May 2nd, 10:30 AM - 12:00 PM

Variation in juvenile Chinook salmon diet composition and foraging success between two estuaries with contrasting land-use histories

Aaron David
University of Washington, aarontdavid@yahoo.com

Charles Simenstad
University of Washington. School of Aquatic and Fishery Science

Jeffrey R. Cordell
University of Washington

Jason David Toft
University of Washington

Christopher Ellings
Nisqually Indian Tribe

See next page for additional authors

Speaker
Aaron David, Charles Simenstad, Jeffrey R. Cordell, Jason David Toft, Christopher Ellings, Ayesha Gray, and Hans B. Berge

Wetland loss and juvenile Chinook salmon foraging performance in Salish Sea (and other) estuaries

Aaron David[1], Charles Simenstad[1], Jeffery Cordell[1], Jason Toft[1], Christopher Ellings[2], Ayesha Gray[3], Hans Berge[4]

[1]University of Washington, School of Aquatic and Fishery Sciences

[2]Nisqually Indian Tribe, Department of Natural Resources

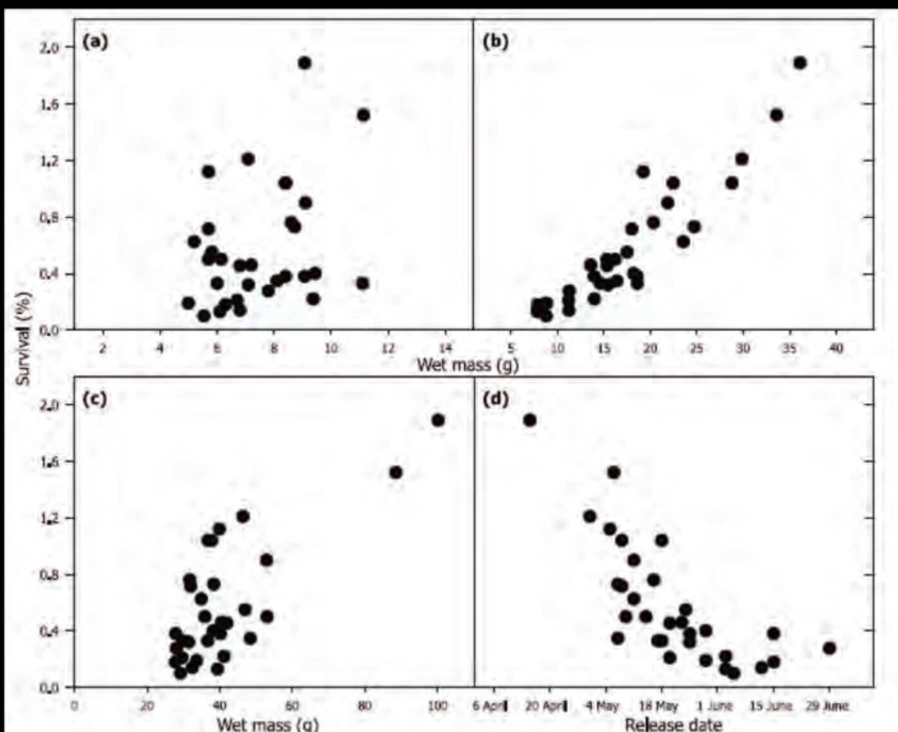
[3]Earth Design Consultants

[4]King County, Water and Land Resource Division

A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change

R.J. Beamish [a,*], Conrad Mahnken [b]

[a] Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC, V9R 5K6, Canada
[b] National Marine Fisheries Service, 7305 Beach Drive East, Port Orchard, WA 98366, USA



From Duffy and Beauchamp (2011)

Size Selective Predation Among Juvenile Salmonid Fishes in a British Columbia Inlet

ROBERT R. PARKER

Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

1513

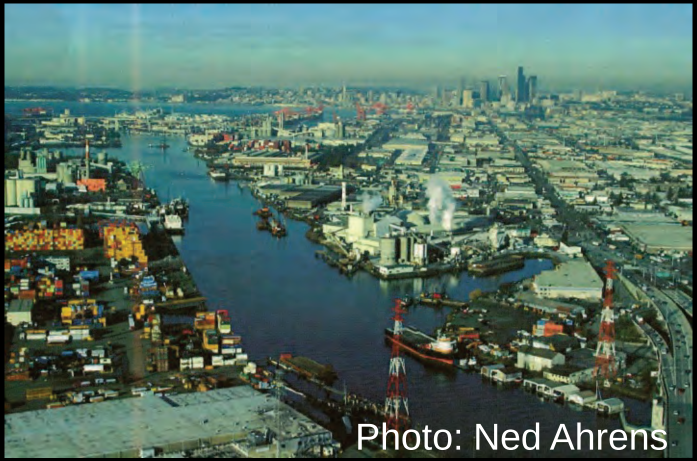
Over-winter lipid depletion and mortality of age-0 rainbow trout (*Oncorhynchus mykiss*)

