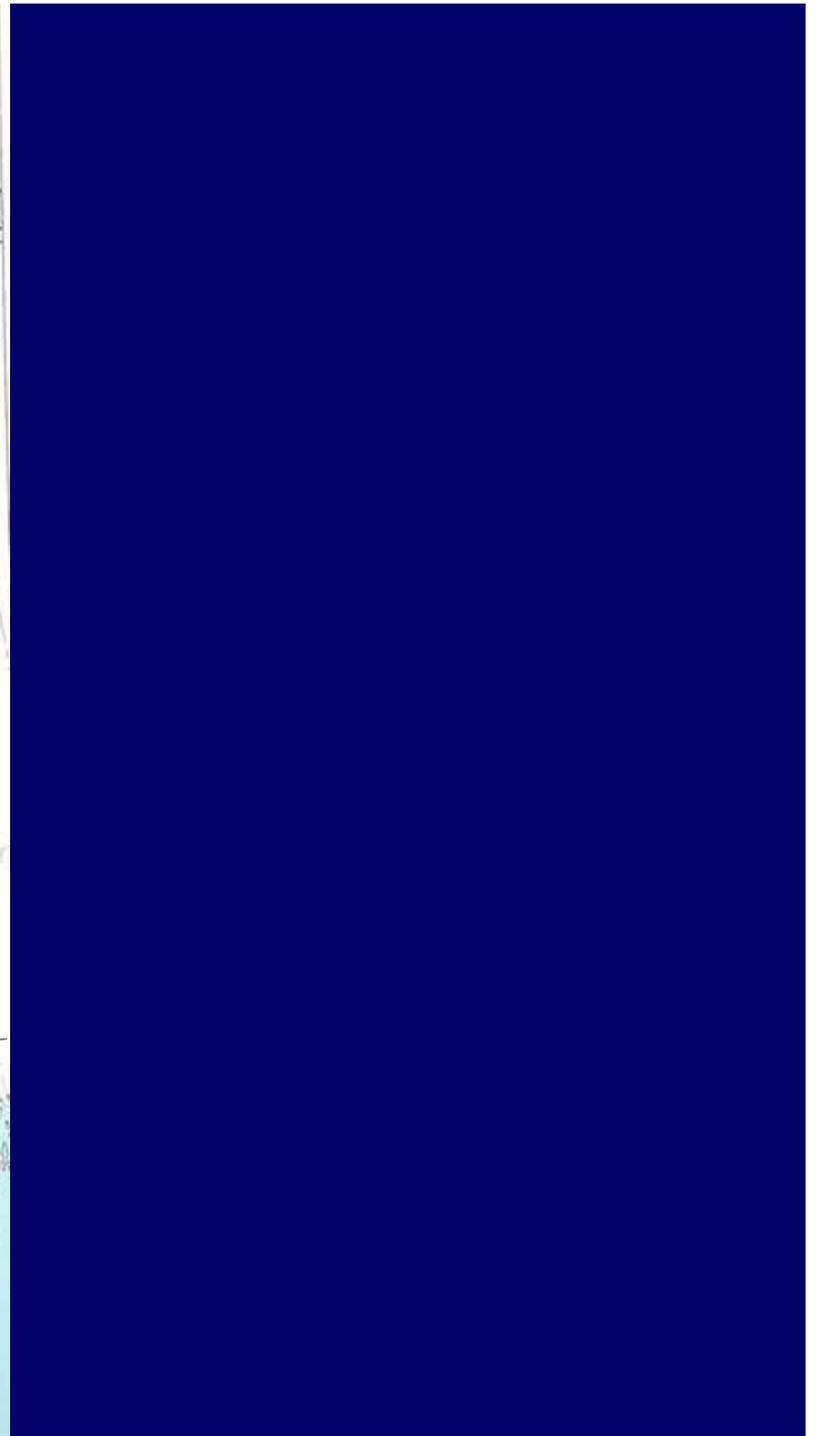
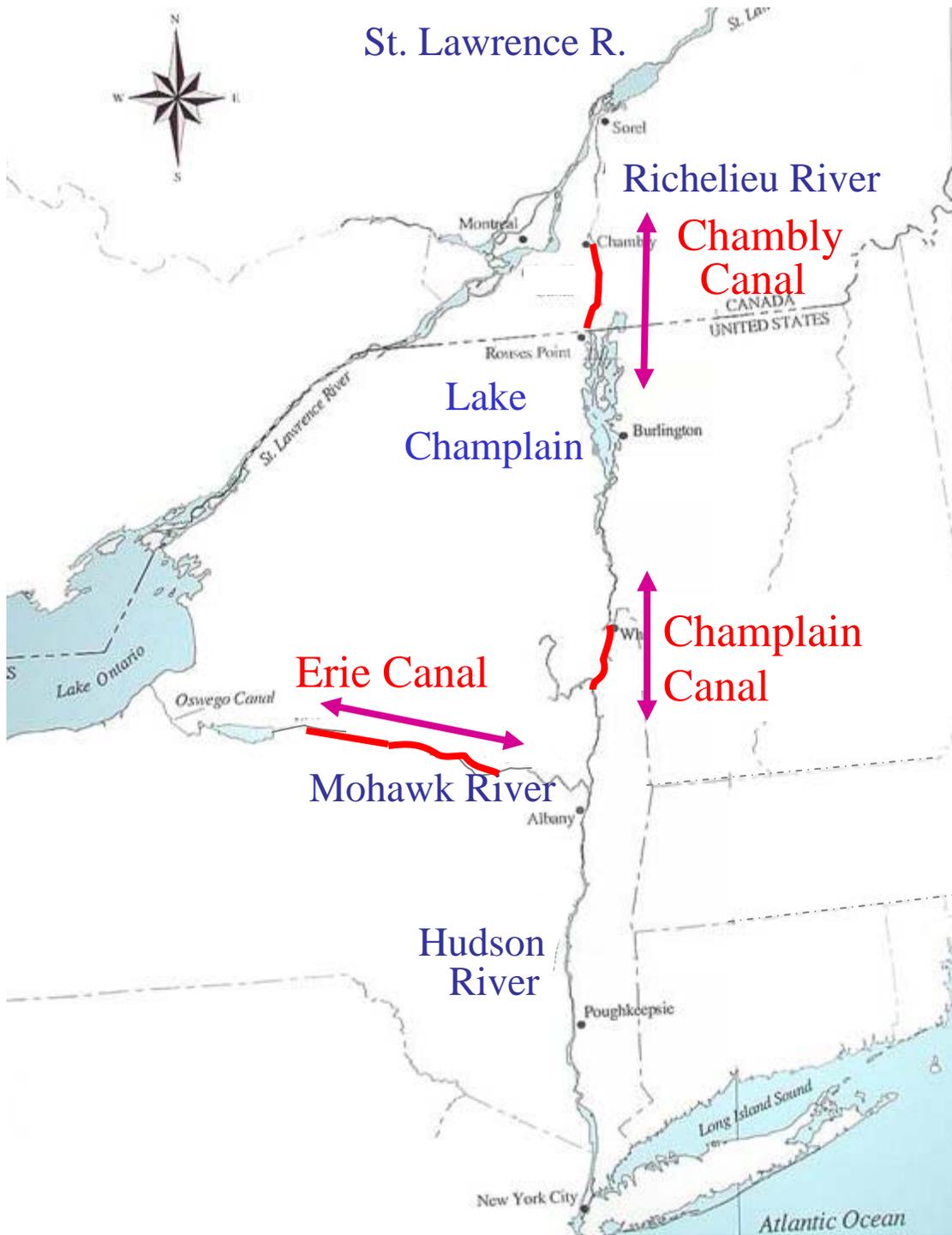
