

The Natural History of American Eel on Cape Cod



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Waquoit Bay NERR, Falmouth, April 17, 2018



Bob Michelson

Diadromous Fish in Massachusetts

- American eel
- rainbow smelt
- alewife
- blueback herring
- American shad
- white perch
- sea lamprey
- Atlantic tomcod
- sea-run brook trout
- striped bass



Unique Biology

- Catadromous (born at sea)
- Panmictic (no homing)
- Semelparous (spawn and die)
- High age of maturity (8-15 years old)
- High fecundity (3-10 million eggs)
- Geographic range (Greenland to Brazil)

Highly Successful Fish

Amphibious?



Environmental Sex Determination

- Sexual determination occurs at about 8 - 10 in.
- Thought to be density - dependent
- Watershed characteristics drive sex ratio

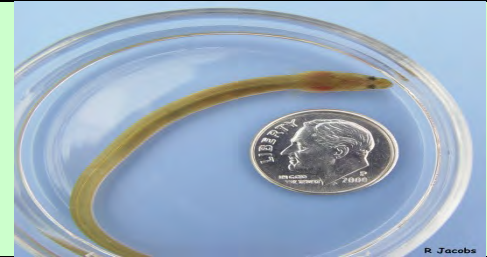


American Eel Life Stage Definitions

Glass eel: An unpigmented (transparent) or partially pigmented miniature American eel less than 4 inches.



Elver: A wholly pigmented American eel 4-8 inches with a rounded body, possessing all of the characteristics of a yellow eel.



Yellow Eel: An immature American eel larger than 8 inches with a dark to green back and a yellowish belly.



Silver Eel: A sexually mature eel migrating to the ocean during the fall, > than 16 inches long and is often characterized by dark coloration on the back, white on the bottom, bronze or silver on the sides, enlarged eyes.



Yellow Eels

- Present in most drainages
- Top fish biomass in freshwater rivers
- Yellow eels are targeted in fisheries for food and bait



Silver eel

Fisheries - common in Canada
but none presently in MA

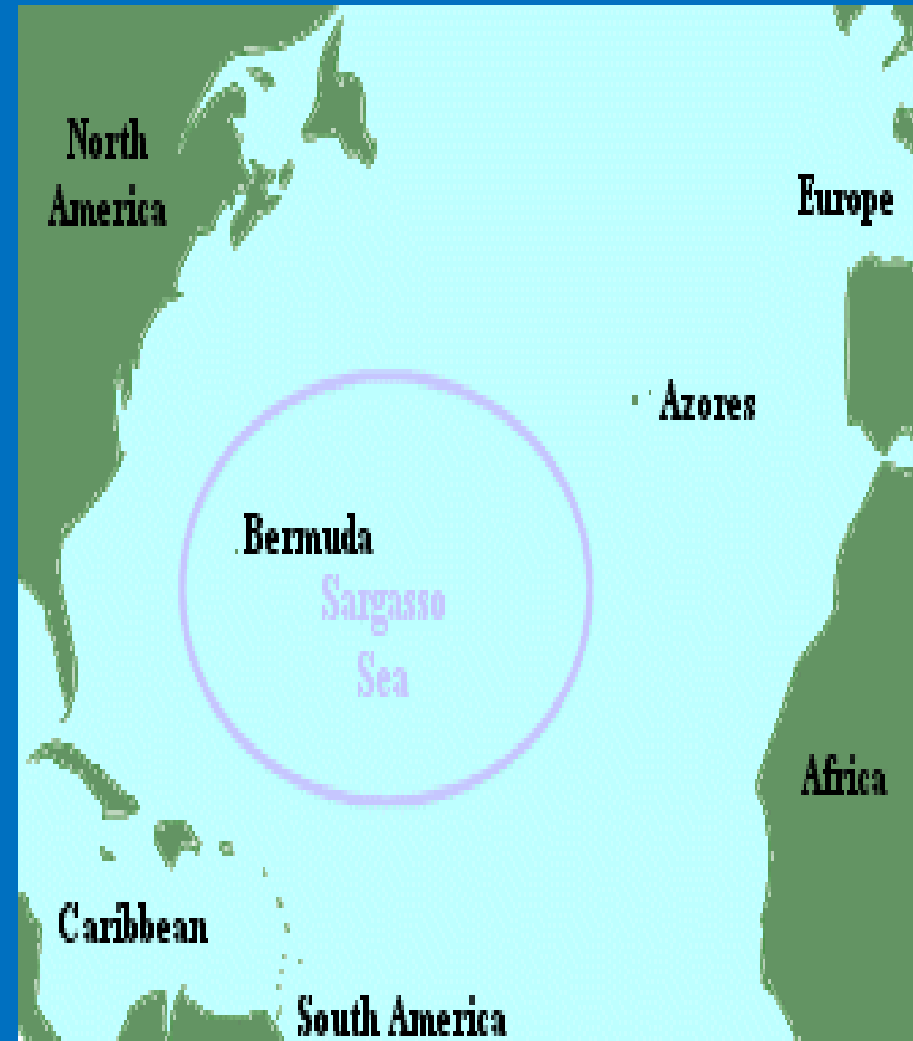
Stealthy Migration - rarely seen
as the migrate to the ocean in
the fall

Environmental Triggers -
moon phase, declining water
temperature and storm events
prompt exodus from coastal
rivers



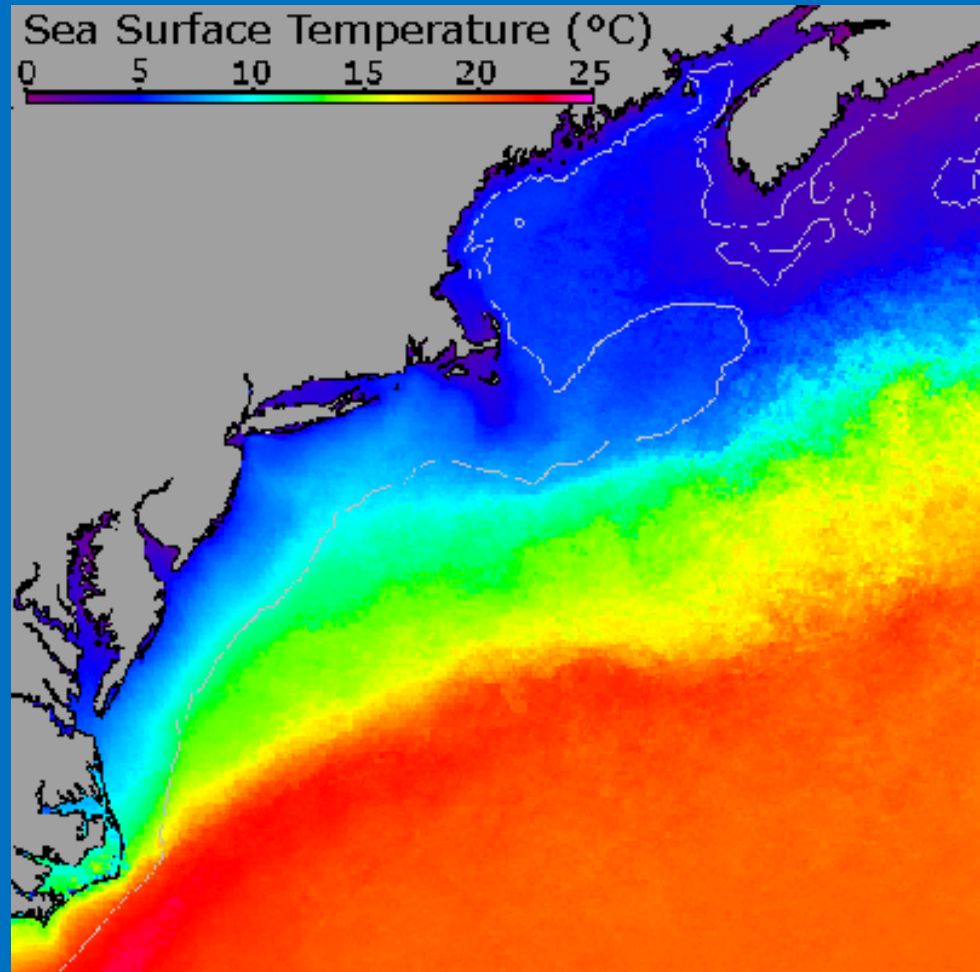
Reproductive Biology

- Sexually dimorphic: males <16", females >18"
- Spawn February through April in Sargasso Sea.
- Random mating assumed for all American eel



