Balancing Freshwater Inflows in a Changing Environment

September 7, 2012 GBRA River Annex in Seguin, Texas

September 10, 2012 Bay Education Center in Rockport, Texas

Our Project . . .

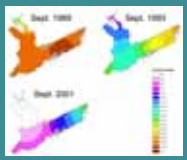
Freshwater inflows: Determining flow regimes in the face of land use, climate change, and other unknowns

OBJECTIVE 1

Examine the effects of land use and climate change on freshwater inflows to the Guadalupe and Mission-Aransas.

OBJECTIVE 2

Improve inputs to the TxBLEND salinity model of the Texas Water Development Board.



OBJECTIVE 3

Collaborate with intended users to identify and conduct a priority research project related to a focal species mentioned in the BBEST report.

OBJECTIVE 4

Develop shared systems learning among the local stakeholders and scientists for construction of a system dynamics model.

MISSION • ARANSAS

TEXAS A&M UNIVERSITY

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE

UNIVERSITY of NEW HAMPSHIRE

Focal species for determining freshwater inflow needs of the Mission-Aransas Estuary

Ed Buskey

Research Coordinator, Mission-Aransas NERR

Professor Department of Marine Science

The University of Texas at Austin

Senate Bill 3: Environmental Flow Recommendations

Directed the development of environmental flow recommendations to:

- **protect** a "sound ecological environment"
- **maintain** the productivity, extent, and persistence of key aquatic habitats in bays and estuaries

Focal Species

- Estuarine species sensitive to changes in salinity
- Changes in the abundance or distribution such species could indicate ecosystem change in response to altered freshwater inflow conditions

Focal Species

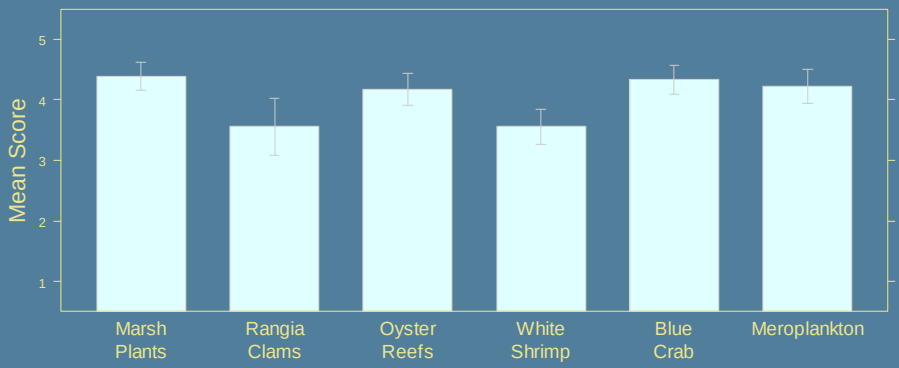
Focal Species

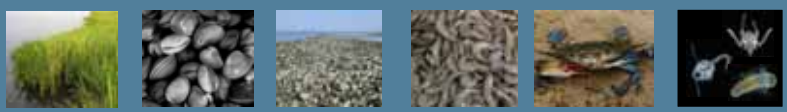
We chose studies for this project with consideration to:

- **Input from stakeholders** and interested parties

- **Study recommendations** made in the BBASC Work Plan for Adaptive Management

Stakeholder Survey Results





Adaptive Management Plan

The BBASC Work Plan for Adaptive Management includes five focal species study recommendations

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Priority Tier

1
- *Rangia* clam investigations
- Life cycle habitat and salinity studies for blue crab and white shrimp

2
- Distribution and abundance of marsh vegetation in the Guadalupe estuary delta
- Habitat suitability models for eastern oysters, blue crabs, and white shrimp

3
- Role of Cedar Bayou in the exchange of water and meroplankton to the Guadalupe estuary

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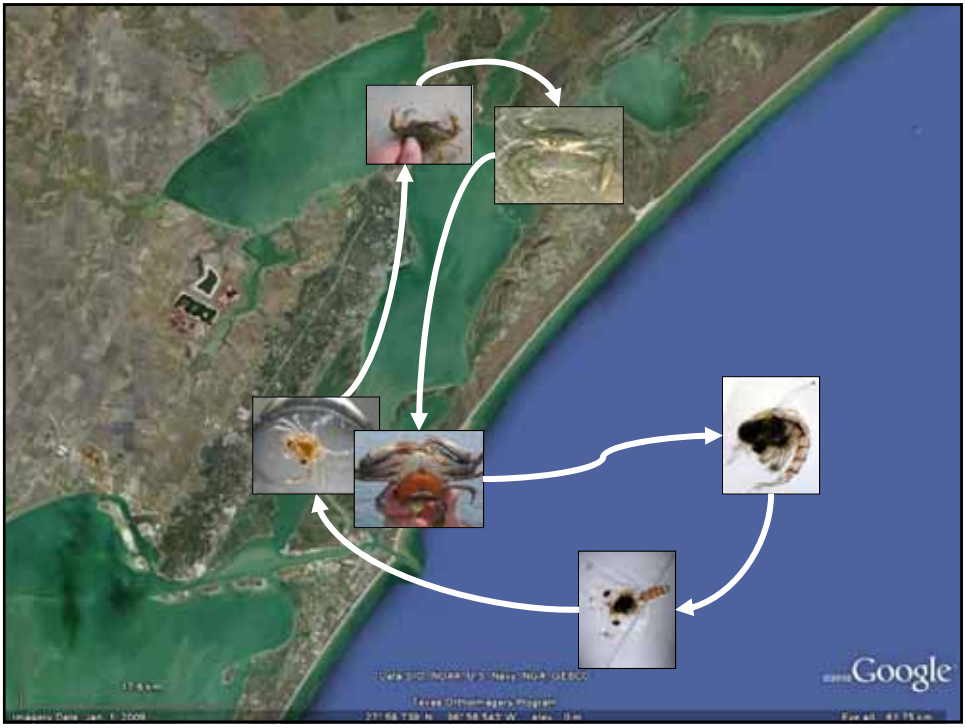
Blue crabs (*Callinectes sapidus*)

Economic importance

- 3.5 million lbs harvested in 2010
- $3.1 million ex-vessel value

Ecological importance

- Preyed on by fish (e.g., red drum, croaker, cobia)
- Food source for endangered whooping cranes (60-98% of energy intake)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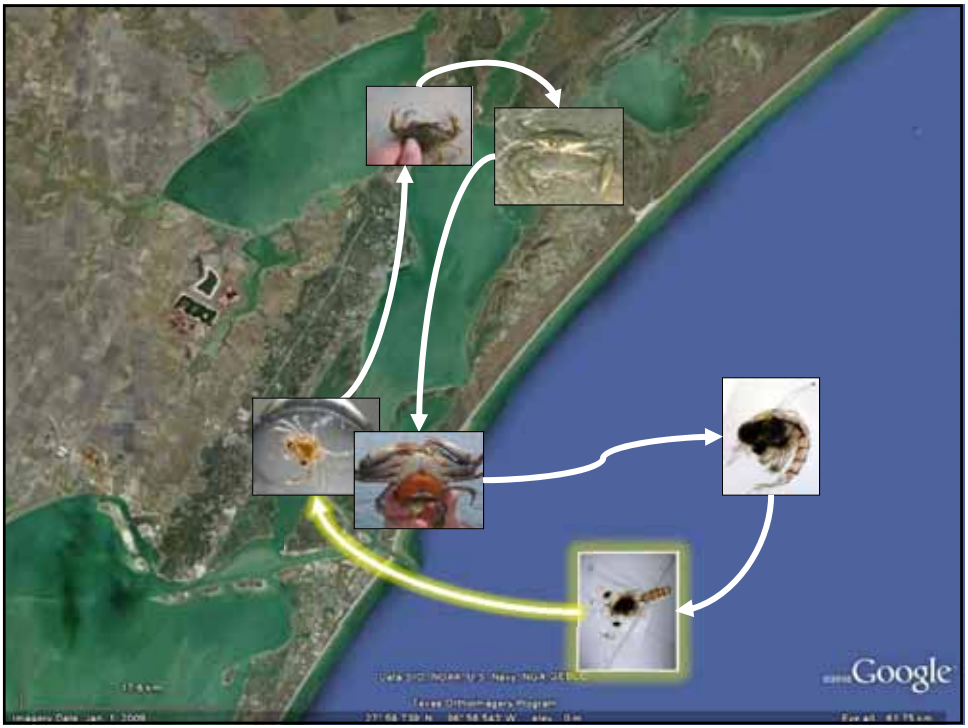
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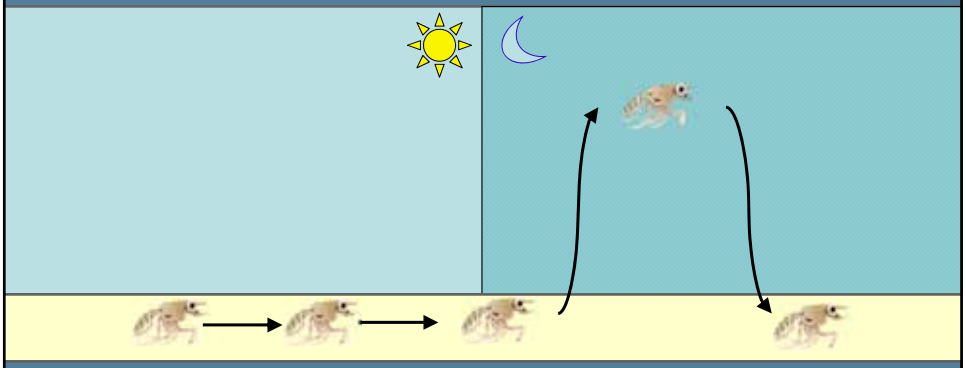
Selective tidal-stream transport



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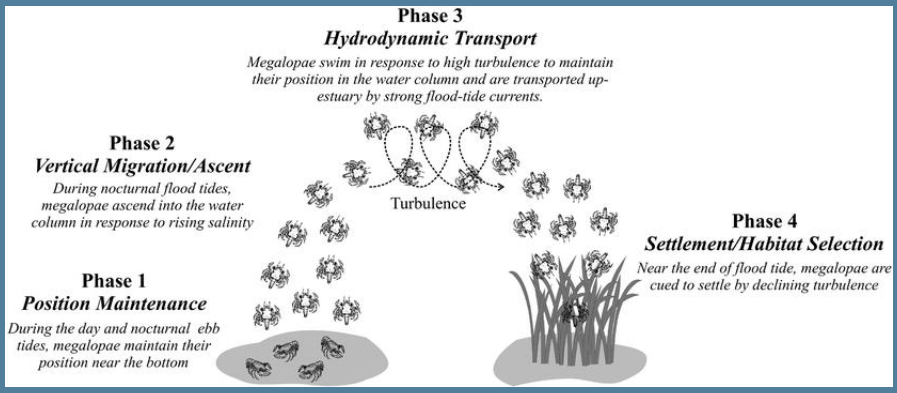

