Potential effects of wounds and sea lice on the health of Pacific salmon on the high seas

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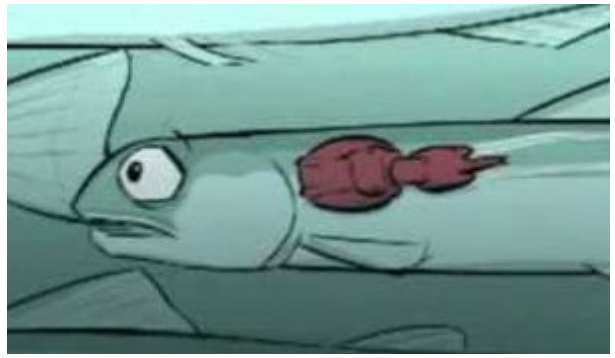
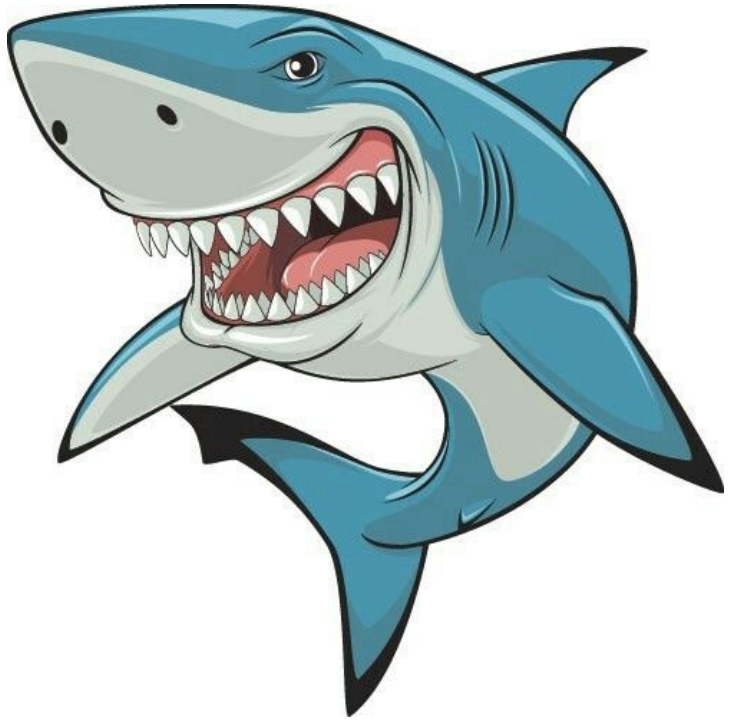
Life on the high sea can be tough!



External parasites

Deformities

Diseases



Predators

Cold temperature inhibits wound healing

- Even minor wounds can be a source of secondary infection, with potentially lethal consequences
- Cold water (4°C) inhibits wound healing compared to warmer water (>10°C)
- Diets high in micronutrients also increase healing rates

Expect wounds or sea lice infestations are especially detrimental to fish health in winter due to cold temperatures and potentially poor diets

Jensen et al. 2015. Fish Physiol Biochem 41:1527–1543

Research questions

1. Are all species and sizes of salmon equally susceptible to all types of external marks?
   - Wounds, scars, sea lice, deformities, black spot
2. Are external marks associated with decreases in salmon health at long or short time scales?
   - Long term = condition factor
   - Short term = stomach fullness
3. Are some stocks more vulnerable?
   - Travel in areas with more predators or parasites?
   - Are marks disproportionate to abundance?

Only looking at survivors!