Young-of-Year American Eel

- *Adult* eel spawn in the Sargasso Sea during February to April
- Leptocephalii transform to glass eel between 8-12 months of age while on the continental shelf
- YOY eels take about 8-16 months to reach the continent



Return Migration

- Leptocephalii move westward with course broadly set by earth's magnetic field
- Transport is assisted by ocean currents
- Destinations are expressed as random dispersal with no link to parental region



Panmixia Paradox

- No evidence of spatial or temporal genetic differences across a large range
- Yet, clear differences in phenotypes among regions
- Are variations driven by environmental plasticity?
- with presently unknown genetic variation?



Historical Eel Fisheries

- Important subsistence fisheries for native Americans and colonial MA
- First MA eel fishery law: 1797 in the Town of Orleans to sustain the local fishery
- 9 of the first 10 eel fishery laws in MA from 1797 to the 1800s set at Cape Cod towns



Goode (1884) The Fisheries of Massachusetts – 1879 references

- Reported commercial catch of nearly 400,000 lbs in MA
- Bass River – Yarmouth.
20 Fishermen sold about 20,000 lbs from the river
- Waquoit Bay / East Falmouth.
Eel fishery gave winter employment to 100 men with 300 barrels shipped to NY



Commercial Eel Harvest, 1880-2010

ASMFC Stock Assessment- 2012

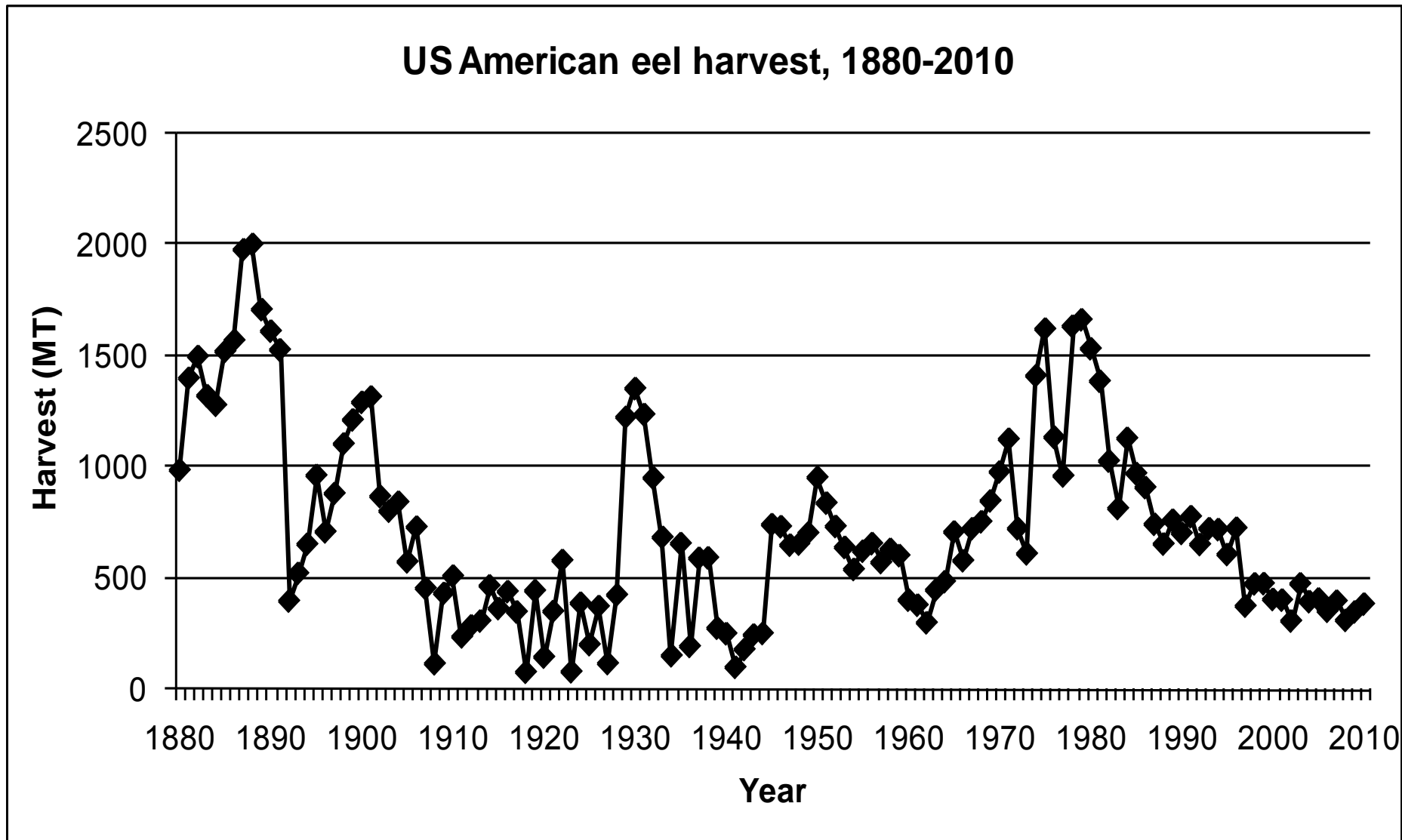
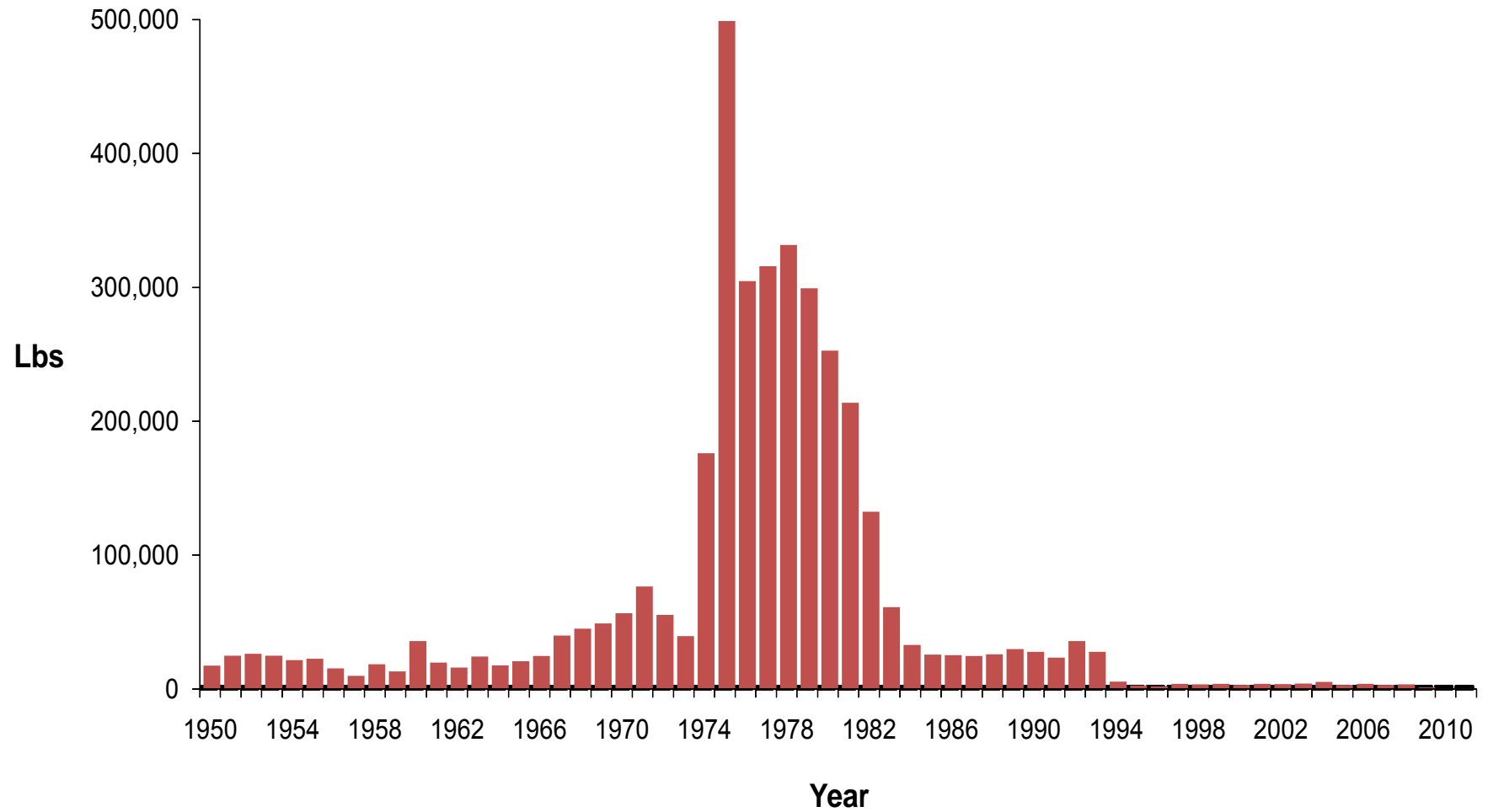


