Balancing Freshwater Inflows in a Changing Environment

Our Project...

**OBJECTIVE 1**
- Examine the effects of land use and climate change on freshwater inflows to the Guadalupe and Mission-Aransas.

**OBJECTIVE 2**
- Improve input data for 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.

**Science to Policy**

- **TCEQ - Regulatory Agency**
  - More informed users for BBEST, BRASC, & public comment

- **TWDB - Regulatory Agency**
  - Forecasted precipitation rates
  - Human water demand with changes in land use and climate

- **Computer model**
  - Indicator species

**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

**Project Team Members**

**Turning Point Technologies**

Keypad Polling Introduction
How far did you have to travel to attend today's meeting?

1. Less than 10 minutes
2. 10-15 minutes
3. 15-30 minutes
4. 30-45 minutes
5. 45-60 minutes
6. More than an hour

True or False: I have attended one of the three previous stakeholder collaborative meetings for this project.

1. True
2. False

How would you describe your professional or organizational affiliation?

1. Local Government
2. County Government
3. State Government
4. Federal Government
5. Non-Profit Organization
6. Community-based Organization
7. University/Academia
8. Community Member/Citizen
9. Land Use Planner
10. Private Business

How did you learn about this workshop?

1. Telephone call from host(s)
2. Word of Mouth
3. Email Announcement
4. Other (please specify on card)

Freshwater inflows:

Circulation
Tilt Current Meters

Deployment / Retrieval Methods

Weighted wood cross base

PVC stake base
Test Deployment Data

Stations:
- Aransas Bay
- Copano East
- Copano West
- Mosquito Bay

Deployment period:
2 weeks
(October 16-30)

Logging interval:
1 reading \text{ / min}

Stick plot

Strong Northward flow
Weak Northeastward flow
Strong Southward flow

Raw data

Smoothed over 30 min
Test Deployment Data

Line length = mean velocity of flow in the direction
Line darkness = percent time of flow in the direction
Blue = incoming tide
Red = outgoing tide

All Wind Data (m/s)

Low Wind (< 2 m/s)

High Onshore Wind (> 7 m/s)

High Offshore Wind (> 7 m/s)
Tilt meter locations suggested at May 30th Stakeholder meeting

Tilt meter locations for first round of deployments

Next Steps

- Deploy at selected stations
- Determine flow patterns under different wind and tidal conditions
- Relocate meters as needed

Test Deployment Data
Test Deployment Data

Please select the choice that best represents how you feel about the following statements:

1. Natural resource management decisions are best made by technical experts; I am willing to comply with the resulting regulations and expect the same from others.

   1. Strongly agree
   2. Agree
   3. Neither agree nor disagree
   4. Disagree
   5. Strongly Disagree
Natural resource management decisions are best made by individuals; and each individual should be allowed to make his or her own decisions.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

People have no control over natural resources; and it does not really matter what I think about how natural resources should be managed.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Which categories best describe your role in this collaboration meeting? Please choose your top three most relevant roles, in order of most relevant (1) to least relevant (3).

1. Resource manager (government; water authority, etc.)
2. Civic/community member (Chamber of commerce, media, etc.).
3. Conservationist (SABP, Sierra Club, etc.).
4. Educator & researcher (teacher, biologist, etc.).
5. Tourism operator (guides, hotels, etc.).
6. Non-tourism business operator (fisher, oil & gas extraction, etc.).
7. Land user (rancher, builder, etc.).
8. Recreational user (hunter, bird watcher, etc.).

Please rank the following statements in order of how you agree/disagree with them. Choice 1 is the statement you “agree most strongly with”, and Choice 4 is the statement you “disagree most strongly with.”

1. [Rank 1-4] Natural resource management decisions are best made by technical experts.
2. [Rank 1-4] Natural resource management decisions are best made by individuals.
3. [Rank 1-4] Natural resource management decisions are best made by communities.
4. [Rank 1-4] It does not really matter how natural resources are managed.
May 30, 2012 Workshop

- Everyone identifies their place in the estuary and shares ideas about important species, water circulation, and future land use.
- Participants draw concept maps of management issues and challenges.

September 2012 Workshops

Participants develop a qualitative model of the estuary.

- Part I: Individuals identify needs and concerns about the estuary into the future. This leads to specific questions.

Individuals ask:

- What do I want/need from the estuary?
- What concerns/worries do I have about the estuary’s ability to satisfy my wants/needs into the future?
- Given these wants/needs; what single question is most important for the model to answer?

The results are the basis for model development.