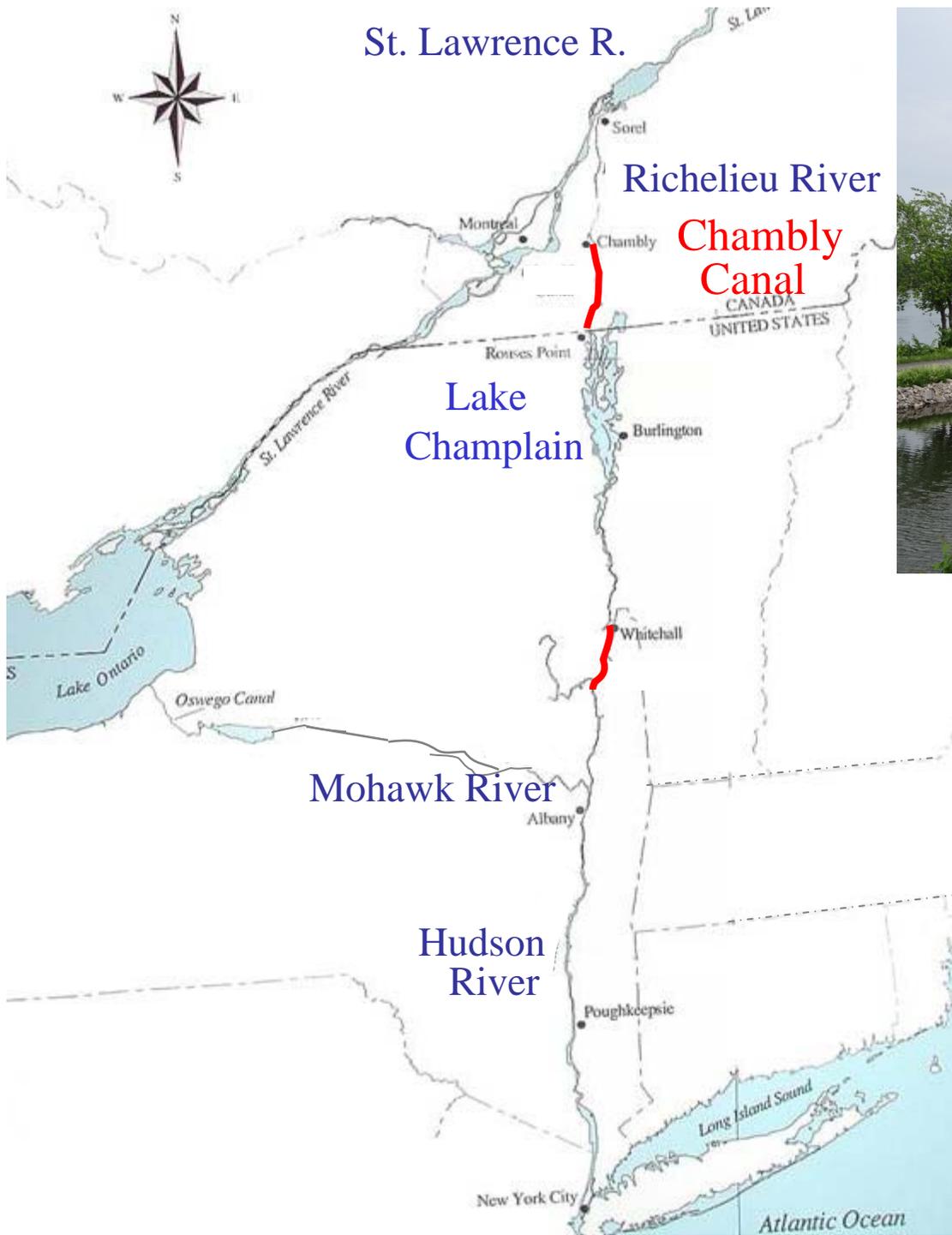