Figure 1. Massachusetts commercial American eel landings reported for 1950 to 2011.



Present Eel Populations

- Eels are still found in most drainages
- Massachusetts commercial landings have declined presently to lowest levels on record
- Sharp declines in Canadian and US fisheries following peaks of about 4 million pounds in late 1970s. Growing continent-wide concerns over population status

American Eel Management

- Long history of Town and State management
- Recent interstate management required by Federal statutes
- Endangered Species Act



Endangered Species Act

- Endangered Species Act: defines an **endangered** species as any species in danger of extinction throughout all or a significant portion of its range
- USFWS reviewed ESA petitions in 2007 and again in 2015: listing not warranted



Aquatic Biodiversity Monitoring Network

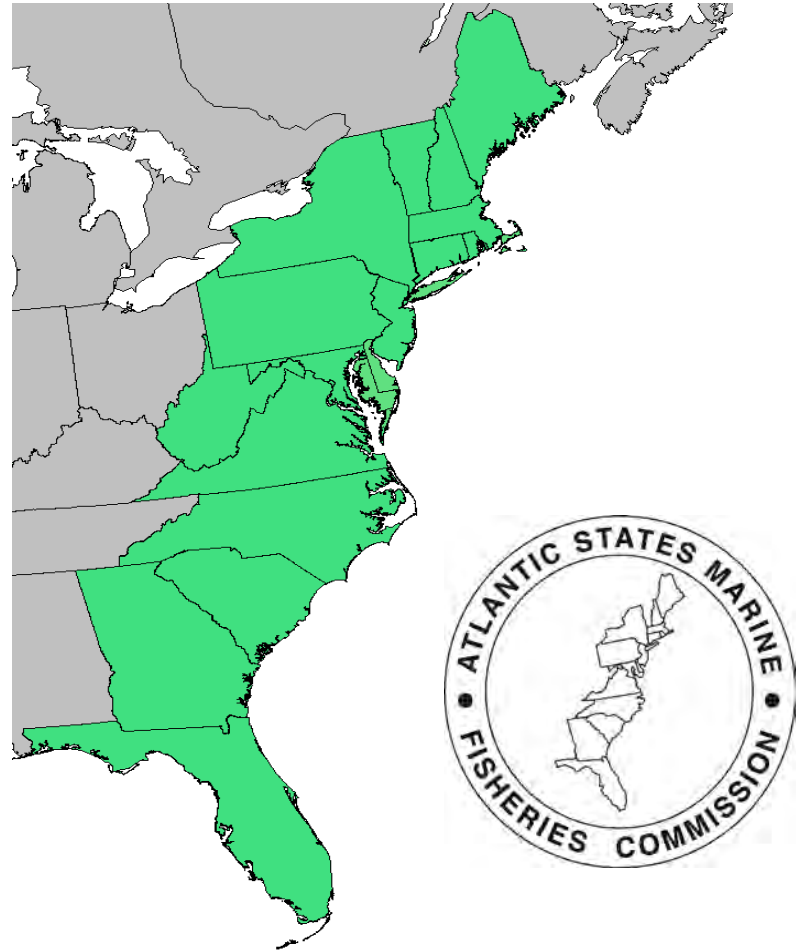
MA Eel Management

MGL Chapter 130, Sections 52 and 100D

- Commercial Harvest: 9 inch min. size, permit with reporting, marked pot buoys
- Recreational Harvest: 9 inch min. size and catch limit of 25 eels per day
- Net Closure: no nets or traps in coastal rivers from February 15th to June 15th with openings < 1/8 inch
- Allows Town control for managing eels
- DFW also has management authorities in freshwater

Atlantic States Marine Fisheries Commission

- Coast-wide American eel Management plan: 2000
- Benchmark stock assessment in 2012 and update in 2017
- Amendments to Mgt. Plan: 2013 - 2014

