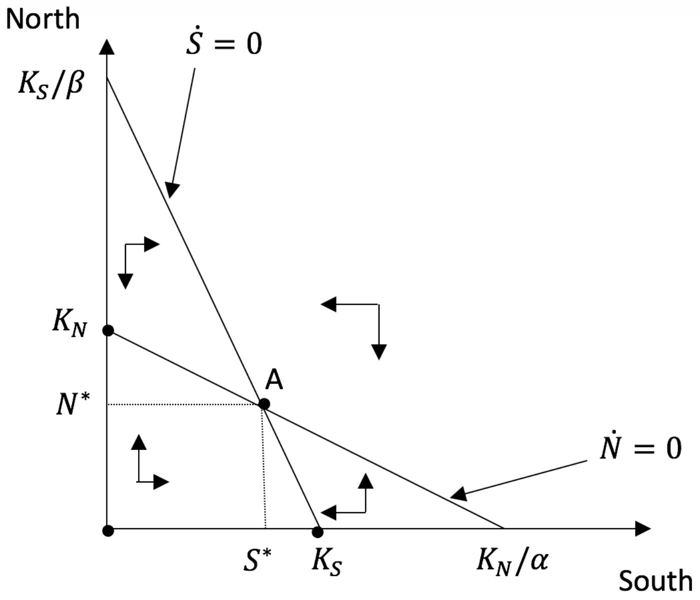
Extra Slides

Modelling Competing Species

$$\frac{dN}{dt} = rN[1 - \frac{N}{K_N} - \frac{\alpha S}{K_N}] \equiv rN[g(N, S, K_N, \alpha)] \quad (1)$$

$$\frac{dS}{dt} = rS[1 - \frac{S}{K_S} - \frac{\beta N}{K_S}] \equiv rS[G(S, N, K_S, \beta)] \quad (2)$$

- $r, \alpha, \beta, K_N, K_S$ are all positive given parameters of the system
- Initial populations are assumed to be non-negative ($N(0) \geq 0$, $S(0) \geq 0$)


North
$\dot{S} = 0$
K_S/β
K_N
A
N^*
$\dot{N} = 0$
S^*
K_S
K_N/α
South

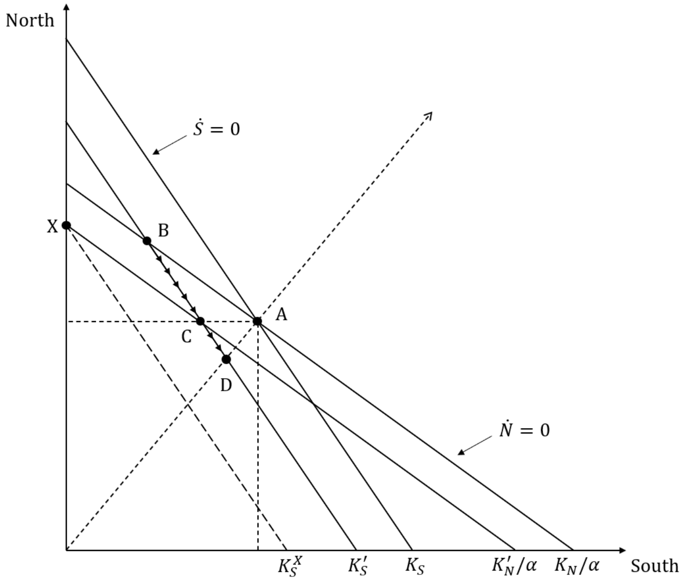
The Interior Steady State

$$\frac{1}{\beta} > \frac{K_N}{K_S} > \alpha \tag{3}$$

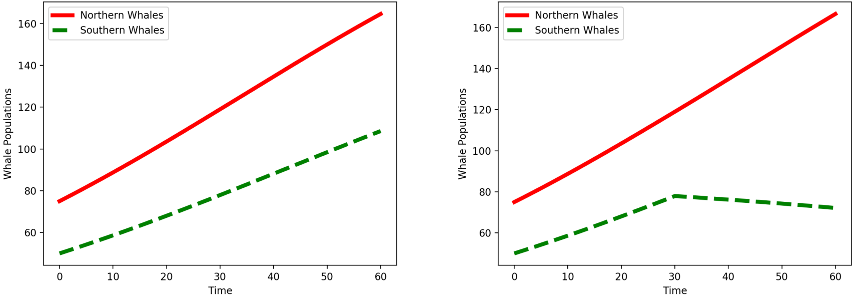
$$N^* = \frac{K_N - \alpha K_S}{[1 - \alpha\beta]} > 0 \tag{4}$$

$$S^* = \frac{K_S - \beta K_N}{[1 - \alpha\beta]} > 0 \tag{5}$$

The Competitive Exclusion Principle



Transition Paths:
Baseline plus Shock to Southern Habitat



Conclusion from Theory

- Common shocks lead to common responses (Salmon availability)
- Asymmetric shocks lead to very different, and magnified, NRKW or SRKW responses.
- Correlated shocks create correlated responses that differ in magnitudes.
- One path to SRKW extinction is correlated shocks magnified by competitive exclusion.