(Forward and Tankersley 2001)

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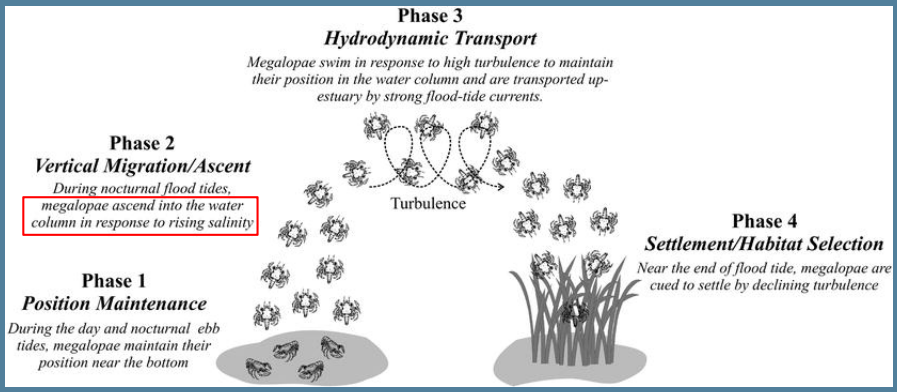

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Research Questions

Do the behavioral responses of crab megalopae to ambient changes in salinity differ between wet and drought years?

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Could changes in megalopae behavior affect their transport into the estuary?

Research Questions

Do the behavioral responses of crab megalopae to ambient changes in salinity differ between wet and drought years?

↳ Laboratory experiments to examine the swimming behavior of crab megalopae under different salinity conditions

Could changes in megalopae behavior affect their transport into the estuary?

↳ Incorporate crab swimming behaviors under different salinity conditions into a larval transport model

Behavior Experiments

Do the behavioral responses of crab megalopae to ambient changes in salinity differ between wet and drought years?

- Use cameras to monitor megalopae swimming behavior under different salinity conditions

NORMAL

Add **ocean salinity** water

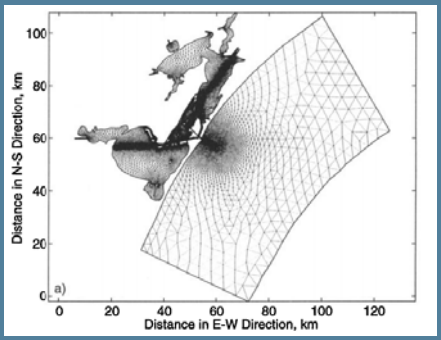
DROUGHT

Add **hypersaline** water

Transport Model

Could changes in megalopae behavior affect their transport into the estuary?

- Simulate circulation within study area
  - Use local wind and tide data
  - ADvanced CIRCulation model (ADCIRC)

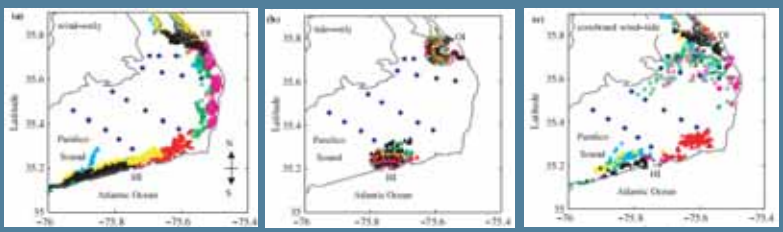


Brown et al. 2000

Transport Model

Could changes in megalopae behavior affect their transport into the estuary?

- Simulate megalopae dispersal under different conditions
  - Examine relative influences of tides & winds
  - Test effects of different megalopae swimming behaviors by limiting times at which particles are free to move



Reyns et al. 2007

Transport Model

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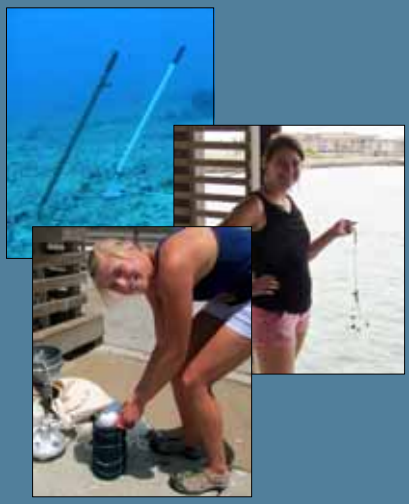


- Assess model results with field data
  - Current data from Seahorse tilt current meters
  - Megalopae abundance data from settlement collectors or traps

Any questions?

What is an estuary?

- An estuary is a partially enclosed water body where freshwater from rivers mix with saltwater from the sea
- Tidally influenced: where water levels are affected by tides

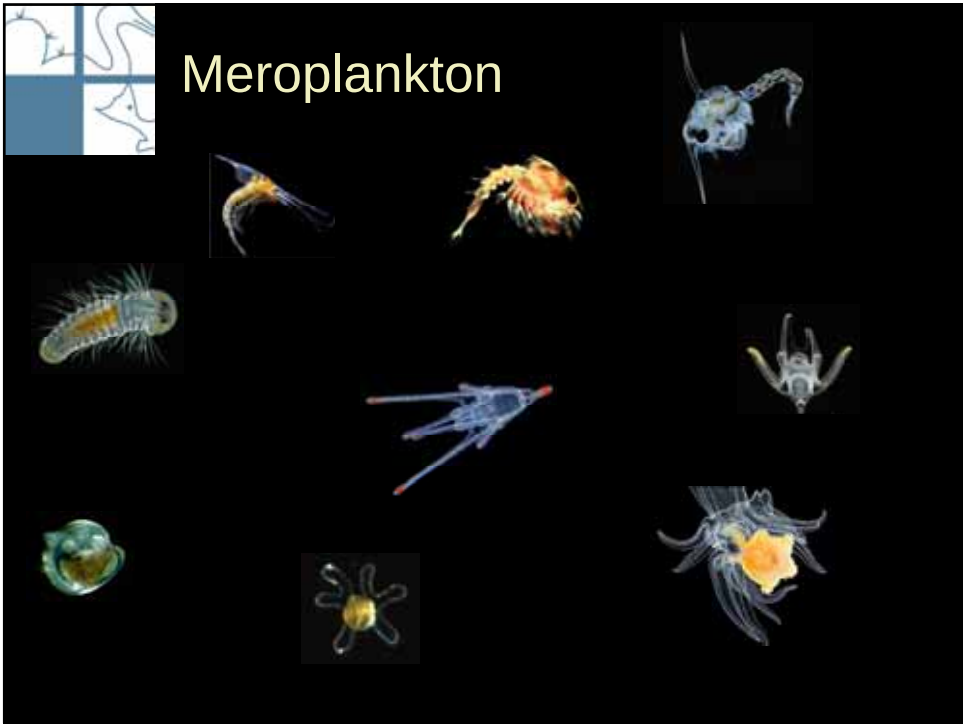
Why are estuaries important?

- Environmental and Economic Benefits
  - One of the most biologically productive habitats
  - Most fish and shellfish of commercial importance spend at least part of their lives in estuaries – “nurseries of the sea”
  - Filter, trap and transform many pollutants before they enter the sea (especially excess nutrients from agriculture and municipal waste)
  - Provide flood protection by absorbing excess flood waters and buffers against strong storms
  - Economic benefits from recreation, shipping, commercial fish catch

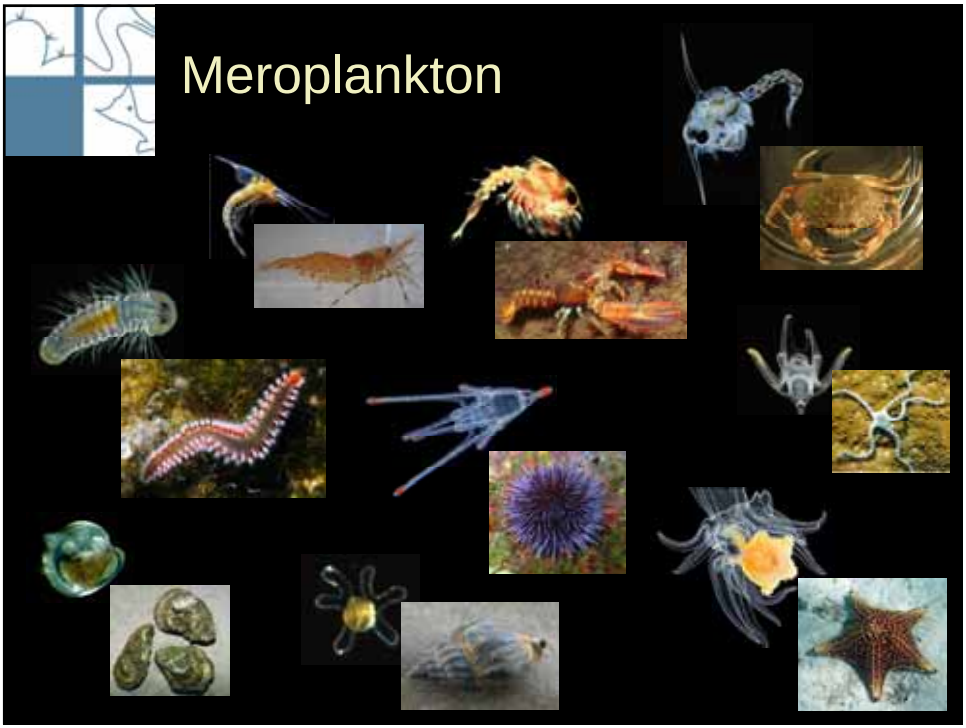
Why do estuaries need freshwater inflow?

