River otters predation on adult and juvenile salmonids

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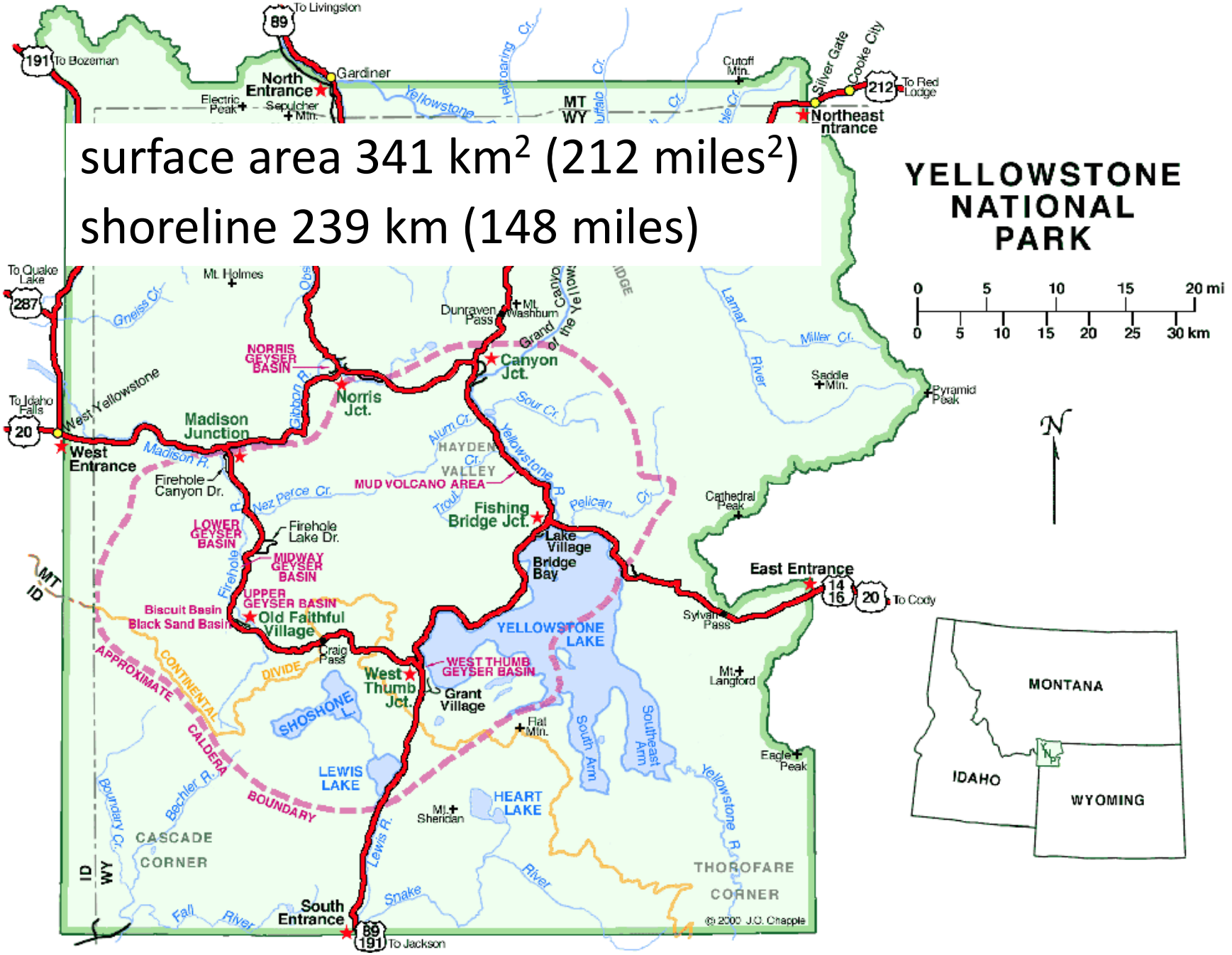
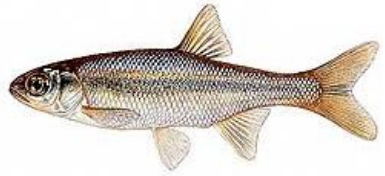

surface area 341 km² (212 miles²)
shoreline 239 km (148 miles)
YELLOWSTONE NATIONAL PARK
0 5 10 15 20 mi
0 5 10 15 20 25 30 km
N
To Livingston
89
191 To Bozeman
North Entrance
Gardiner
Electric Peak
Sepulcher Mtn.
MT
WY
Cutoff Mtn.
Silver Gate
Cooke City
212 To Red Lodge
Northeast Entrance
To Quake Lake
287
Mt. Holmes
Gneiss Cr.
Dunraven Pass
Mt. Washburn
Grand Canyon of the Yellowstone
Canyon Jct.
NORRIS GEYSER BASIN
Norris Jct.
Gibbon R.
Lamar River
Miller Cr.
Saddle Mtn.
Pyramid Peak
To Idaho Falls
20
West Yellowstone
West Entrance
Madison Junction
Madison R.
Firehole Canyon Dr.
Alum Cr.
Sour Cr.
HAYDEN VALLEY
MUD VOLCANO AREA
Yellowstone R.
Nez Perce Cr.
Trout
Pelican Cr.
Fishing Bridge Jct.
Cathedral Peak
LOWER GEYSER BASIN
Firehole Lake Dr.
MIDWAY GEYSER BASIN
Lake Village
Bridge Bay
East Entrance
14 16 20 To Cody
Sylvan Pass
UPPER GEYSER BASIN
Biscuit Basin
Black Sand Basin
Old Faithful Village
Craig Pass
YELLOWSTONE LAKE
WEST THUMB GEYSER BASIN
West Thumb Jct.
Grant Village
Mt. Langford
APPROXIMATE
CONTINENTAL DIVIDE
CALDERA BOUNDARY
SHOSHONE L.
Flat Mtn.
South Arm
Southeast Arm
Eagle Peak
LEWIS LAKE
HEART LAKE
Mt. Sheridan
Bechler R.
Boundary Cr.
CASCADE CORNER
THOROFARE CORNER
Lewis R.
Yellowstone R.
Snake River
Fall River
ID
WY
South Entrance
89 191 To Jackson
© 2000 J.O. Chapple
MONTANA
IDAHO
WYOMING

Yellowstone Lake Fish

Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*)
(406 mm; 19 inches)

longnose dace (*Rhinichthys cataractae*)
(102 mm; 4 inches)

longnose sucker (*Catostomus catostomus*)
(541 mm; 21 inches)

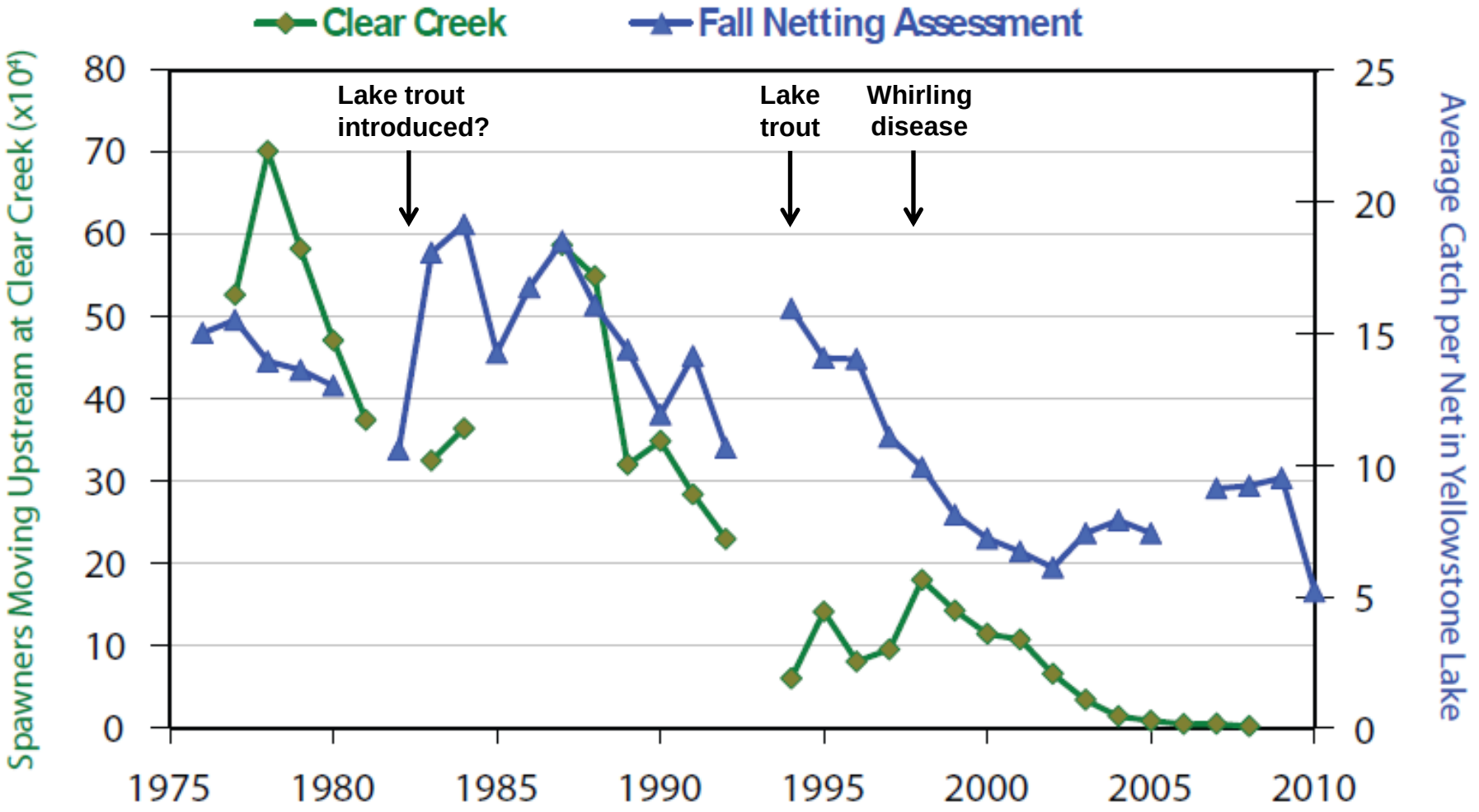


redside shiner (*Richardsonius balteatus*)
(127 mm; 5 inches)

lake chub (*Couesius plumbeus*)
(140 mm; 5.5 inches)

lake trout (*Salvelinus namaycush*)
(up to 903 mm; 36 inches)

