Fish Passage into North Carolina's Largest Natural Lake: Mattamuskeet

Lake Mattamuskeet Informational Meeting
Mattamuskeet National Wildlife Refuge
November 18, 2013

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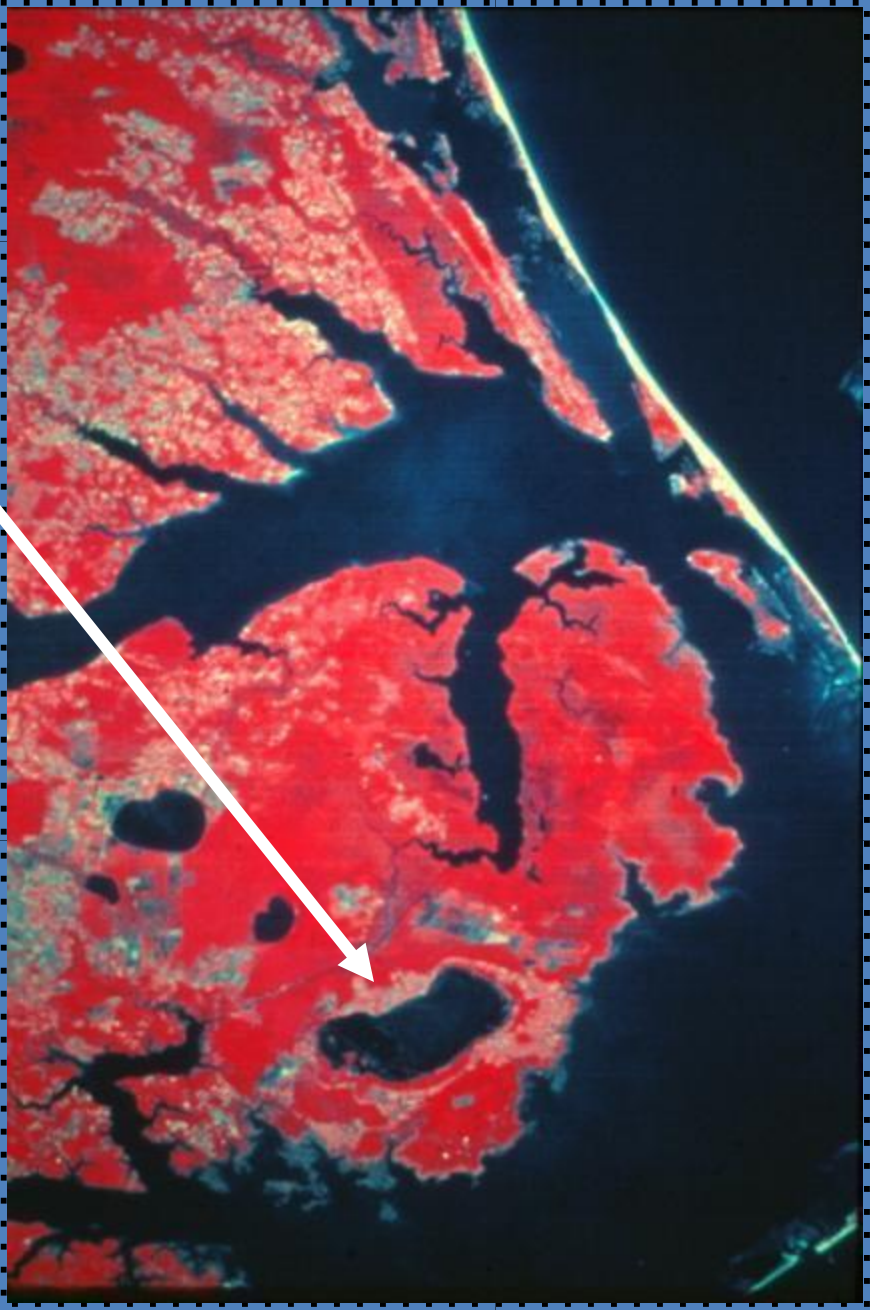
ECU Students Working on this Problem

- Wall, Brian. Biology, ECU, 2003 (MS). Research Title: "Fish passage through water control structures at Mattamuskeet National Wildlife Refuge, North Carolina".
- Egbert, Mary Elizabeth, Biology, ECU, 2003 (MS). Research Title: "Basic life history characteristics of the Atlantic needlefish, *Strongylura marina*, in Lake Mattamuskeet, North Carolina".
- Godwin, Charlton, Biology, ECU, 2004 (MS). Research Title: "Performance assessment of retrofitted water control structures at Mattamuskeet National Wildlife Refuge, North Carolina".
- Cudney, Jennifer, Biology, ECU, 2004 (MS). Research Title: "Population demographics and critical habitat of American eel (*Anguilla rostrata*) in Northwestern Pamlico Sound, North Carolina".
- Alderman, Heidi, Biology, ECU, 2006 (MS). Research Title: "Osprey, *Pandion haliaetus*, as a model of mercury accumulation in top predators of aquatic ecosystems in eastern North Carolina".