Talk overview

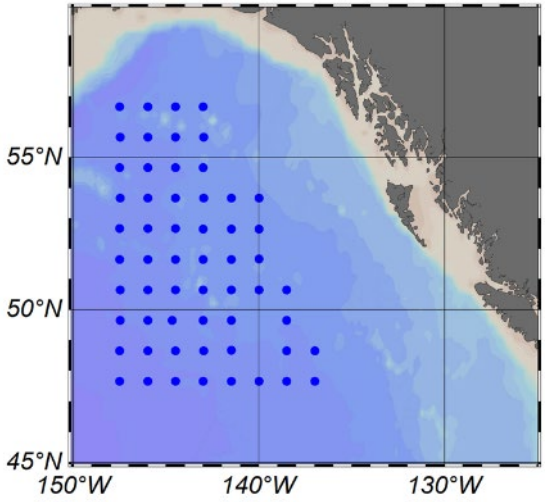
- Methods
- Results
  - Incidence of external marks
  - Relationship to salmon size & condition
  - Marks by stock
- Summary & conclusions
- Recommendations for 2022

2019
R/V *Professor Kaganovskiy*

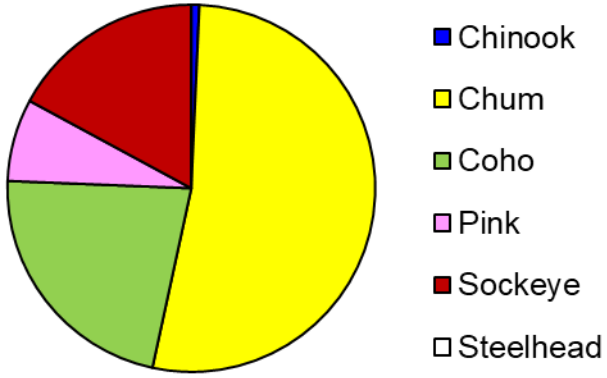
2020
F/V *Pacific Legacy*

Methods--Surveys

2019



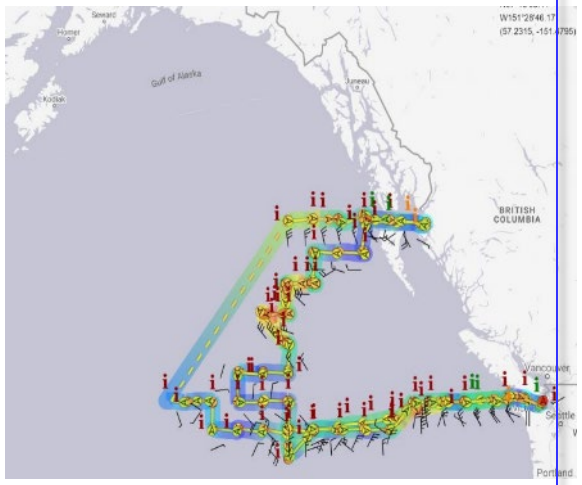
60 stations

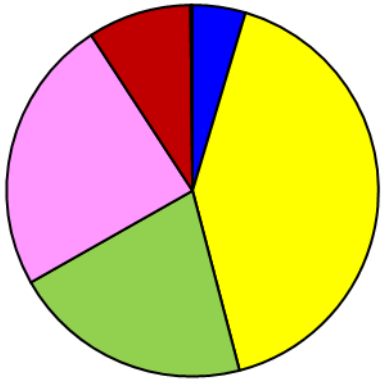


N = 427

2020

52 stations

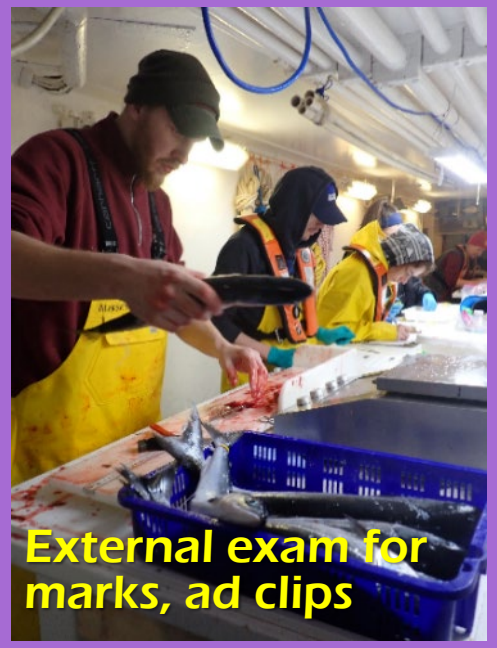




N = 566

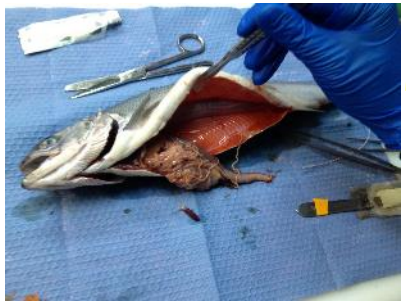
Salmon processing


Sort by species


External exam for marks, ad clips


Measure, scale & fin clip samples, otoliths


Fish health tissues, stomachs, muscle for bioenergetics




Not much left over!