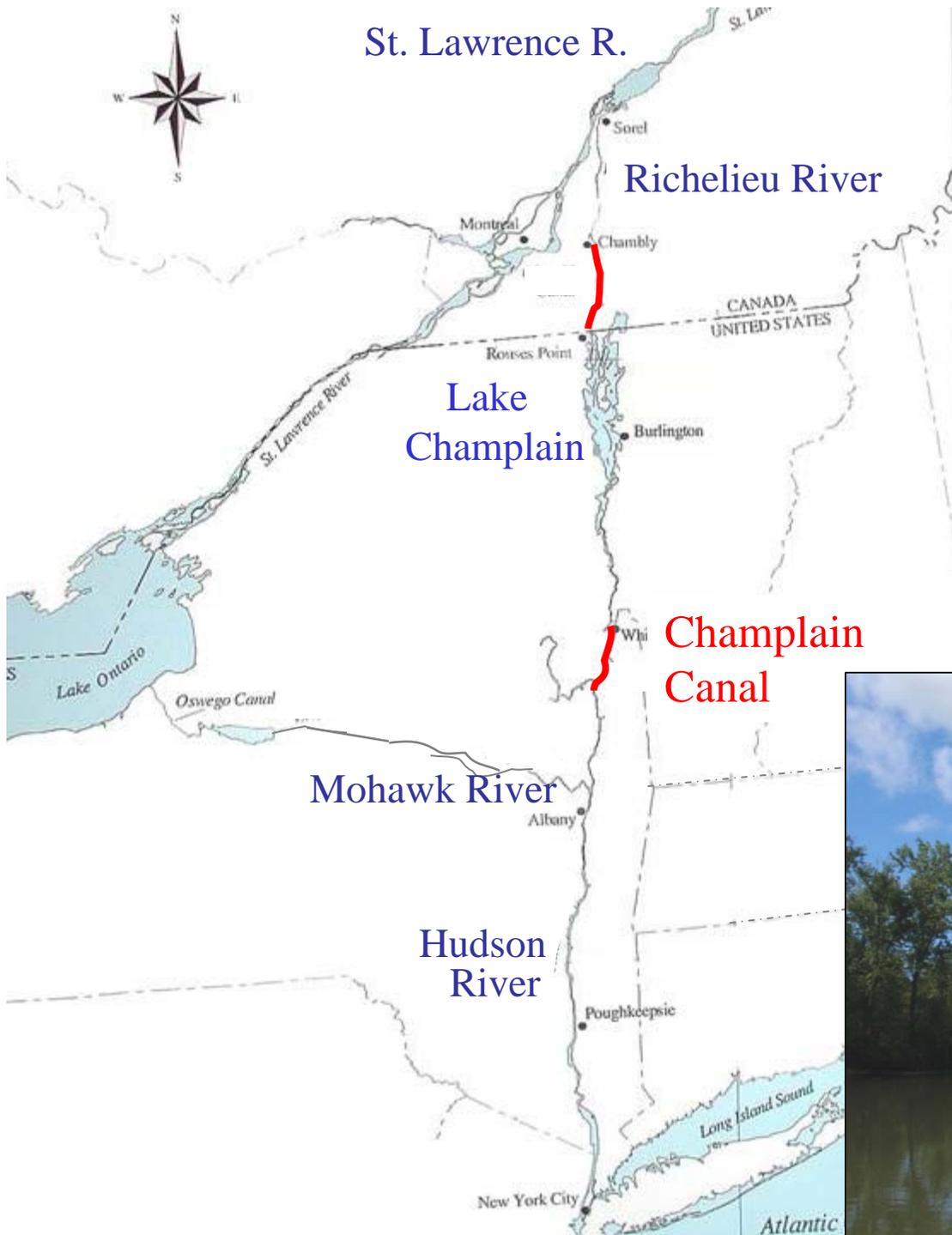
# Morphology and Function of the Champlain Canal relative to AIS Transfer: Past, Present and Future