<table>
<thead>
<tr>
<th>Want/Need</th>
<th>Category</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you want/need?</td>
<td>Sustainable Fisheries</td>
<td>16</td>
</tr>
<tr>
<td>What concerns/worries do I have about the estuary's ability to satisfy my wants/needs into the future?</td>
<td>Freshwater Inflows</td>
<td>22</td>
</tr>
<tr>
<td>Given these wants/needs; what single question is most important for the model to answer?</td>
<td>Estuary Health</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Biodiversity</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Clean Water</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Toxic Pollution</td>
<td>12</td>
</tr>
</tbody>
</table>

Questions the model might address:

- How much freshwater inflows are needed to sustain estuarine species?
- What do we need to do to maintain estuary health?
- What are significant physical and ecological interactions in the estuary?
- How do freshwater inflow increases/decreases affect food web dynamics in the estuaries?
Model Development

- Ask a specific question.
- Keep it simple – you can always add.
- Use existing resources.

Preliminary Model Question:

How do freshwater inflows affect blue crab populations in the Mission-Aransas and Copano Bay system?

January 17, 2013 Workshop

- First draft of the Blue Crab Model.

How could this model be used for estuary management?

- Harvest /fishery management
- Estuary health/restoration
- Water flow issues
- Outreach
- Crane issues

Some of the updates you asked for...

- Make it easier to plug in monthly alterations or hurricane events
- Show the week # on the bottom of the crab population chart
- Add harvest data (recreational and commercial)
- more control on how to specify phases for fresh water pulses.

Today....

1. An updated version of the model based on your feedback in January.

2. Think of ways that this model can be useful to you.

3. What is your role and who do you communicate with about estuary and inflow issues?
Running the Model
- You have an overview of the adjustable buttons for the model and instructions as to how to run the model.
- We appreciate your feedback on the usefulness of these instructions as we try to improve the model.

Predictions
- The following questions relate to components of the model, namely observed effects of salinity and temperature as well as trapping on blue crab populations.
- Use your clickers to answer these questions.

Do you think freshwater inflow (controlling the salinity levels) is an important component of the blue crab simulation model?
1. Yes, I think freshwater inflow is an important component of the blue crab simulation model.
2. No, I do not think freshwater inflow is an important component of the blue crab simulation model.
3. I am not sure if freshwater inflow is important.

Do you think water temperature affects blue crab growth?
1. Yes, water temperature affects blue crab growth.
2. No, water temperature does not affect blue crab growth.
3. I am not sure if water temperature affects blue crab growth.

Do you think water temperature affects blue crab mortality?
1. Yes, water temperature affects blue crab mortality.
2. No, water temperature does not affect blue crab mortality.
3. I am unsure if water temperature affects blue crab mortality.
Do you think trapping affects blue crab populations?

1. Yes, trapping affects blue crab populations. 59%
2. No, trapping does not affect blue crab populations. 34%
3. I am unsure if trapping affects blue crab populations. 7%

Do you think Whooping Crane predation affects blue crab populations?

1. Yes, crane predation affects blue crab populations. 27%
2. No, crane predation does not affect blue crab populations. 27%
3. I am unsure if crane predation affects blue crab populations. 47%

HYPOTHESES
What do you think is most likely to happen to the total blue crab population when relative freshwater inflow into the estuary is at high (1)? (High depicts low salinity level)

1. The total blue crab population increases. 86%
2. The total blue crab population decreases. 7%
3. Has no impact on the blue crab population. 7%

HYPOTHESES
What do you think is most likely to happen to the total blue crab population when relative freshwater inflow into the estuary is set at low (-1)? (Low depicts high salinity level)

1. The total blue crab population increases. 0%
2. The total blue crab population decreases. 3%
3. Has no impact on the blue crab population. 97%

Mission-Aransas NERR
Balancing Freshwater Needs in a Changing Environment

Fourth Meeting of Collaborative Participants

April 2013, Port Aransas

Mediated Modeling Presentation
(A Few Thoughts)

A Few Thoughts about Models and Modeling

Bill Grant
Ecological Systems Laboratory
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas USA
Outline of Talk (Plan A)

- Confessions
- A Story
- A Joke
- Why do Complex Systems Surprise Us?
- How Complex Should a Model Be?

Confessions

- I am a teacher and a scientist

A Story

- The powers of 10

A Joke

- So, what is $2 + 2$?