Observed Declines in Cutthroat Trout in Yellowstone Lake



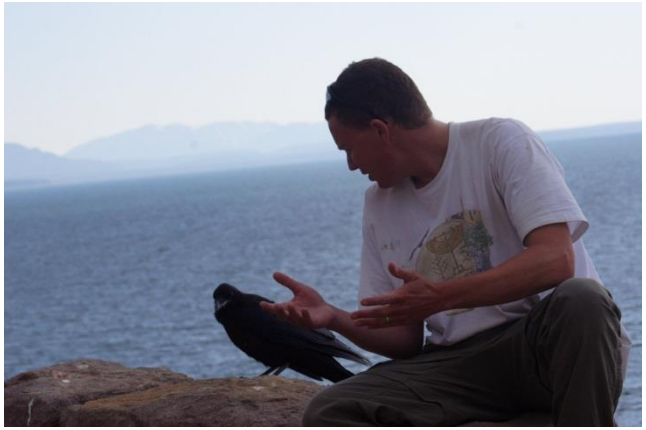
Koel et al. 2012

Sampling effort

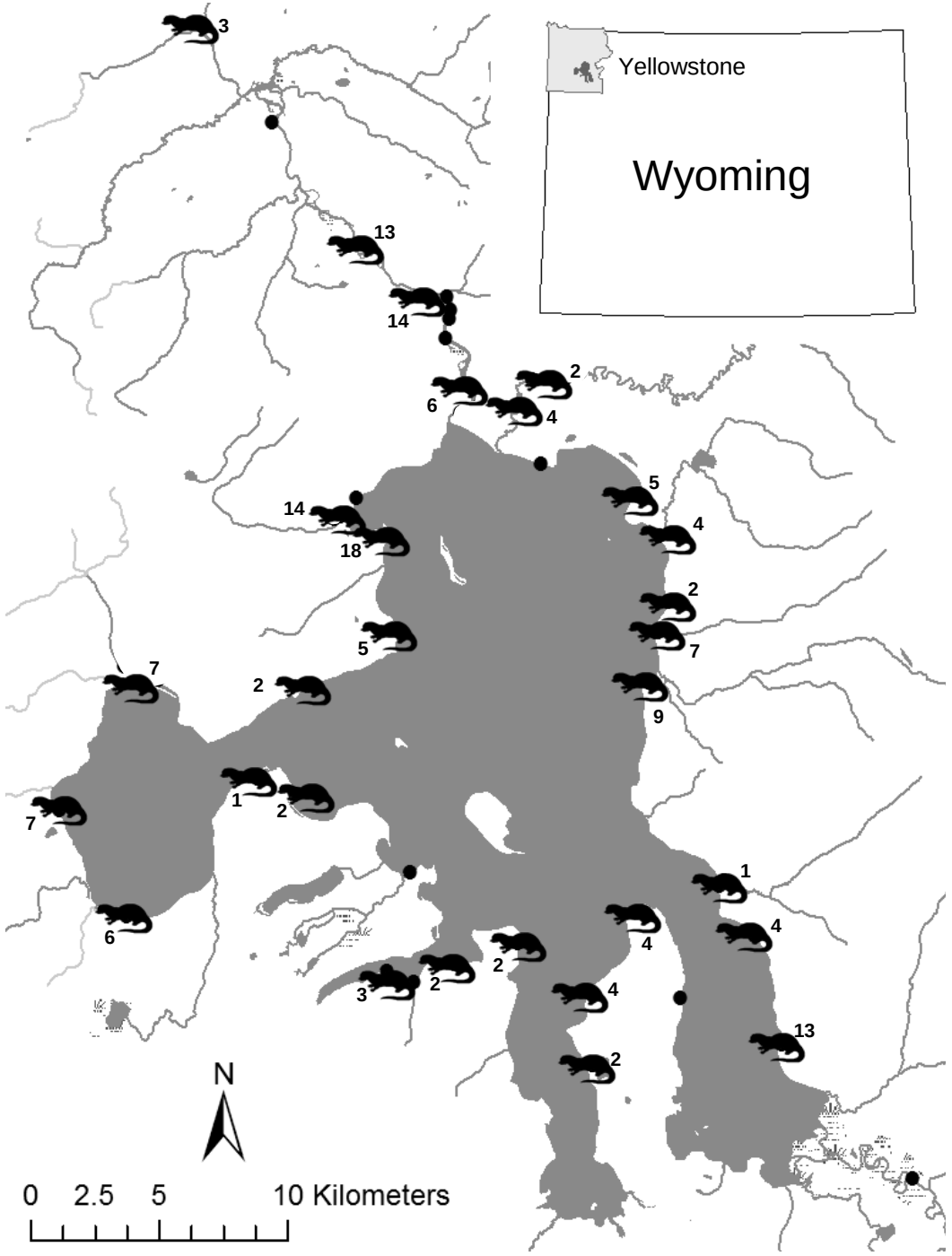
Summer 2002-2003 & 2005-2010

<u>94 otter latrines</u>
(52 on streams,
42 on lake)

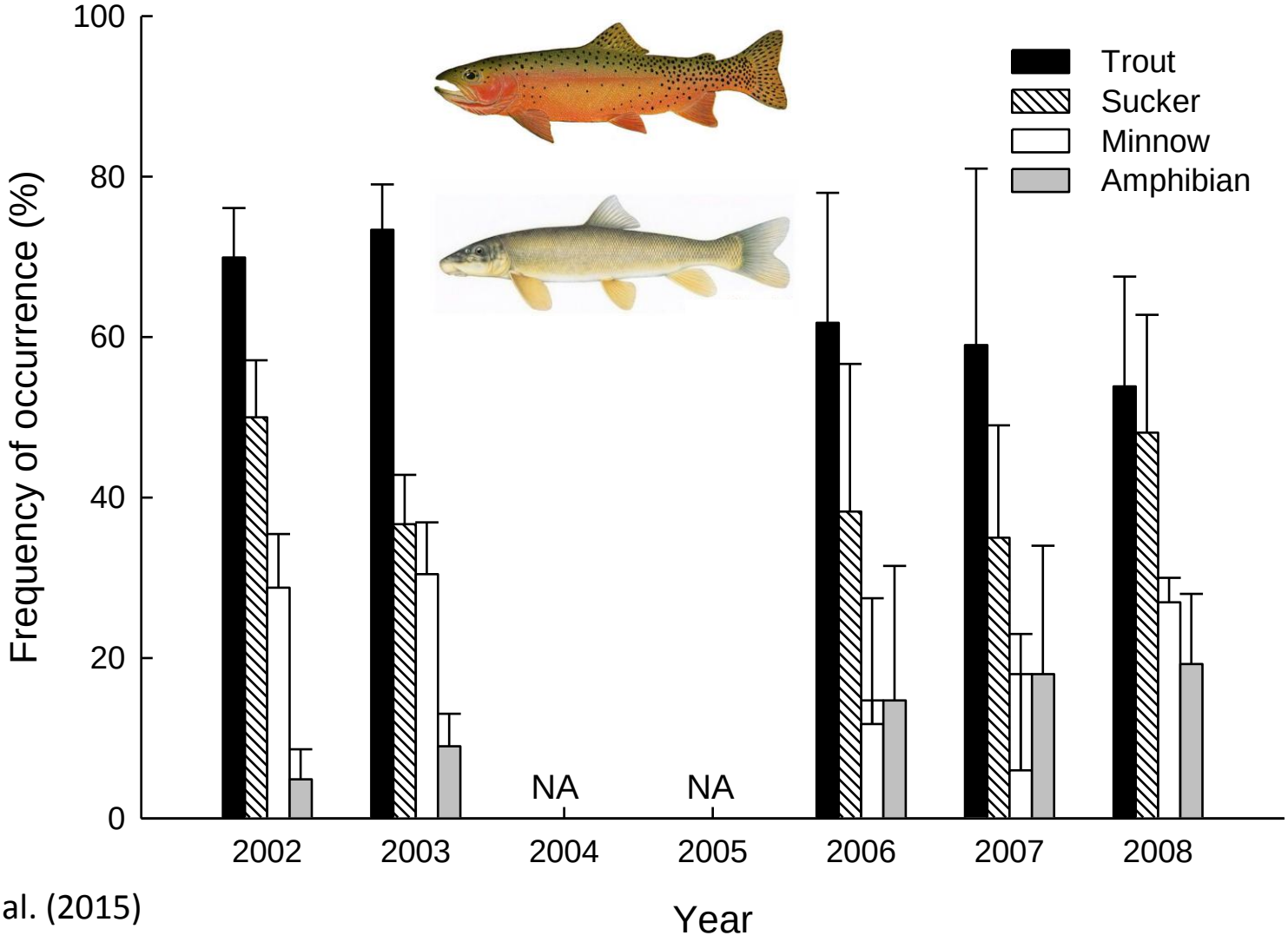
<u>Survey length</u>
Streams: 52.8 km
Lake: 203 km



Jamie Crait

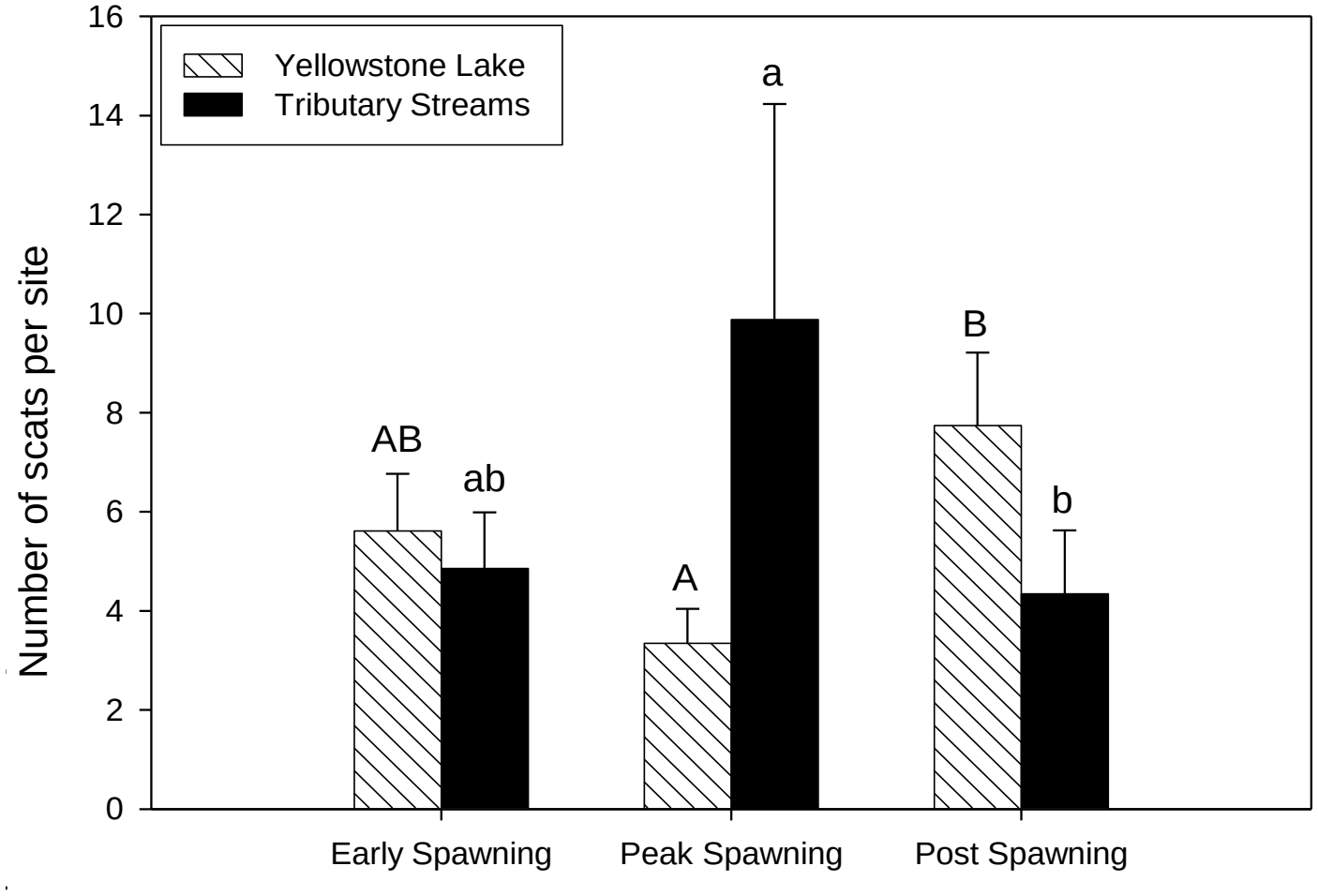


Cutthroat trout are the main prey for river otters in Yellowstone Lake but declined in otter feces from 73% to 53%