J. Ellen Marsden  
University of Vermont

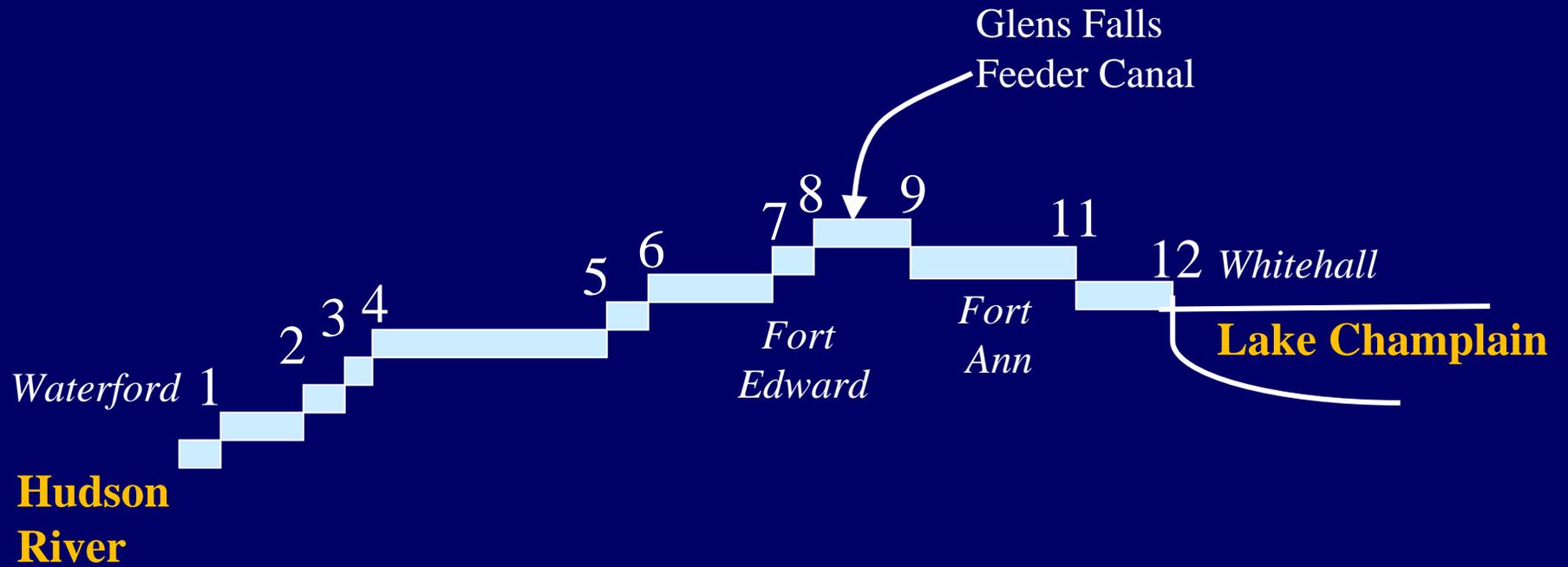








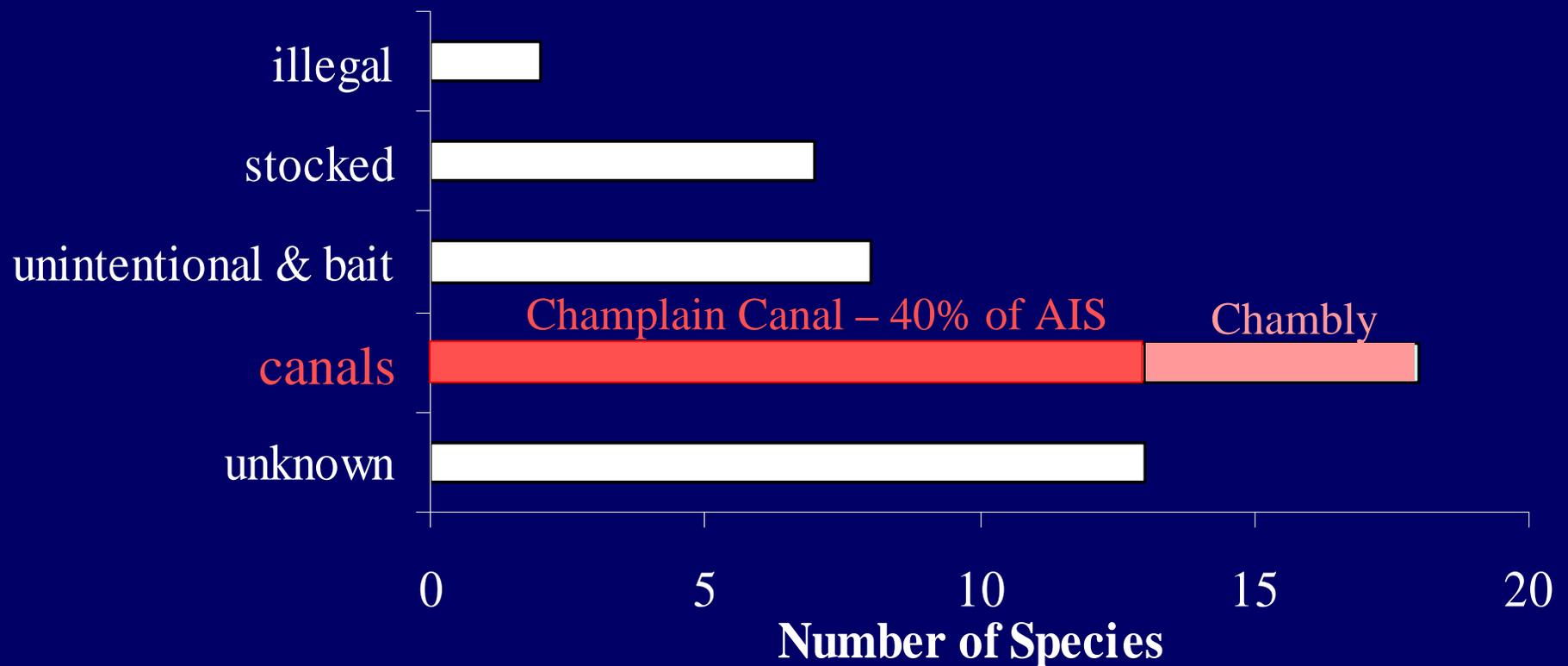
# Champlain Canal



# Vectors of exotic species introduced into Lake Champlain

N = 48 species (+1)

(Marsden and Hauser 2009 *Exotic species in Lake Champlain. JGLR 35:25-265*)



## Introductions via the Champlain Canal

Purple loosestrife

Water chestnut

Yellow floating heart?

Flowering rush?

European frog's bit?

Slender-leafed naiad?

Carp

Blue-back herring

Gizzard shad

Brook silverside

White perch

Largemouth bass

*Bythinia*

Woodland pondsnail

Banded mystery snail

Buffalo pebble snail

Sharp hornsnail

Piedmont snail

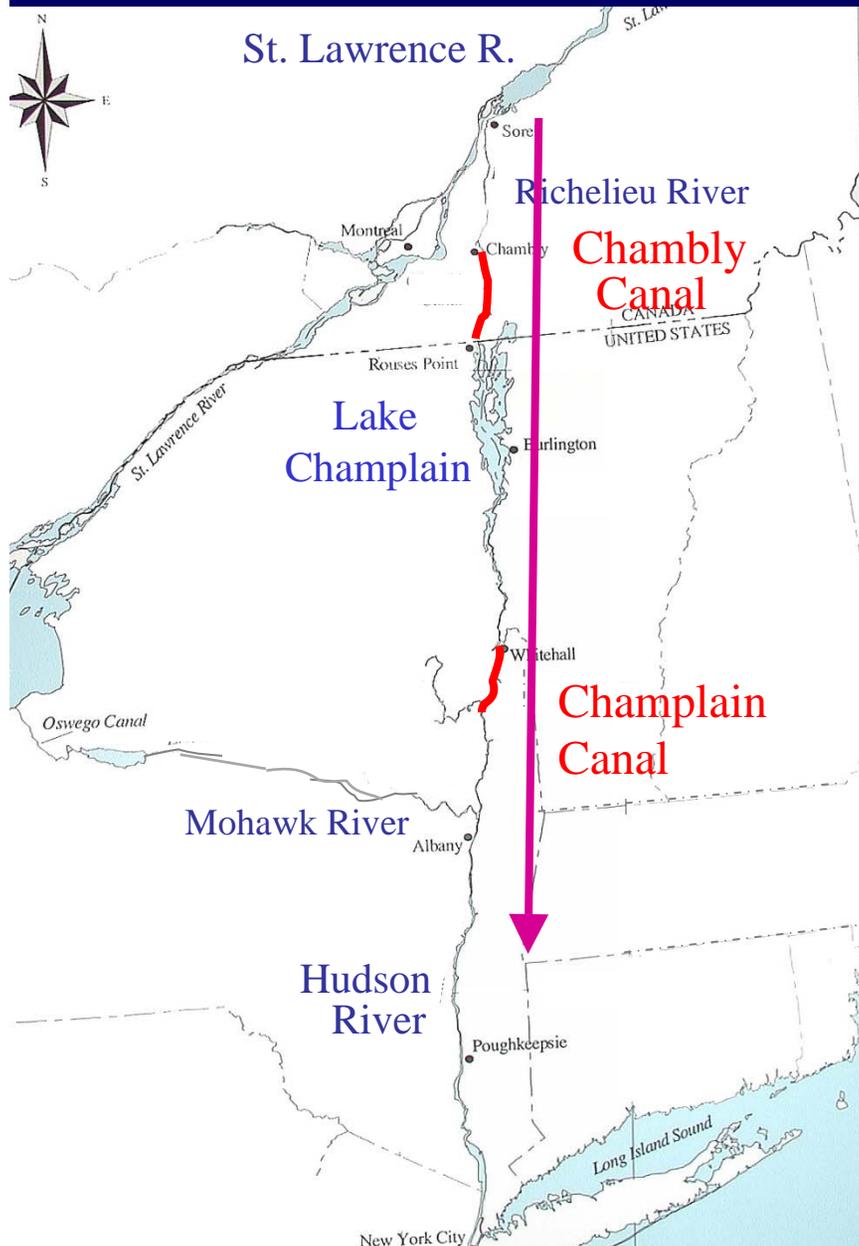
Zebra mussel

Asian clam (*en route*)

Water flea (*Eubosmina*)

Spiny water flea (*Bythotrephes*)  
(*en route*)