Peter A. Biro, Ashley E. Morton, John R. Post, and Eric A. Parkinson

Estuaries provide productive foraging opportunities



But human impacts to estuaries may affect juvenile salmon foraging performance

Wetland loss/
modification

Reduced invertebrate populations

Shifts in invertebrate assemblages

Reduced salmon foraging performance

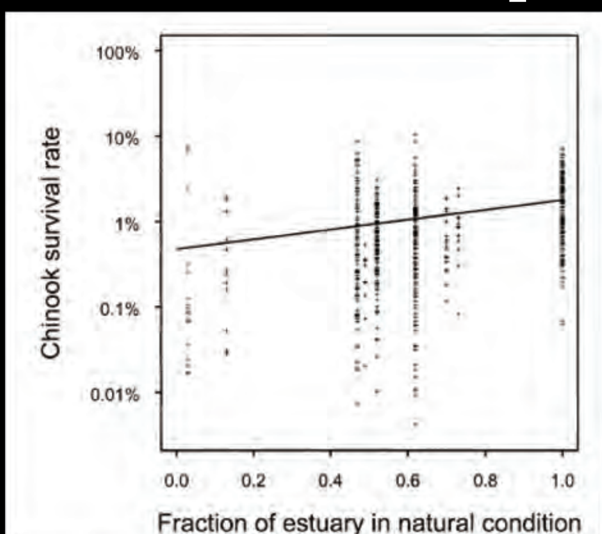
?

?