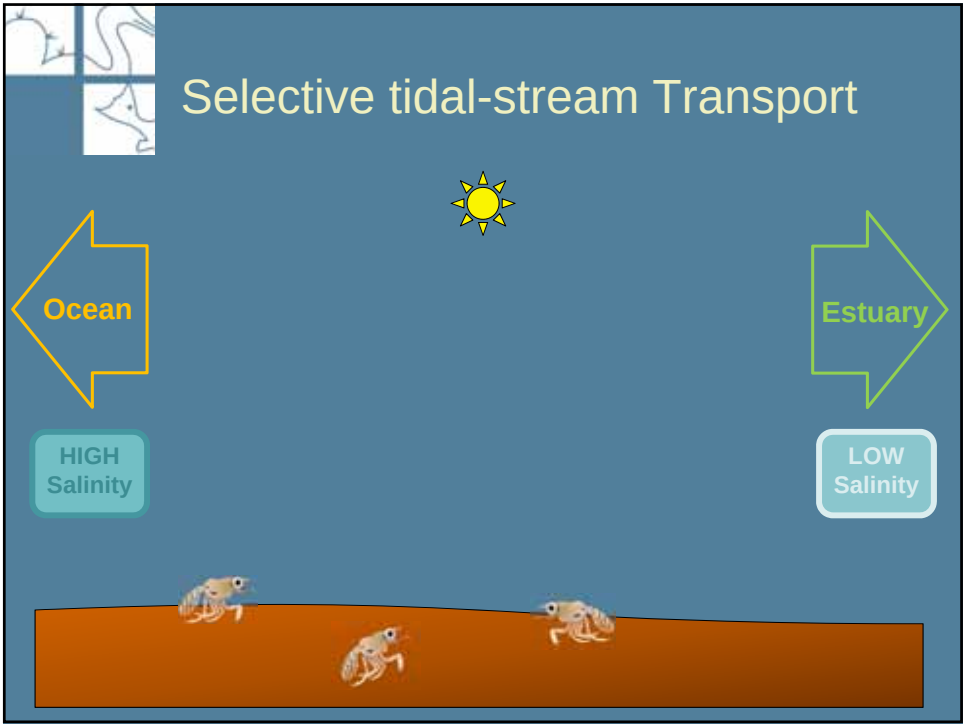
- Maintain zones of reduced salinity
  - Some estuarine-dependent species require zones of reduced salinity
  - For other species reduced salinity reduces competition, predation and/or disease
- Delivers essential nutrients to support plant growth at base of food web
- Delivers sediments to offset losses by erosion and coastal subsidence