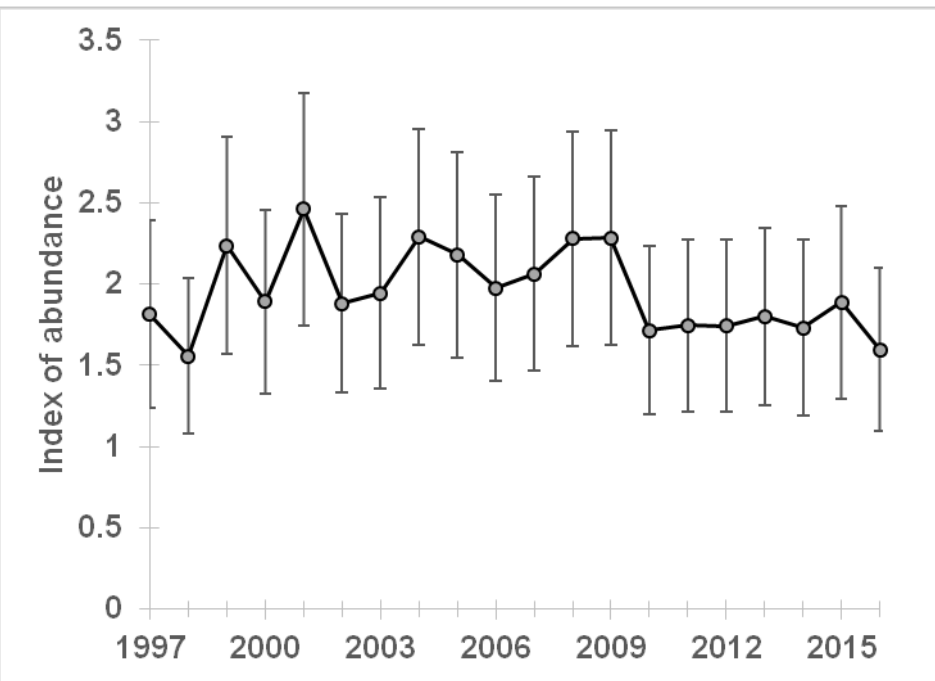


Eel Stock Status - 2012

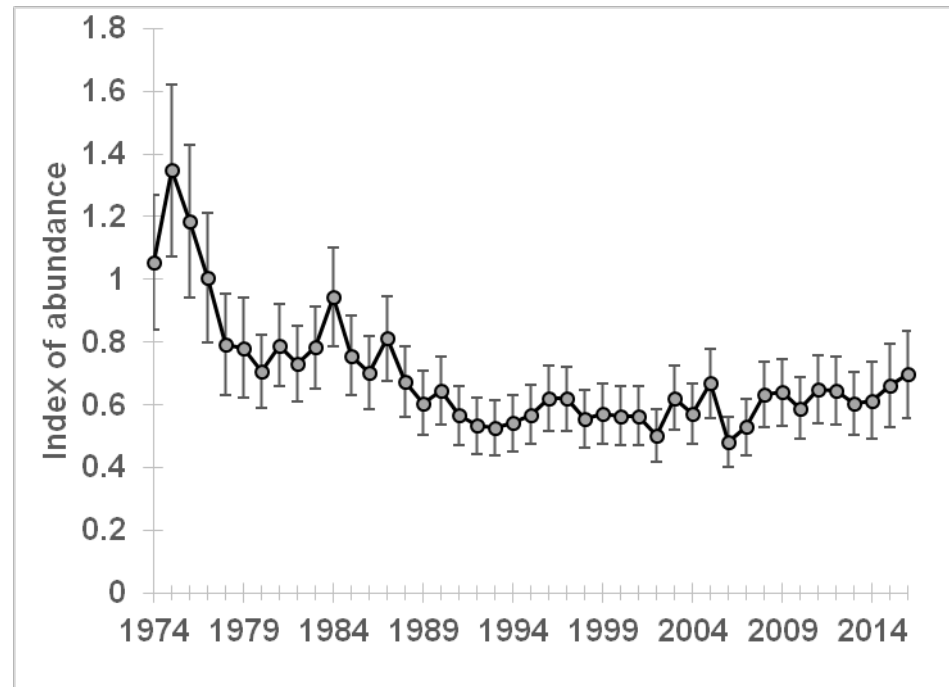
- Stock declared “depleted”
- Multiple sources of mortality have contributed to reduced biomass including, but not limited to
 - Substantial harvest in the 1970s
 - Loss of habitat
 - Passage mortality
 - Disease and parasites
 - Potentially shifting oceanographic conditions
- Reduction in mortality is needed
- Same finding with 2017 assessment update

ASMFC Yellow Eel standardized index of abundance for the Atlantic Coast

20-Year Index



40-Year Index



ASMFC Addendum IV

Eel Fishery Management Plan - 2014

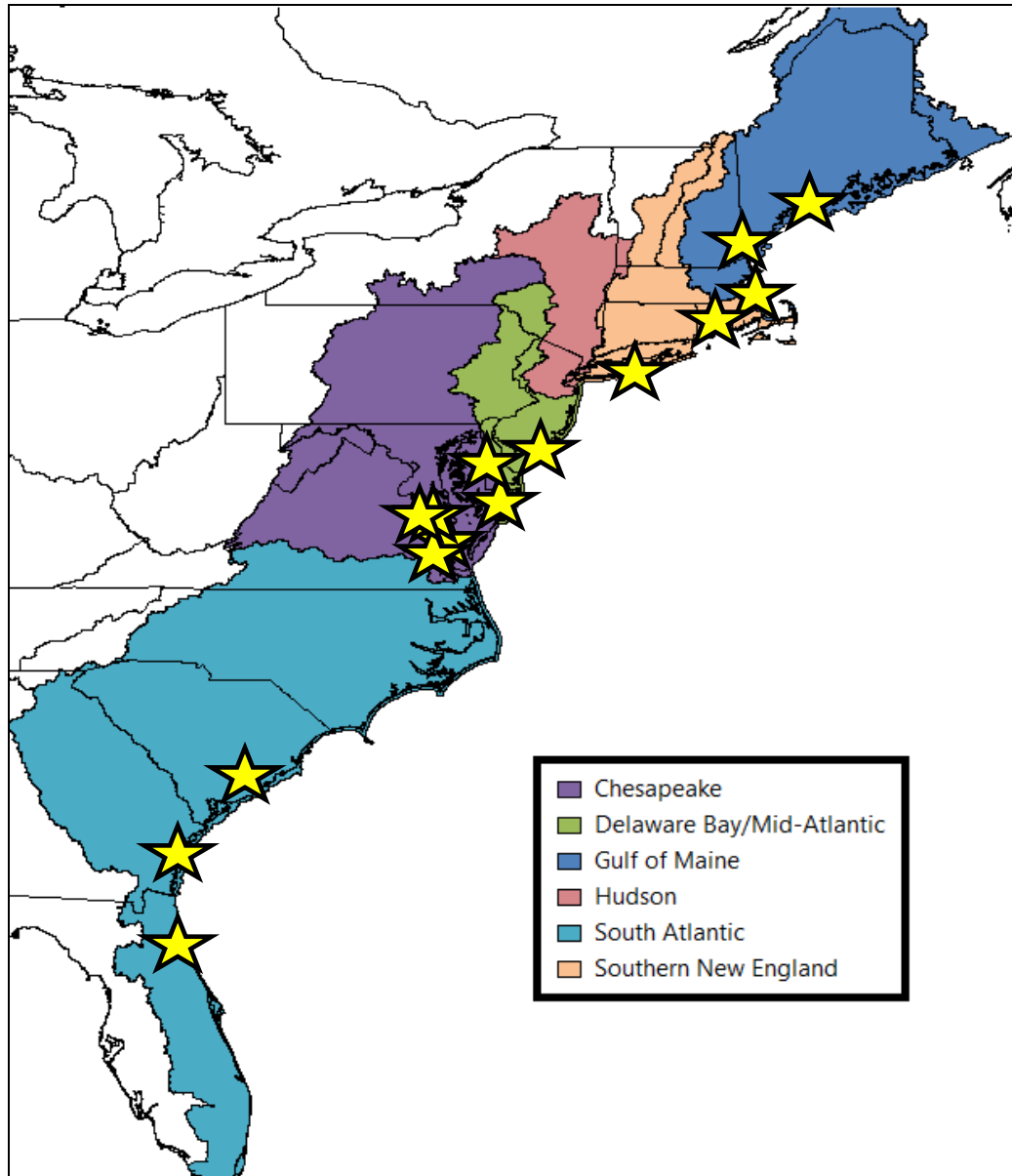
Yellow Eel Fishery - set a commercial catch cap for East Coast harvest based on recent time periods

Glass Eel Fishery - set a glass eel quota for Maine and SC

- allowed development of new glass eel fisheries
- allowed harvest for research and aquaculture

Conservation Goal..... Start quota based management

ASMFC YOY surveys



Jones River Glass Eel Index



Figure 3. American eel YOY Sheldon trap catch in the Jones River, Kingston, MA, 2001-2016. Geometric mean catch per haul are shown for April and May hauls with 95% CI and linear series trendline added.