Reduced juvenile salmon growth

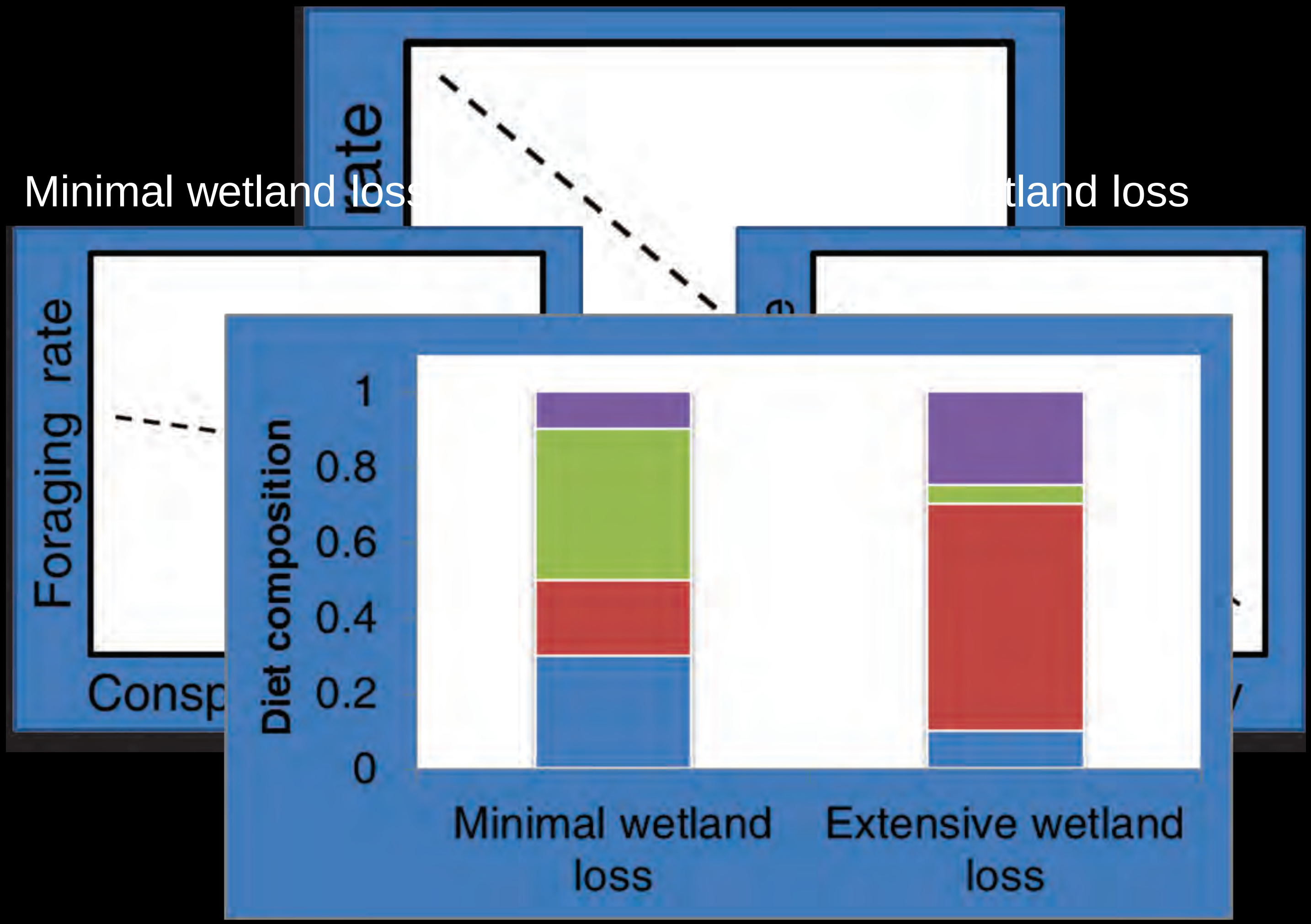
Density of conspecifics

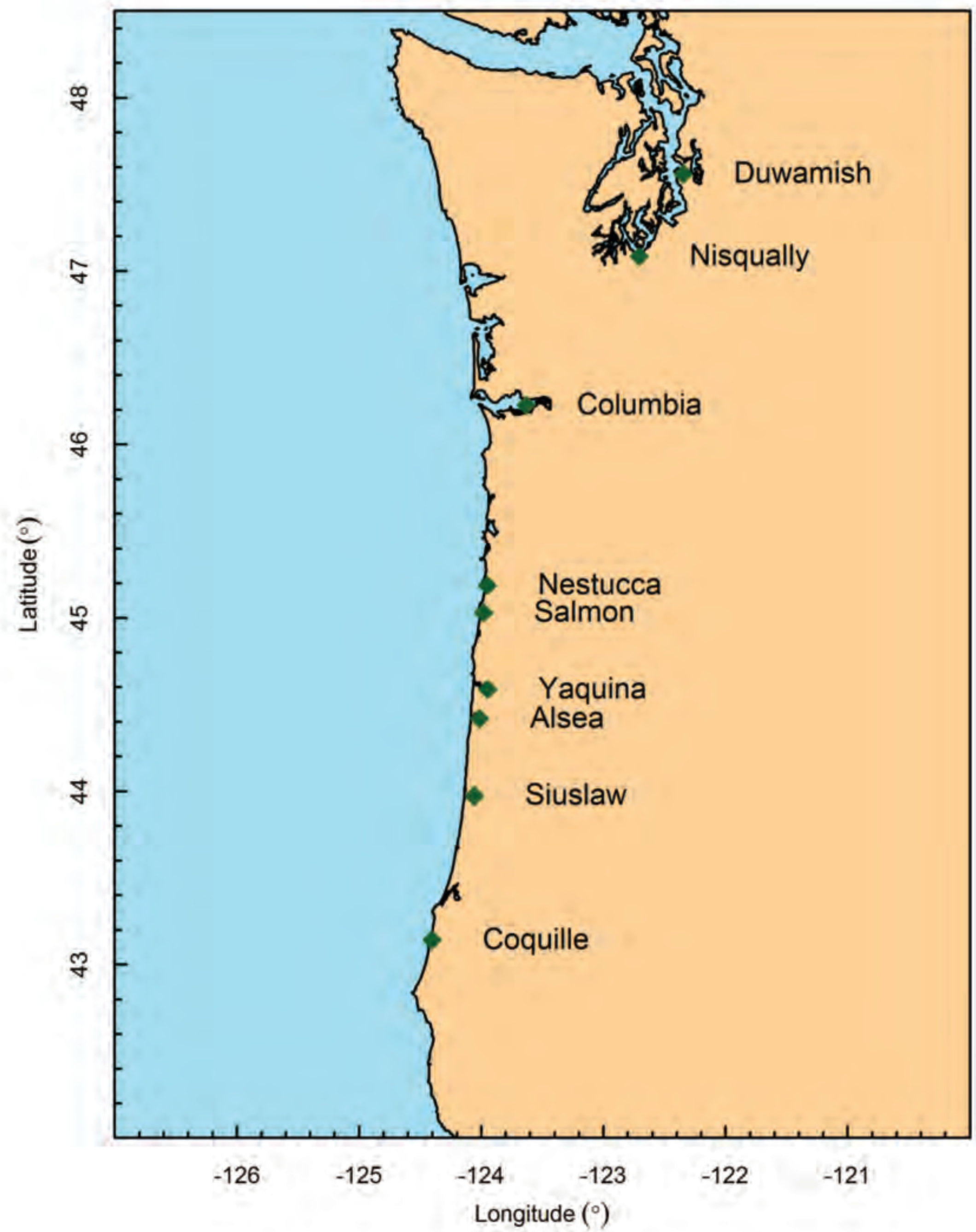
Reduced estuarine and marine survival



From Magnusson and Hilborn (2003)