## Lake Champlain as an exotic species conduit...

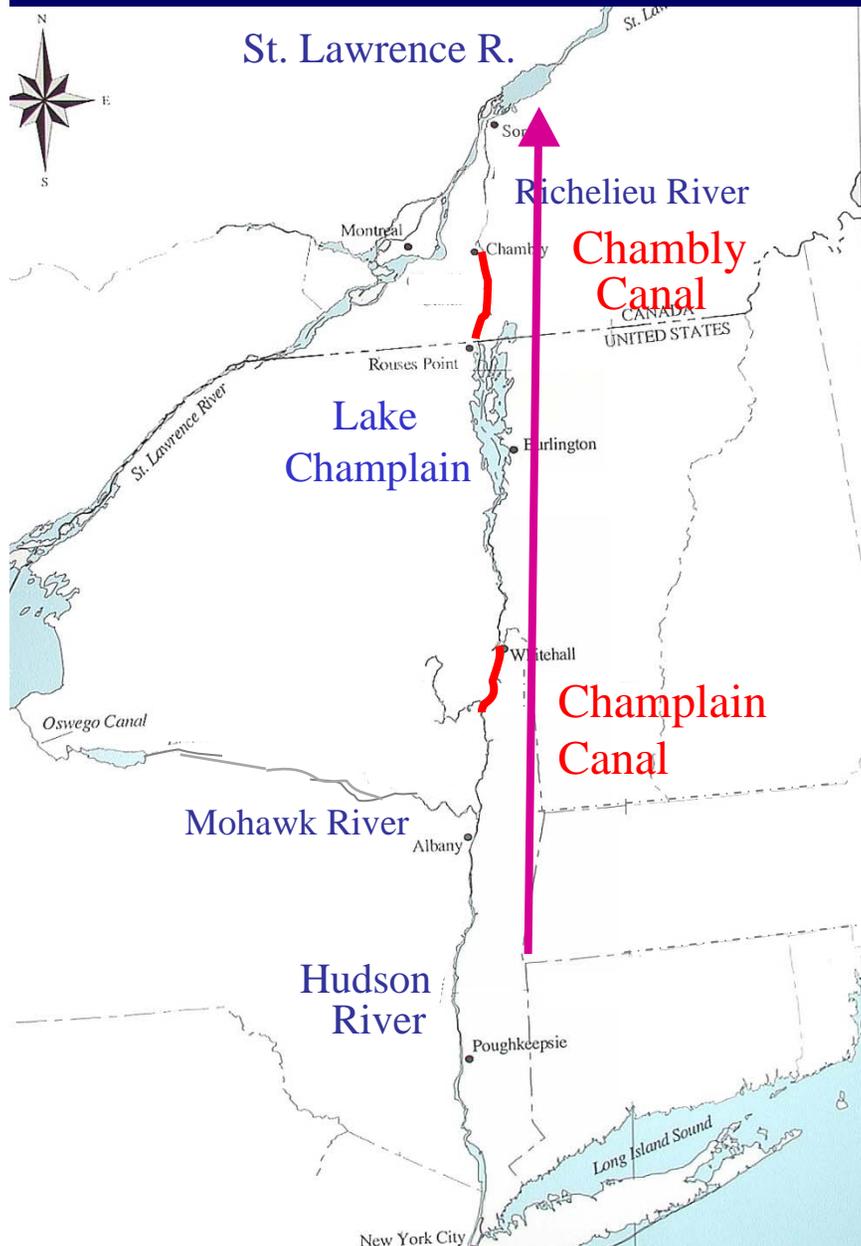


## From St. Lawrence to Hudson

silver lamprey  
longnose gar  
bowfin  
brook stickleback  
rock bass  
logperch  
liver elimia

*from Daniels 2001*

## Lake Champlain as an exotic species conduit...



## From St. Lawrence to Hudson

silver lamprey  
longnose gar  
bowfin  
brook stickleback  
rock bass  
logperch  
liver elimia

## From Hudson to St. Lawrence

blueback herring  
gizzard shad  
common carp  
emerald shiner  
redfin pickerel  
brook silverside  
white perch

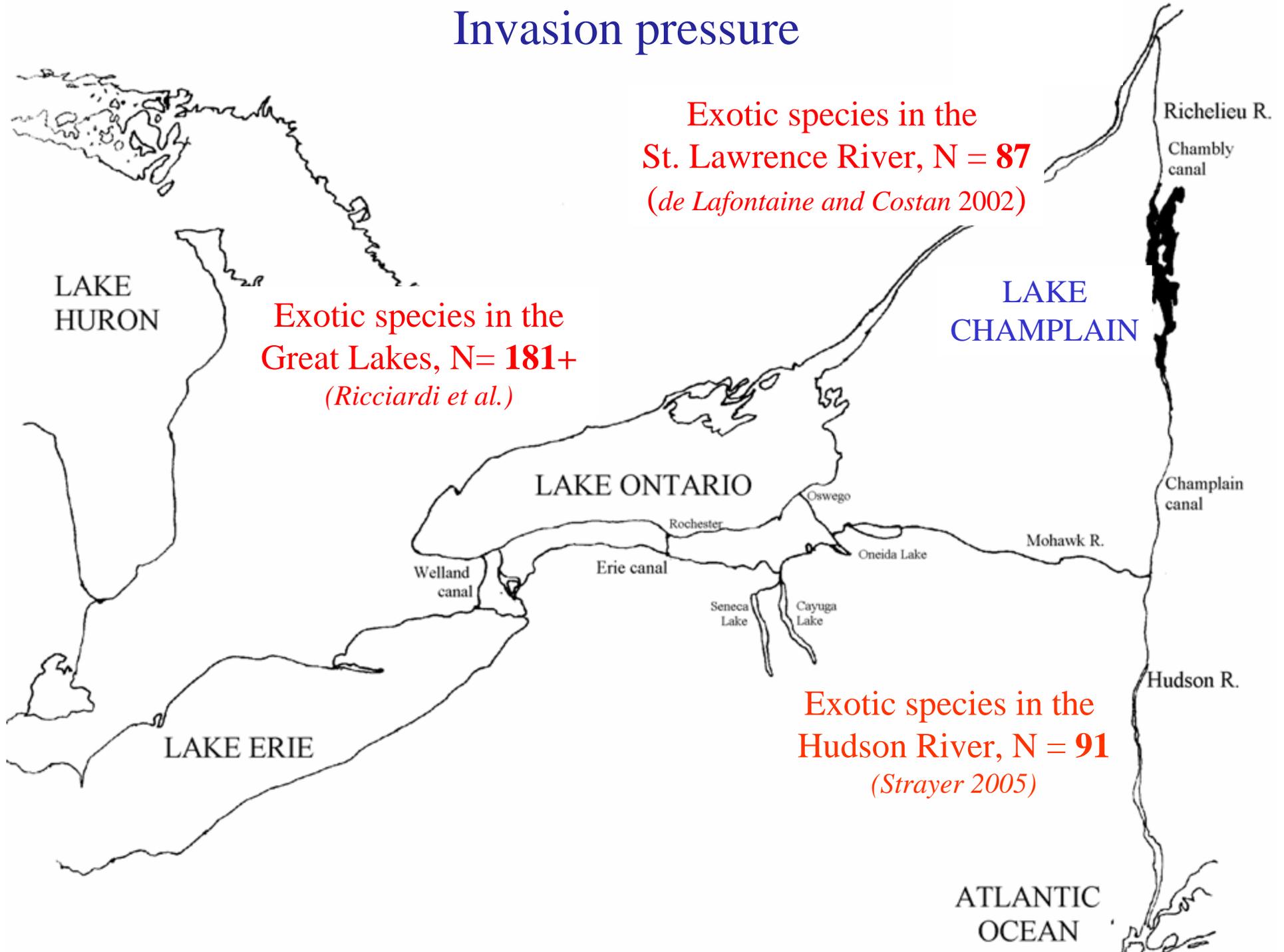
*from Daniels 2001*

# Invasion pressure

Exotic species in the  
St. Lawrence River,  $N = 87$   
(*de Lafontaine and Costan 2002*)

Exotic species in the  
Great Lakes,  $N = 181+$   
(*Ricciardi et al.*)

Exotic species in the  
Hudson River,  $N = 91$   
(*Strayer 2005*)