Crait et al. (2015)

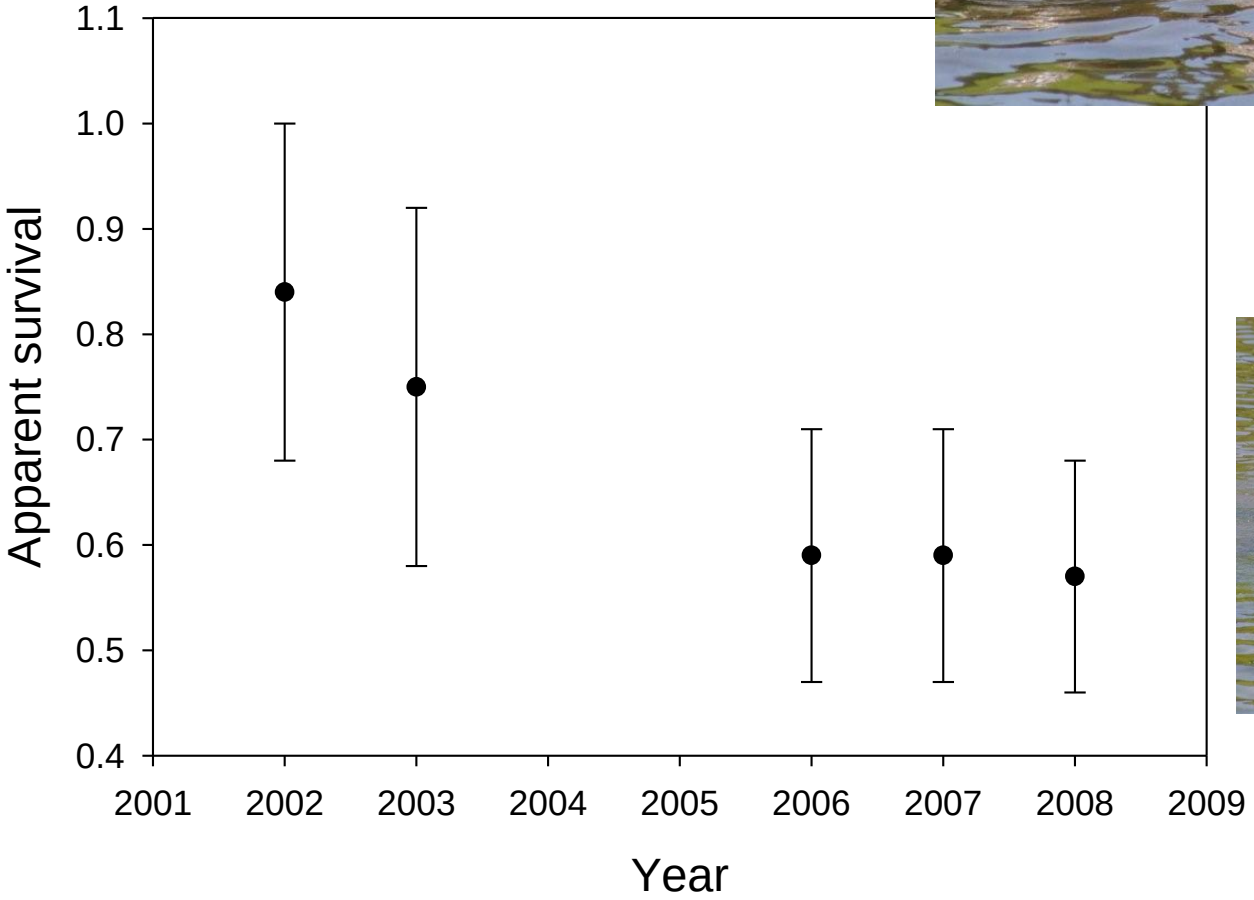
Otters follow the movement of spawning cutthroat trout to tributary streams

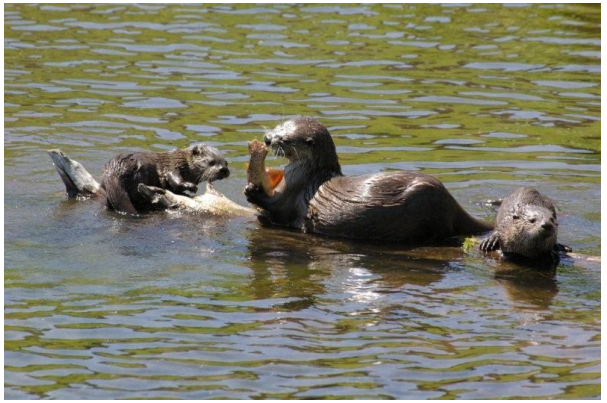


Crait and Ben-David (2006)


Cindy Goeddel PHOTOGRAPHY

Otter survival declines with reductions in spawning cutthroat trout

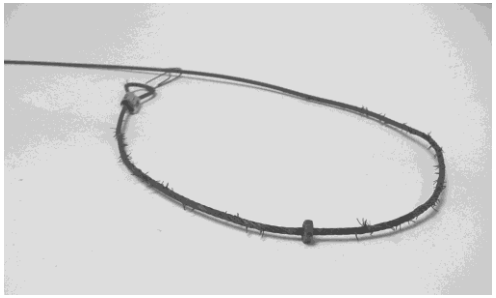




Crait et al. (2015)

How many river otters?

Capture re-capture population estimates from non-invasive genetic sampling



DePue and Ben-David (2007)

Site	Date	Lab ID	733		701		801		829		Rio-01		Rio-05		Rio-17		Rio-19	
LP06111	6/13/2006	PWS234	172	180	206	206	230	234	236	240	280	F	342	351	171	171	272	280
LP06111	6/13/2006	PWS103	172	180	206	206	230	234	236	240	280	284	342	351	171	171	272	280
HB06074	6/2/2006	PWS425	180	188	202	206	234	234	240	244	280	F	0	0	171	175	272	280
HB06021	7/5/2006	PWS703	180	188	202	206	234	234	240	244	280	288	339	345	171	175	272	280
HB06067	7/7/2006	PWS129	180	188	202	206	234	234	240	244	280	288	339	F	171	175	272	280
HB06004	8/10/2006	PWS547	180	188	202	206	234	234	240	244	280	288	345	F	171	175	272	280
HB06015	7/18/2006	PWS952	180	188	202	206	234	234	240	244	280	288	345	F	171	175	272	280
HB06203	6/28/2006	PWS025	180	188	198	202	234	234	240	244	280	284	327	351	171	175	272	280
LP06111	6/13/2006	PWS112	180	188	198	202	234	234	240	244	280	284	327	351	171	175	272	280
HB06182	6/26/2006	PWS013	180	188	198	202	234	234	240	244	280	284	327	351	171	175	272	280
HB06119	7/6/2006	PWS311	180	188	198	202	234	234	244	F	280	284	327	351	171	175	272	280
HB06183	8/12/2006	PWS582	180	188	202	F	234	234	240	244	280	284	327	351	171	175	272	280
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HB06185	5/24/2026	PWS200	180	188	202	206	234	234	244	244	280	288	0	0	171	175	272	280
HB06060	7/7/2006	PWS143	180	188	202	206	234	234	244	244	280	288	336	339	171	175	272	280
LP06005	6/3/2006	PWS490	180	188	202	206	234	234	244	F	280	288	336	339	171	175	272	280
HB06004	8/10/2006	PWS772	180	188	202	206	230	234	236	240	280	284	336	339	171	175	280	280
HB06004	8/10/2006	PWS779	180	188	202	206	230	234	236	240	280	284	336	339	171	175	280	280
HB06004	7/5/2006	PWS572	180	188	206	206	230	234	240	248	280	288	336	342	171	175	280	288
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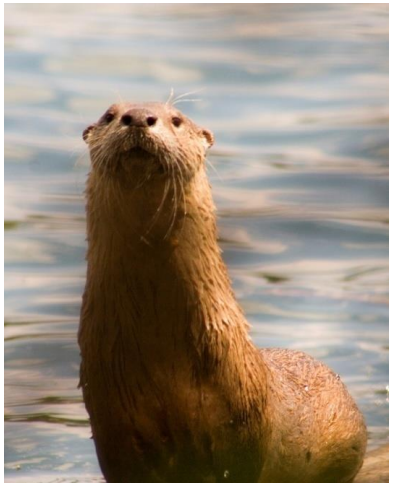
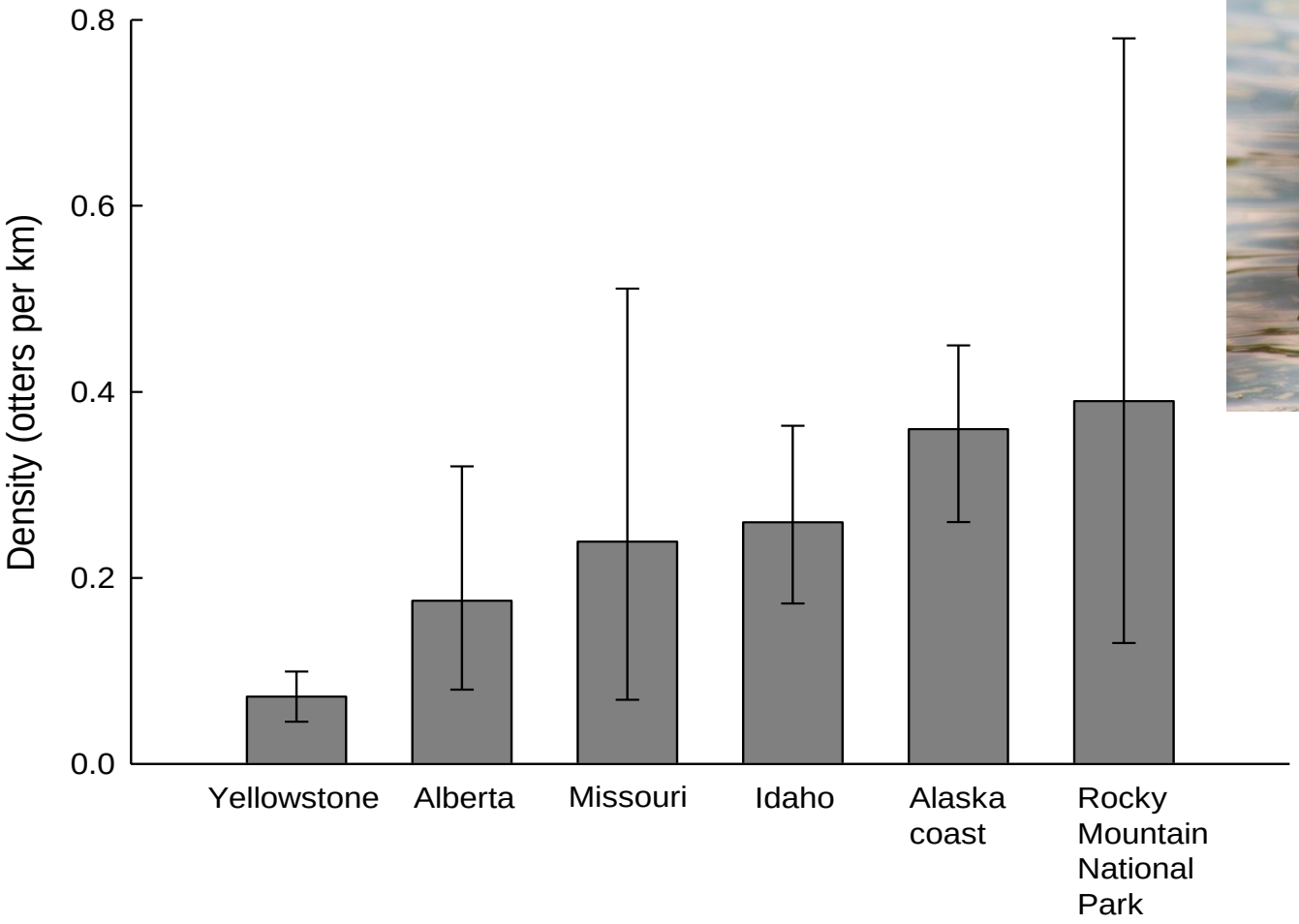
LP06111	6/5/2006	PWS115													171	177	272	272
EI06018	67/23/06	PWS699													171	177	272	272
EI06001	6/13/2006	PWS228													171	177	272	272
HB06070	6/19/2006	PWS074	172	180	202	206	230	234	240	244	288	292	342	348	171	175	272	280
LP06014	6/29/2006	PWS020	172	180	202	206	230	234	240	244	288	292	342	348	171	175	272	280
HB06207	5/25/2006	PWS450	180	180	202	202	230	230	240	248	280	292	0	0	171	177	272	280
HB06067	7/7/2006	PWS137	180	180	202	202	230	230	240	248	280	292	339	351	171	177	272	280
LP06005	6/3/2006	PWS610	180	180	202	202	230	230	240	248	280	292	339	351	171	177	272	280
EI06001	6/14/2006	PWS260	180	184	206	206	230	234	236	240	280	288	342	351	171	177	272	284