Hypotheses

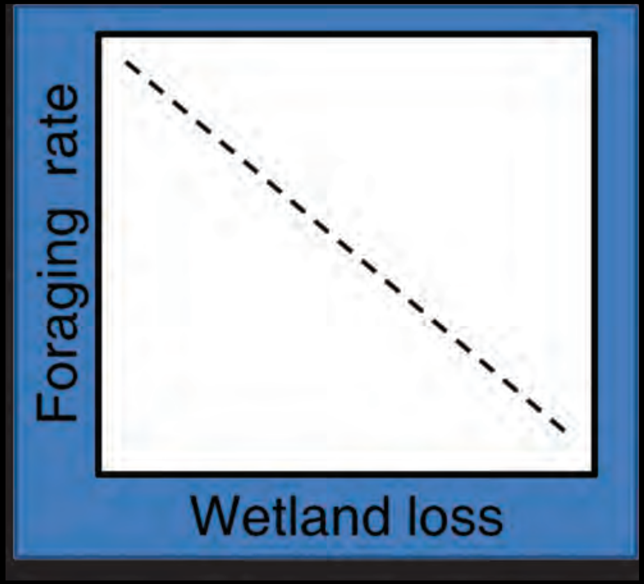

Minimal wetland loss
tland loss
rate
Foraging rate
Consp
Diet composition
1
0.8
0.6
0.4
0.2
0
Minimal wetland loss
Extensive wetland loss



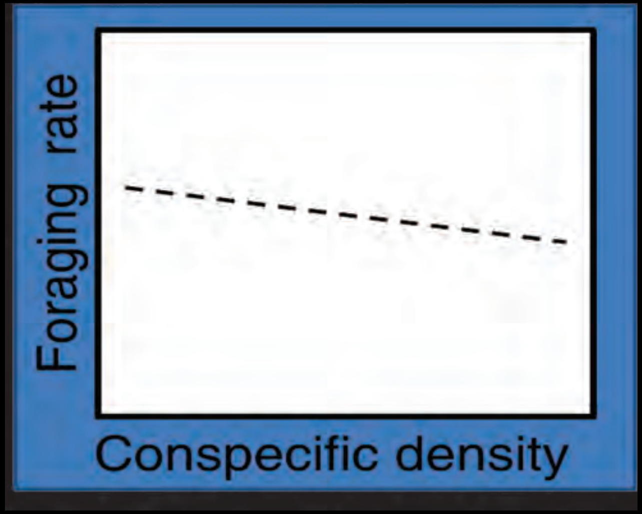
Duwamish
Nisqually
Columbia
Nestucca
Salmon
Yaquina
Alsea
Siuslaw
Coquille
48
47
46
45
44
43
Latitude (°)
-126
-125
-124
-123
-122
-121
Longitude (°)

Estuary	Relevant references	Number of salmon	Years sampled	Percent wetlands lost
Alsea	(Bieber 2005)	**74**	**2004**	**59.1**
Columbia	(Lott 2004)	**288**	**2002-2003**	**62.9**
Coquille	(Bieber 2005)	**43**	**2003**	**94.3**
Duwamish	(Cordell et al. 2011, Ruggerone et al. 2006)	**1000**	**2003; 2005**	**98.9**
Nestucca	(Bieber 2005)	**50**	**2003**	**91.3**
Nisqually	unpublished	**505**	**2010-2012**	**41.3**
Salmon	(Bieber 2005, Gray 2005, Gray et al. 2002)	**567**	**1998-2002; 2004**	**2.4**
Siuslaw	(Bieber 2005)	**158**	**2003-2004**	**62.7**
Yaquina	(Bieber 2005)	**32**	**2003**	**70.6**