Mattamuskeet is the largest natural lake in North Carolina:

- 40,000 acres
- Averages 2.5 feet deep
- Connected to Pamlico Sound by canals
- Freshwater <u>but</u> has many marine species of fish and shellfish
- Important for threatened species alewife and American eel
- The <u>premier</u> overwintering site for pintails, tundra swan, snow goose, and Canada goose



Mattamuskeet and Swan Quarter National Wildlife Refuges

A variety of available habitats at Mattamuskeet NWR:

Open water

Soundside canals

Lakebed canals

Water Control Structures

Water control structure with Mattamuskeet "pumping station"

Fishing for river herring in the 1970s. (Top-hinged flapgate in WCS).

Various Water Control Configurations

Original top-hinged wooden flapgate

Leaked terribly, increased salinity in lake (but best fishing in history)

Wooden stop block with V-shaped surface fish passage slot and stainless steel flapgate near bottom

Beginning of the end – water velocities too fast for fish to swim into lake

WCS Stop Block with Steel One-way Flapgate Mounted at the Bottom

Alewife runs occur in early spring, nearly extirpated with this design.

American eel, which once supported a commercial fishery in the Lake, was nearly wiped out.

Various Water Control Configurations

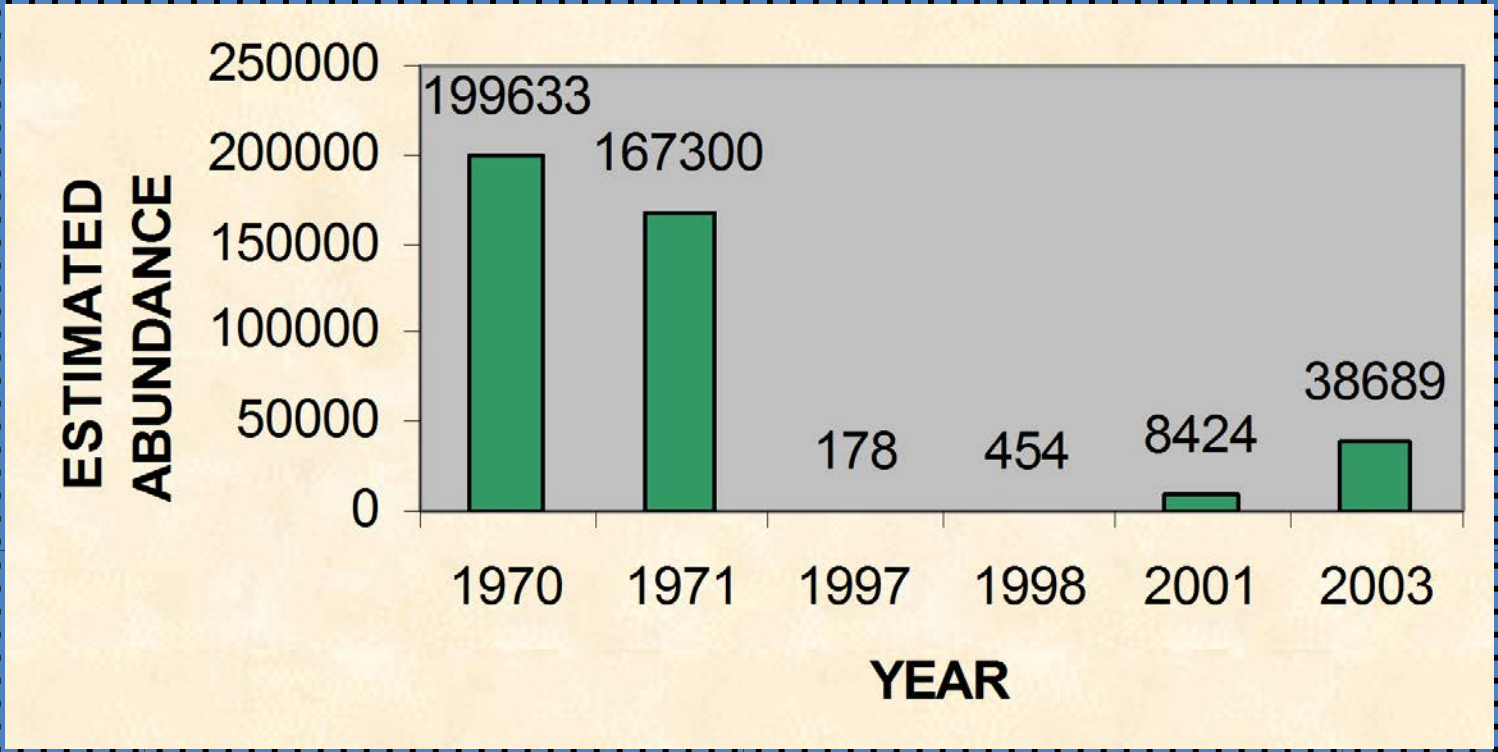
Beginning of alewife resurgence – spawning runs increase (Godwin)