# Species in, or close to, the canal system

## Fishes

- round goby
- bitterling
- grass carp
- Eurasian ruffe
- silver carp
- big-head carp



## Molluscs

- Asian clam
- quagga mussel
- Piedmont elimia snail
- New Zealand mud snail
- European stream valvata
- liver elimia
- Wabash pigtoe
- paper pondshell
- Atlantic rangia



## Invertebrates

- spiny water flea (*Bythotrephes*)
- *Gammarus daiberi*
- Asian bryozoan
- fish-hook flea (*Cercopagis*)
- *Daphnia lumholtzi*
- *Echinogammarus*
- *Eurytemora affinis*
- *Procambarus acutus*
- *Ripistes parasita*
- *Cordylophora caspia*
- *Skistodiaptomus pallidus*



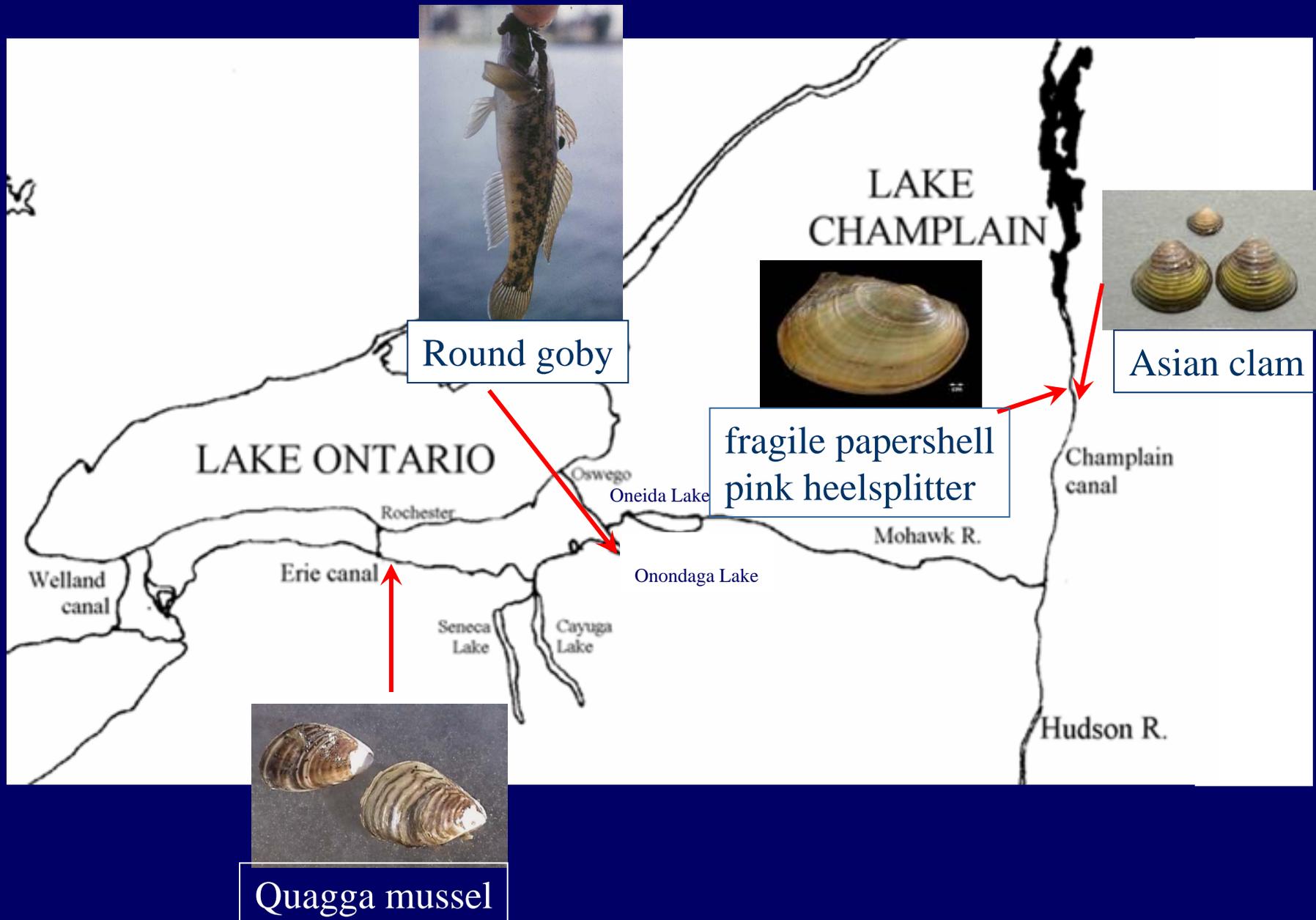
## Plants

- fanwort
- Brazilian elodea
- hydrilla
- parrot's feather
- variable-leaved watermilfoil