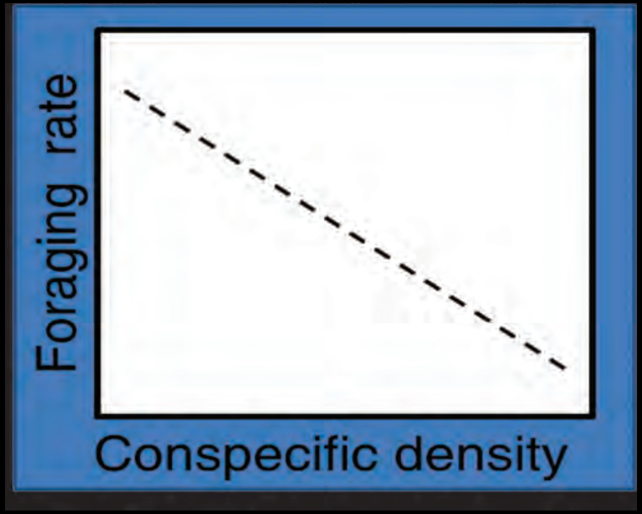
Methods



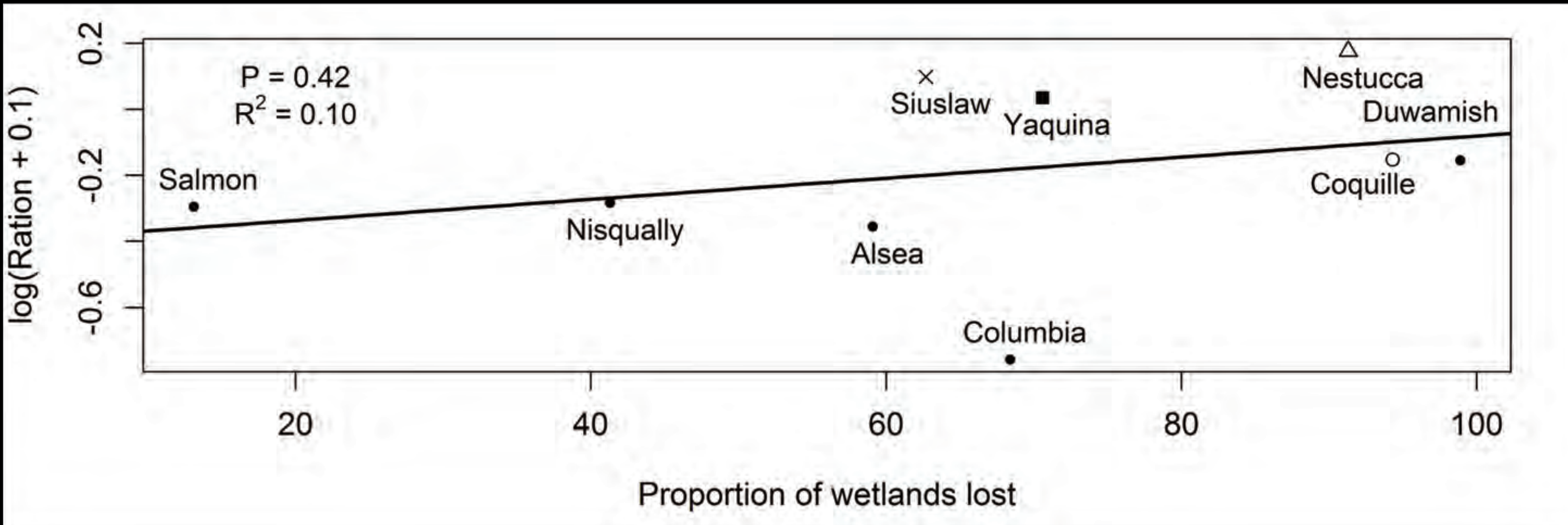
Minimal wetland loss

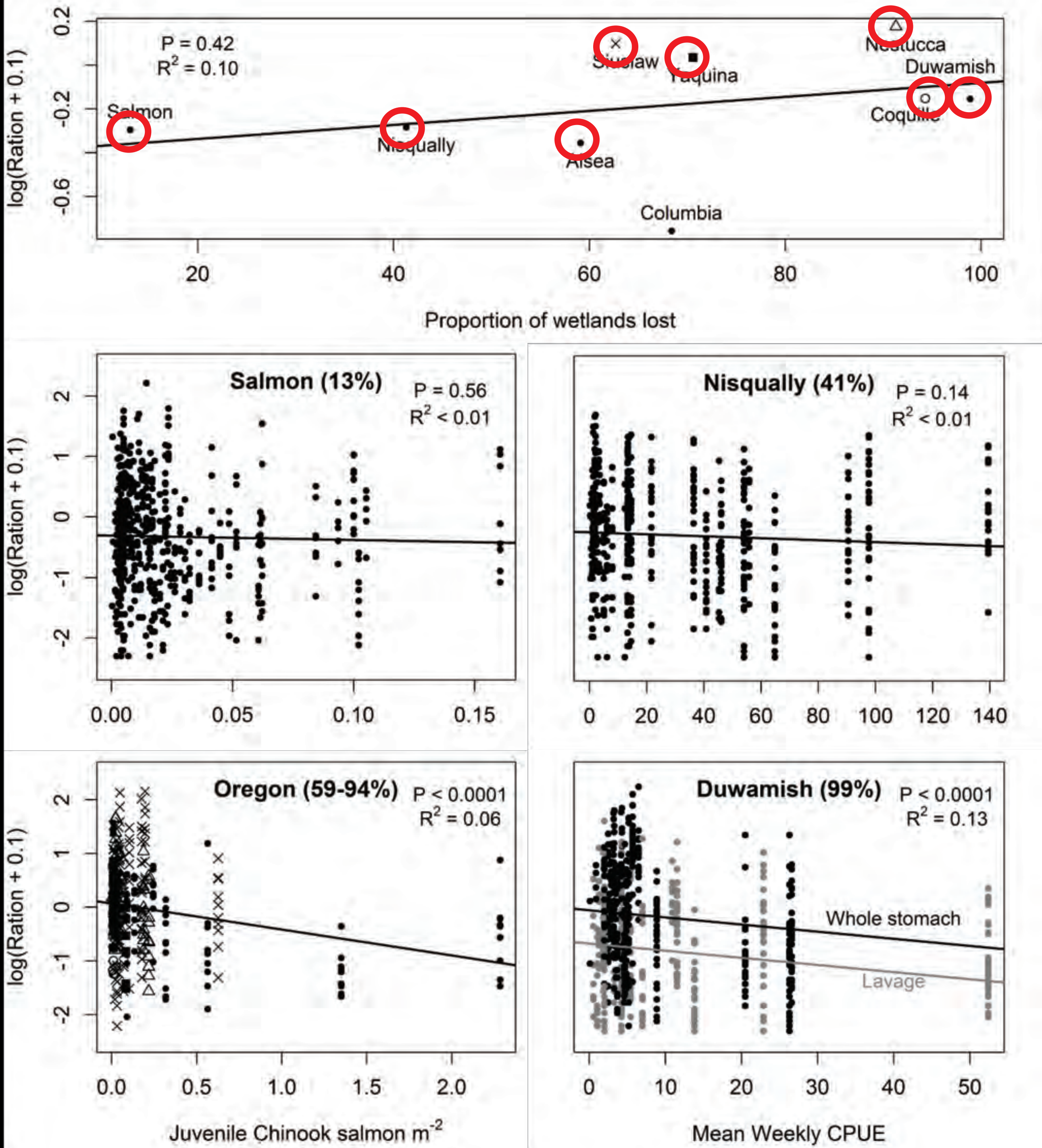