010011010

Otter density in Yellowstone Lake is the lowest recorded

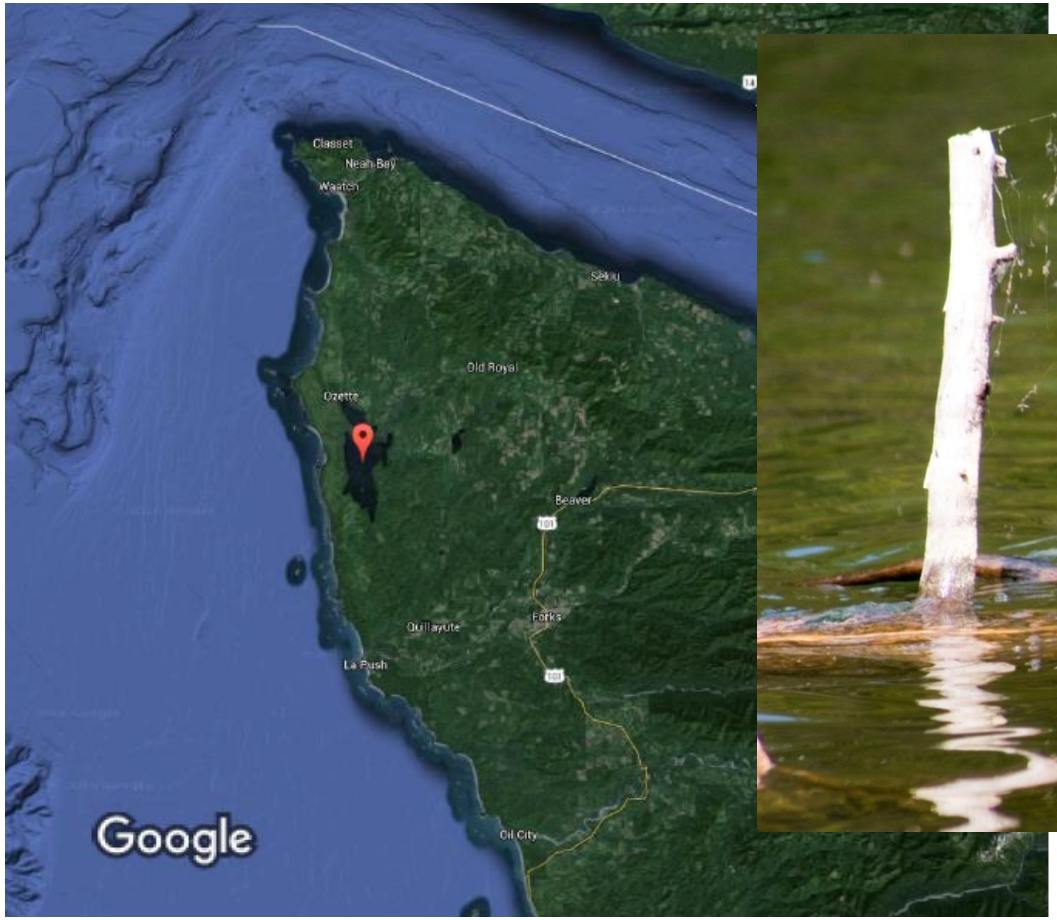


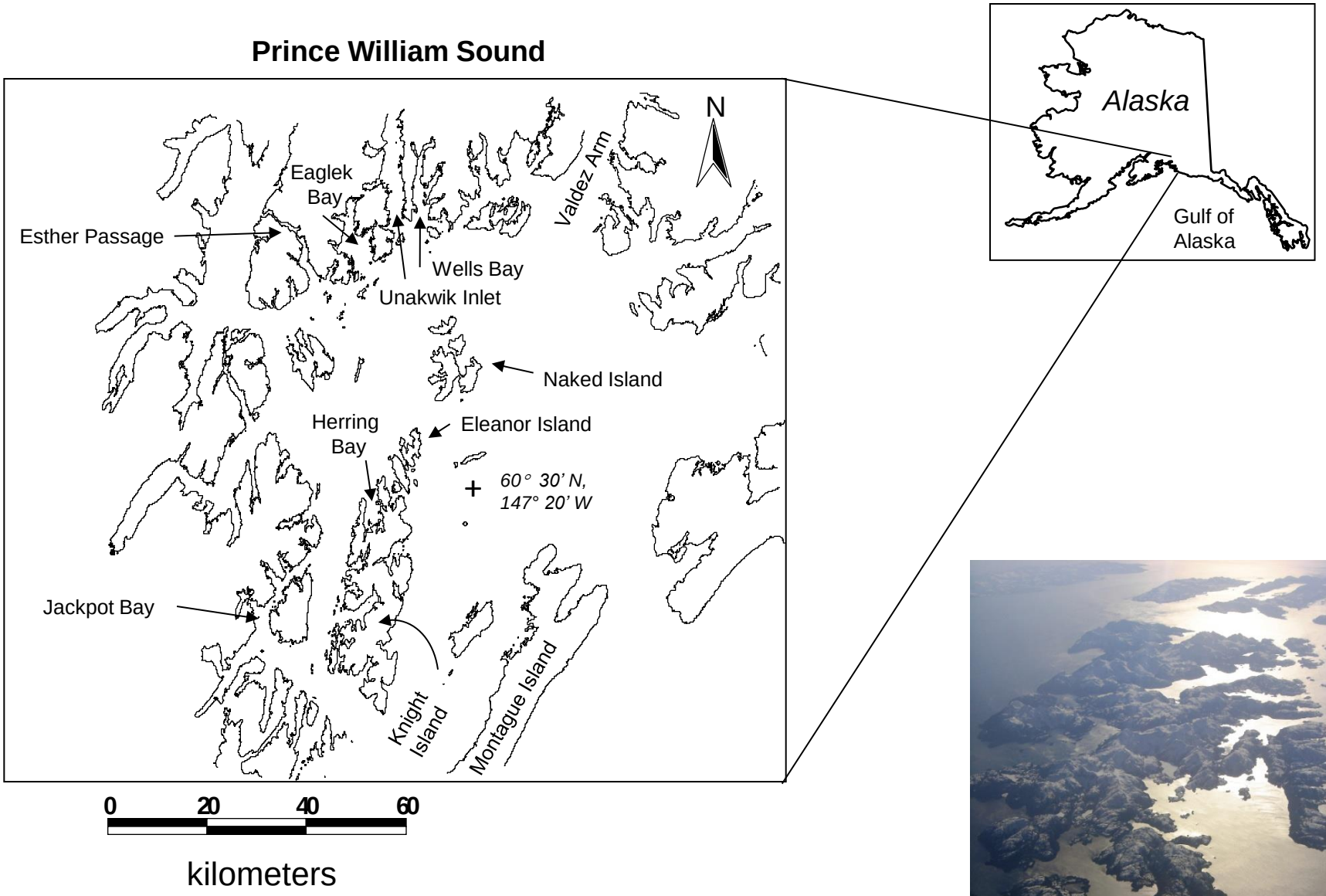


How many cutthroat trout are consumed by otters in Yellowstone Lake?

- A 10 kg otter would consume about 1 kg of fish daily (10% of body mass)
- A 20 – 40 cm cutthroat trout weighs 2 – 4 kg
- At 73% of the diet in 365 days an otter will consume _266_____
- A population of 24 (18 – 30) otters will eat _____6,384_____ each year