Methods-Analysis

Categories of marks

1. Wounds (=fresh, includes lesions)
2. Scars (=healed wounds)
3. Sea lice & SL abrasions
4. "Disease" (black spots, pustules, deformities)

Severity of marks

- Presence/absence
- Rating
    1. Mild (default)
    2. Moderate
    3. Severe

Response variables

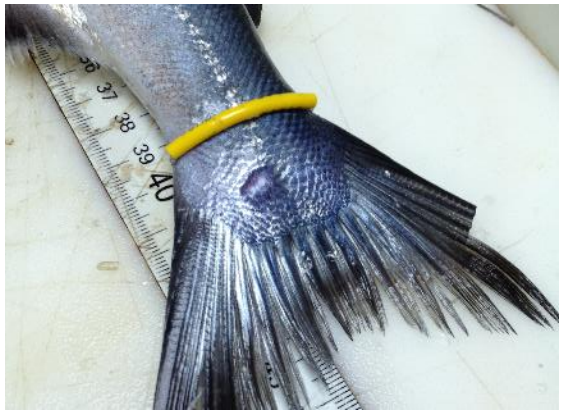
- Length
- Long term health:

Fulton's condition factor
$CF = weight/(length^3)$

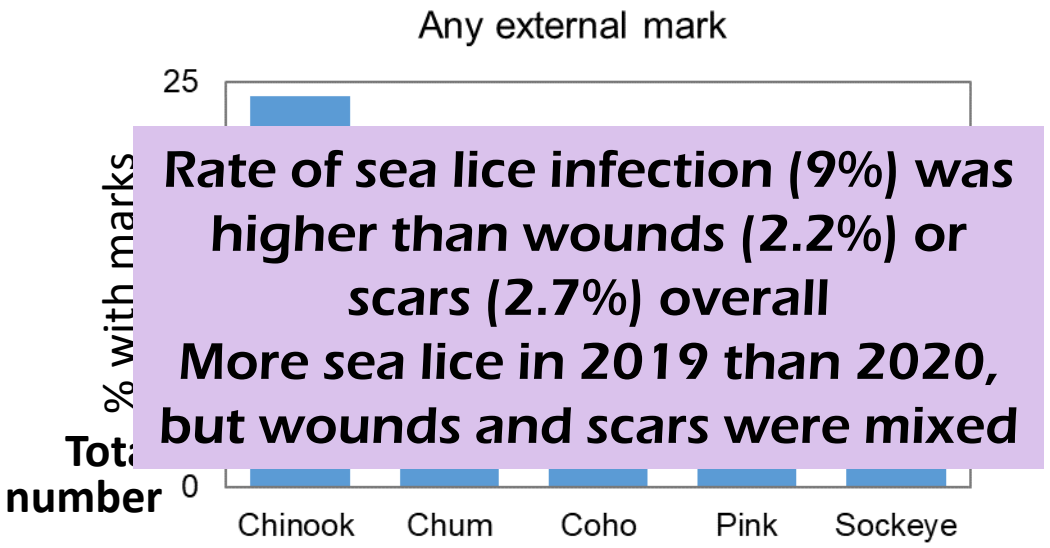
- Short term health: Stomach fullness (% BW), 2019 only
- All transformed using $\ln(x+1)$

Statistics: 2 way ANOVAs for species and mark type (e.g., wounds). Statistical significance at $p<0.05$ (*). Analyses limited by small numbers of salmon with marks.
(Species was always statistically significant at $p<0.05$).