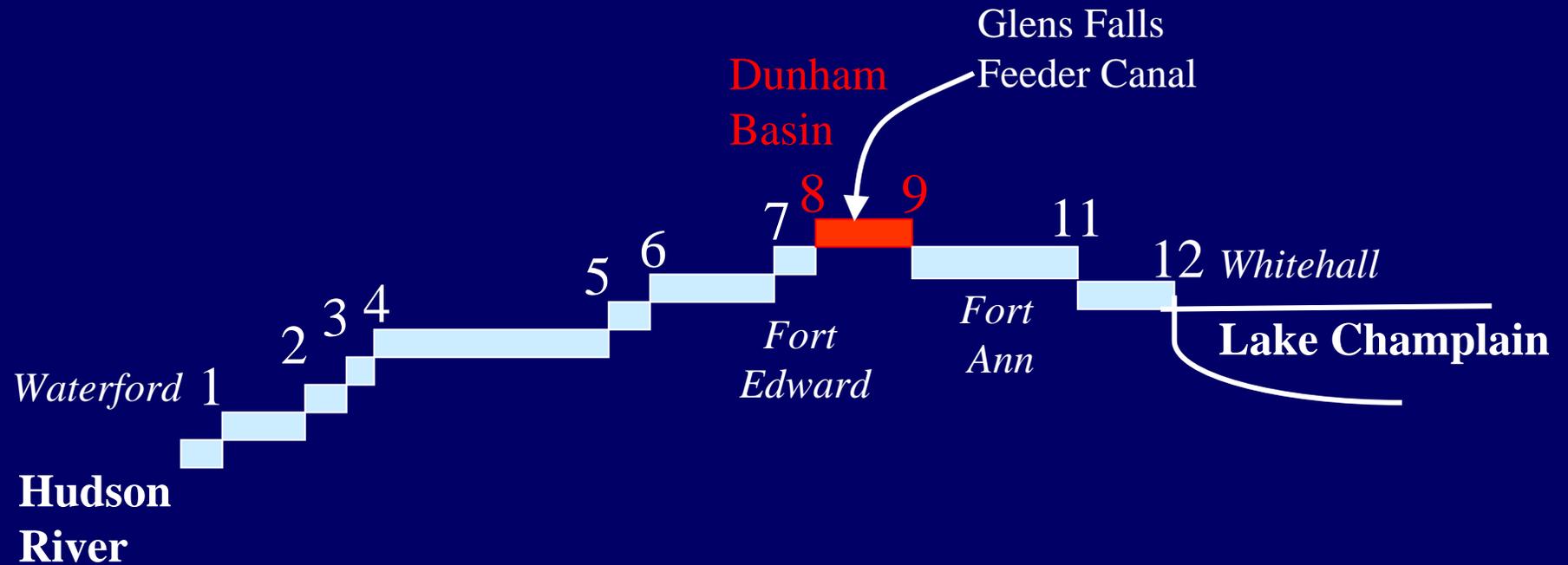


dkimages

# Invaders already in the canal system



# Sampling the Champlain Canal



# Sampling methods

**Fishes:** ichthyoplankton tows, gillnetting, minnow traps, electroshocking



# Sampling methods

**Molluscs:** hand nets, ponar grab, benthic dredge



# Sampling methods

**Plants:** hand harvesting, plant rakes



# Sampling methods

**All taxa:** collections in drained locks (locks 4, 8, and 9)



## Survey of species in the Champlain Canal: plants (25)

Eurasian milfoil (*Myriophyllum spicatum*)

white water lily (*Nymphaea odorata - tuberosa*)

arrow arum (*Peltandra virginica*)

common reed (*Phragmites australis*)

pickerel weed (*Pontederia cordata*)

largeleaf pondweed (*Potamogeton amplifolius*)

curly leaf pondweed (*Potamogeton crispus*)

ribbon leaf pondweed (*Potamogeton epiphydrus*)

slender leaf pondweed (*Potamogeton filiformis*)

floating leaf pondweed (*Potamogeton natans*)

longleaf pondweed (*Potamogeton nodosus*)

clasping leaf pondweed (*Potamogeton perfoliatus*)

small pondweed (*Potamogeton pusillus*)

flatstem pondweed (*Potamogeton zosteriformis*)

coontail (*Ceratophyllum demersum*)

western waterweed (*Elodea nuttallii*)

little duckweed (*Lemna minor*)

purple loosestrife (*Lythrum salicaria*)

broadleaf arrowhead (*Sagittaria latifolia*)

softstem bullrush (*Scirpus tabernaemontani*)

big duckweed (*Spirodela polyrhiza*)

sago pondweed (*Stuckenia pectinata*)

water chestnut (*Trapa natans*)

eelgrass (*Vallisneria americana*)

water star-grass (*Zosterella dubia*)

orange: exotic in Hudson and/or Champlain

## Survey of species in the Champlain Canal: molluscs (21)

faucet snail (*Bithynia tentaculata*)

mud amnicola (*Amnicola limosa*)

Buffalo pebblesnail (*Gilia altilis*)

woodland pond snail (*Stagnicola catascopium*)

pumpkin physa (*Physa ancillaria*)

pond snail (*Physa gyrina*)

ash gyro (*Gyraulus parvus*)

marsh ramshorn snail (*Heliosoma trivolvis*)

two-ridge rams horn (*Helisoma anceps*)

sharp sprite (*Promenetus exacuus*)

boreal turret snail (*Valvata sincera*)

Asian clam (*Corbicula fluminea*)

zebra mussel (*Dreissena polymorpha*)

fingernail clam (*Musculium partumeium*)

fingernail clam (*Musculium transversum*)

striated fingernail clam (*Sphaerium striatinum*)

eastern elliptio (*Elliptio complanata*)

eastern lampmussel (*Lampsilis radiata*)

fragile papershell (*Leptodea fragilis*)

pink heelsplitter (*Potamilus anatus*)

giant floater (*Pyganodon grandis*)

orange: exotic in Hudson and/or Champlain

## Survey of species in the Champlain Canal: fishes (40)

silver lamprey

American eel

blueback herring\*

gizzard shad

longnose gar

spotfin shiner

common carp\*

eastern silvery minnow\*

common shiner

golden shiner\*

emerald shiner\*

blacknose shiner

spottail shiner

rosyface shiner

bluntnose minnow\*

fathead minnow

fallfish

white sucker\*

silver redhorse

shorthead redhorse

yellow bullhead\*

brown bullhead

channel catfish\*

eastern sand darter

tessellated darter

yellow perch\*

logperch\*

walleye

trout-perch

brook silverside\*

freshwater drum\*

chain pickerel\*

northern pike\*

rock bass\*

pumpkinseed\*

bluegill\*

smallmouth bass\*

largemouth bass\*

white crappie\*

white perch\*

\* = reproducing in the canal (22 species)  
orange: exotic in Hudson and/or Champlain

## Survey of species in the Champlain Canal: other (5)

rusty crayfish (*Orconectes rusticus*)

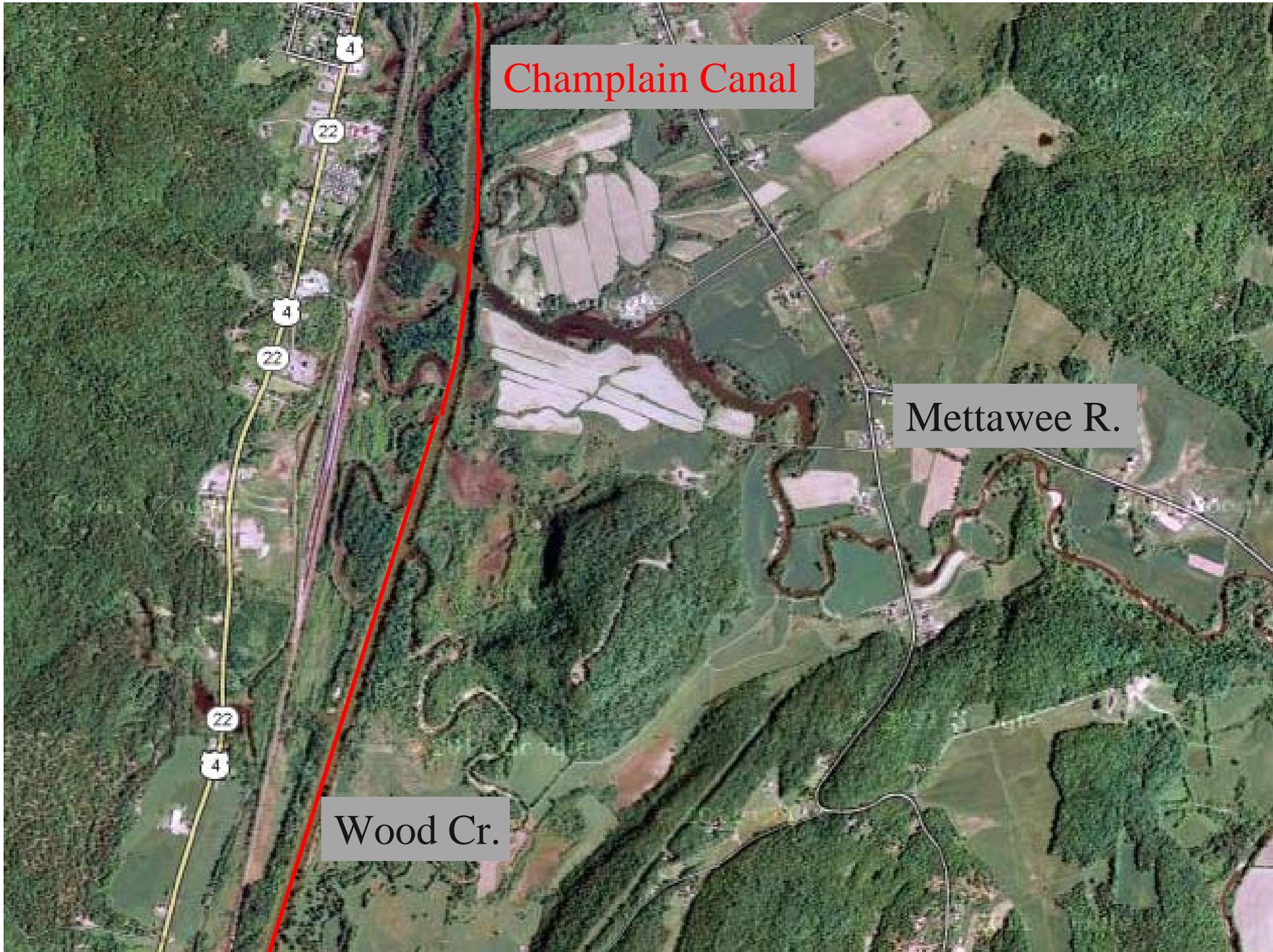
White River crayfish (*Procambarus acutus*)