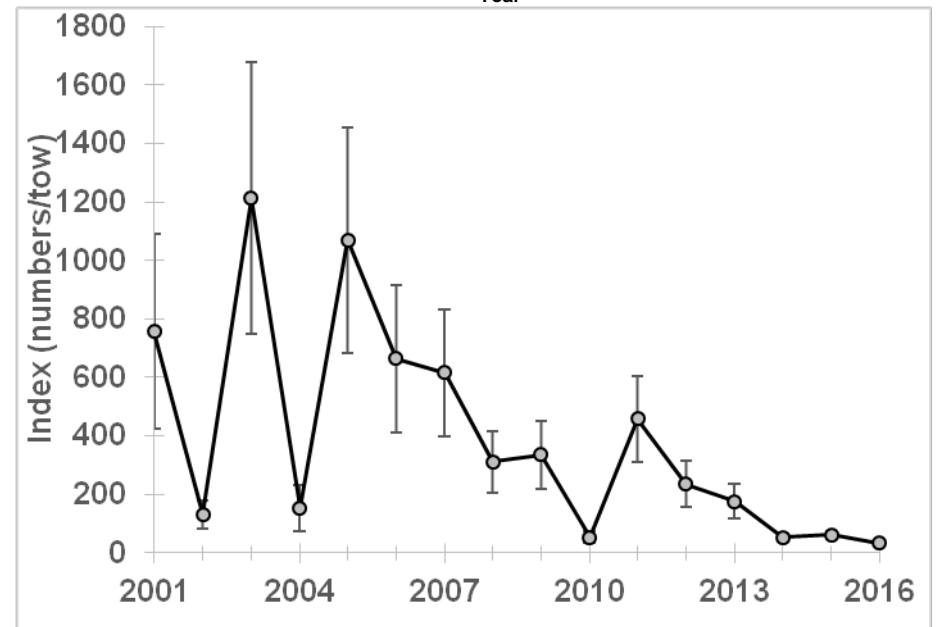
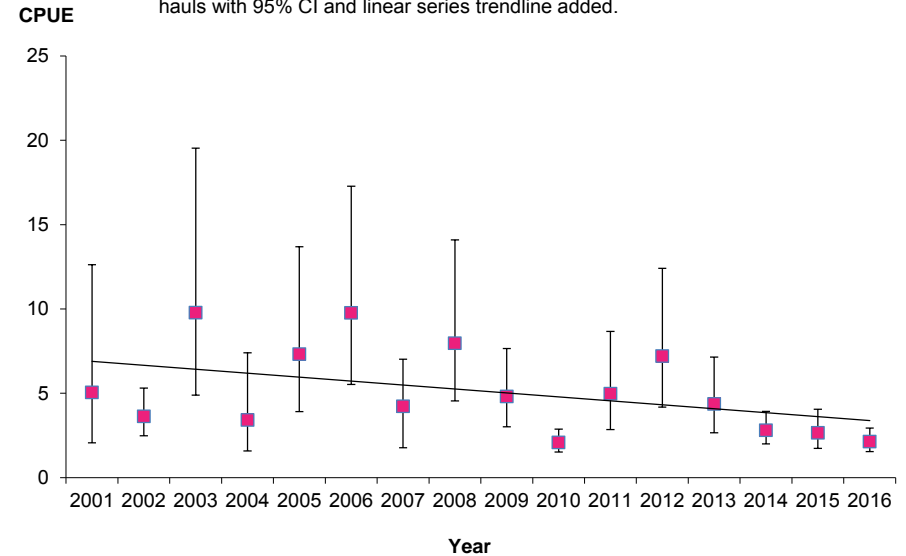
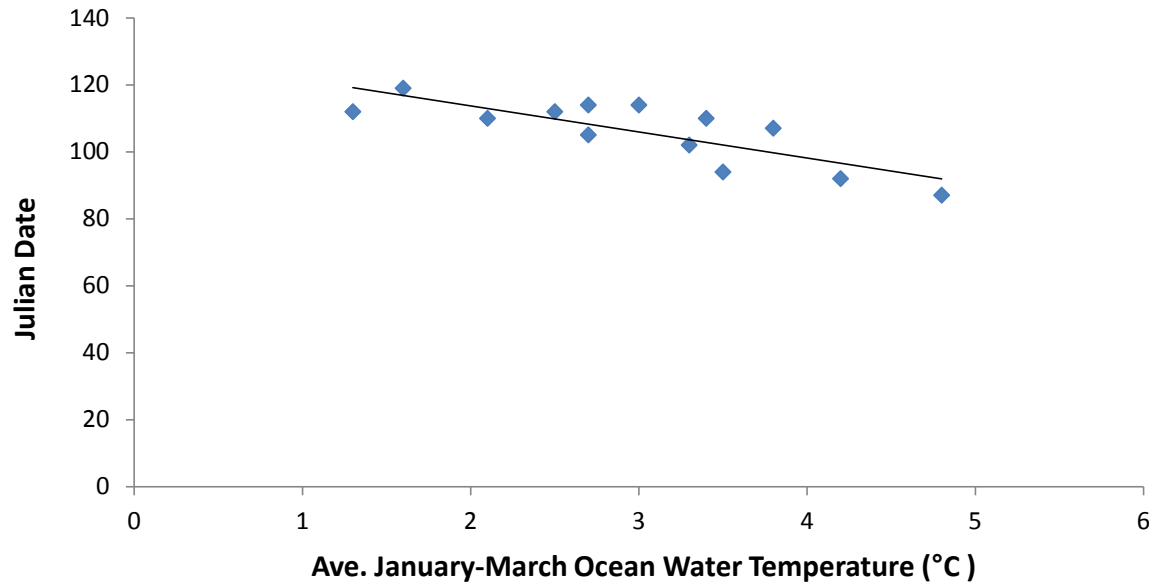
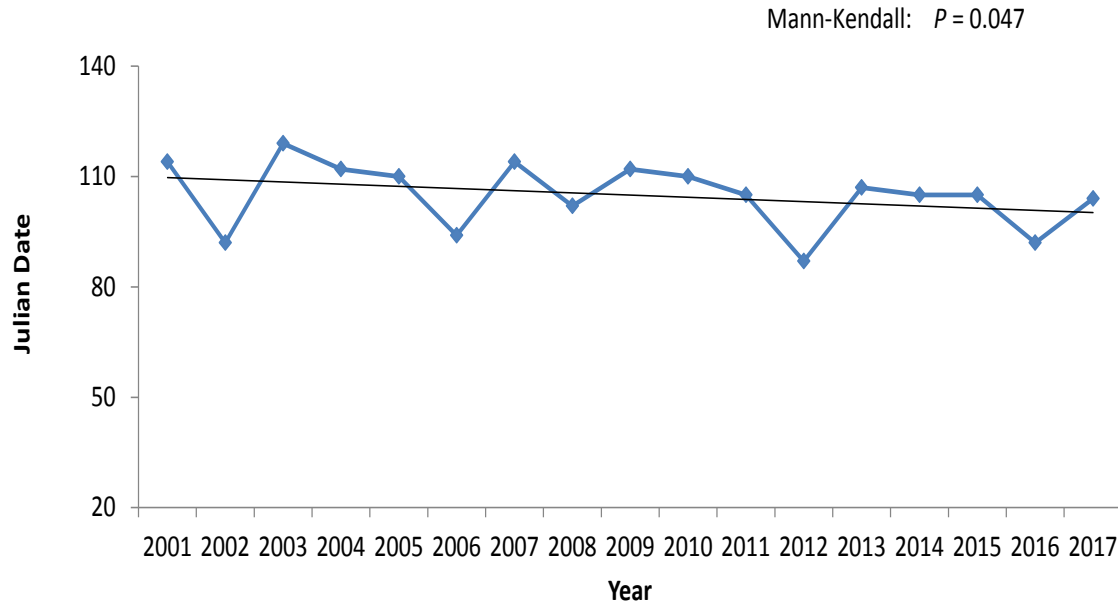


Figure 5.20. GLM-standardized index of abundance for YOY American eels, Jones River, MA, 2001–2016.