Examples of external marks

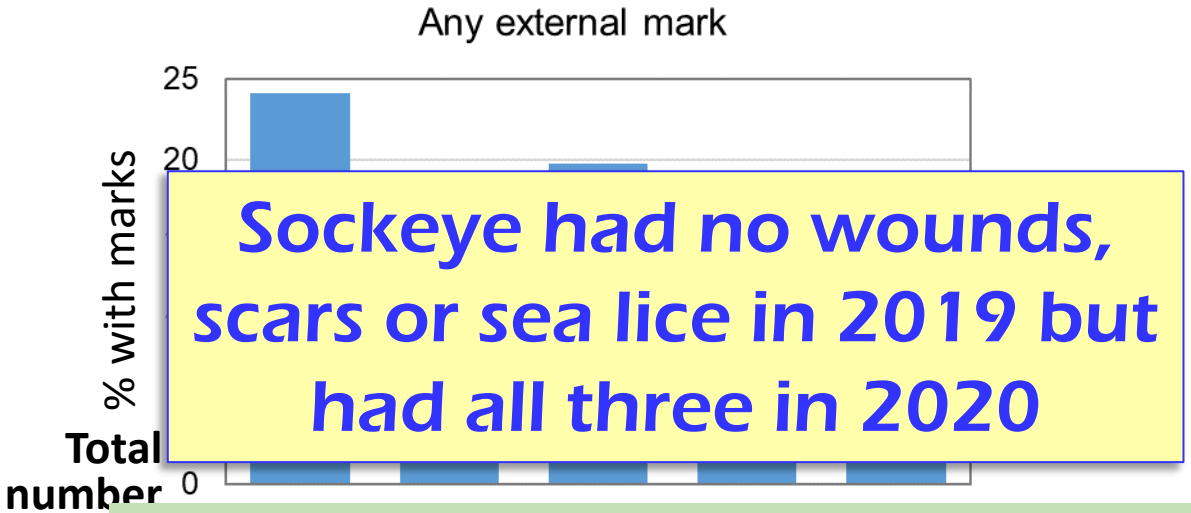
	Wound	Scar	Sea lice	Disease
Mild				
Moderate Severe				

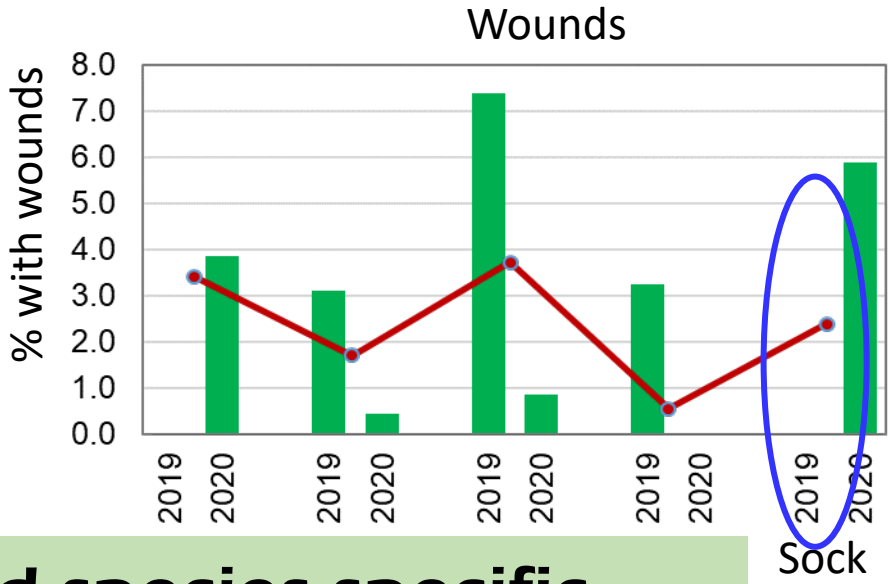
Results – Species-specific rates



Rate of sea lice infection (9%) was higher than wounds (2.2%) or scars (2.7%) overall
More sea lice in 2019 than 2020, but wounds and scars were mixed