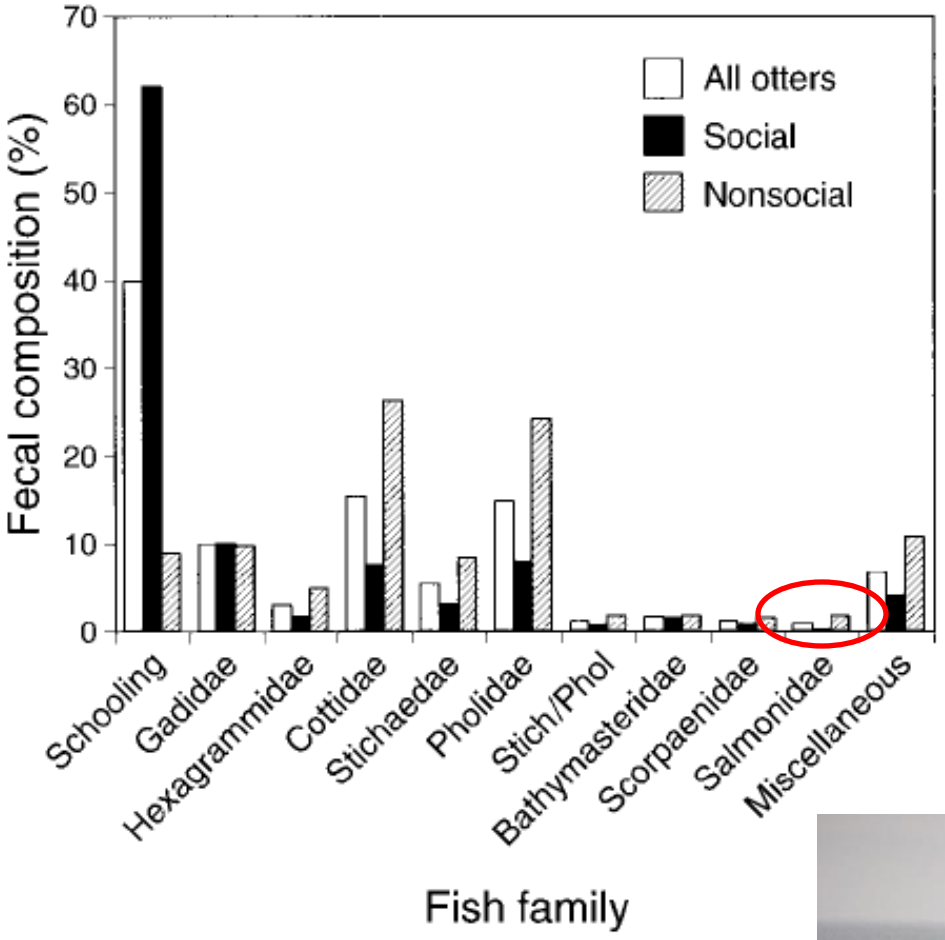
Lake Ozette, Washington, is less than 5 km (3 mi) from the coast





Coastal Alaska

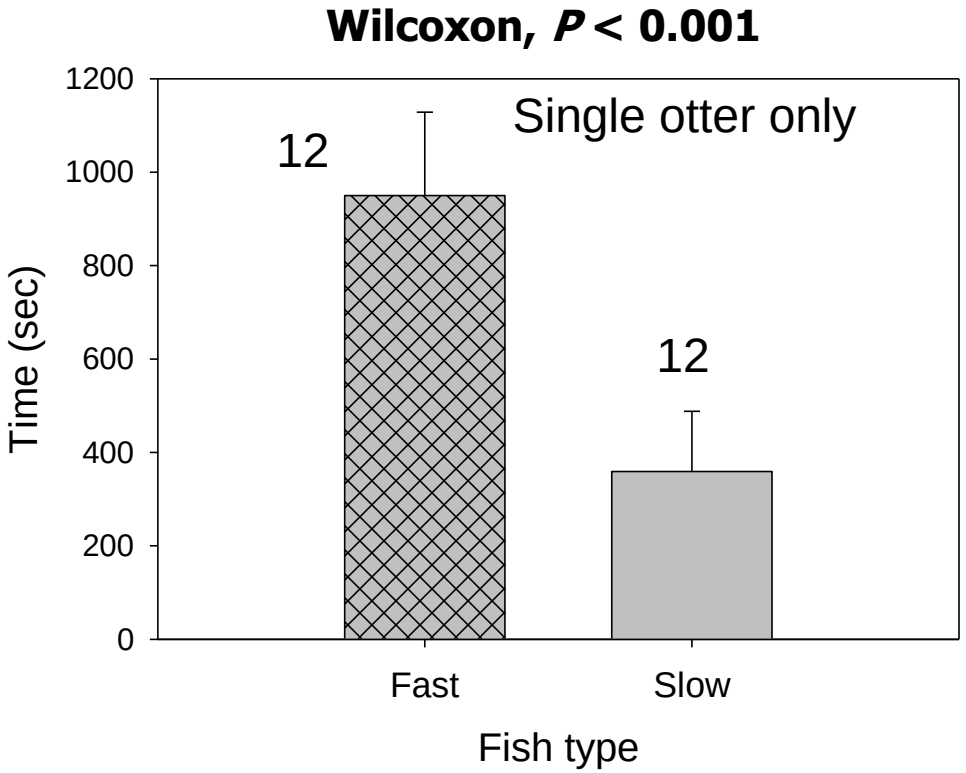
Coastal river otters follow spawning migrations of salmon up river

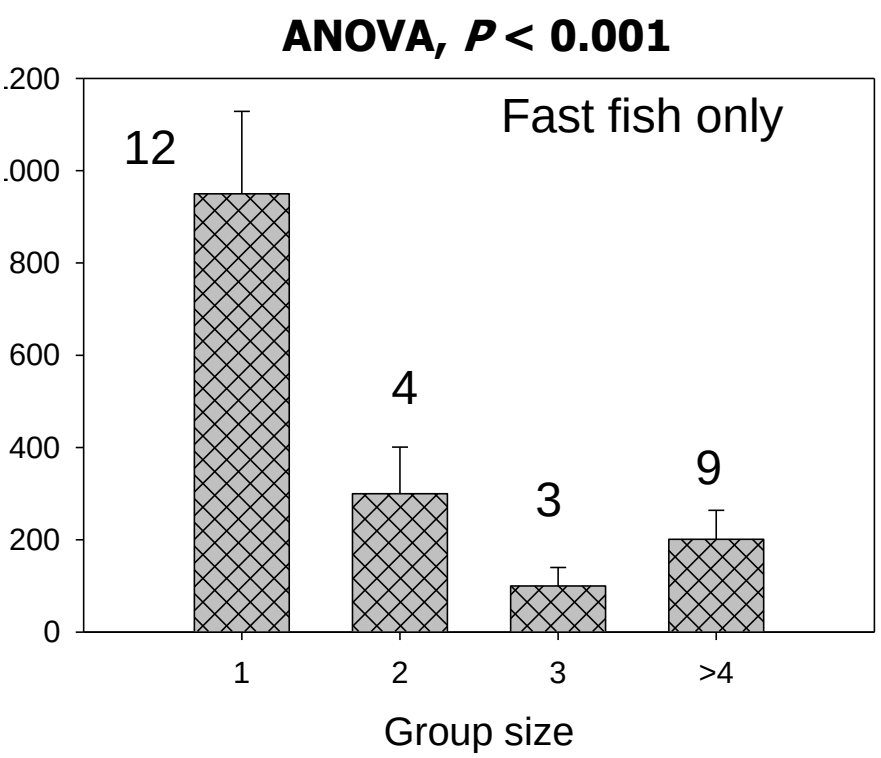


River otters feed on inter- and sub-tidal fish and consume schooling pelagic fishes when they become available in the nearshore environment. But salmonids constitute a small fraction of their diet.

Ben-David et al. (2005)

Foraging success (time to first capture) of captive river otters is a function of fish type and group size

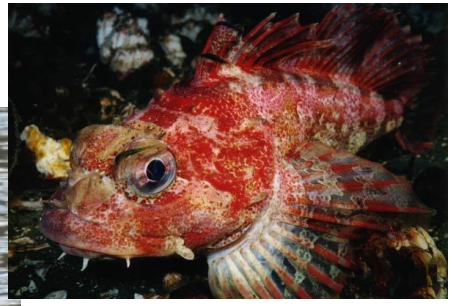


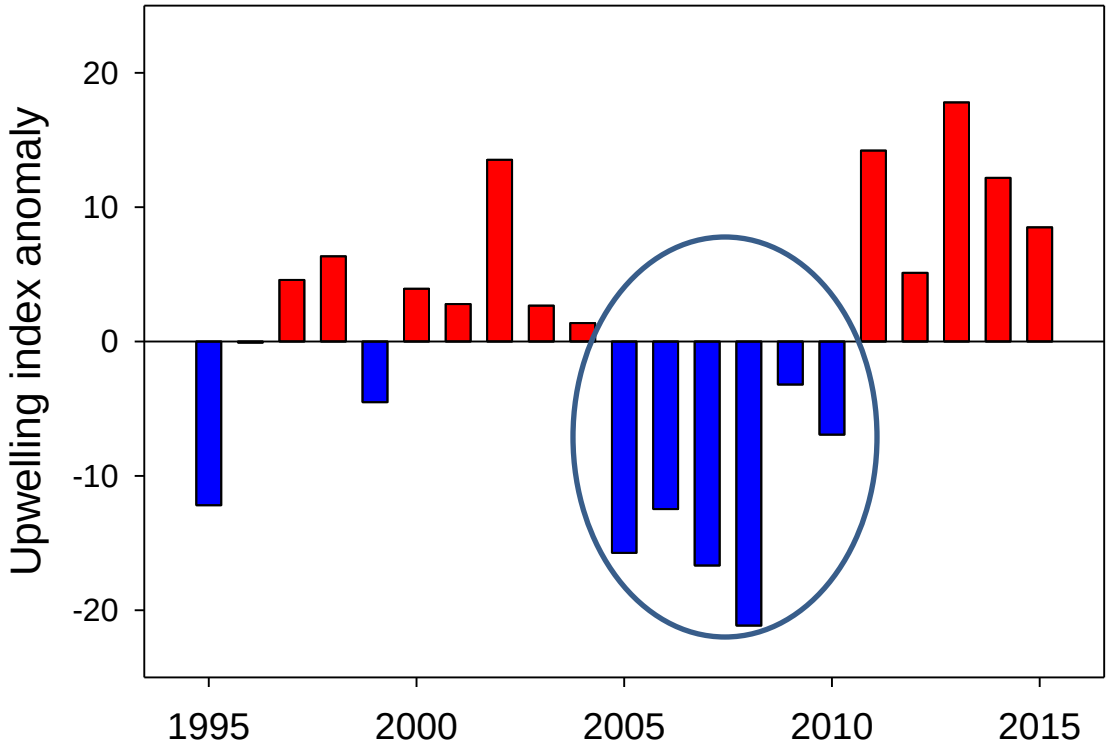


Ben-David *Unpublished Data*

Which is why coastal river otters form large groups (of males!!!)