Jones River – Glass Eel Trap



Ocean Temperature –
Run Onset Correlation

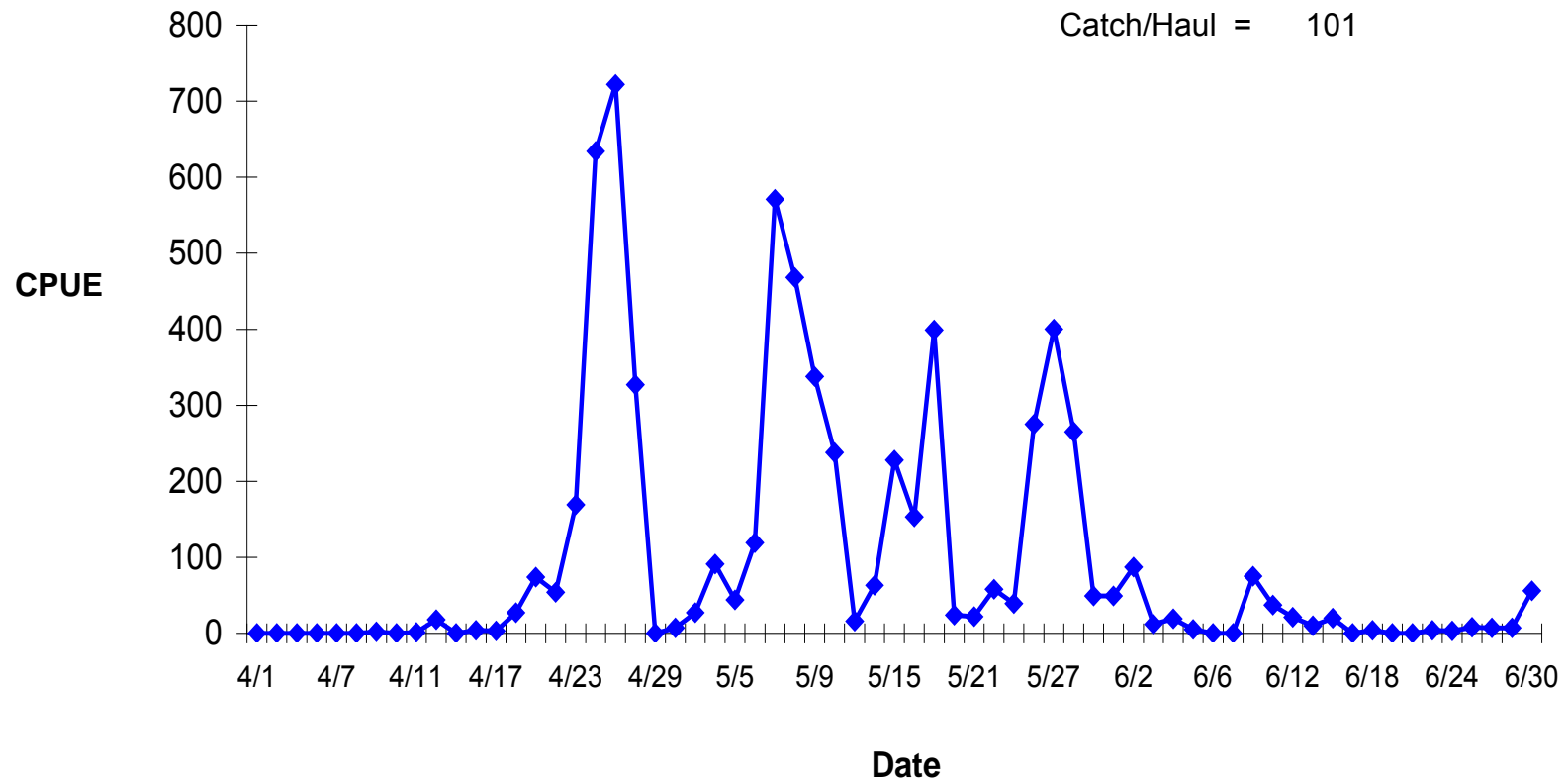


Time Series
of Run Onset

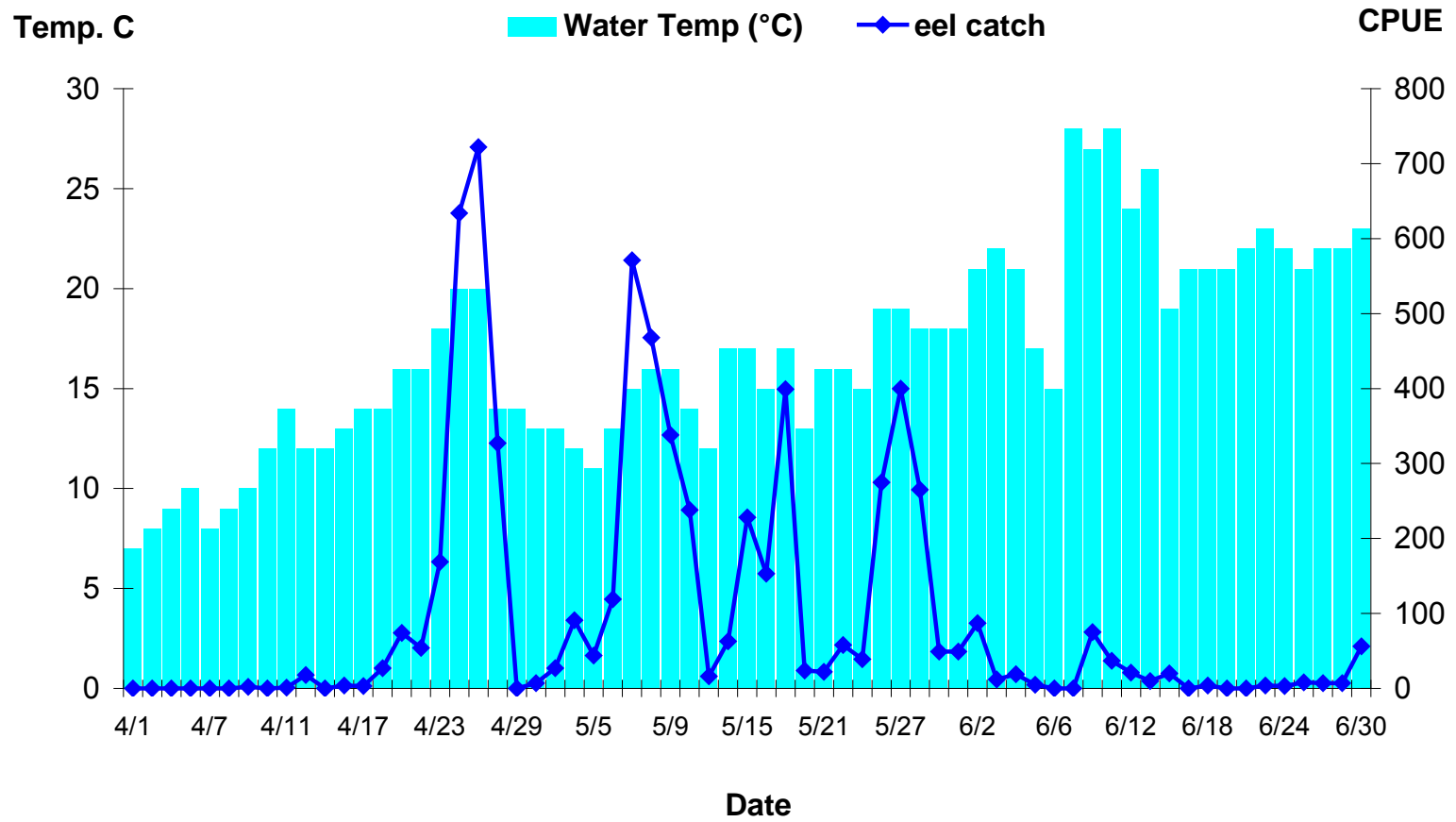
Saugus River Eel Ramp Catch, 2008.