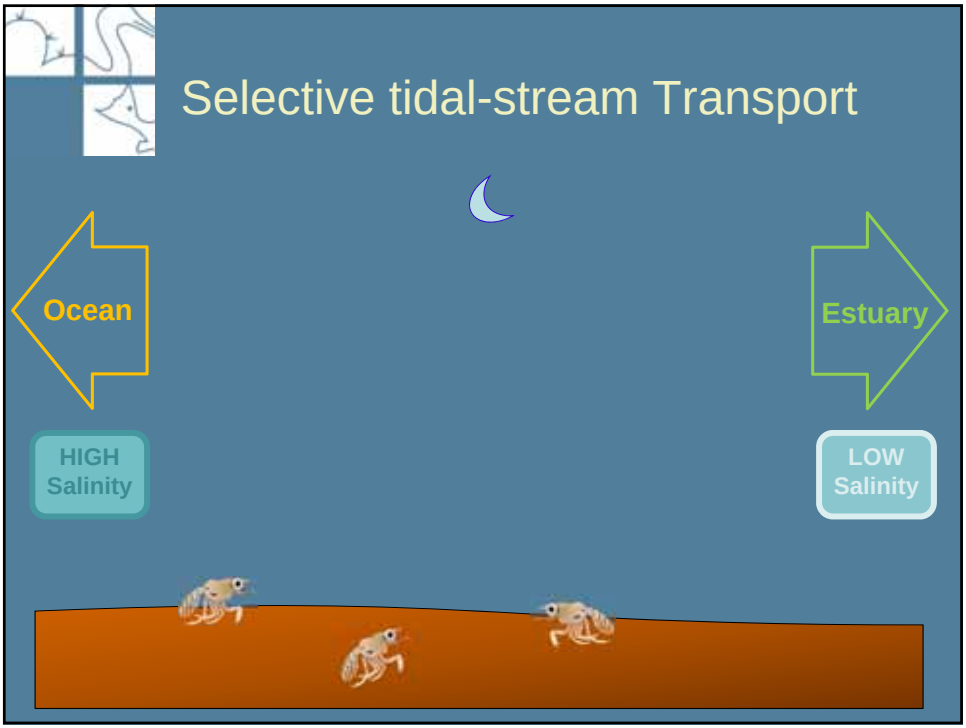
Meroplankton



Meroplankton




Selective tidal-stream Transport
Ocean
Estuary
HIGH Salinity
LOW Salinity


Selective tidal-stream Transport
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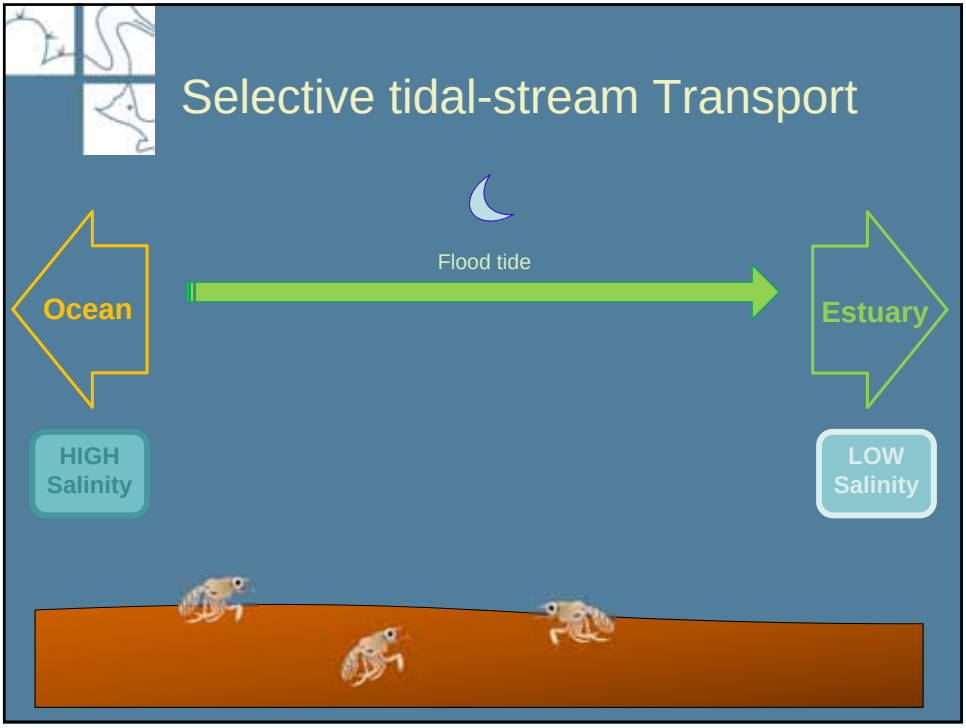
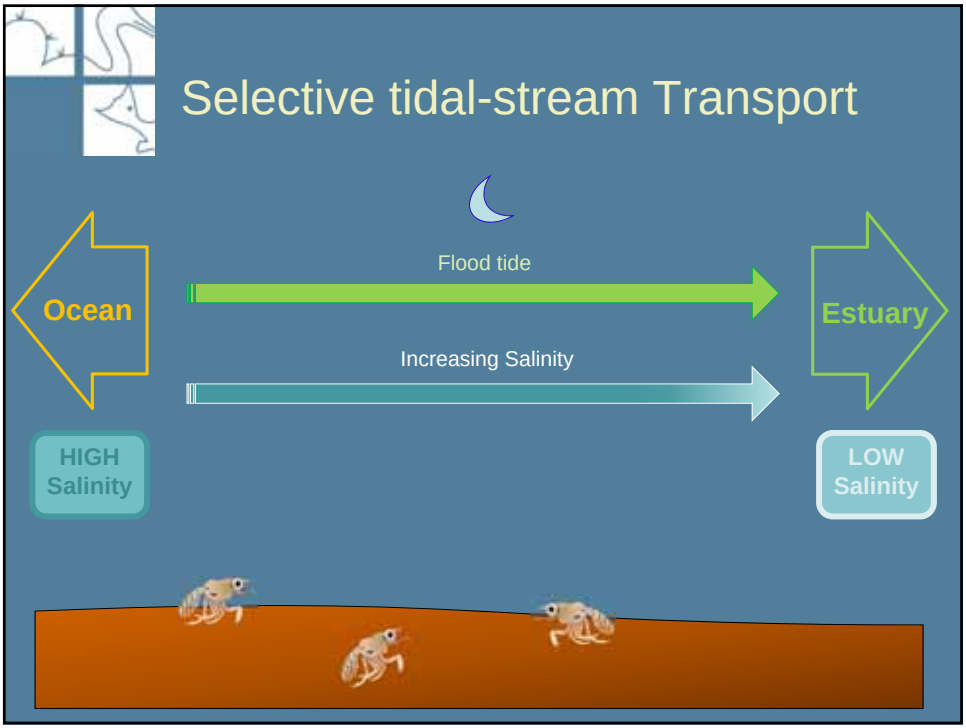
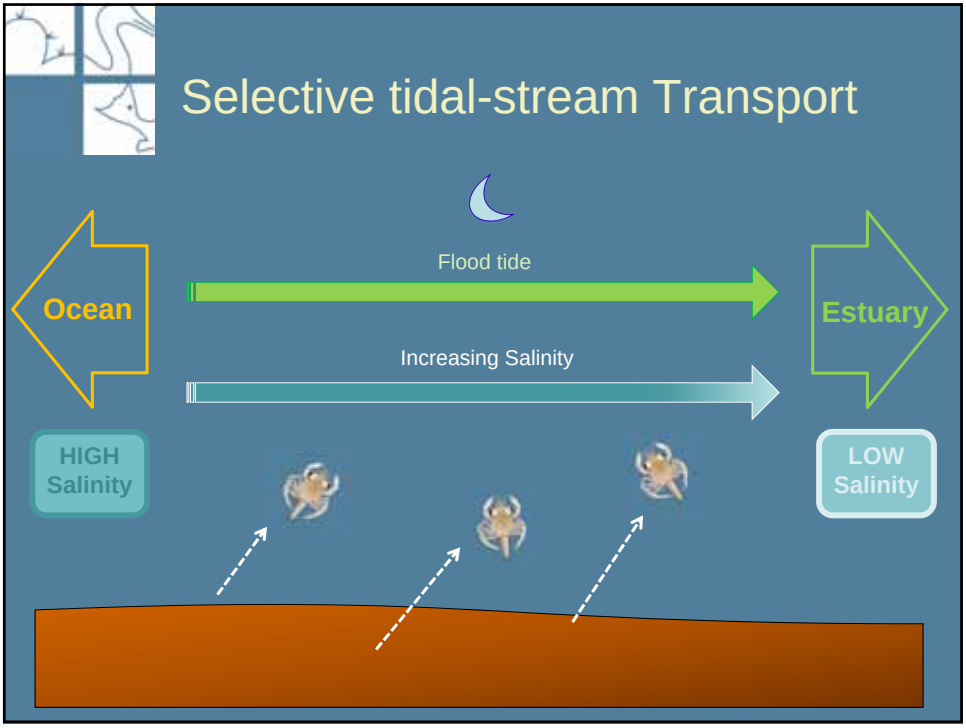
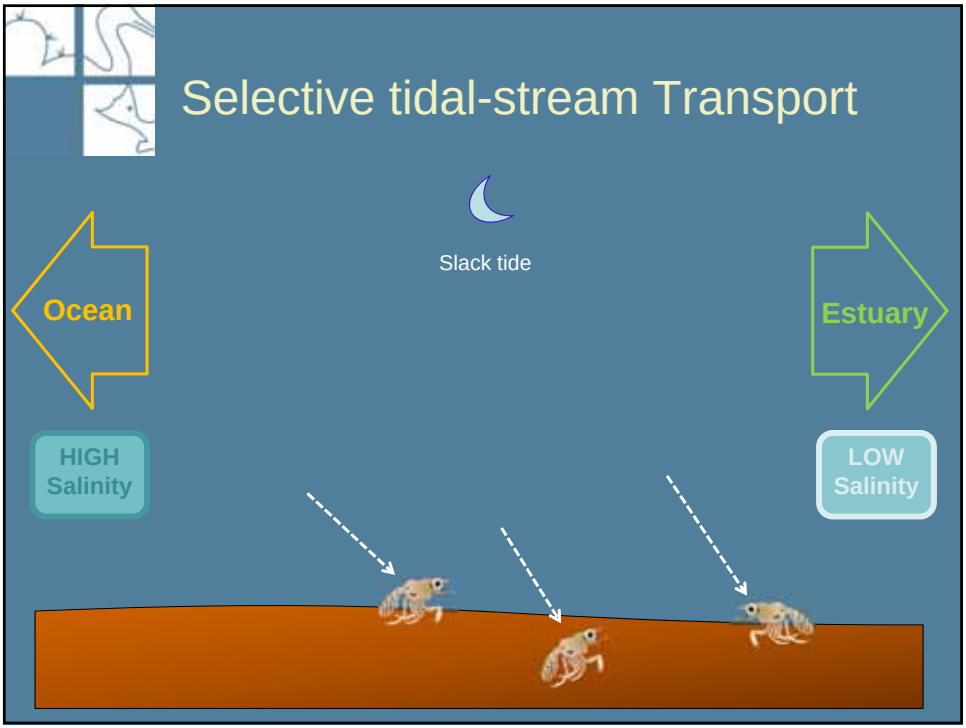
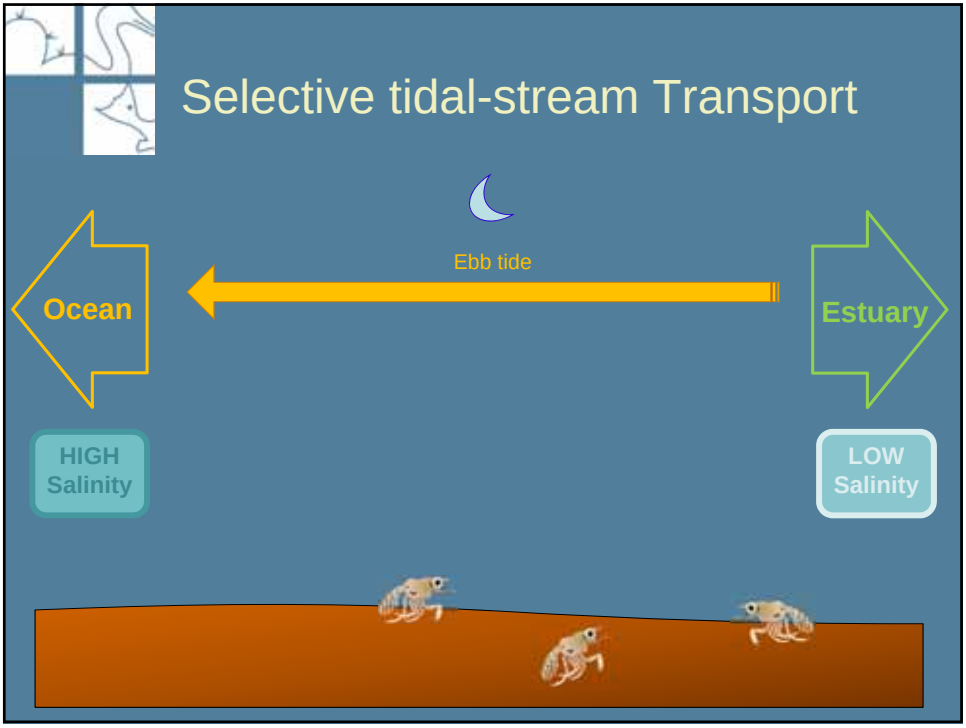
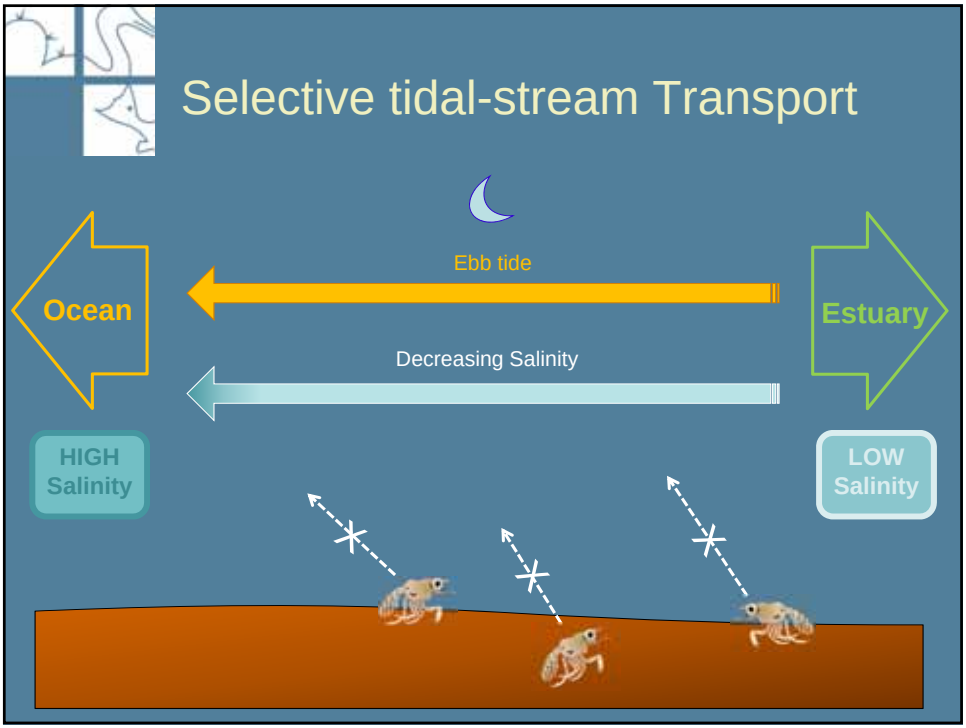

Selective tidal-stream Transport
Flood tide
Ocean
Estuary
HIGH Salinity
LOW Salinity

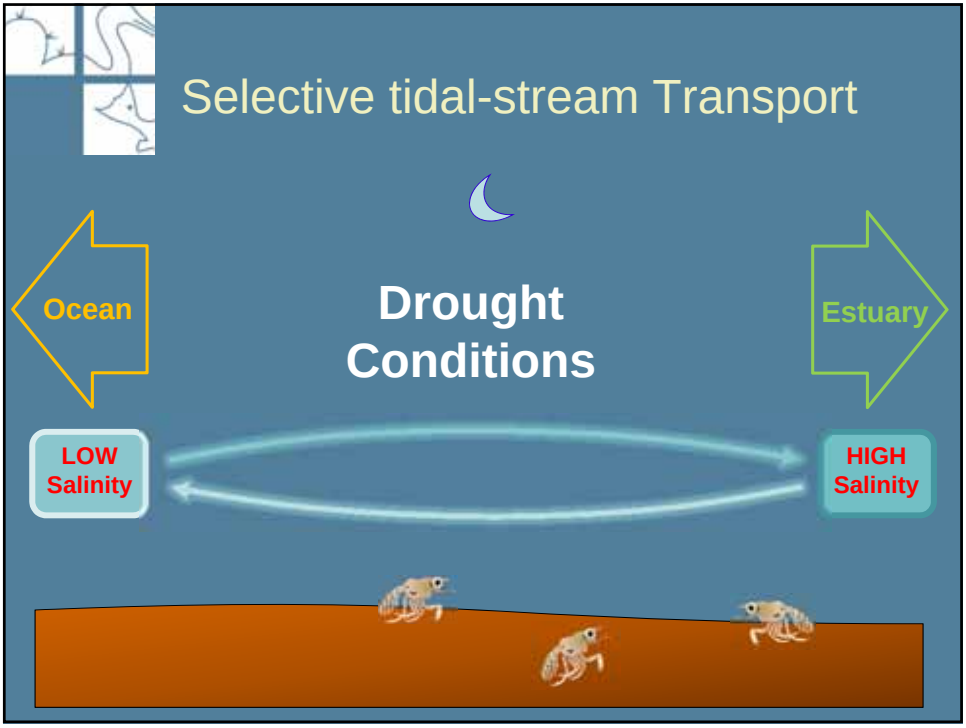

Selective tidal-stream Transport
Flood tide
Increasing Salinity
Ocean
Estuary
HIGH Salinity
LOW Salinity