Why Do Complex Systems Surprise Us? (Meadows, 2005)

- Linear minds in a non-linear world
- Non-existent boundaries (“side effects”)
- Layers of limits
- Ubiquitous delays
- Bounded rationality (“the invisible foot”)

How Complex Should a Model Be? (modified from Jørgensen and Bendoricchio, 2001)
The End?

S-shaped (logistic) curve describing the growth of a population that could be exploited.

Figure 15.1

Theta-logistic model of population growth

Correct Eqn. \( \frac{dN}{dt} = r N \left( 1 - \frac{N}{K} \right) \)

MSY and Density Dependent Birth and Death Rates

Scenario 1: Normal Freshwater Inflow Conditions

- Run the model according to the instructions for Scenario 1.
- Use the paper response sheet to fill in the Model Output Table and Model Feedback on this simulation.
Scenario 2: High Freshwater Inflow Conditions

- Run the model according to instructions for Scenario 2.
- Use the paper response sheet to fill in the Model Output Table and Model Feedback on this simulation.

Scenario 3: Low Freshwater Inflow Conditions

- Run the model according to the instructions for Scenario 3.
- Use the paper response sheet to fill in the Model Output Table and Model Feedback on this simulation.

Scenario 2: Results

Do the results generated from the simulations of high freshwater inflow conform to your initial expectations on the impacts of changes in freshwater inflows on the blue crab population?

1. Yes, the results generated conform to my initial expectations. (62%)
2. No, the results generated did not conform to my initial expectations. (23%)
3. The results generated only partially conform to my initial expectations. (15%)

Scenario 3: Results

Do the results generated from the simulations of low freshwater inflow conform to your initial expectations on the impacts of changes in freshwater inflows on the blue crab population?

1. Yes, the results generated conform to my initial expectations. (33%)
2. No, the results generated did not conform to my initial expectations. (0%)
3. The results only partially conform to my initial expectations. (0%)

Model Feedback

Based on your results from running these model simulations of normal, high, and low freshwater inflow, please rate how much confidence you have in the model:

1. No Confidence (0%)
2. Low Confidence (30%)
3. Moderate Confidence (60%)
4. High Confidence (90%)
5. Absolute Confidence (100%)

Scenario 4: Variable Inflows

- We live in a changing environment.

  Each year is different. There are periods of drought, sparse rainfall, hurricanes, upstream releases – and any combination of events affecting freshwater inflow.

  This is your opportunity to test how environmental changes influence the balance of this system.
Scenario 4: Variable Inflows

This model is a bit more complicated than the previous version. Scenario 4 is designed to guide you through a simulation that requires you to change the conditions in the estuary over time.

Read the instructions through before you begin.

It is complicated, but there are many parts to this system.

Scenario 4: Results

Do you think freshwater inflow (controlling the salinity levels) is an important component of the blue crab simulation model?

1. Yes, I think freshwater inflow is an important component of the blue crab simulation model.
2. No, I do not think freshwater inflow is an important component of the blue crab simulation model.
3. I am not sure if freshwater inflow is important.

Scenario 4: Results

Do you think that water temperature affects blue crab populations?

1. Yes, water temperature affects blue crab populations.
2. No, water temperature does not affect blue crab populations.
3. I am unsure if water temperature affects blue crab populations.

Scenario 4: Results

Based on your results from running these model simulations, please rate how much confidence you have in the model.

1. No Confidence (0%)
2. Low Confidence (30%)
3. Moderate Confidence (60%)
4. High Confidence (90%)
5. Absolute Confidence (100%)
Blue crab recruitment and life history research

Zack Darnell
Research Associate
Mission-Aransas NERR

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Research projects

• Blue crab recruitment dynamics in the Mission-Aransas estuary
  – Citizen-science megalopae monitoring project
  – Behavioral responses of megalopae to changes in salinity
  – Mesquite Bay juvenile study

• Determining critical life history parameters

Citizen-science megalopae settlement monitoring

• June, 2012: Project began with 3 sites

• April, 2013: Expanded to 5 sampling sites

• Sample processing is ongoing

Preliminary results

Blue crab recruitment dynamics in the Mission-Aransas estuary

• Approach:
  – Large-scale, citizen-science survey of daily megalopal settlement (proxy for abundance?)

  – Small-scale lab experiments assessing transport behavior as a function of salinity regime

  – Monthly surveys of juvenile abundance and distribution in Mesquite Bay
Settlement mechanisms and collector efficiency

Behavioral responses of megalopae to changes in salinity

Does transport mechanism still function under altered salinity gradients? Experiments are ongoing.