FWS went with aluminum flapgates because of increased buoyancy and minimal maintenance

"Retrofit" wooden top-hinged flapgate – Recommended by Wall; tested by Godwin

Hollow aluminum top-hinged flapgate currently in place

Alewife Population Status in Lake Mattamuskeet



1970-71 – Research by Harold Tyus (NCSU)

1997-2003 – Research by Rulifson Lab (ECU): Brian Wall, and Charlton Godwin

New Design Concept: Swings Open like a Door

Wood block covers crank to manually open gate (or it will open with water pressure)

Open automatically with water pressure toward Pamlico Sound

But “Drains the Lake”

- Public is unhappy about the new gates, and “operation” of the lake.
- Status of alewife spawning run and eel are unknown since 2003.

The NC Wildlife Resources Commission conducts periodic fish surveys in the Lake.

Effects of state-wide drought on the Lake bed, 2002-03.

Alewife use West Side of Lake as a Nursery Ground

How do Open Flapgates Influence Fish Passage and Lake Salinity?

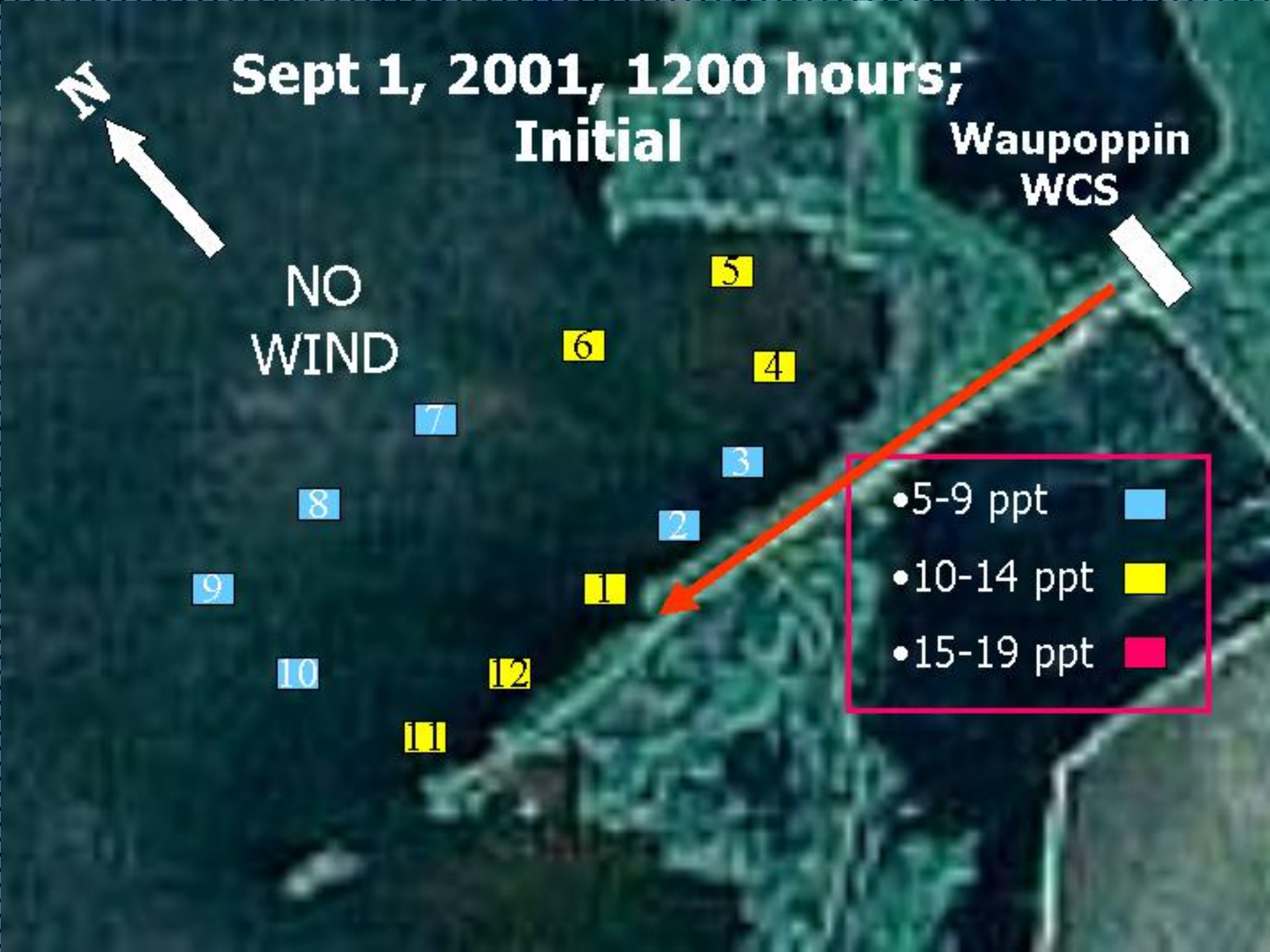
- Original and "retrofit" flapgates only open toward the Sound.
- When Lake water levels are high, flapgates open to let water out through the canals to Pamlico Sound.
- When canal waters are higher than Lake, flapgates close blocking fish access.