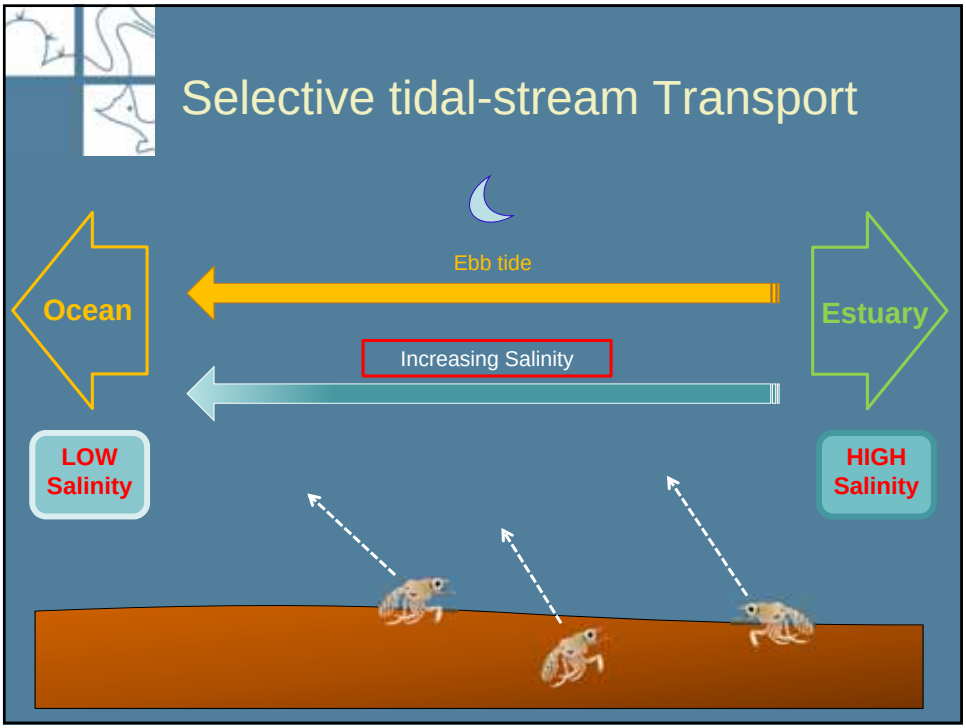

Selective tidal-stream Transport
Flood tide
Ocean
Estuary
Increasing Salinity
HIGH Salinity
LOW Salinity


Selective tidal-stream Transport
Slack tide
Ocean
Estuary
HIGH Salinity
LOW Salinity

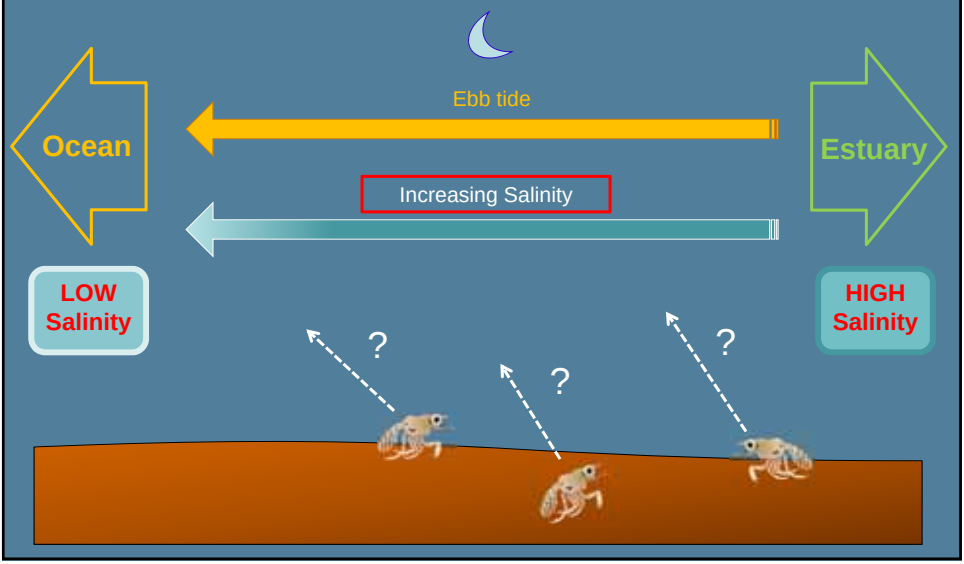

Selective tidal-stream Transport
Ebb tide
Ocean
Estuary
HIGH Salinity
LOW Salinity


Selective tidal-stream Transport
Ebb tide
Decreasing Salinity
Ocean
Estuary
HIGH Salinity
LOW Salinity


Selective tidal-stream Transport
Ocean
Drought Conditions
Estuary
LOW Salinity
HIGH Salinity


Selective tidal-stream Transport
Ebb tide
Ocean
Estuary
Increasing Salinity
LOW Salinity
HIGH Salinity

Selective tidal-stream Transport



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NORMAL

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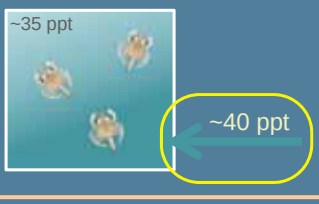
DROUGHT

Add **hypersaline** water



Add water from **ocean** vs. **estuary**

Focal Species

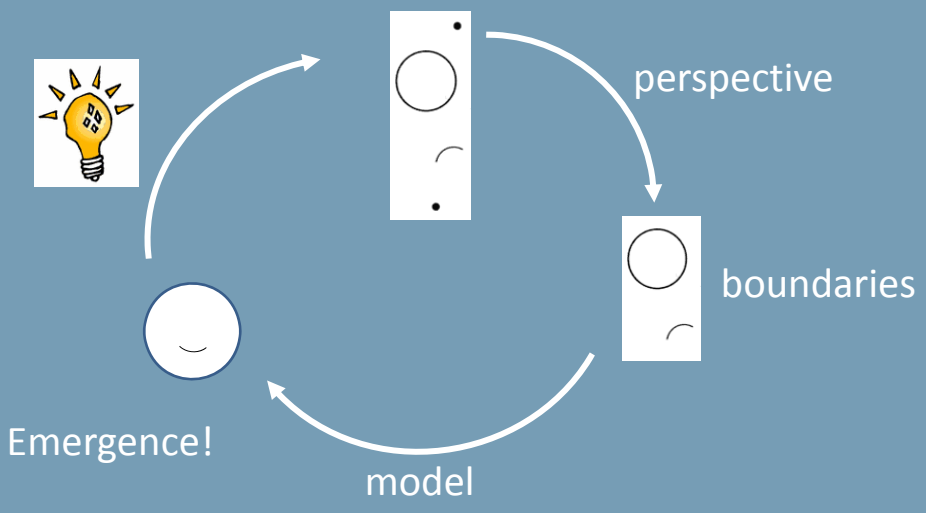
Developing a system-dynamics model

Balancing Freshwater Needs in a Changing Environment: Building on May 30 Activities

September 7, 2012

Tarla Rai Peterson, PhD
Boone and Crockett Chair of Wildlife & Conservation Policy
Texas A&M University

Models lead to new perspectives



System-dynamics modeling tutorial

1. Tell a story of the system.
2. Identify components & actions
3. Translate into modeling language.
4. Retell the story with a model.
5. Try out the model and revise.

1.Tell the story of the estuary

What is the setting?

1.Tell the story of the estuary

Who
are the
characters?








1.Tell the story of the estuary

What
 is the
main
action?


2. Identify components & describe interactions

	Birds	Fishes	Plants	Humans	Inverte-brates	Plankton	Water	Substrate / soil	Tides/ Currents	Precipitation	Sunlight (Energy)	Wind
Bacteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
Birds		B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Fishes			C3	C4	C5	C6	C7	C8	C0	C10	C11	C12
Plants				D4	D5	D6	D7	D8	D9	D10	D11	D12
Humans					E5	E6	non-point pollution E7	E8	E9	E10	E11	#12
Invertebrates						F6	F7	F8	F9	F10	F11	F12
Plankton							F7	F8	G9	G10	G11	G12

3. Translate into modeling language

The central components of the estuary are - - (STOCKS)

The actions that influence them are - - (FLOWS)

The issues that drive or inhibit those actions are - - (CONVERTERS)

4. Retell the story with a model

Use the components (stocks), actions (flows), and modifiers (converters) to draw a model map.

4. Retell the story with a model

Use modeling software to formalize your model.

What data do we need?

How should the information fit together?

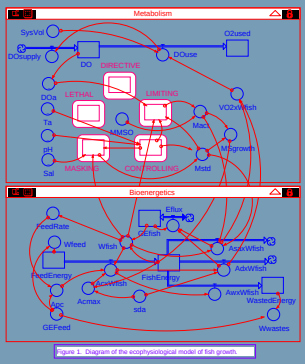
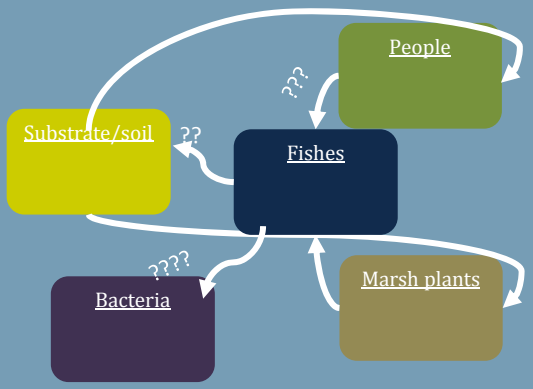


Figure 1. Diagram of the ecophysiological model of fish growth.

Try out the model and revise



January 17 2012

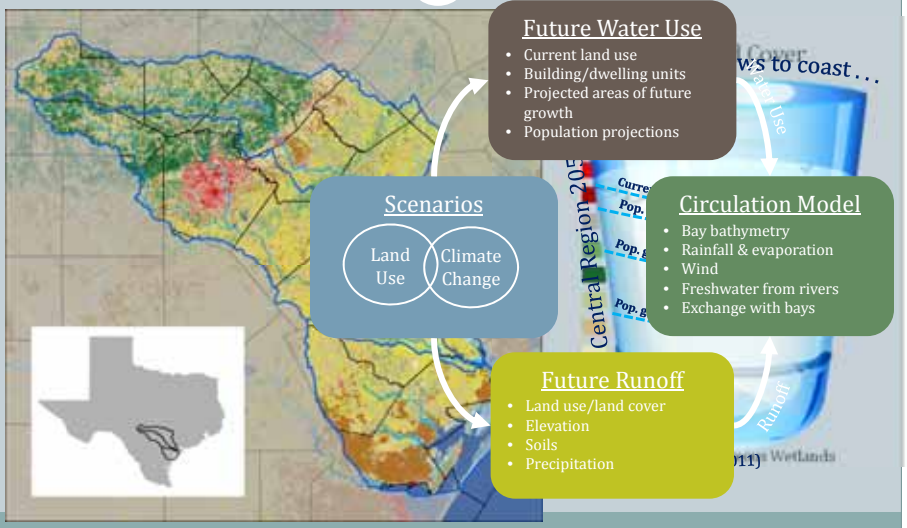
Port Aransas

Freshwater Inflows:

Determining the Effects of Land Use & Climate Change

KIERSTEN MADDEN
Stewardship Coordinator
Mission-Aransas NERR

FUTURE FRESHWATER INFLOWS



FUTURE LAND USE

Aransas Pass, Bayside, Lamar, Port Aransas, Refugio, Rockport-Fulton (Group 1)

High Density: highly developed areas where people reside or work in high numbers; impervious surfaces = 80-100%

Medium Density: areas with a mixture of constructed materials and vegetation; impervious surfaces = 50-79%

Low Density: areas with a mixture of constructed materials and vegetation; impervious surfaces = 20-49%