Juvenile abundance and distribution in Mesquite Bay

- Objectives:
  - Assess seasonal patterns in abundance
  - Determine timing and stage of arrival in distant areas of estuary
  - Collect baseline data to assess impact of re-opening of Cedar Bayou

- Study began Feb 2013

Mesquite Bay study design

Control (unimpacted) sites

Experimental (impacted) sites
Two sampling methods:
1. Suction sampling
2. Seining

Determining critical life history parameters

- Approach:
  - Experimentally examine environmental control of growth and maturity
  - Examine spatial population ecology using existing datasets

Environmental control of growth and maturity

- Objectives:
  - Accurately measure growth rates
  - Assess impact of salinity and temperature on growth

- Methods:
  - 2 temperatures (20, 30°C)
  - 3 salinities (20, 30, 40 ppt)
  - Monitor daily for molting

Preliminary results

- Carapace width (mm) vs. Time since metamorphosis (days)
- 20°C vs. 30°C
- Stages J1 to J6
Spatial population ecology using existing datasets

- Objectives:
  - Determine population-level shifts in habitat use in response to freshwater inflow/salinity
  - Assess impacts of altered freshwater inflows on spawning locations and connectivity

- Data sources:
  - TPWD fishery-independent surveys
  - GSMFC SEAMAP surveys

Questions?
Scenario 5: Your Simulation

- You now have the opportunity to run your own simulation design.
- Consider which changes you want to make (adjustable blue buttons) and how you want to manage the time periods BEFORE you begin.

Conclusions
Do you think freshwater inflow (controlling the salinity levels) is an important component of the blue crab simulation model?

1. Yes, I think freshwater inflow is an important component of the blue crab simulation model.
2. No, I do not think freshwater inflow is an important component of the blue crab simulation model.
3. I am not sure if freshwater inflow is important.

Conclusions
Do you think water temperature affects blue crab populations?

1. Yes, water temperature affects blue crab populations.
2. No, water temperature does not affect blue crab populations.
3. I am not sure if water temperature affects blue crab populations.

Conclusions
Do you think trapping affects blue crab populations?

1. Yes, trapping affects blue crab populations.
2. No, trapping does not affect blue crab populations.
3. I am not sure if trapping affects blue crab populations.

Conclusions
Based on your results from running these model simulations, please rate how much confidence you have in the model.

1. No Confidence (0%)
2. Low Confidence (30%)
3. Moderate Confidence (60%)
4. High Confidence (90%)
5. Absolute Confidence (100%)

A Few (¿Simple?) Questions

- How many crabs are there now?
- Is recruitment related to crab number?
- Is trapping success related to crab number?
Land Use and Climate Change Scenarios:
Modeling changes in water use and runoff

Dr. Kiersten Madden
Stewardship Coordinator
Mission-Aransas National Estuarine Research Reserve

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Study Area

Land Use/Land Cover
Waterways
Developed: Open Space
Developed: Low Intensity
Developed: Medium Intensity
Developed: High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Grassland/Herbaceous
Hay/Pasture
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands

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Scenario Development

Round 1

Round 2

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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 Texas Estuarine Ecosystem.

OBJECTIVE 2
Assess impacts to the Texas Estuarine Ecosystem 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.

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Scenario Development

Timeframe: 2020, 2060
Emissions: A2 (High), B1 (Low)
Approach: Annual, Seasonal

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What time horizon(s) would you like included in the land use and climate change modeling?
1. 2020 (32%)
2. 2040 (28%)
3. 2060 (25%)
4. 2080 (4%)
5. 2100 (11%)

Which of the following approaches would you prefer to see used for the land use and climate modeling?
1. Monthly (3%)
2. Seasonal (9%)
3. Annual (6%)
4. Monthly & Seasonal (11%)
5. Monthly & Annual (9%)
6. Seasonal & Annual (34%)
7. Monthly, Seasonal, & Annual (29%)

Which climate change scenarios would you prefer to see used for the climate change and land use modeling?
1. A2 (High) (6%)
2. A1B (Medium) (18%) *
3. B1 (Low) (3%)
4. A2 & B1 (High & Low) (21%)
5. All three (54%)

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What time horizon(s) would you like included in the land use and climate change modeling?
1. 2020 (32%)
2. 2040 (23%) *
3. 2060 (34%)
4. 2080 (6%)
5. 2100 (5%)

Which of the following approaches would you prefer to see used for the land use and climate modeling?
1. Monthly (3%)
2. Seasonal (9%)
3. Annual (0%)
4. Monthly & Seasonal (16%)
5. Monthly & Annual (3%)
6. Seasonal & Annual (50%)
7. Monthly, Seasonal, & Annual (19%)

Which climate change scenarios would you prefer to see used for the climate change and land use modeling?
1. A2 (High) (6%)
2. A1B (Medium) (18%) *
3. B1 (Low) (3%)
4. A2 & B1 (High & Low) (21%)
5. All three (54%)

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Area = 5 acres
Density = 1 DU/acre
Numeric DUs = 5

Physical shape restricts development.
Spatial DUs = 4

A simpler approach . . .