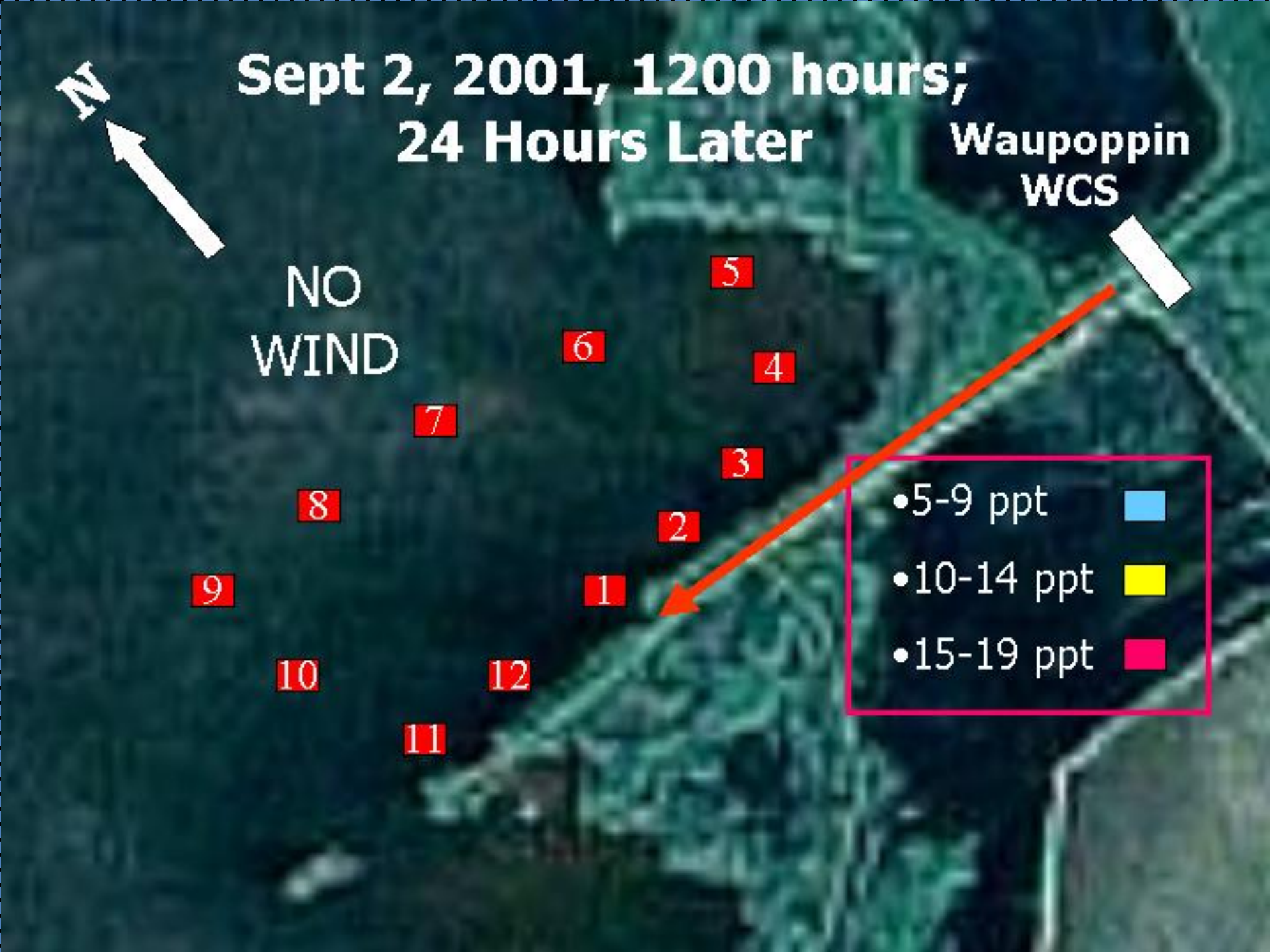
- Two experiments were conducted in 2001 to determine changes in Lake salinity resulting from forcing open flapgates in Waupoppin Canal.
- This will allow fish to restock the Lake but may increase salinity.

Flapgates Forced Open, and Resultant Salinity Changes

- Experiment 1:
  - 12 stations on East side of Lake next to Waupoppin WCS.
  - Salinity monitored at beginning and end of experiment 24 hours later.