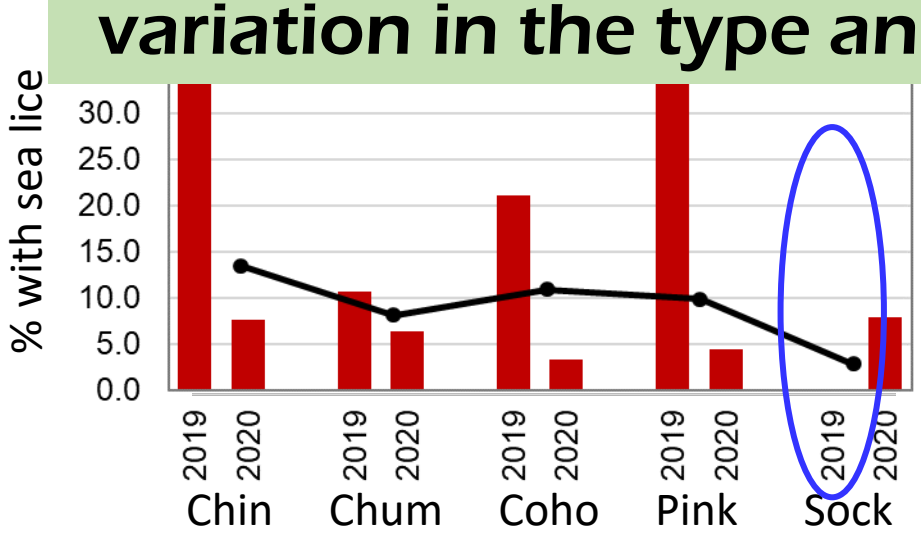
Results – Species-specific rates

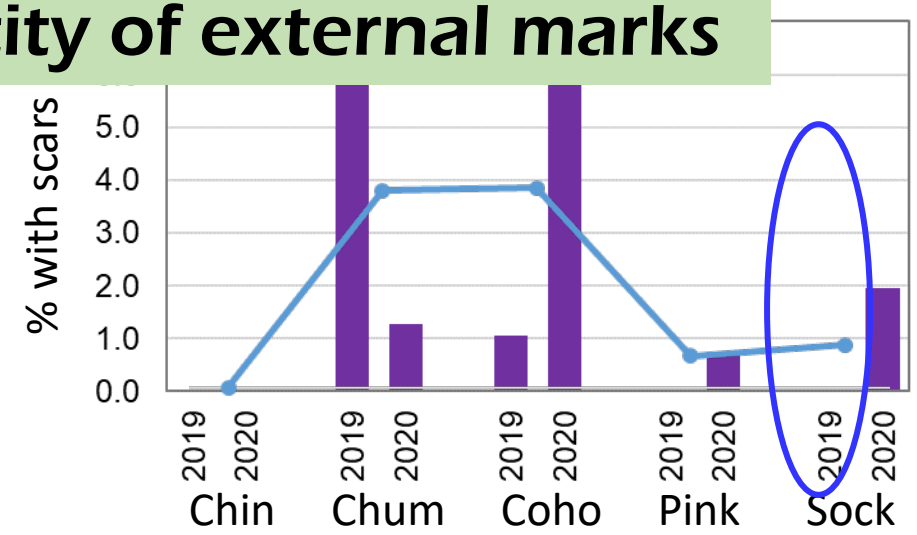




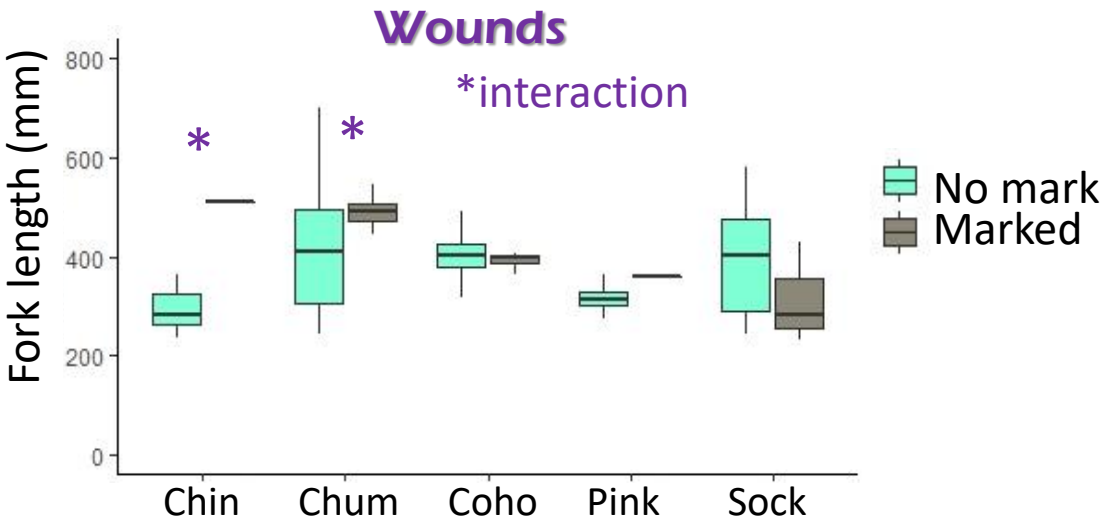
Sockeye had no wounds, scars or sea lice in 2019 but had all three in 2020

Considerable interannual and species-specific variation in the type and quantity of external marks



