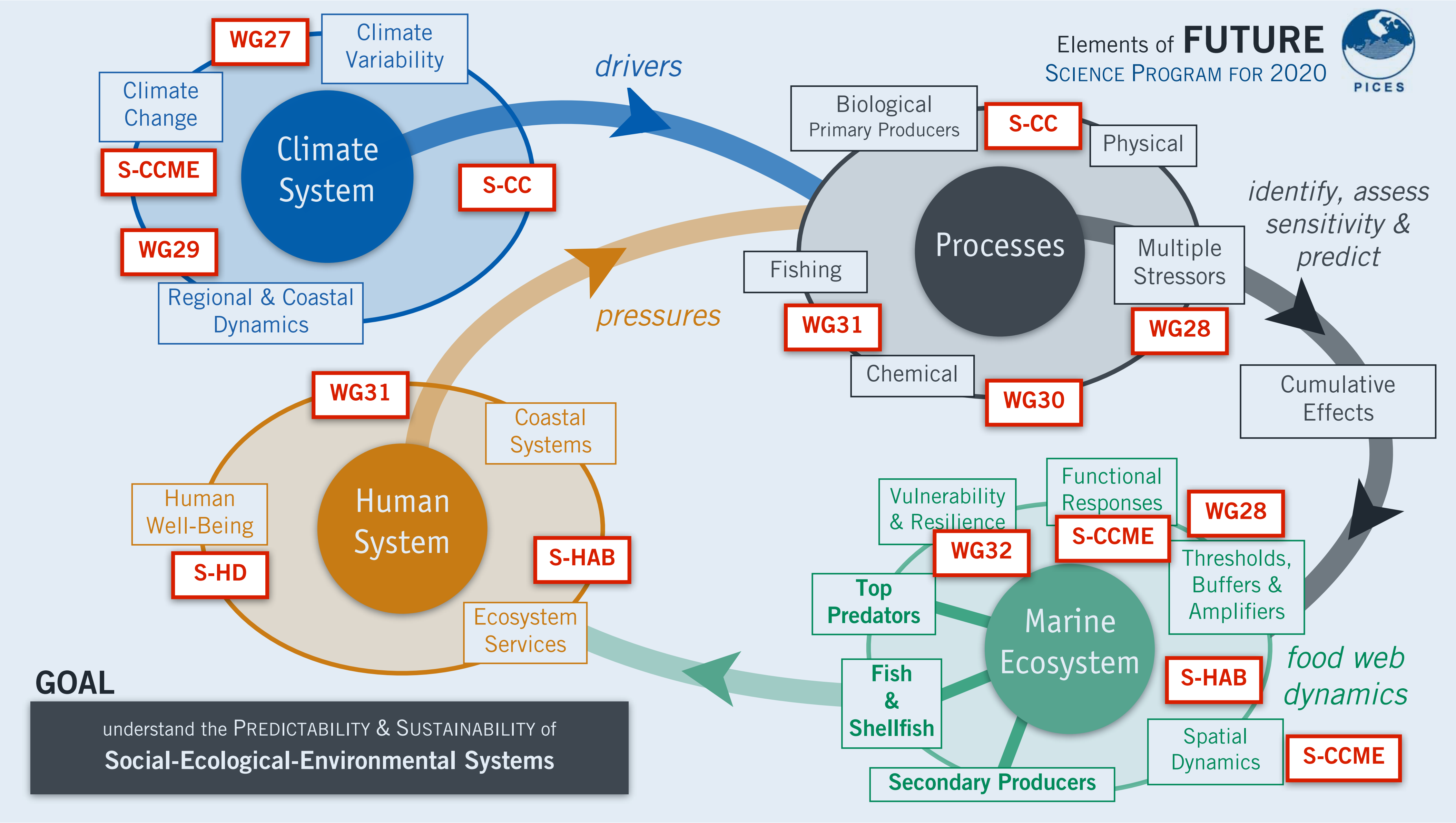
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