Number of dwelling units = Size of Parcel (acres) / Size of the dwelling unit (acres/unit)

Population = Number of Dwelling Units * Average Household Size Assumption

Residential Water Use = Population (people) * Water Use Assumption (gal/person/day)

Verifying and refining assumptions . . .

Size of dwelling unit:
- Rural: > 40 acres/unit → > 80 acres/unit
- Exurban: 2 – 40 acres/unit → > 25 acres/unit
- Suburban: 0.25 – 2 acres/unit → > 1 acre/unit
- Urban: < 0.25 acre/unit → > 0.25 acre/unit

Average Household Size = 2.68
**Indicator: Land Use**

![Graph showing land use data](image)

**Indicator: Land Cover**

![Graph showing land cover data](image)

**Indicator: Irrigation Water Use**

\[
\text{Irrigation Water Use} = \text{Acres of Cropland} \times \text{Water Use Assumption (inches/acre/year)} \times \% \text{ of Acres Irrigated Assumption}
\]

Source: “Status and Trends of Irrigated Agriculture in Texas” (TWRI, 2012)

**Indicator: Irrigation**

![Graph showing irrigation data](image)

**Next Steps**

- Continue to . . .
  - Refine data inputs and assumptions for residential water use estimates (e.g., average household size, dwelling unit size)
  - Refine/modify existing indicators (e.g., add assumption about surface water vs. ground water usage)
  - Develop new indicators (e.g., commercial/industrial water use; ranching water use)
  - Verify results
- Begin modeling runoff
Questions

This project is funded by the National Estuarine Research Reserve System Science Collaborative, a partnership of the National Oceanic and Atmospheric Administration and the University of New Hampshire.

Data Gathering

Nonpoint-Source Pollution and Erosion Comparison Tool

Land Cover
Elevation
Precipitation
Hydrologic Soils Group
Soil Erodibility
Rainfall Erosivity

Data Gathering

Elevation (USGS: NED)
Precipitation (PRISM / Climate Wizard)
Soils (NRCS: SSURGO)
LULC (USGS: NLCD / EPA: ICLUS)

Stakeholder Feedback

Announcements and Updates

Want to provide regional project ideas for RESTORE funding? Submit project ideas to SharonL@ctexas.com no later than May 17, 2013.

Texas Bays and Estuaries Meeting
April 25-26, 2013 at UTMSI
To register visit http://www.utmsi.utexas.edu/tbem2013/TBEM_files/Page4_04.htm

RESTORE public meeting
July 16th at UTMSI
Hosted by Sea Grant, Environmental Law Institute, TCEQ, GLO, UTMSI, NERR

Objective 1
Examine the effects of land use and climate change on freshwater inflows to the Guadalupe-San Antonio and Mission-Aransas.

Central Region 2050

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Workshop Evaluation

Time to grab your clickers!

Has your knowledge or understanding of freshwater inflows increased as a result?

1. Yes
2. No
3. Unsure
4. Not Applicable

Do you intend to apply this knowledge in your work?

1. Yes
2. No
3. Unsure
4. Not Applicable

Did your ability to access resources (e.g., people and information) relevant to your work increase as a result of this workshop?

1. Yes
2. No
3. Unsure
4. Not Applicable

Do you think you will apply new perspectives in your work and/or decision-making as a result of this workshop?

1. Yes
2. No
3. Unsure
4. Not Applicable

Do you intend to contact others about the information you learned as a result of this workshop?

1. Yes
2. No
3. Unsure
4. Not Applicable
I am satisfied with the knowledge level and communication of the presenters.

1. Strongly disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree

I am satisfied with the content of the workshop (e.g. materials, value of information presented).

1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree

I am satisfied with the format of the workshop.

1. Strongly disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree

I am satisfied with the networking opportunities provided.

1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree

Do you feel you need additional training related to freshwater inflows?

1. Yes
2. No
3. Unsure
4. Not Applicable

Questions, comments, or suggestions

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