Extensive wetland loss

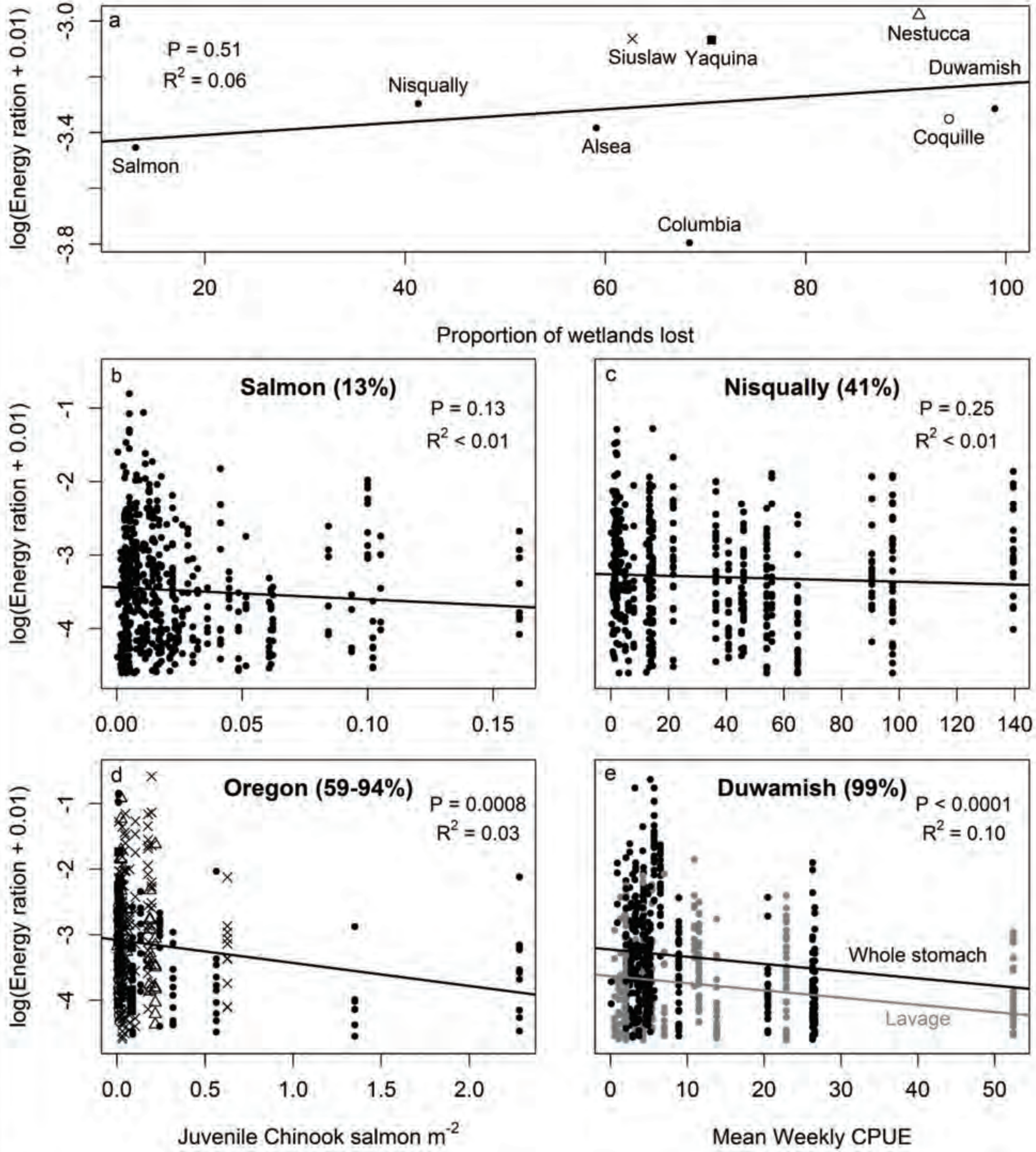


Ration size = 100*(stomach contents mass / fish mass)