Back

Vessel Arithmetic

Vessel Trips and Walras' Law

$$I_t = \sum_{i \notin u_c} \sum_{j \in u_c} X_{ijt} \tag{6}$$

- Incoming Trips

$$W_t = \sum_{i \in u_c} \sum_{j \in u_c} X_{ijt} \tag{7}$$

- Within Trips

Vessel Arithmetic

Vessel Trips and Walras' Law

$$O_t = \sum_{i \in u_c} \sum_{j \notin u_c} X_{ijt} \tag{8}$$

- Outgoing Trips

$$P_t = \sum_{i \in u_p} \sum_{j \in u_p} X_{ijt} \tag{9}$$

- Pass Through Trips

Vessel Arithmetic

Walras' Law

$$VL_t = I_t + W_t \tag{10}$$

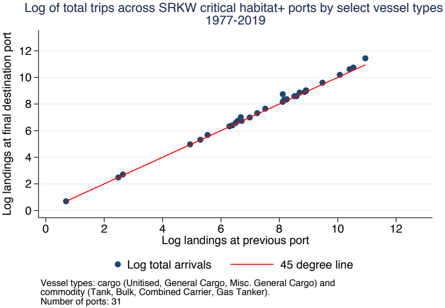
- Landings are either Incoming or Within; Exits must equal Entries; Foreign Vessel Outgoing Trips are residual needed to balance budget

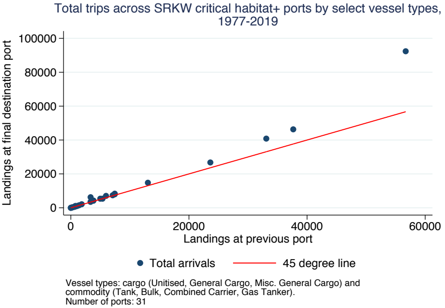
$$\begin{aligned} VL_t &= VE_t \\ VE_t &= O_t + W_t \end{aligned} \tag{11}$$

$$I_t = O_t \tag{12}$$

$$I_t = \sum_{i \in u_c} \sum_{j \in \underline{u}} X_{ijt} + \sum_{i \in u_c} \sum_{\substack{j \notin u_c \\ j \in \bar{u}}} X_{ijt} \tag{13}$$

Evaluating Vessel In - Vessel out assumption





Back to Vessel Arithmetic

Back to Malthus

Births

Figure: Percentage of females with births by age in the pooled RKW populations, 1979-2019

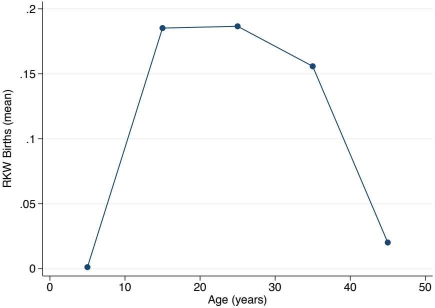
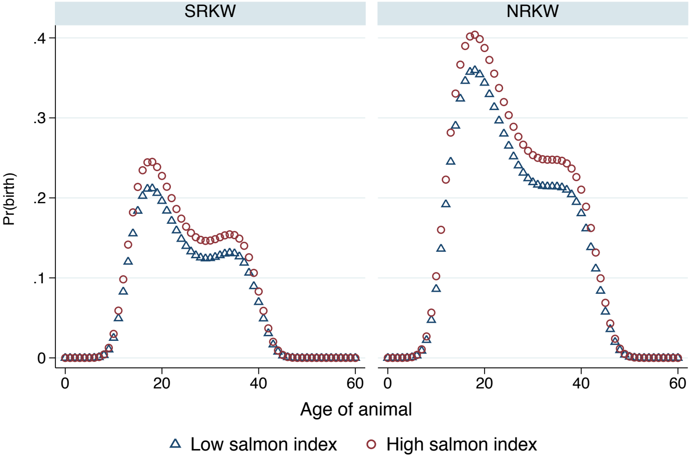


Table: Births in the pooled RKW populations by age, 1979-2019

		Birth		
Age group	*n*	without	with	Mean
0 – 9	1645	1643	2	0.001
10 – 19	1215	990	225	0.185
20 – 29	922	750	172	0.187
30 – 39	751	634	117	0.156
40 –	1288	1262	26	0.020
Total	5821	5279	542	0.093

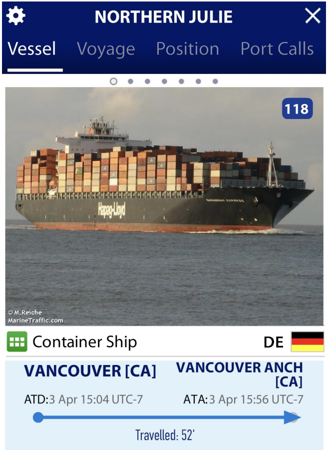
Predicted Probabilities of Birth



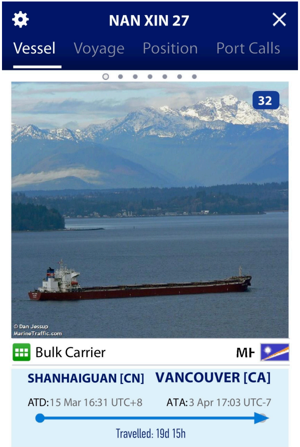
Within Population Graphs differ by Salmon Availability