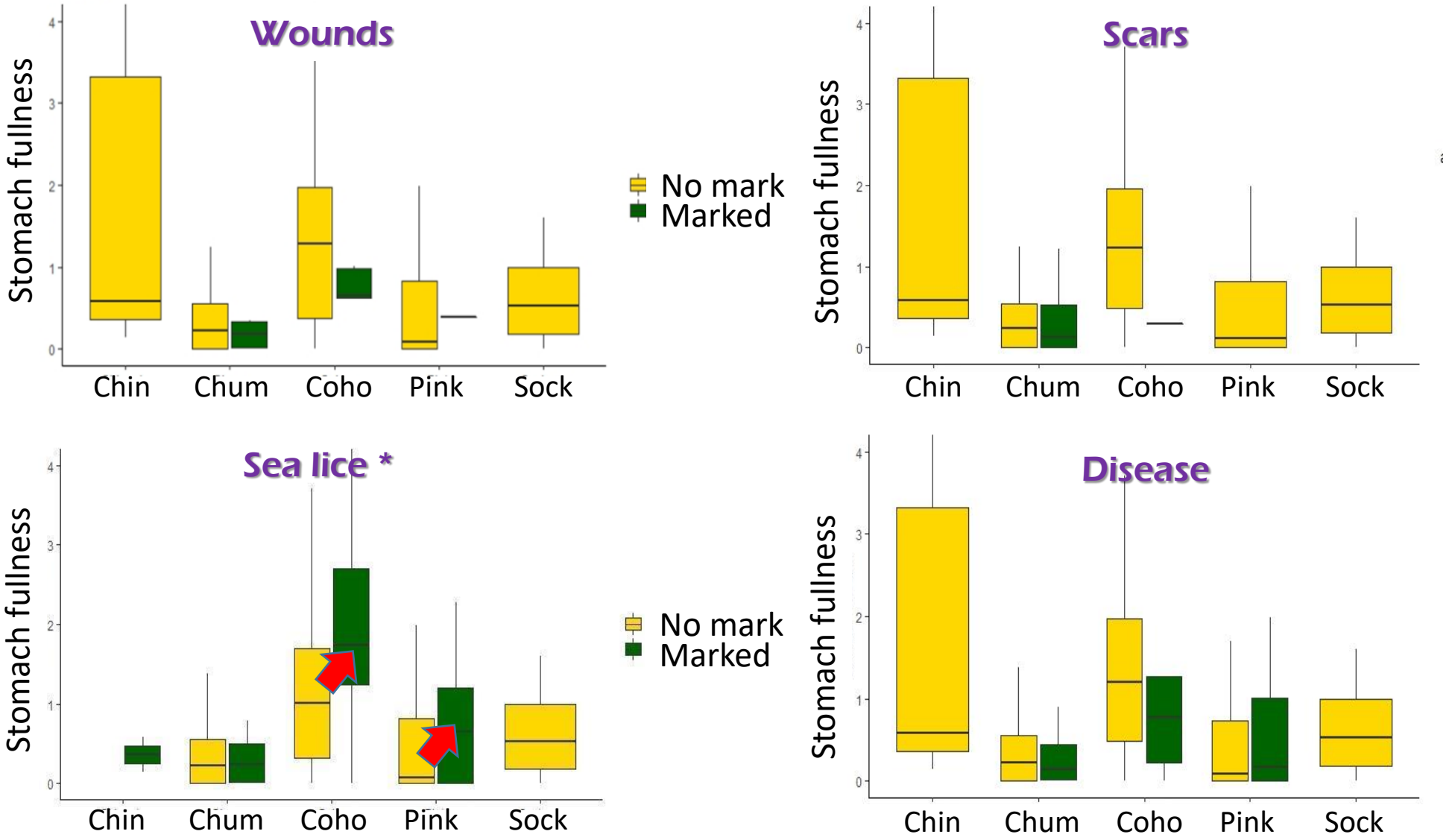


Results: Length and Mark Presence/Absence