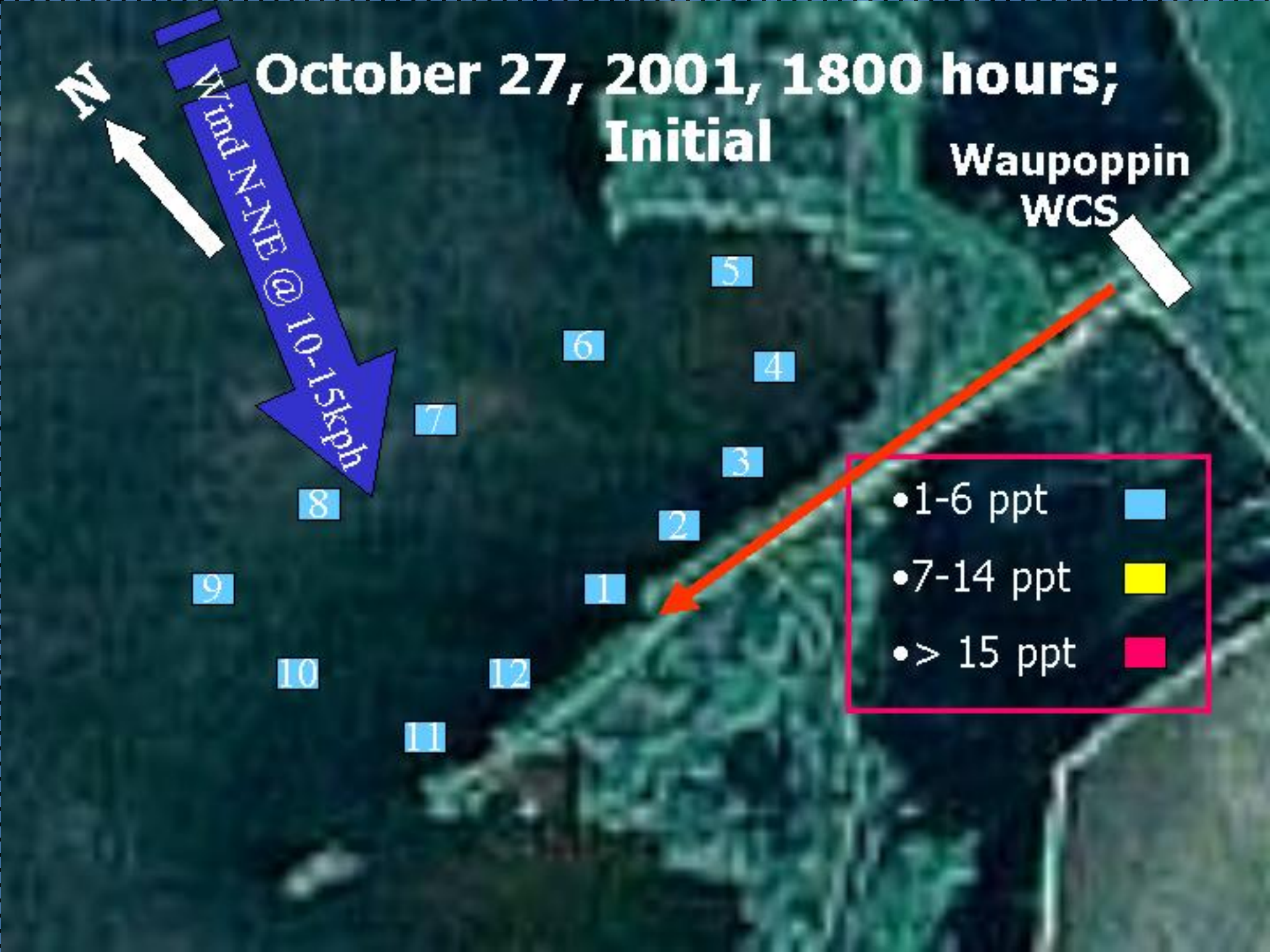
- Results – see next 2 slides:
  - No wind present.
  - Initial salinity readings were between 5 and 14 ppt (ocean water is 35 ppt).
  - After 24 hours, salinities of 15-19 ppt were at all 12 sites in East side of Lake close to the WCS.
  - Water continued to flow into the Lake through the entire experiment.