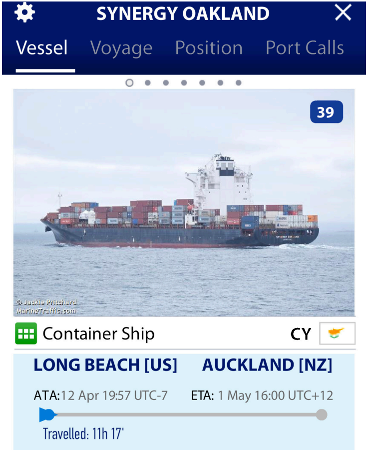
Back

Vessel Types Container & Tanker



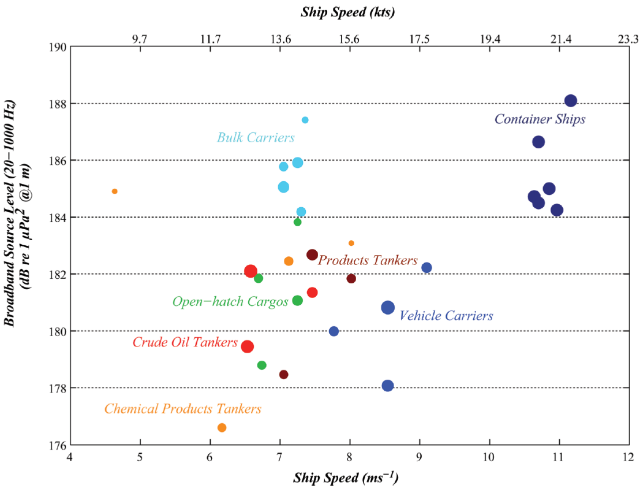
Vessel Types Bulk & General Cargo





Back

Vessel Noise vs Type



Source: Figure 5. in McKenna et. al (2012) Back

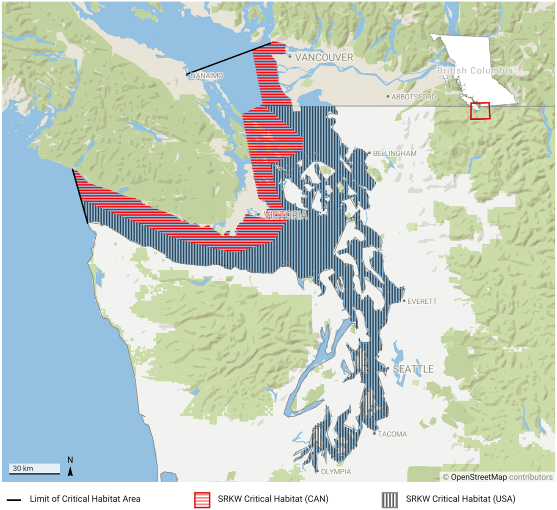
The NRKW Critical Habitat

Northern Resident Killer Whale Critical Habitat

Created with Datawrapper

The SRKW Critical Habitat

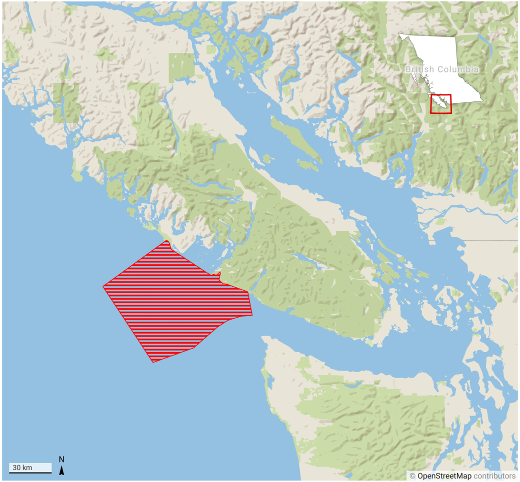
SRKW Critical Habitat



Created with Datawrapper

The New (2018) Shared Critical Habitat

New Killer Whale Critical Habitat



Created with Datawrapper

Back

Policy

Incomplete - in fact totally back of the envelope calculation!

- Slower speeds mean lower decibels generated by vessels. Some estimates imply 1 decibel reduction for 1 knot lower speeds
- Halving current speeds of Container and Bulk ships adds .4 to .3 of a day over longest inbound transit
- Estimates of this cost of delay (Hummels and Schaur (2013, AER,: Time as a Trade Barrier) suggest this amounts to less than a 1% ad valorem tariff on goods. There is however about 100 billion annually of exports/imports shipped via container ships through Vancouver-Fraser River ports alone.
- Dam breaching, fishing moratoriums, etc. may prove to be more costly ways to improve the marine habitat. Back