Developed Open Space: areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses; impervious surfaces = less than 20%

FUTURE LAND USE

Aransas Pass, Bayside, Lamar, Port Aransas, Refugio, Rockport-Fulton (Group 2)

High Density: highly developed areas where people reside or work in high numbers; impervious surfaces = 80-100%

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FUTURE LAND USE

Austwell, Bloomington, Port Lavaca, Seadrift, Victoria

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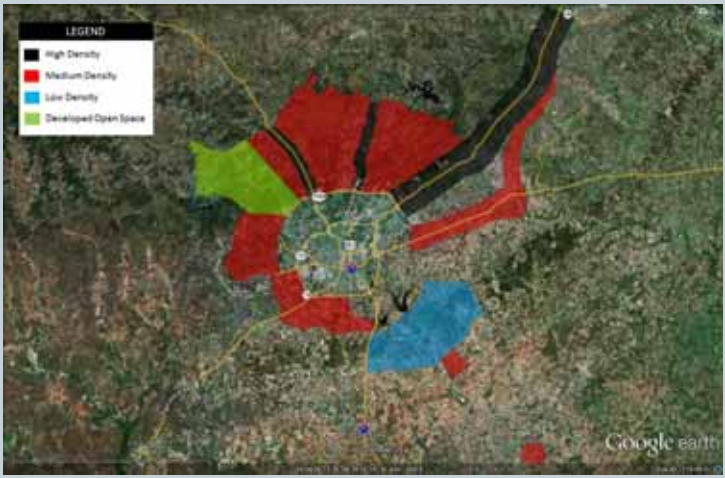
FUTURE LAND USE

Kerrville, New Braunfels, San Antonio, San Marcos, Seguin



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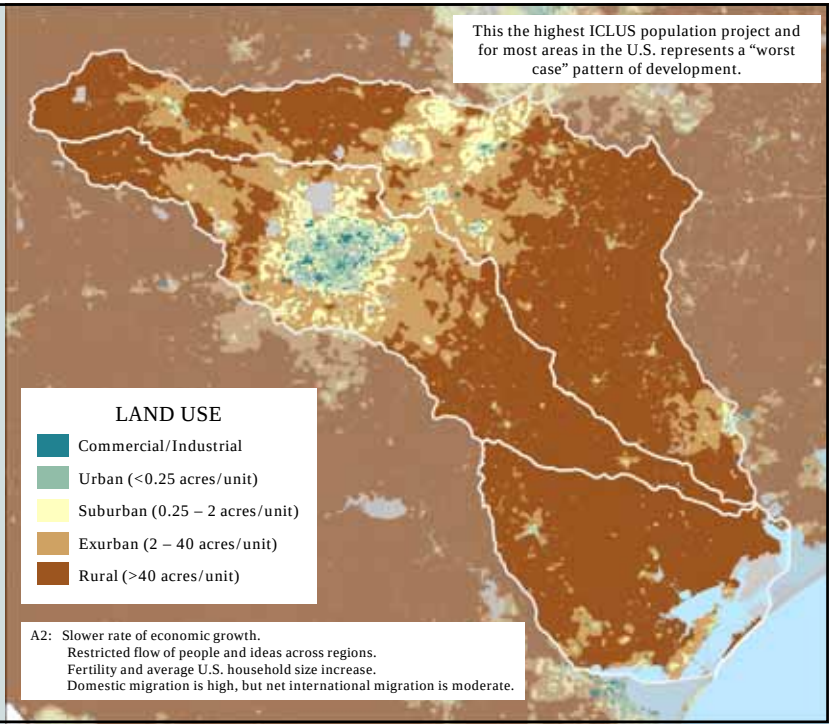
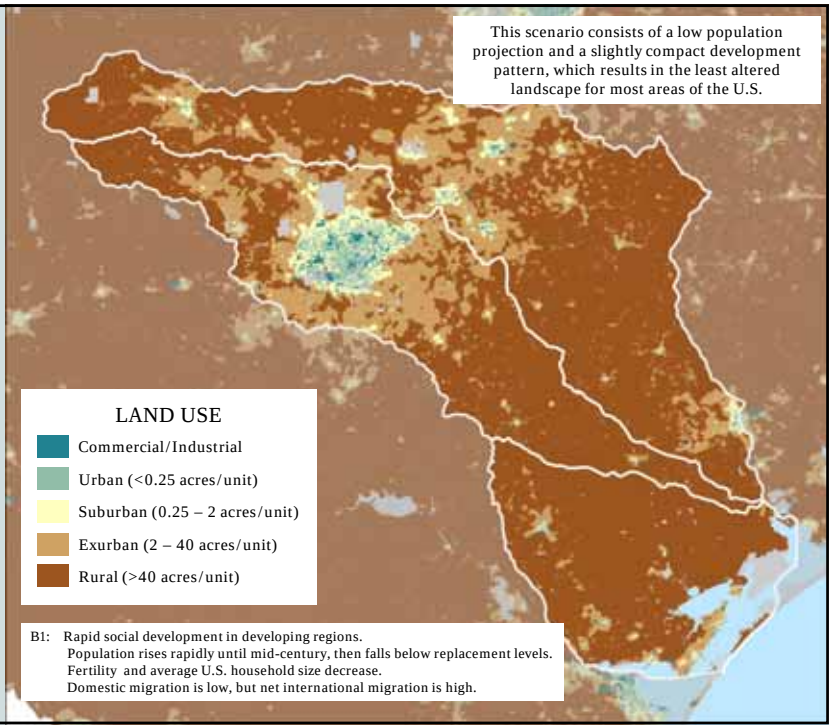
ICLUS

INTEGRATED CLIMATE AND LAND USE SCENARIOS



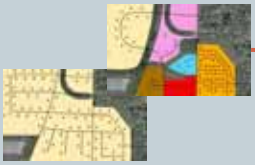
ICLUS

INTEGRATED CLIMATE AND LAND USE SCENARIOS



community viz

Create land use scenarios



Create indicators measuring impacts (economic, social, environmental)

Create 3D visual models

Experiment interactively and see changes

Project impacts into the future

BUILD OUT

1

Numeric Build-out

Mathematical calculation based on area and density rules.

OUTPUT: Calculated Number

Area = 5 acres

Density = 1 DU/acre

Numeric DUs = 5

2

Spatial Build-out

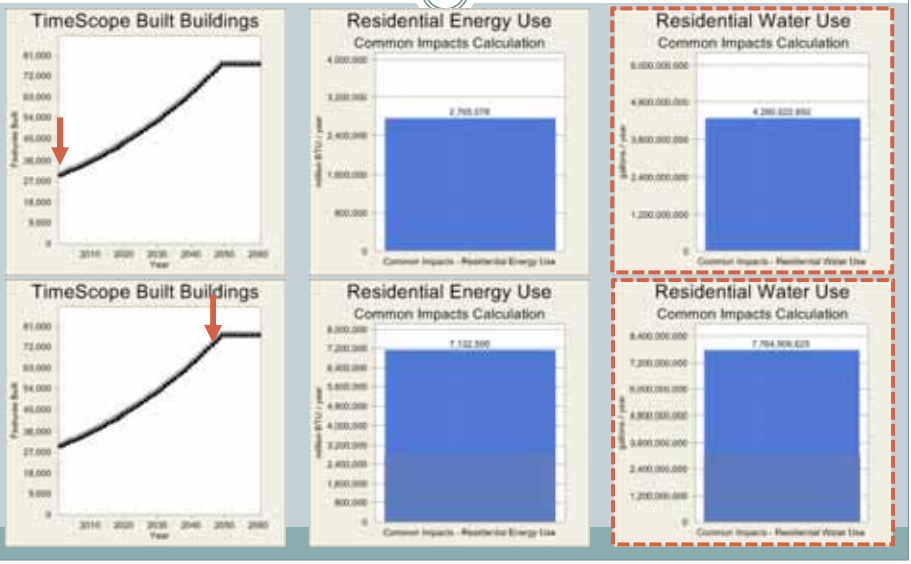
Creates map layer with points or polygons representing buildings by possible locations.

OUTPUT: Points on map

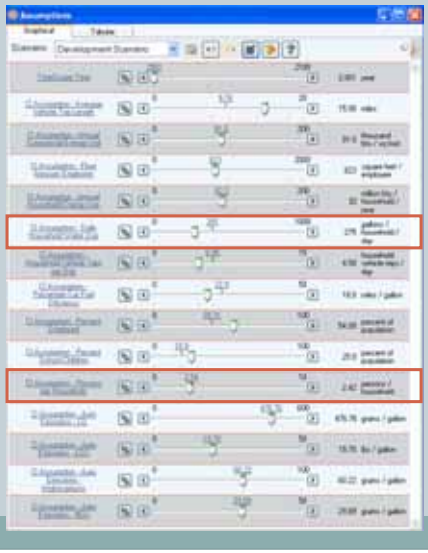
Physical shape restricts development.

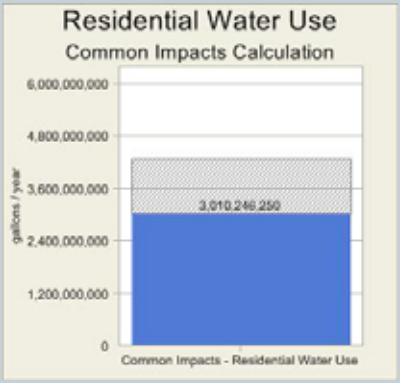
Spatial DUs = 4

COMMON IMPACTS

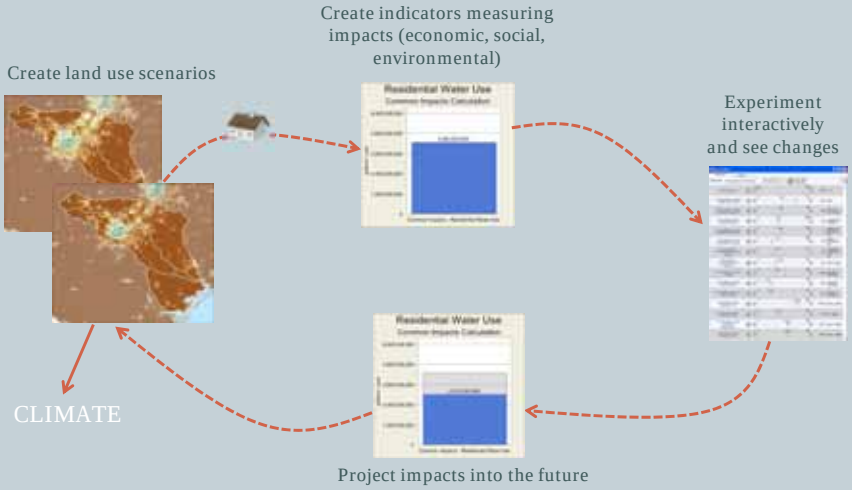


CHANGING ASSUMPTIONS





WHAT'S NEXT?