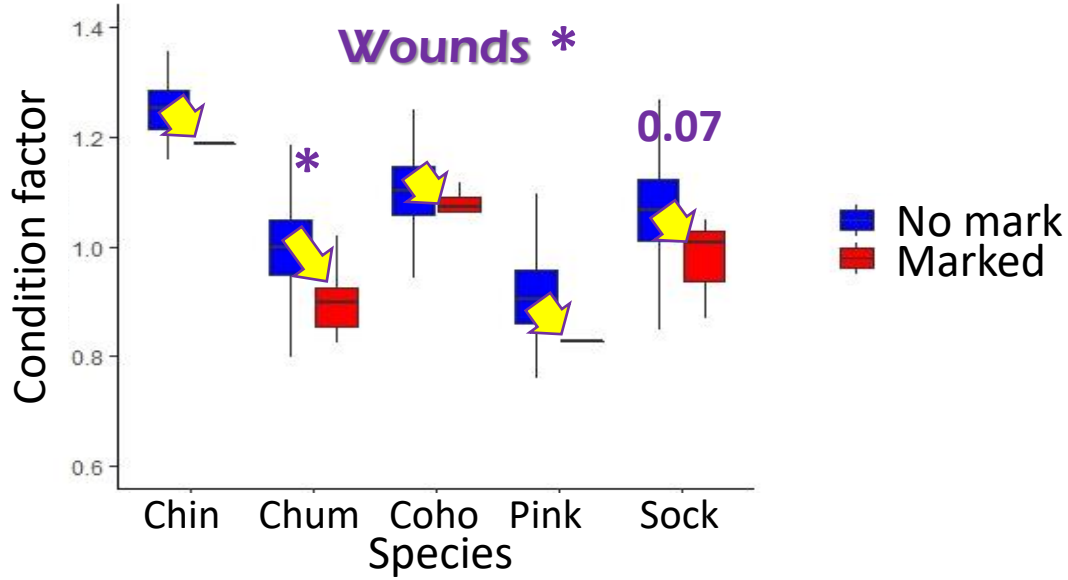
Results: Stomach fullness (2019) and Mark Presence/Absence