northern clearwater crayfish (*Orconectes propinquus*)

mudpuppy (*Necturus maculus*)

unidentified sponges

orange: exotic in Hudson and/or Champlain



Champlain Canal

Mettawee R.

Wood Cr.



# Methods of exotic species transit via canals

1. Passive, via lock water (plankton, seeds, plant fragments, fish)



# Methods of exotic species transit via canals

1. Passive, via lock water
2. Passive, on boats (encrusting organisms; onboard in live wells; entrained in boundary layer)



## Methods of exotic species transit via canals

1. Passive, via lock water
2. Passive, on boats
3. Active, migration (fish, crayfish)



## Methods of exotic species transit via canals

1. Passive, via lock water
2. Passive, on boats
3. Active, migration (fish, crayfish)
4. Population expansion as residents (all species)



# Habitat preferences of fishes in the Champlain Canal

## Warm, macrophytes

chain pickerel  
northern pike  
longnose gar  
rock bass  
pumpkinseed  
largemouth bass  
white crappie  
common carp

## Warm, turbid, muddy

white sucker  
yellow bullhead  
brown bullhead  
channel catfish  
banded killifish  
silver lamprey  
American eel  
logperch

## Cool, pelagic

yellow perch  
brook silverside  
emerald shiner  
gizzard shad

## Cool, benthic

eastern sand darter  
tessellated darter

## Warm, clear water

blacknose shiner  
rosyface shiner  
silver redhorse  
shorthead redhorse

# Conclusions

Champlain Canal contains a diverse community with reproducing fish communities

Habitat is largely warm, shallow, lentic, with mud-sand substrates

Canal is accessible to cold- and cool-water fishes

= few obstacles to future invasions

## Attributes of an ideal barrier:

- feasible
- affordable
- does not impede boat traffic
- minimal non-target effects
- effective against a range of taxa (fish, invertebrates, plants, plankton)

## Guiding principles:

- no barrier is likely to be 100% effective
  - *this should not be a goal*
- an optimal solution may utilize several strategies simultaneously
  - *public education is particularly important*

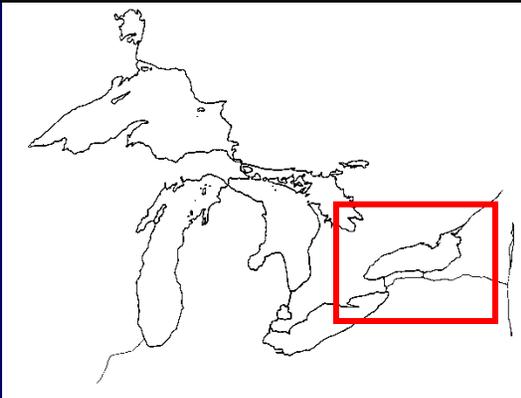
# Canal Invasive Species Management Options

## *Alternatives:*

1. do nothing
2. close the Champlain Canal
3. behavioral barrier (electrical, bubble)
4. chemical/water quality barrier
5. biological barrier (predators)
6. physical/mechanical modification of canal

# Hydrological separation

Big Chute Marine Railway, Trent-Severn Canal, Ontario  
- rebuilt to prevent sea lamprey from entering L. Simcoe



# Hydrological separation

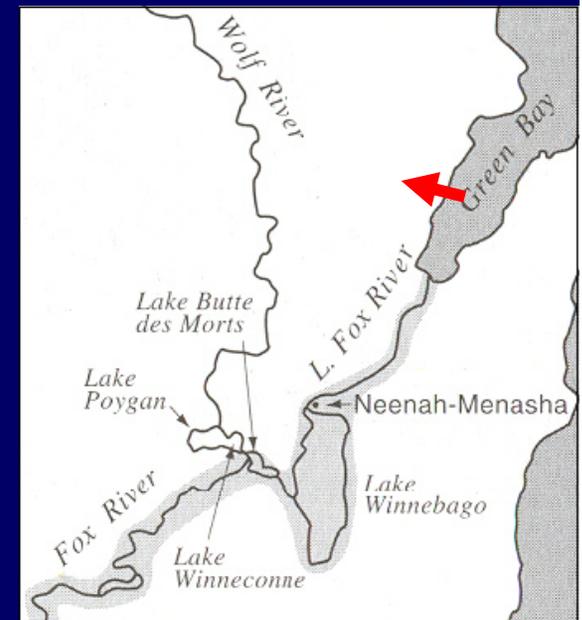
## Fox River lock system, Lake Winnebago WI

- series of 17 locks, reopened in 2000s
- lamprey, VHS threaten Lake Winnebago

**Solution:** leave Rapide Croche lock closed  
hoist boats into lock chamber  
inspect hull, gear; immerse in 145° water



M. Malchoff, LCSG, SUNY Plattsburgh



# Boat transit options



Travel lift



Fork lift



Marine Railway (Big Chute, Ontario)

# Boat transit options



Falkirk Wheel, Scotland