Total Catch = 6,353

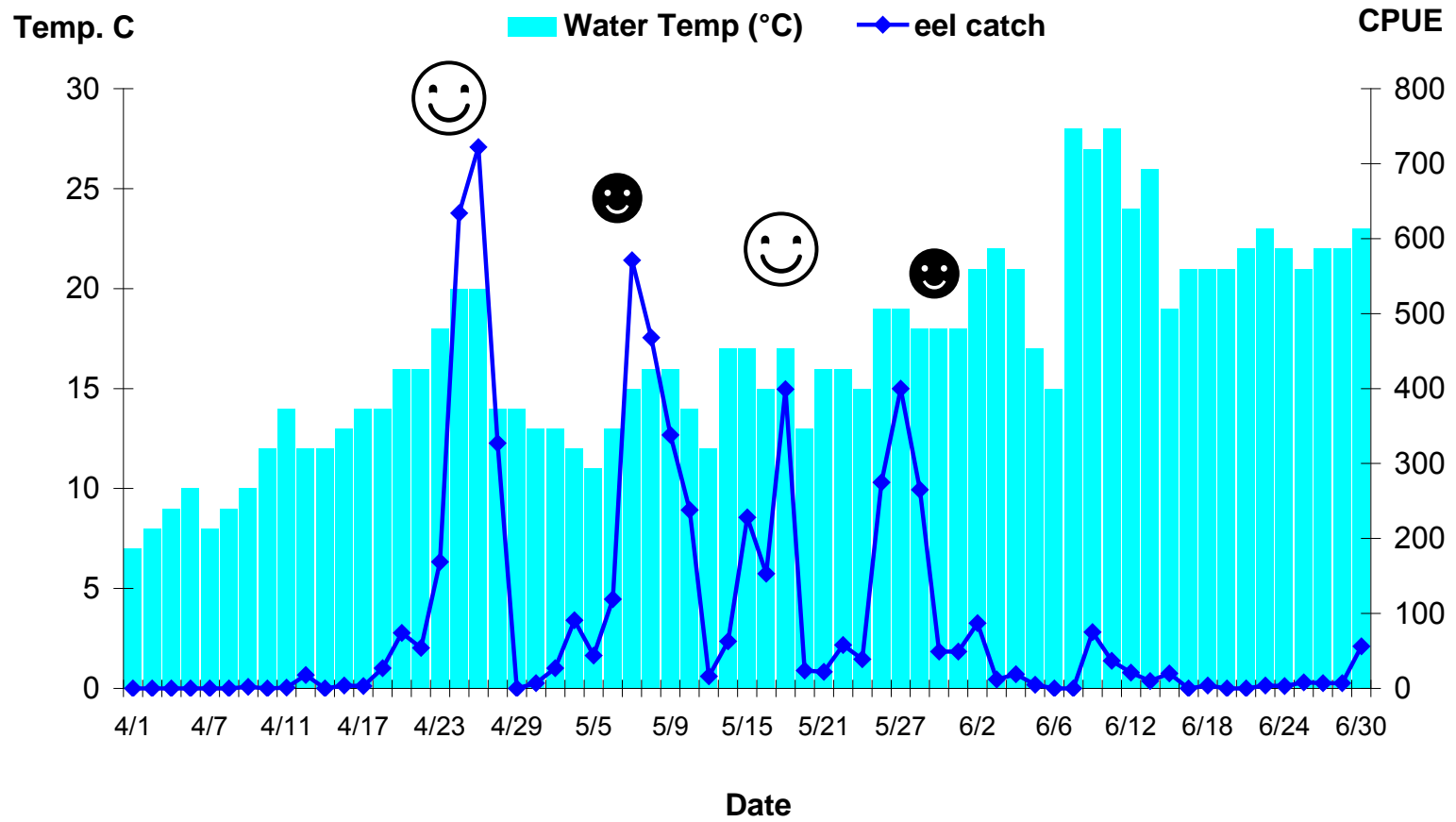
Catch/Haul = 101



Saugus River Eel Ramp Catch, 2008.



Saugus River Eel Ramp Catch, 2008.



Environmental Influences on Glass Eel Migration

| | |
|---------------------------|--|
| Tide amplitude: | Delivers glass eels from estuary to river mouth. Catch peaks are significantly association with moon phase. 76% of peaks occurred at new or full moon. |
| River water temp: | 10 -12 °C stimulates migration. |
| Discharge: | negative relationship to migration rate. |
| Water velocity: | glass eels will rest on the bottom at flows >25 cm/s. |
| Ocean temperature: | warm winters will cause earlier onset to run. The date of migration onset is significantly related to winter ocean temperature. |

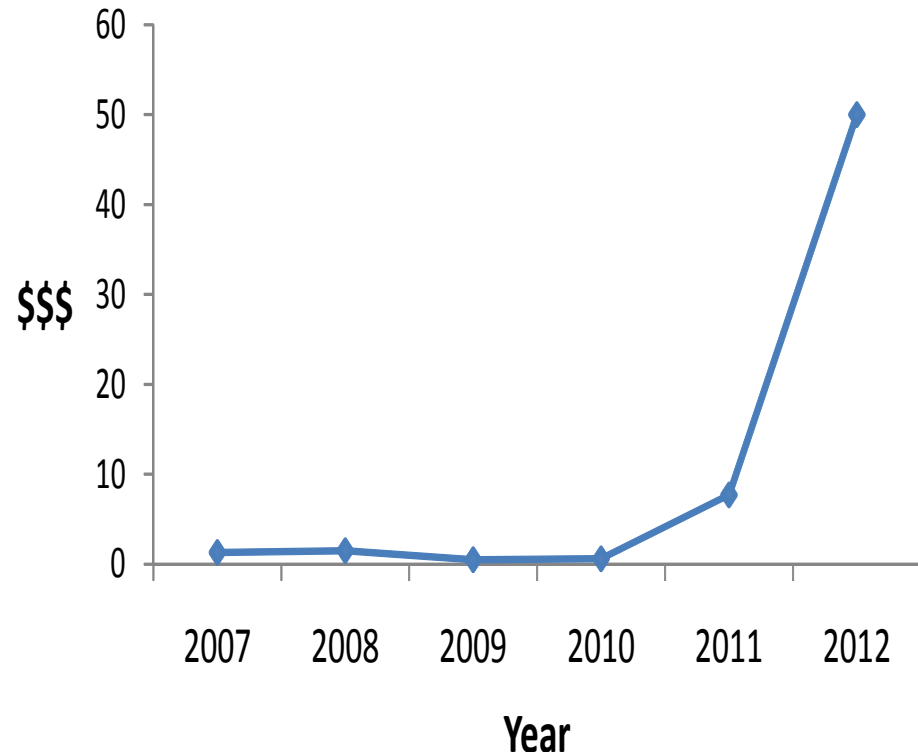
Eel Aquaculture

- Glass eels shipped live to Asian countries
- Culture eels to 12-18" in 1.5 years
- Turning to American eel.....