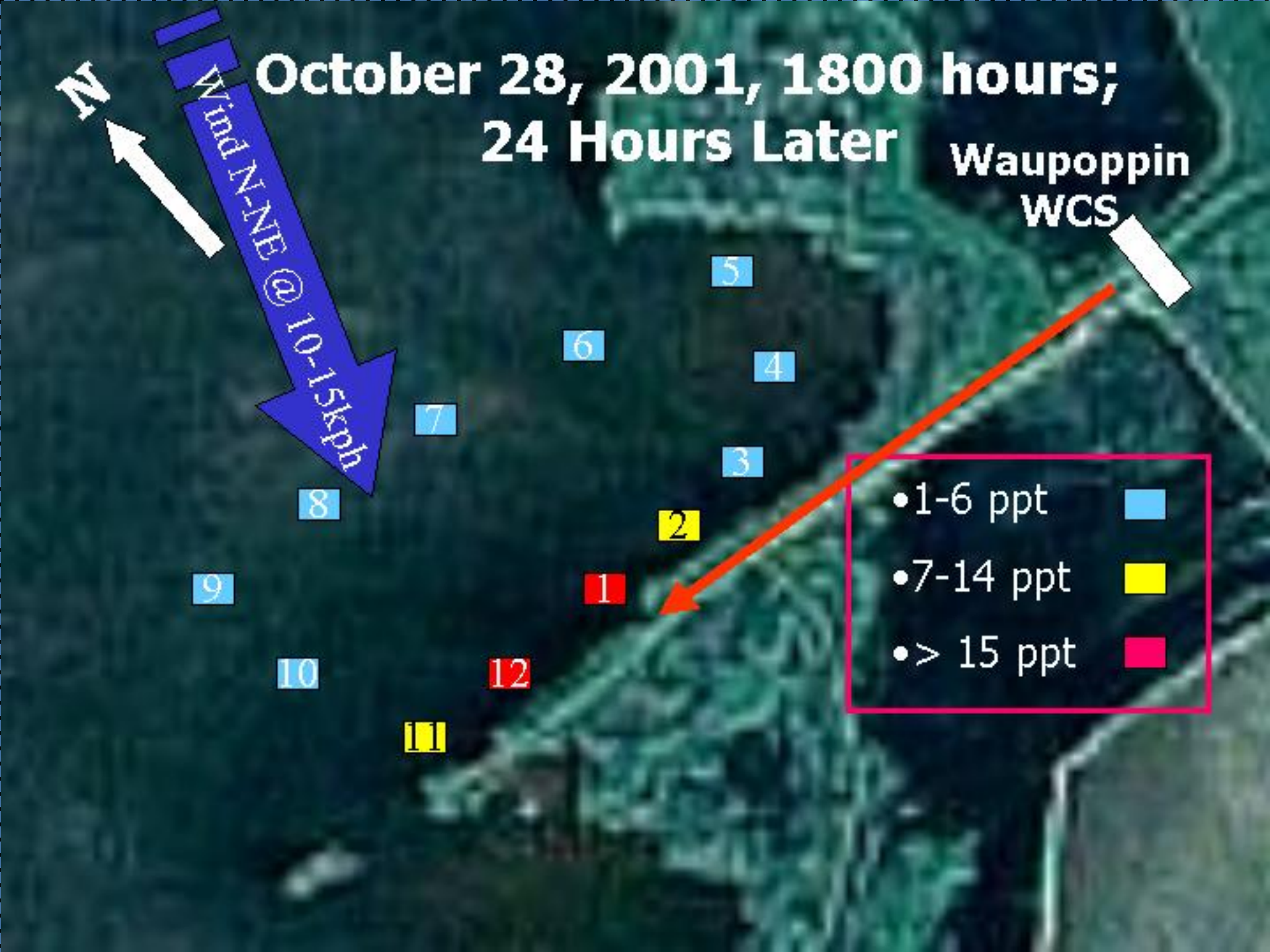

Sept 1, 2001, 1200 hours;
Initial
N
Waupoppin
WCS
NO
WIND
5
6
4
7
3
8
2
9
1
10
12
11
•5-9 ppt
•10-14 ppt
•15-19 ppt


Sept 2, 2001, 1200 hours;
24 Hours Later
N
Waupoppin
WCS
NO
WIND
5
6
4
7
3
8
2
9
1
10
12
11
•5-9 ppt
•10-14 ppt
•15-19 ppt

Flapgates Forced Open, and Resultant Salinity Changes (continued)

- Experiment 2:
  - 12 sites close to Waupoppin WCS were monitored for salinity changes.
  - Winds were N-NE 10-15 kilometers per hour.
  - Experiment lasted 48 hours (October 27-29, 2001).
- Results (see next 3 slides):
  - Initial salinity readings were 1-6 ppt.
  - Only sites closest to the WCS had increased salinities 24 hours after forcing flapgates open.
  - Even after 48 hours, salinities increased only at those sites closest to the WCS with winds from N-NE (water continued to flow into the lake during the entire experiment).


October 27, 2001, 1800 hours;
Initial
N
Wind N-NE @ 10-15kph
Waupoppin
WCS
5
6
4
7
3
8
2
9
1
10
12
11
•1-6 ppt
•7-14 ppt
•> 15 ppt