QUESTIONS

Kiersten Madden

Stewardship Coordinator
Mission-Aransas NERR

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361.749.3047

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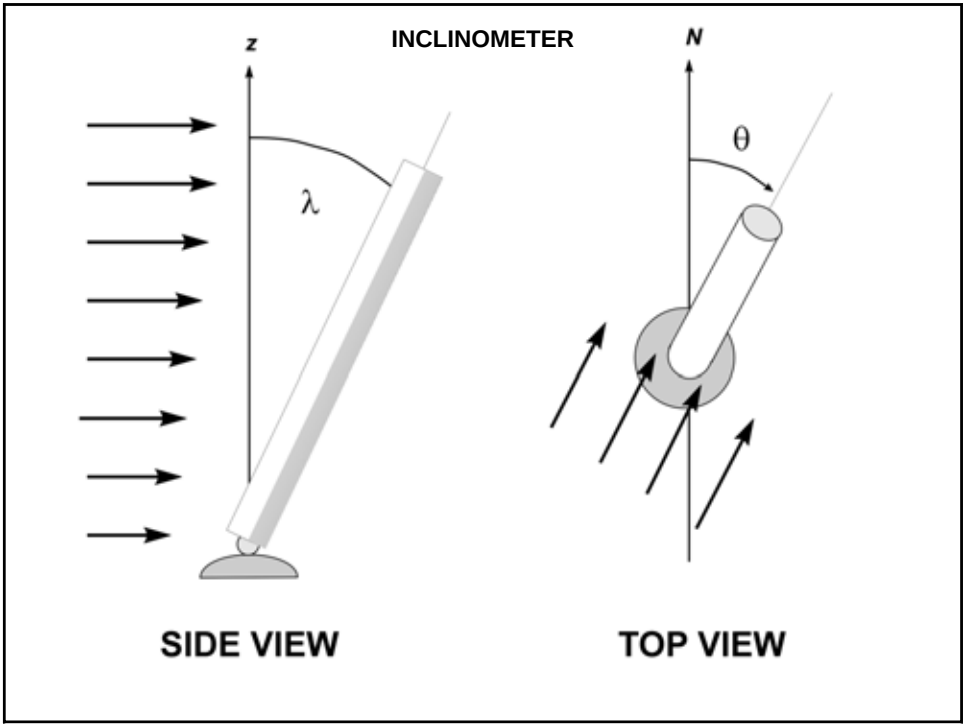
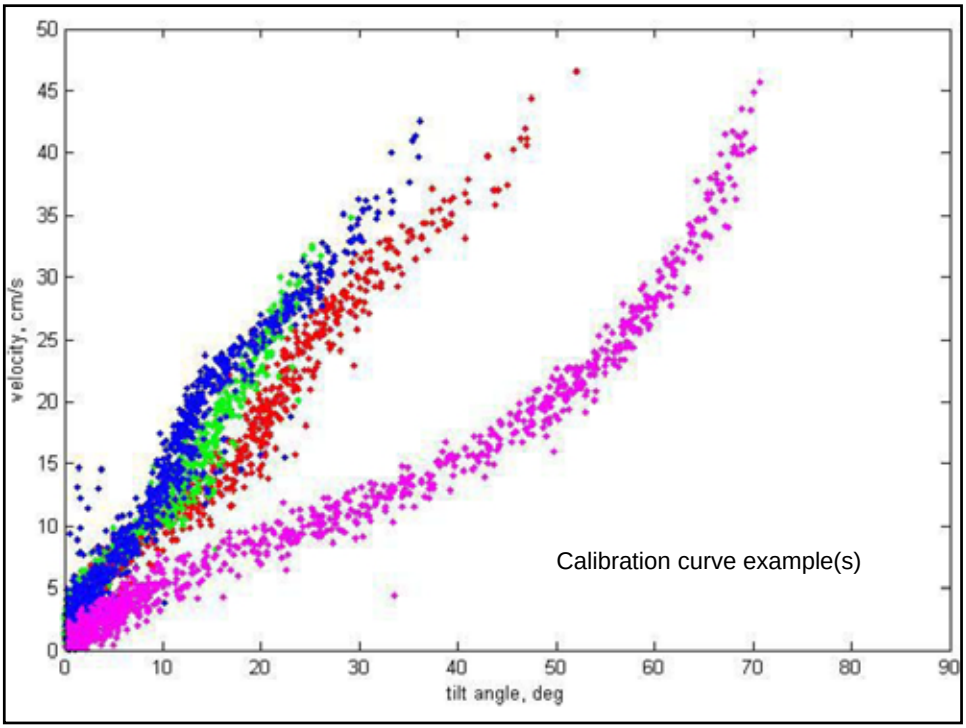
NERR current measurement

CURRENT METERS

INCLINOMETER


INCLINOMETER
z
λ
N
θ
SIDE VIEW
TOP VIEW


velocity, cm/s
tilt angle, deg
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
Calibration curve example(s)

Seahorse current meters


kilometres
Guadalupe River
Suggested tiltmeter stations from recommendations of Stakeholders 30 May 2012
SAN ANTONIO BAY
ST CHARLES BAY
MISSION BAY
MESQUITE BAY
COPANO BAY
ARANSAS BAY
REDFISH BAY
Gulf of Mexico

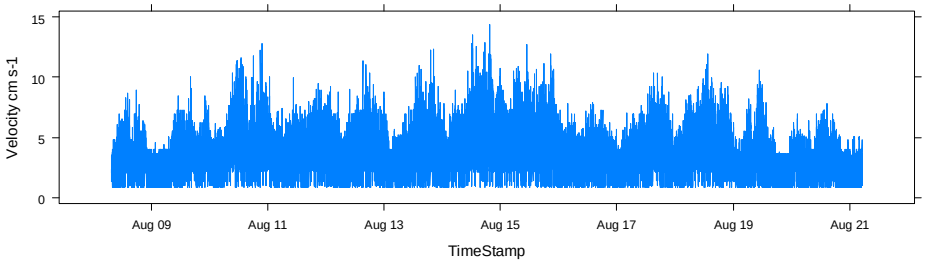
Current meter painted w/ anti-fouling paint for longer-term deployment

Current meter + its pvc stake

Free-diving current meter retrieval

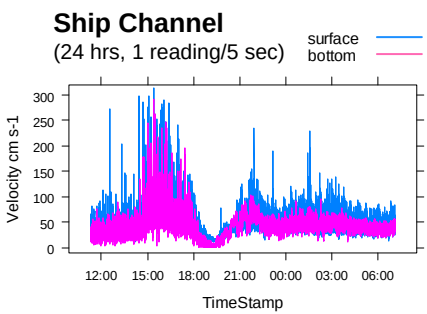
Seahorse tilt test deployment data

Mesquite Bay (2 wks, 1 reading/min)

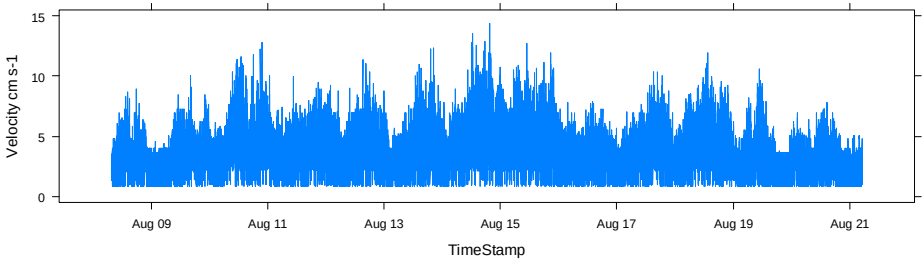


Seahorse tilt test deployment data

Ship Channel
(24 hrs, 1 reading/5 sec)

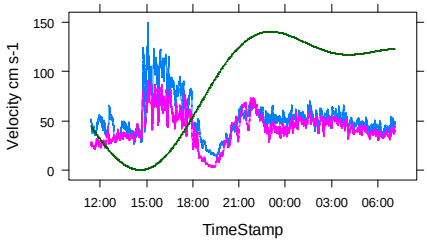


Mesquite Bay (2 wks, 1 reading/min)

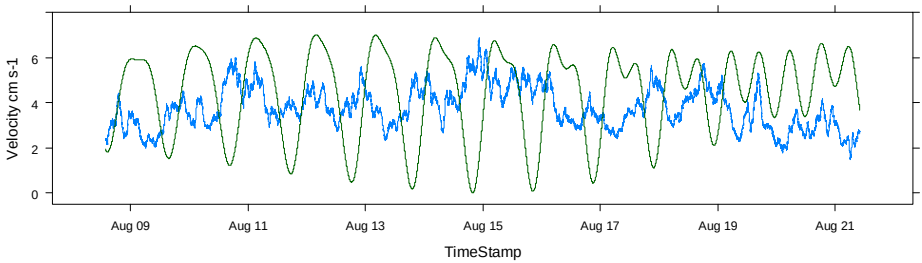


Seahorse tilt test deployment data

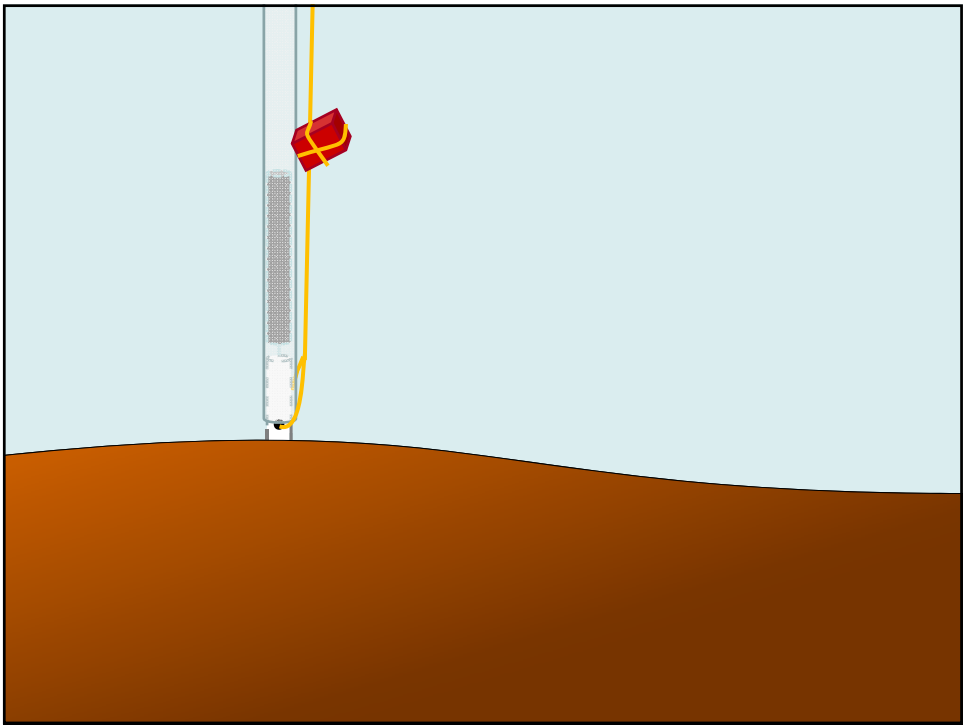
Ship Channel
(24 hrs, 1 reading/5 sec)