Coastal river otters are subsidized by marines resources

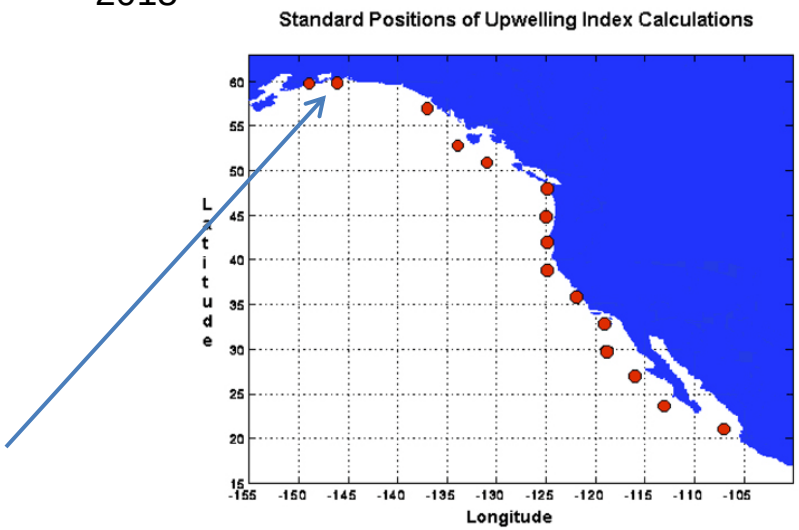




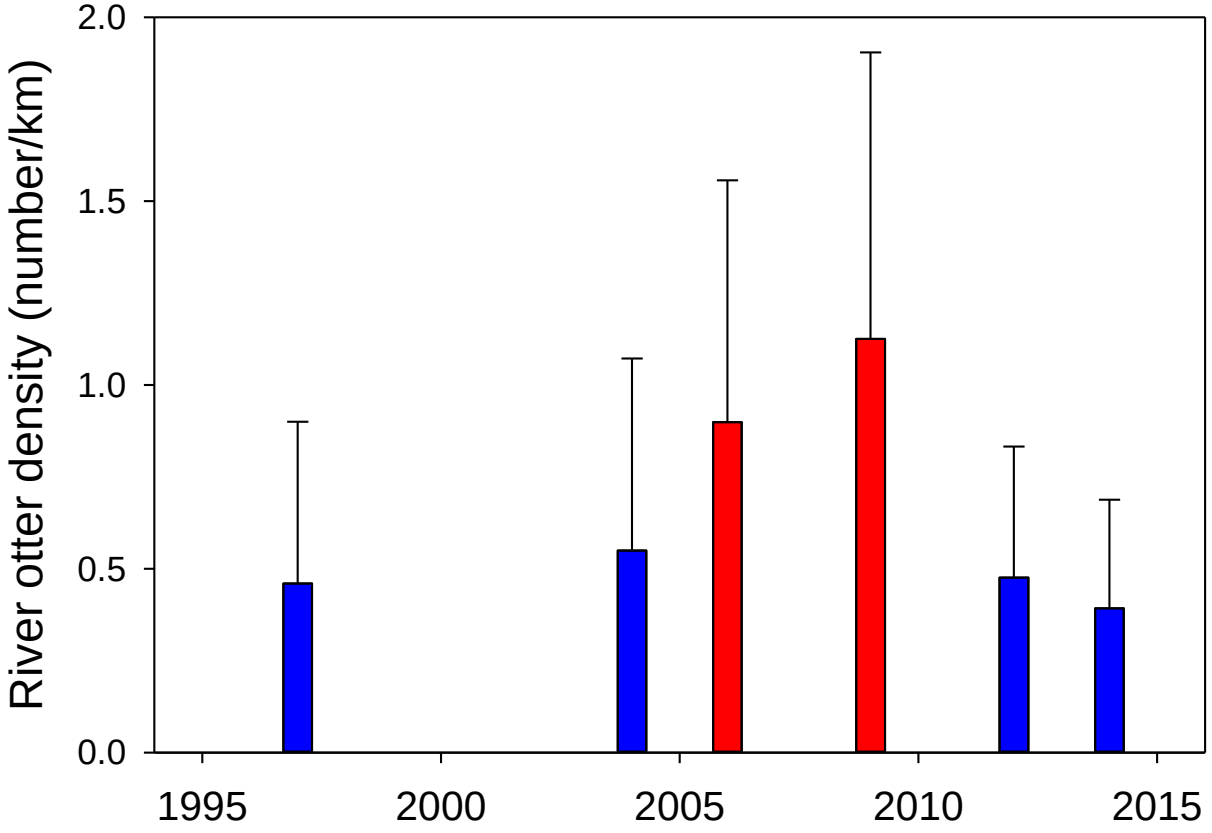
Regime shift in the Gulf of Alaska identified around 2007-2008

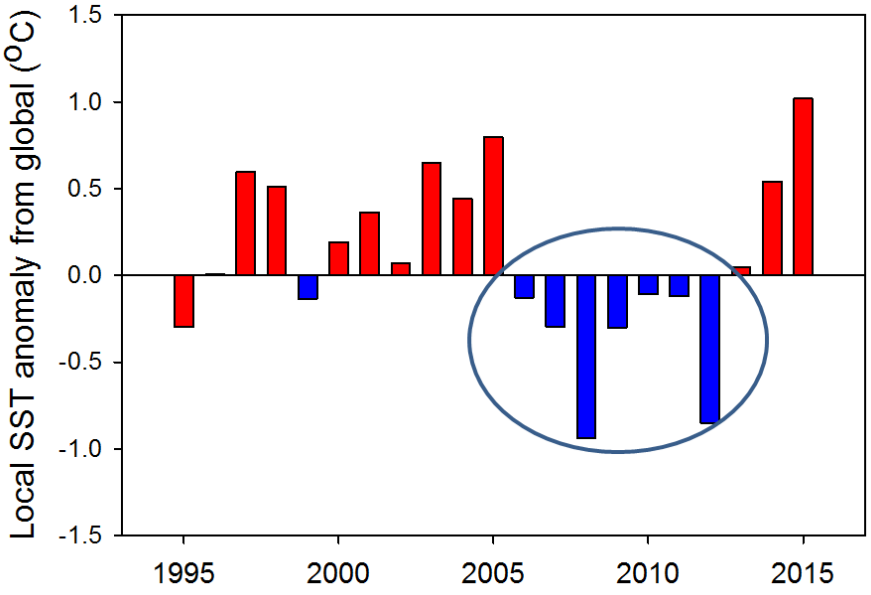
Litzow et al. (2014)

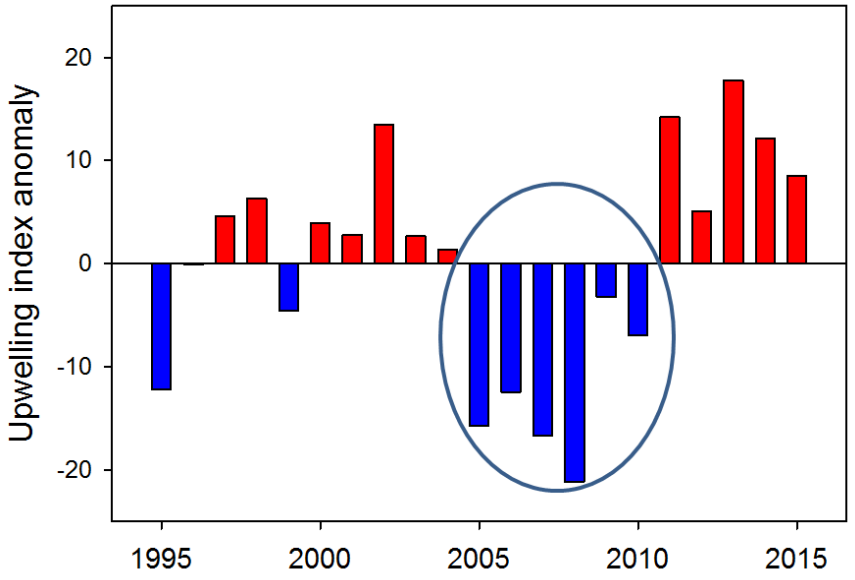
http://www.pfeg.noaa.gov/products/PFEL/

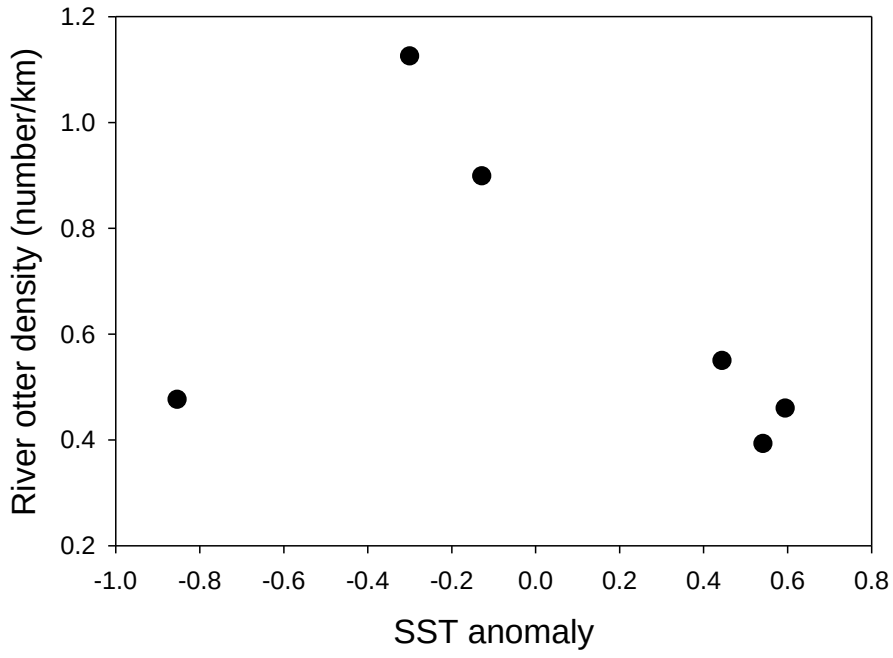


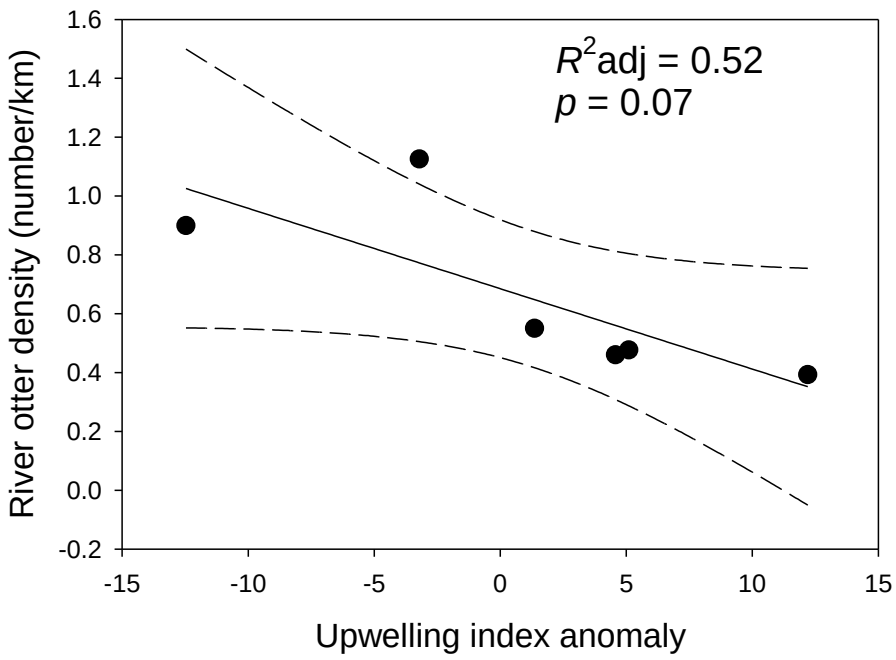
River otter density calculated from spatially explicit capture-recapture data




Local SST anomaly from global (°C)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
1995
2000
2005
2010
2015


Upwelling index anomaly
20
10
0
-10
-20
1995
2000
2005
2010
2015


River otter density (number/km)
1.2
1.0
0.8
0.6
0.4
0.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
SST anomaly


R^2adj = 0.52
p = 0.07
River otter density (number/km)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-15
-10
-5
0
5
10
15
Upwelling index anomaly