October 28, 2001, 1800 hours;
24 Hours Later
N
Wind N-NE @ 10-15kph
Waupoppin
WCS
5
6
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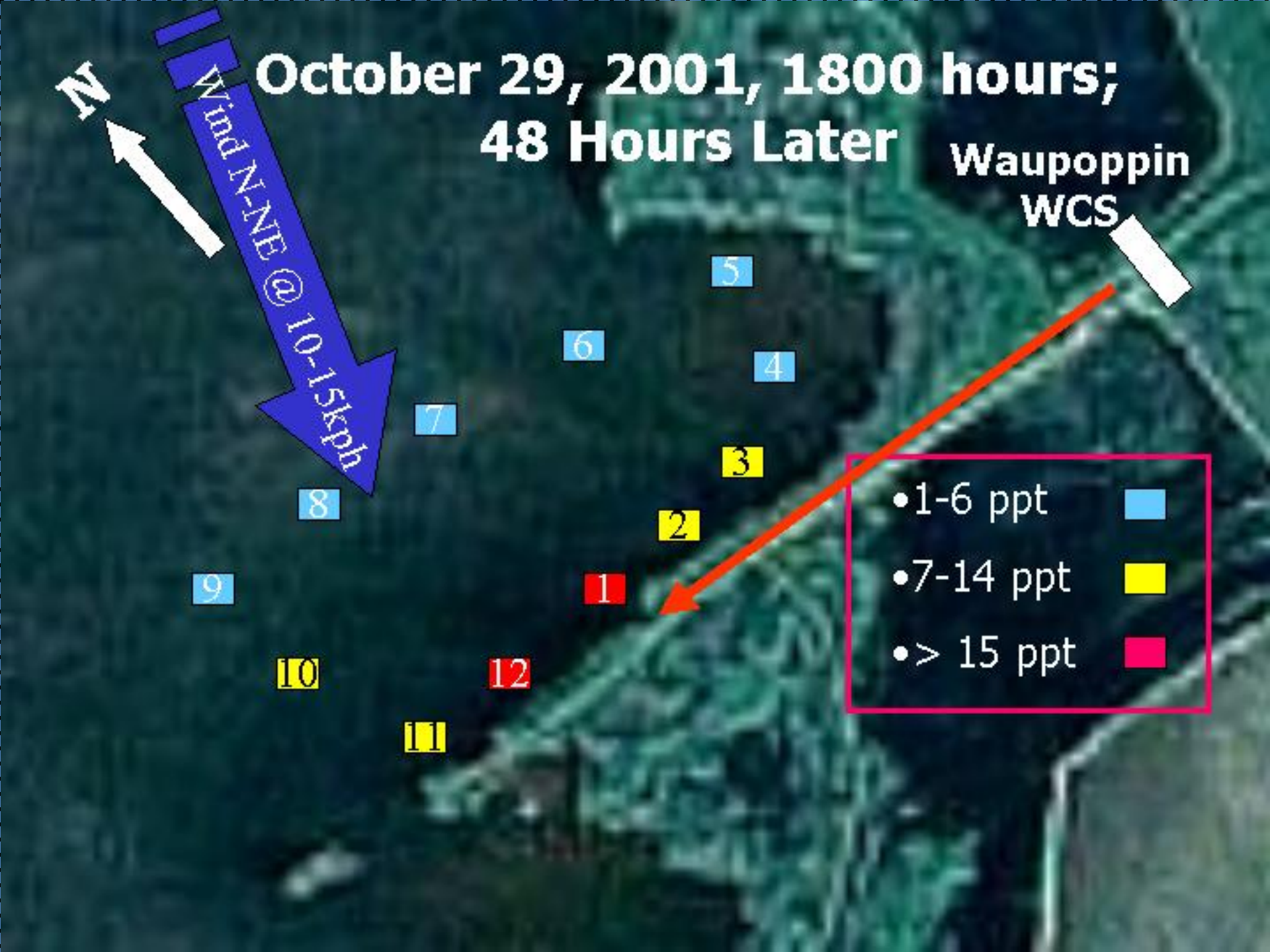
7
3
8
2
9
1
10
12
11
•1-6 ppt
•7-14 ppt
•> 15 ppt


October 29, 2001, 1800 hours;
48 Hours Later
N
Wind N-NE @ 10-15kph
Waupoppin
WCS
5
6
4
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11
•1-6 ppt
•7-14 ppt
•> 15 ppt