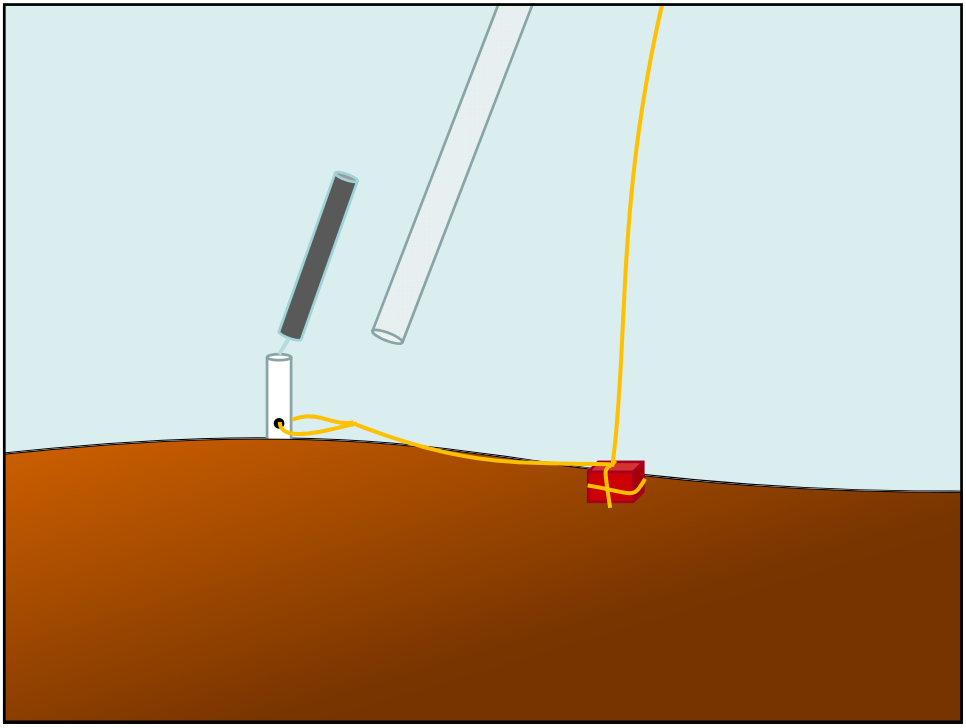


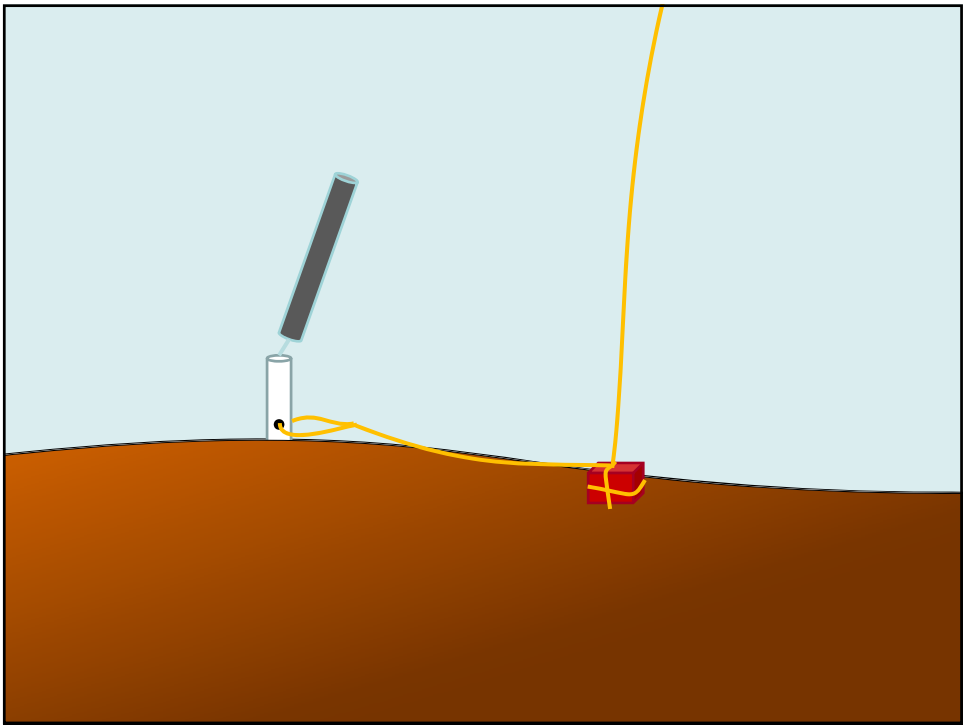
Mesquite Bay (2 wks, 1 reading/min)

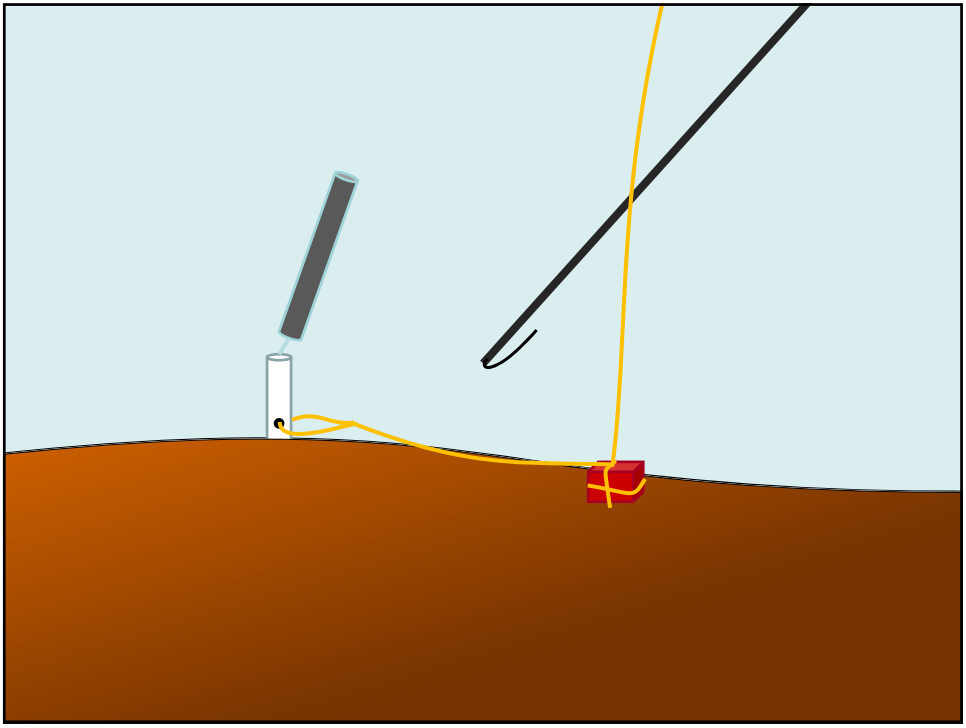


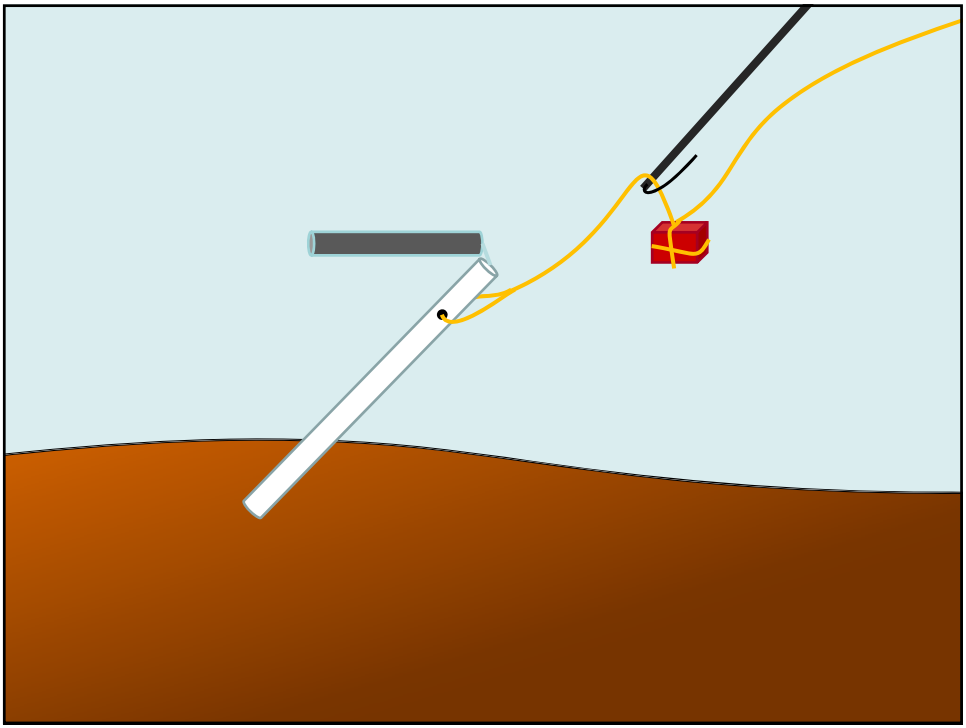
Deployment / Retrieval
Methods











Timeline

Year 1

- Introduce project to intended users (i.e., workshops, interviews)
- Gather data for land use and climate scenario analysis
- Begin circulation study
- Identify focal species study with intended users
- Begin mediated modeling

Year 2

- Analyze land use and climate scenarios
- Continue circulation study
- Collect data for priority research project
- Update intended users through a series of workshops
- Expand mediated modeling effort

Year 3

- Summarize results of land use and climate change analysis
- Analyze and summarize circulation datasets
- Analyze and summarize results from priority research topic
- Discuss results with intended users
- Disseminate results to wider audience

Save the Date

January 17, 2013 is our next meeting

Location: University of Texas Marine Science Institute

Port Aransas, Texas

Questions?

www.missionaransas.org
MissionAransas@gmail.com