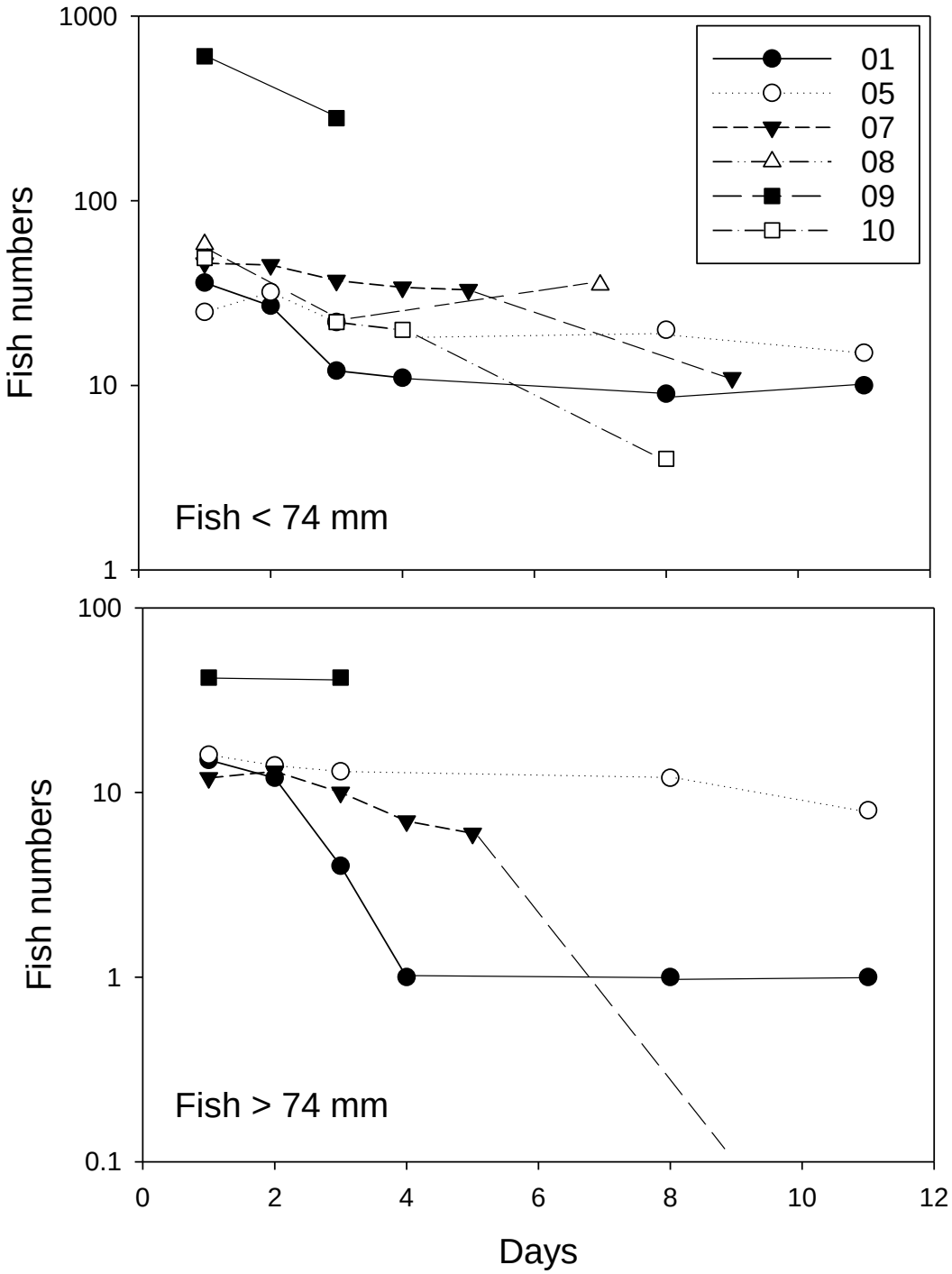
How many **adult** sockeye salmon are consumed by otters in Lake Ozette?

- A 10 kg otter would consume about 1 kg of fish daily (10% of body mass)
- A 20 – 40 cm sockeye salmon weighs 2 – 4 kg
- At ?% of the diet in 365 days an otter will consume _____
- A population of ?? (?? – ??) otters will eat _____ each year

Otter predation on juvenile salmonids?

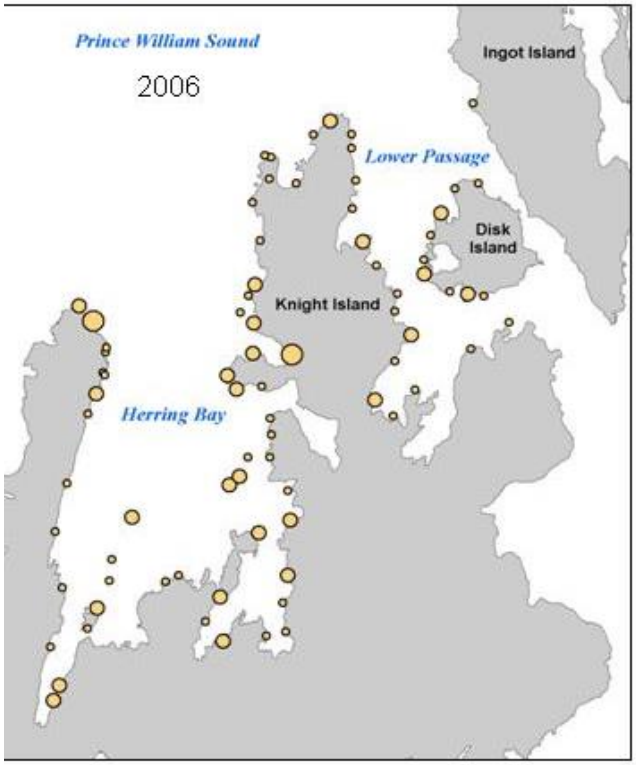
- Preferred prey size 80 – 150 mm
- Otters eat 10% of body mass each day
- Most Juvenile salmonids smolt at smaller size

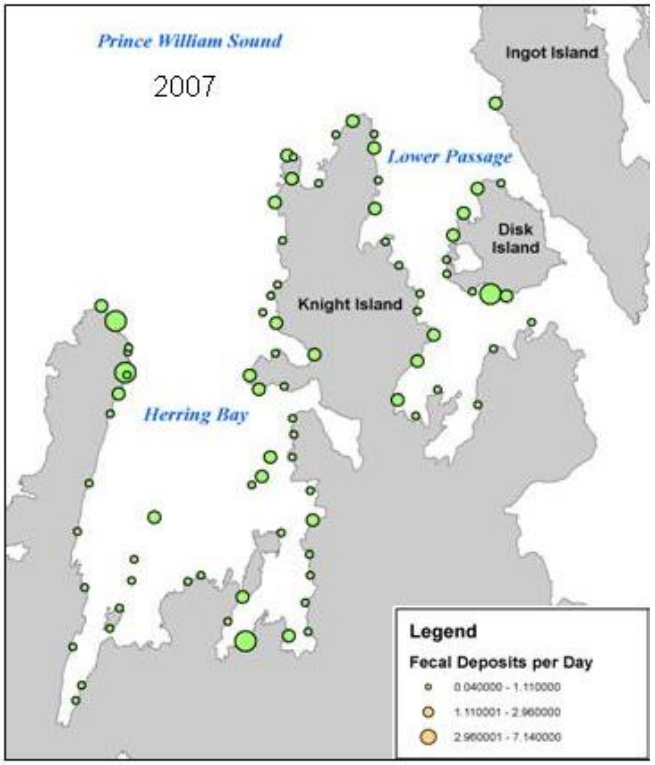
Predation on juvenile salmonids is enhanced in off-channel ponds



Pond No.	Date	Predator			
		Mink	Otter	Merganser	Bald eagle
Beaver pond	July 1	+	+	-	-
01	July 5	-	-	-	-
	July 6	+	-	-	-
	July 8	-	-	++	-
	July 17	+	+	-	-
05	July 8	+	+	-	-
07	July 12	+	-	+	-
	July 14	p	-	-	-
	July 15	+	-	-	-
	July 16	p	-	-	-
	July 17	+	-	-	-
10	July 13	+	-	-	+
	July 17	-	-	-	++

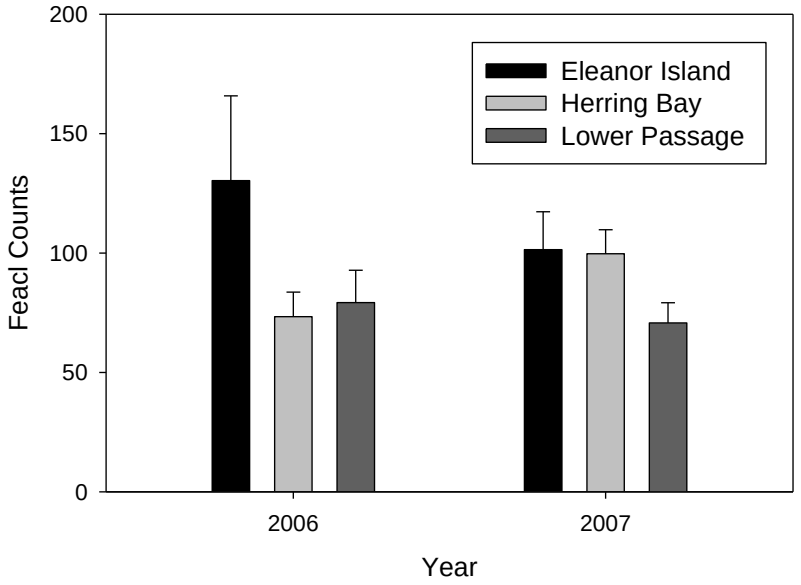
Removal (“lethal translocation”) of river otters from Lake Ozette?





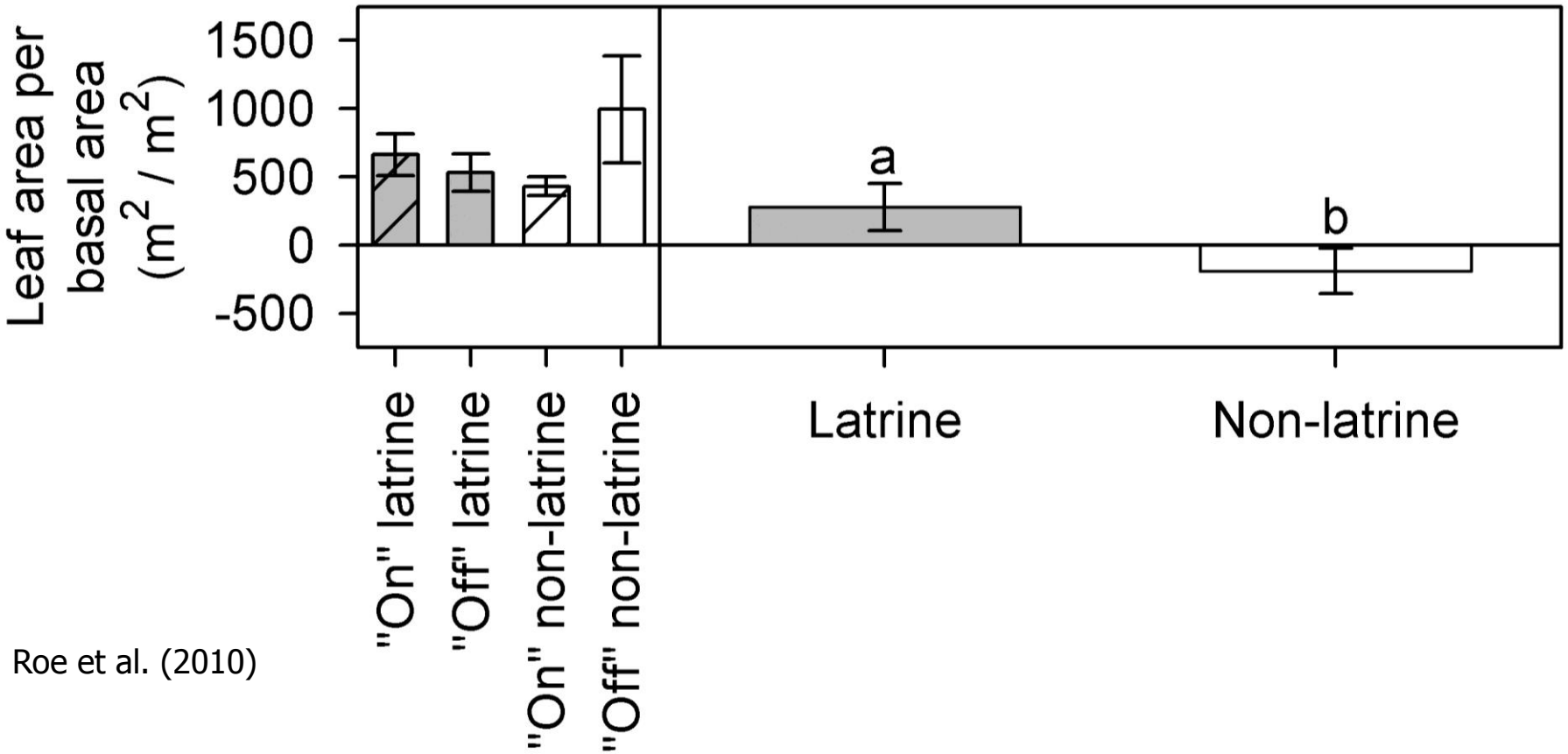
Because of changes in abundance and sociality, otter nutrient transports vary in space and time