Maine Glass Eel Fishery

- Limited entry in 1999 with 827 permits
- 425 active licenses in 2010
- Sharp increase in value, effort and landings in 2012.....and illegal harvest



Glass Eel Poaching in MA



Many Obstructions



Eel Passage Improvements

- Can climb wet, rough surfaces
- Poor swimming capability against higher velocity
- Installing eel passes; one per year since 2007
- Dam removals increasing





Massachusetts Eel Ramps and Passes

(8 deployed since 2007)

| | |
|---------------------------------|---------------------------------|
| Saugus River, Saugus, 2007 | -- AC power pump-supply |
| Grassy Pond, Harwich, 2008 | -- solar power pump-supply |
| Wankinco River, Wareham, 2009 | -- gravity-supply trap/tank |
| Mystic Lakes Dam, Medford, 2010 | -- AC power pump-supply |
| Pilgrim Lake, Orleans, 2011 | -- gravity-supply floating tank |
| Morey's Dam, Taunton, 2012 | -- AC power pump-supply |
| Mill Creek, Rockport, 2013 | -- gravity-supply floating tank |
| Silver Spring, Wellfleet, 2014 | -- solar power pump-supply |

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Saugus River, Lynnfield -- 2007

Watershed -- 21 mi²

River Mile -- 9.4

Pond Acres -- 5

- Saugus River Watershed Council, Lynn Water and Sewer Commission, USGS
- Gulf of Maine Council funding



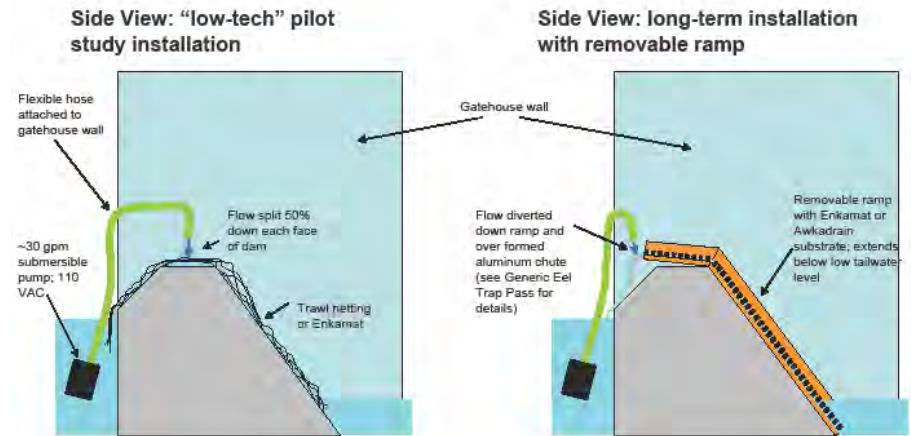
Saugus River Eel Ramp

Length -- 10 ft

Width -- 18 in

Slope -- 45°

- 50 gpm low-head submersible pump



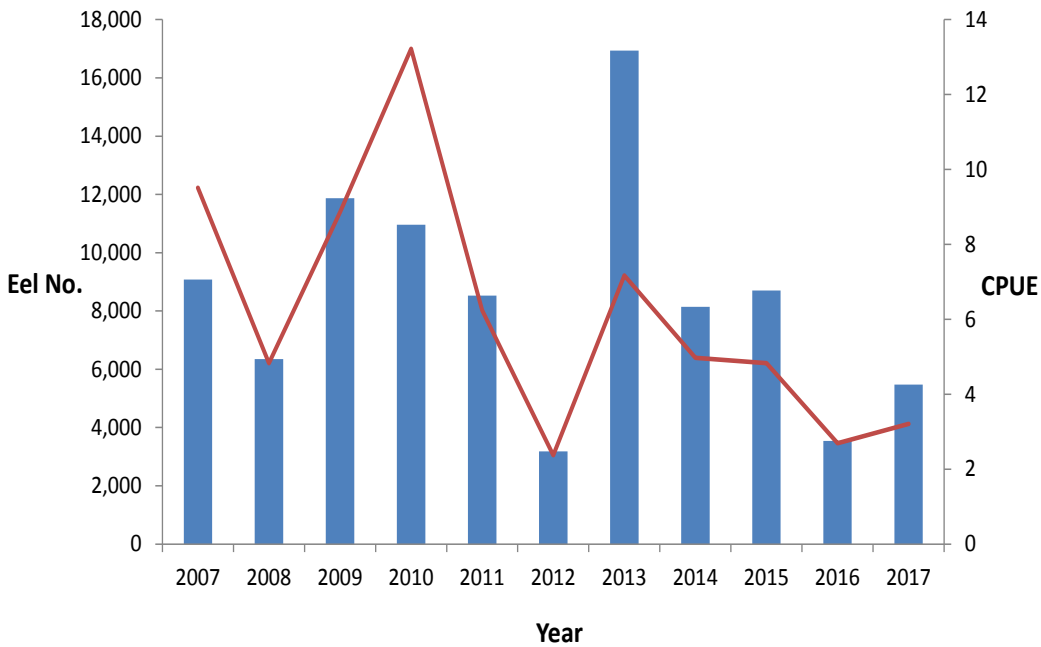
Saugus River Dam Eel Pass Options, Saugus, Massachusetts

Design by Alex Haro
S.O. Conte Anadromous Fish Research Center, U.S.
Geological Survey, Biological Resources Turners Falls, MA
USA

March 2006



Saugus River Eel Ramp



Grassy Pond Eel Ramp, Harwich -- 2008

Watershed -- 1.3 mi²
River Mile -- 1.8
Pond Acres -- 24

- NRCS grant to Harwich Conservation Trust; Town of Harwich
- Started with battery connected to two Sunsei SE-1500 (1.5 amp) panels. Switch to Renogy 100 w panel with three 12 V batteries
- Rule 360 bilge pump: 360 GPH, 2.1 amps at 12.0V



Pilgrim Lake, Orleans -- 2011

Watershed -- $< 1 \text{ mi}^2$

River Mile -- 0.6

Pond Acres -- 39

- Town of Orleans
- Gravity flow from floating tank



Pilgrim Lake, Orleans

Length -- 12 ft

Width -- 4 in. diameter

Slope -- NA

- Over 40,000 glass eels in 2011 and 2012



Lake Sabbatia Eel Abundance Study



Lake Sabbatia Eel Abundance Study



Mark/recapture population estimate:

2013 - 75 (95% CI = 35-203)

2014 - 85 (95% CI = 40-226)

2015 - 138 (95% CI = 121-170)

2016 - 125 (95% CI = 119-137)

2017 - 155 (95% CI = 151-165)



Next Steps:

- PIT antennas at dam installed fall 2017; 30 individuals detected
- Monitor response with last dam removed

Eel PIT tag retention study



Evaluating the Effect of Dam Removals on Yellow-Phase American Eel Abundance in a Northeastern U.S. Watershed

Sara M. Turner, Bradford C. Chase, and Michael S. Bednarski
North American Journal of Fisheries Management, April 2018

Recent Restoration Projects in Falmouth with eel benefits



Coonamessett River, Falmouth

Bourne Pond, Falmouth



Cedar Lake, Falmouth

Cedar Lake, Falmouth - 2014



Bourne Pond, Falmouth - 2016



Bourne Pond, Falmouth



New fish ladder



Dam removal



April 2017

Recent Progress?

- Raising awareness.....
- Conservation Management taking shape
- Passage improvements are increasing
- Populations remain low with uncertainty over slow response
- World markets put glass eel abundance at risk
- Freshwater habitat concerns
- Climate impact on marine habitat