Habitat Parameters Measured During Eel Assessment, 2002-03

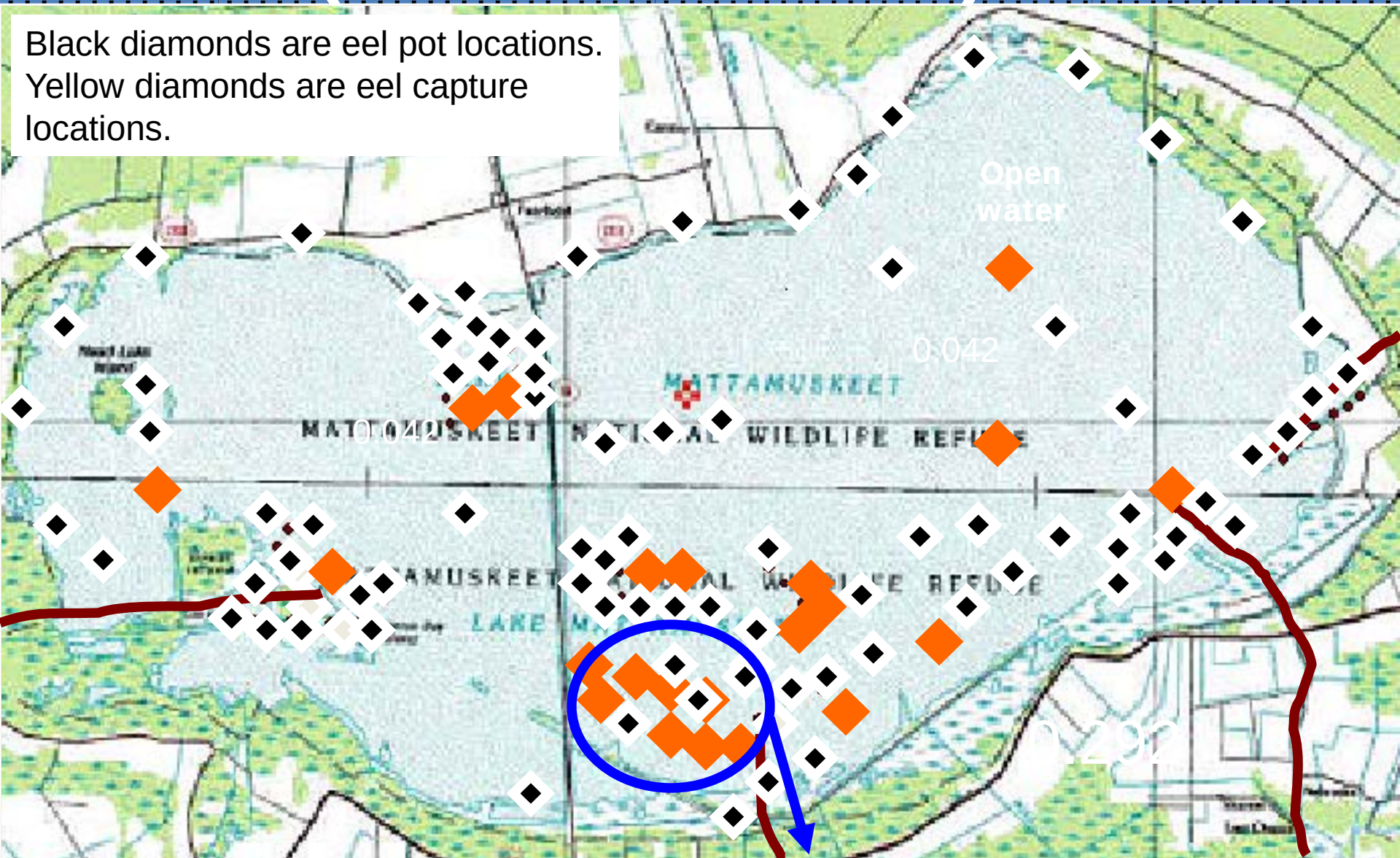
- Water Temperature (°C)
- Air Temperature (°C)
- Wind direction
- Water condition
- pH
- Salinity (ppt)
- Conductivity (umhos)
- Dissolved Oxygen (mg/L)
- Oxygen saturation (%)
- Depth (cm)
- Soft Sediment (cm)
- Secchi (cm)
- Dominant SAV species
- SAV percent cover
- Organic content (%)
- Dominant sediment type
- Percent sand/silt/clay
- Nutrient concentration (NH_4, PO_4, NO_2+NO_3)
- Chlorophyll a concentration
- Quadrant
- Distance to shore/barrier/sound
- Shoreline cover (%)
- Shore vs. open water

Nutrients vs Eel Abundance in Canals

Parameter	Wald	p
Parameter Estimates: Surface		
Ammonia	1.017	0.313
Phosphate	1.380	0.240
Nitrate/Nitrite	0.138	0.711
Chlorophyll a	1.213	0.271
Phaeophytin	0.557	0.456
Parameter Estimates: Bottom		
Ammonia	4.501	0.034
Phosphate	0.366	0.545
Nitrate/Nitrite	1.625	0.202
Chlorophyll a	1.023	0.312
Phaeophytin	0.432	0.511

Presence/Absence of Eels (Summer 2002-03)

Black diamonds are eel pot locations. Yellow diamonds are eel capture locations.



Eel Habitat Strongly Influenced by These Environmental Variables in 2002-03

Canal Habitats

- Oxygen stratification (no oxygen on bottom)
- Salinity
- Temperature (too warm at surface)
- Dissolved oxygen (generally poor)
- Turbidity (black waters and poor water clarity helped heat up waters).

Lake Habitats

- Depth (deeper waters had more eels)
- Percent Organic Matter (sandy areas did not have eels)

Flow characteristics of the Lake and Canals are critically important to maintaining the fish community and ecosystem of the Lake and watershed. It flushes agricultural runoff and poor water quality from the system.

Acknowledgements

- Don Temple, Jerry Fringelli, and Refuge staff.
- Tommy Midgett, Claudia Cahoon, and other Hyde County residents.
- Funding sources:
  - USFWS, Ecological Services, Raleigh
  - NC State Legislature, Fishery Grant Program administered by NC Sea Grant.
- East Carolina University, Institute for Coastal Science and Policy, and Department of Biology