Ott et al. *In prep.*

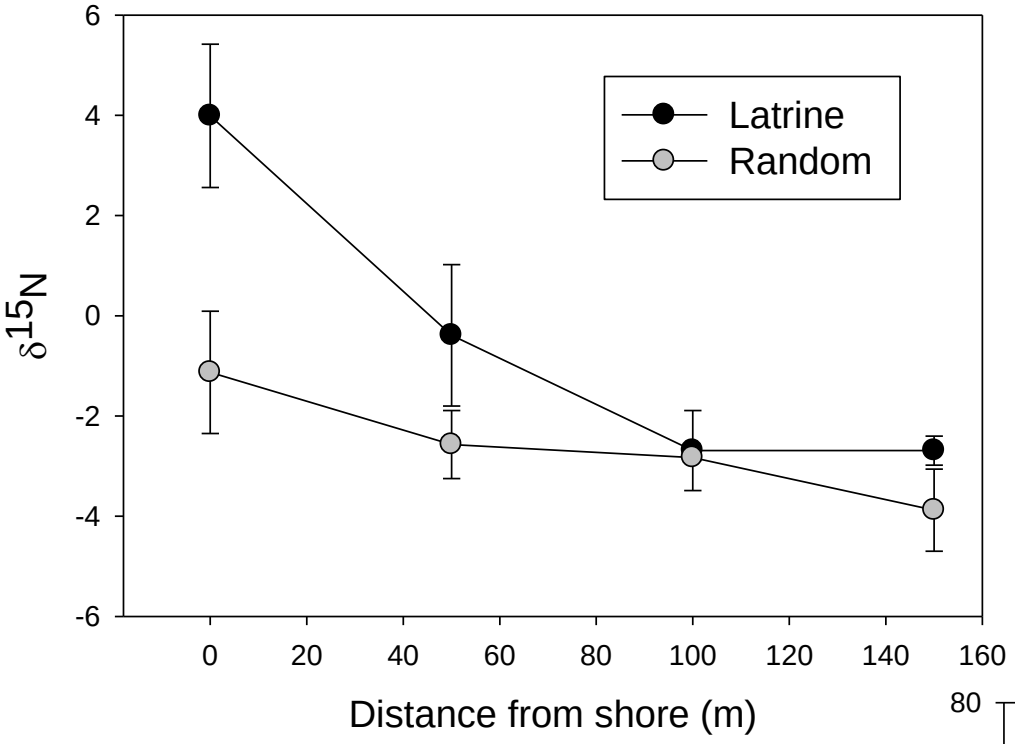


Aaron Roe

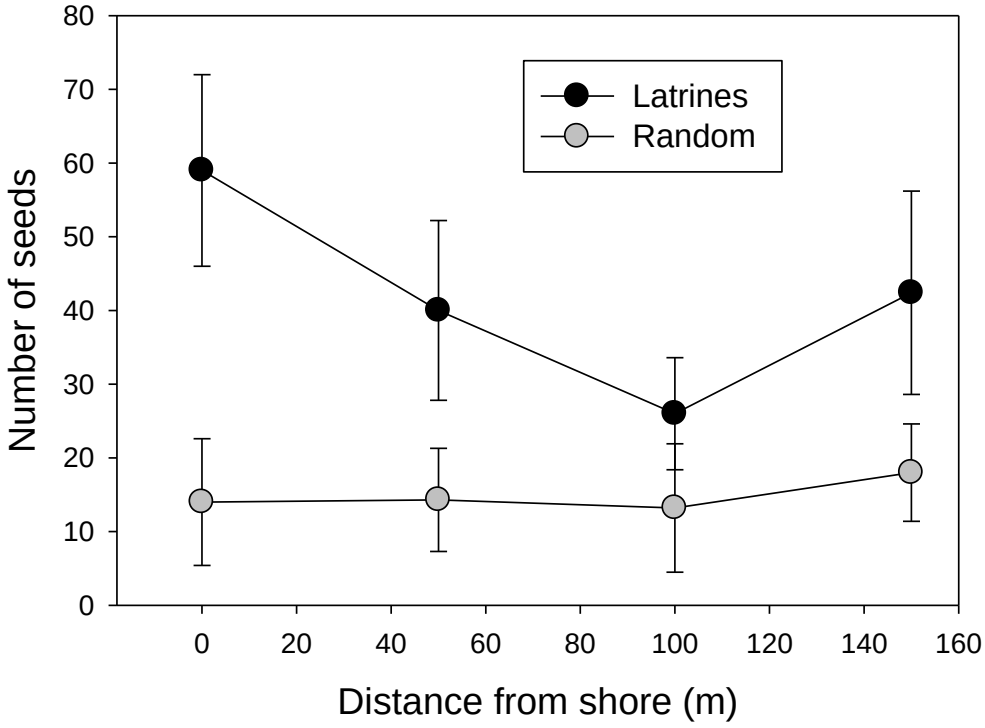
Otter fertilization enhances photosynthetic capacity of trees



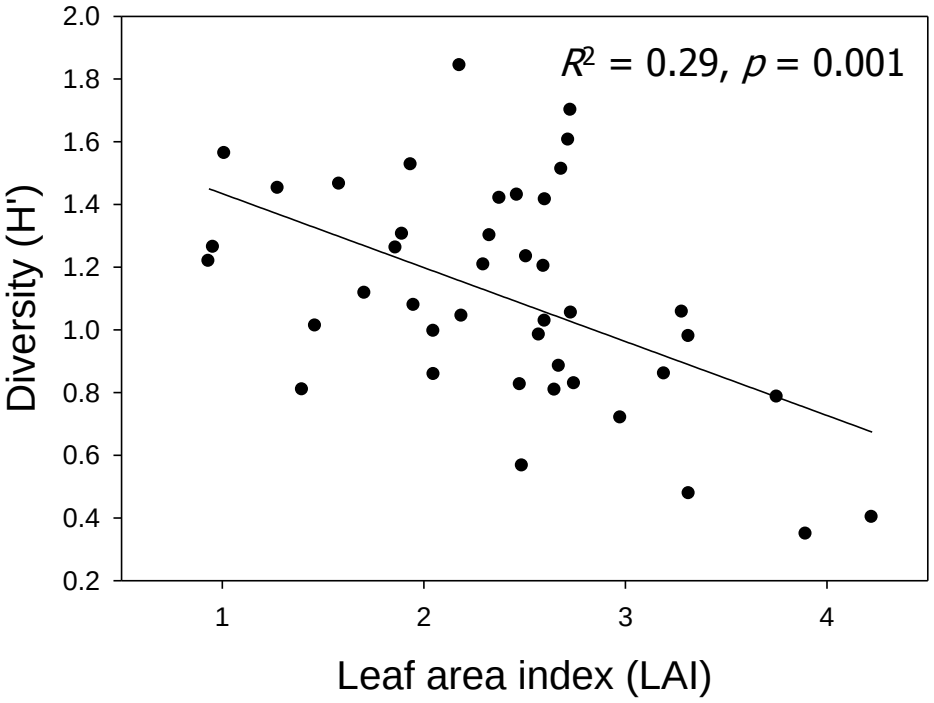
Roe et al. (2010)



Otter fertilization enhances seed production of trees



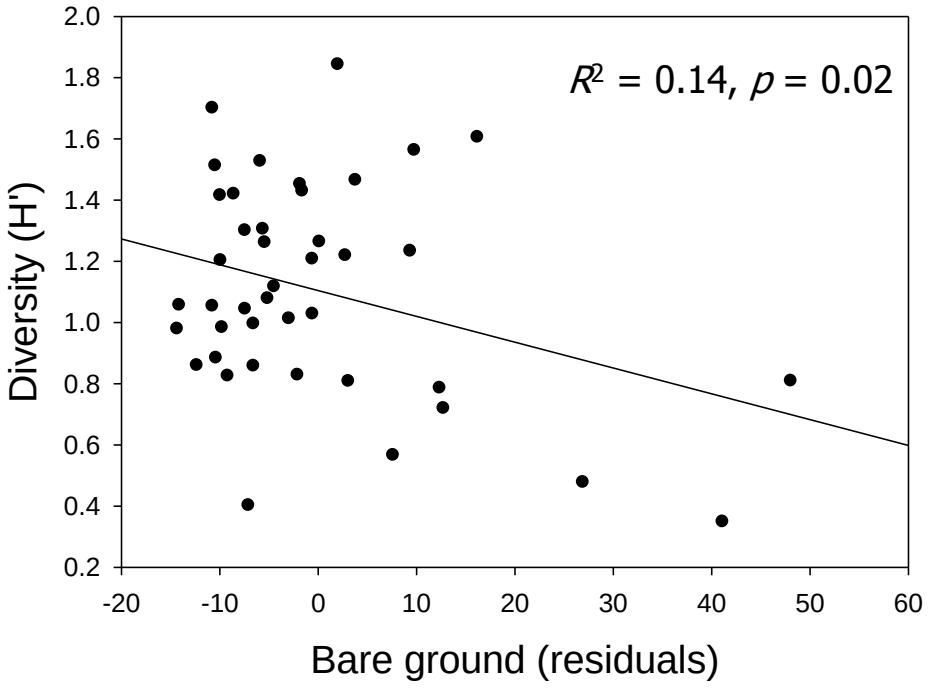
Ben-David et al. *In prep.*



Roe et al. *In prep.*

Otter disturbance and fertilization affect plant diversity

Roe et al. *In prep.*



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