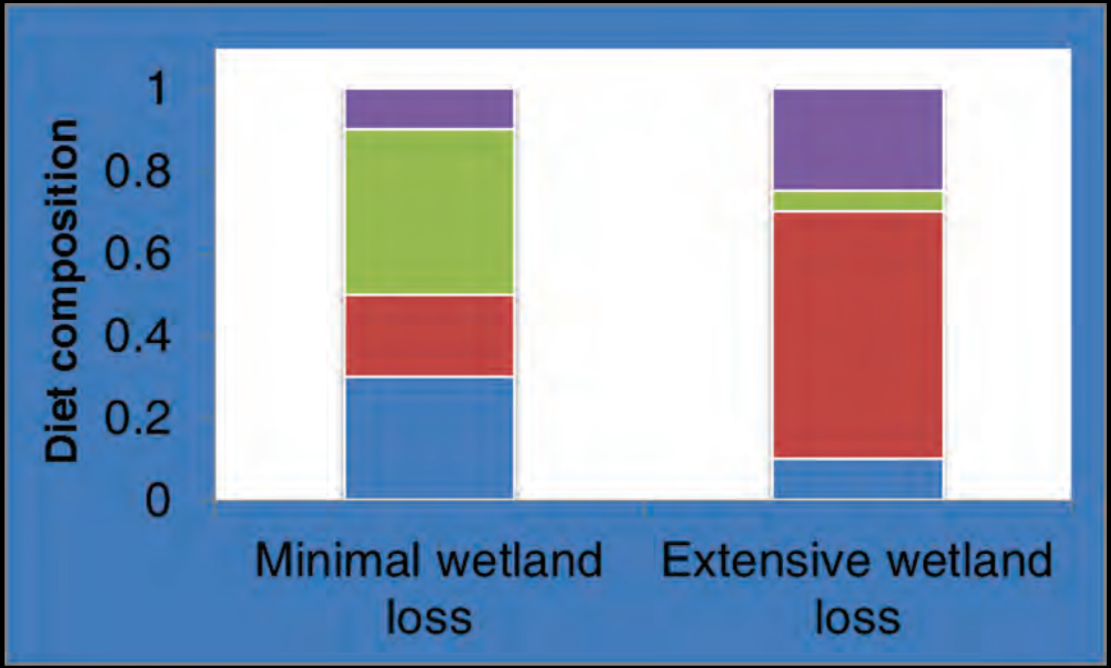

P = 0.42
R2 = 0.10
Salmon
Nisqually
Alsea
Columbia
Siuslaw
Yaquina
Nestucca
Duwamish
Coquille
log(Ration + 0.1)
0.2
-0.2
-0.6
20
40
60
80
100
Proportion of wetlands lost


P = 0.42
R2 = 0.10
Salmon
Nisqually
Alsea
Siuslaw
Yaquina
Nestucca
Duwamish
Coquille
Columbia
log(Ration + 0.1)
Proportion of wetlands lost
Salmon (13%)
P = 0.56
R2 < 0.01
Nisqually (41%)
P = 0.14
R2 < 0.01
Oregon (59-94%)
P < 0.0001
R2 = 0.06
Duwamish (99%)
P < 0.0001
R2 = 0.13
Whole stomach
Lavage
Juvenile Chinook salmon m-2
Mean Weekly CPUE

$$\text{Energy ration} = \sum \text{prey taxa mass}_i * \text{energy density}_i \; / \; \text{fish mass}$$



a
P = 0.51
R^2 = 0.06
Nestucca
Siuslaw
Yaquina
Duwamish
Nisqually
Alsea
Coquille
Salmon
Columbia
log(Energy ration + 0.01)
Proportion of wetlands lost
b
Salmon (13%)
P = 0.13
R^2 < 0.01
c
Nisqually (41%)
P = 0.25
R^2 < 0.01
d
Oregon (59-94%)
P = 0.0008
R^2 = 0.03
e
Duwamish (99%)
P < 0.0001
R^2 = 0.10
Whole stomach
Lavage
Juvenile Chinook salmon m^{-2}
Mean Weekly CPUE


Diet composition
1
0.8
0.6
0.4
0.2
0
Minimal wetland loss
Extensive wetland loss

Multivariate diet analysis

- Canonical correspondence analysis (CCA)

- Used sampling events (location x date) as the unit of observation.

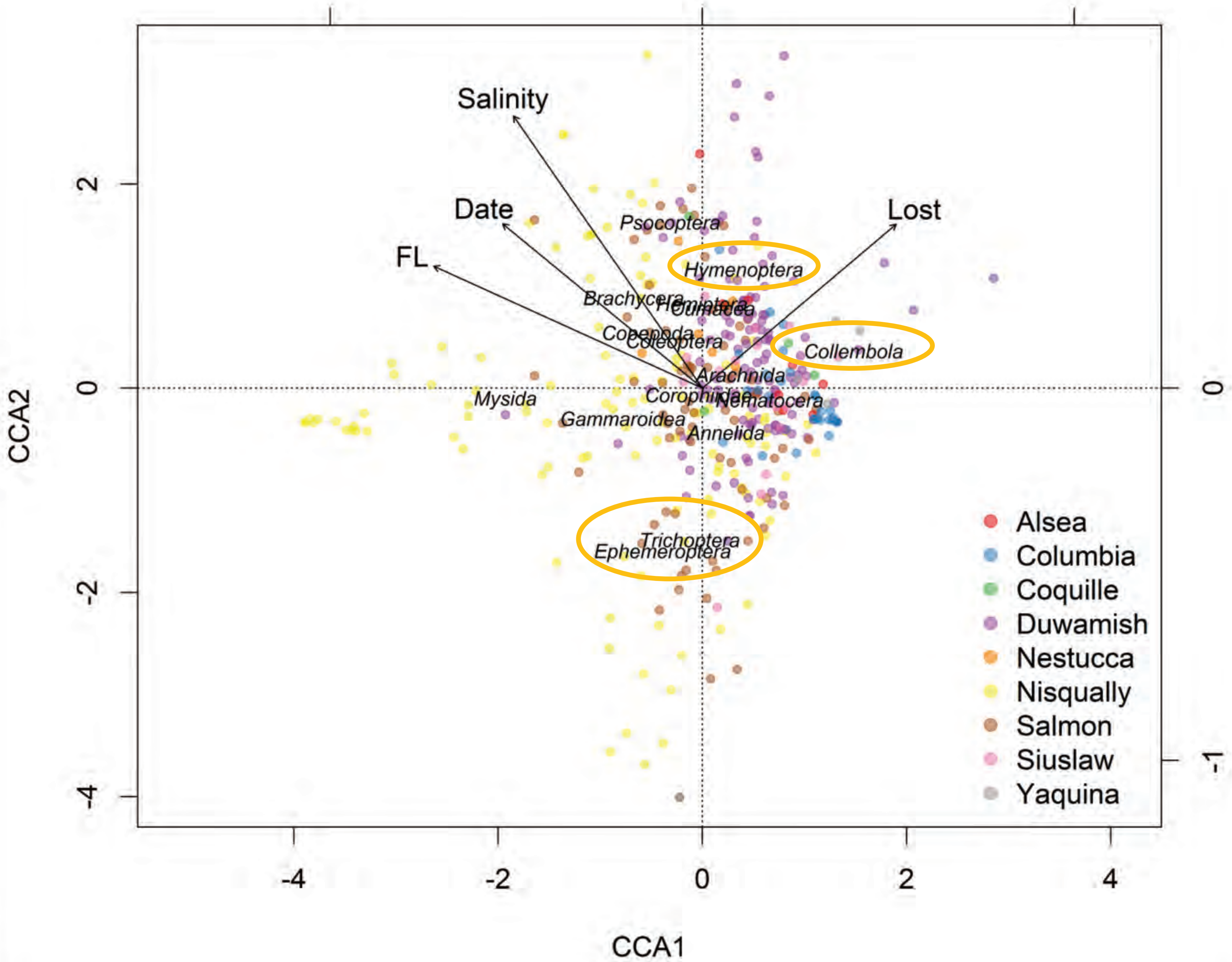
- Explanatory variables:
  - Proportional wetland loss
  - Salinity
  - Day of year
  - Mean fork length

Multivariate results

	df	*F*	N. perm	*P*
Model	4	11.7	500	0.002
Residual	391			

Term	df	*F*	N. perm	*P*
Day of year	1	10.1	500	0.002
Salinity	1	9.9	500	0.002
Fork length	1	12.5	500	0.002
% Loss	1	13.7	500	0.002
Residual	391			

	Inertia	Proportion
Total	5.06	1.00
Constrained	0.53	0.11
Unconstrained	4.53	0.89



Salinity
Date
FL
Lost
Psocoptera
Hymenoptera
Brachycera
Hemiptera
Cumacea
Copepoda
Coleoptera
Collembola
Arachnida
Mysida
Corophiidae
Nematocera
Gammaroidea
Annelida
Trichoptera
Ephemeroptera
Alsea
Columbia
Coquille
Duwamish
Nestucca
Nisqually
Salmon
Siuslaw
Yaquina
CCA1
CCA2
-4
-2
0
2
4
-1

Conclusions

- Little evidence of a direct effect of estuarine wetland loss on salmon foraging performance.
- But, wetland loss appeared to mediate the effect of density on salmon foraging performance.
- Salmon recovery efforts need to recognize that density-dependent processes may still be important at abundances that are low relative to historic levels (Achord et al. 2003; Green and Beechie 2004).

Acknowledgements

Lia Stamatiou
Mary Austill Lott
Walker Duval
Claire Levy
Alisa Bieber
Beth Armbrust
Erin Morgan
Emiliano Perez
Trevan Cornwell
Angela Lind-Null
Karl Stenberg
Dave Beauchamp
Thomas Quinn
ODFW
And many others

Funding: US EPA, NSF Graduate Research Fellowship Program, Nisqually Indian Tribe, US Fish and Wildlife Service, Salmon Recovery Funding Board, King County Conservation Fund, Oregon Sea Grant, Washington Sea Grant

Photos: Michael Grilliot, Jeff Cordell, Jason Toft, Christopher Ellings, Stuart Munsch, the Wetland Ecosystem Team.