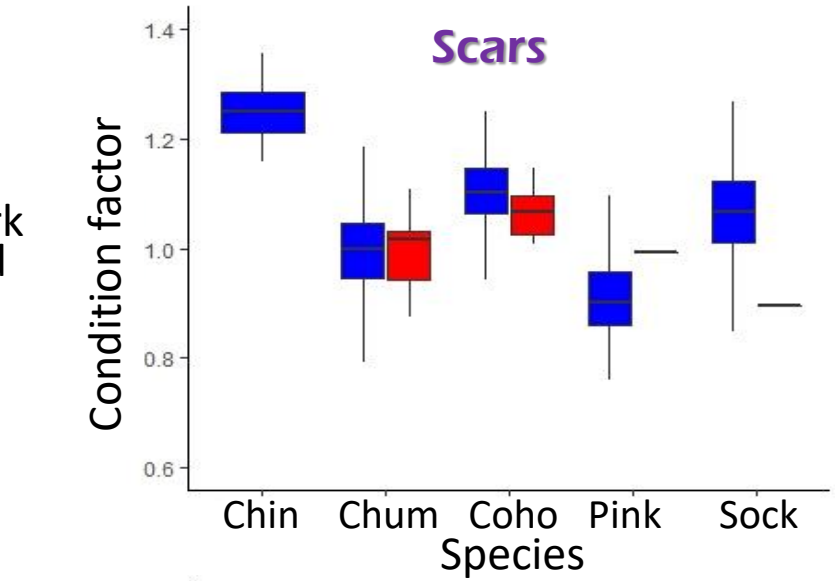
Stomach fullness = measure of short term fish health

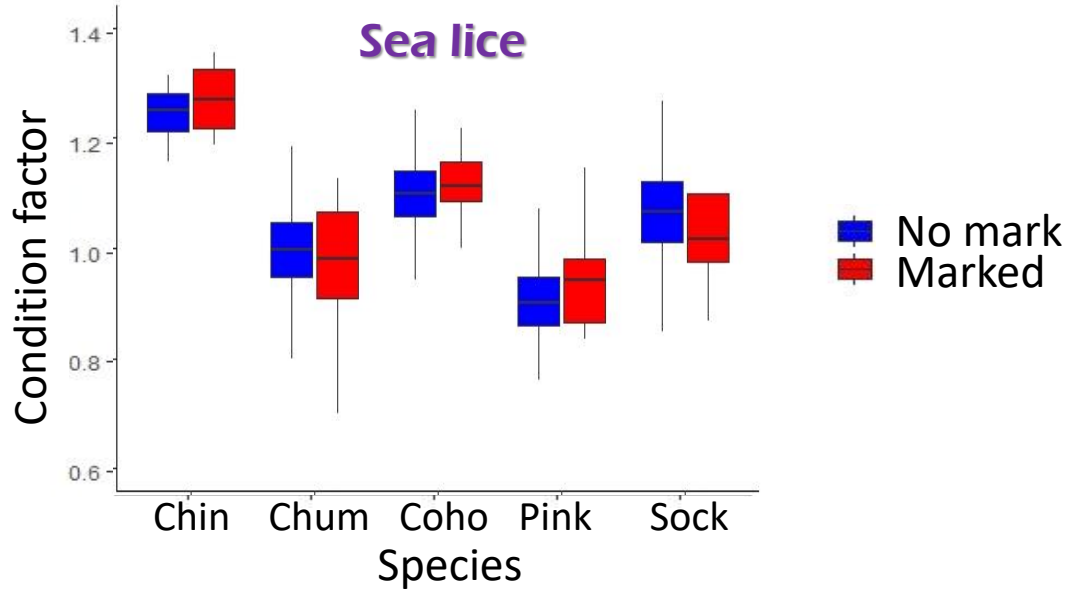


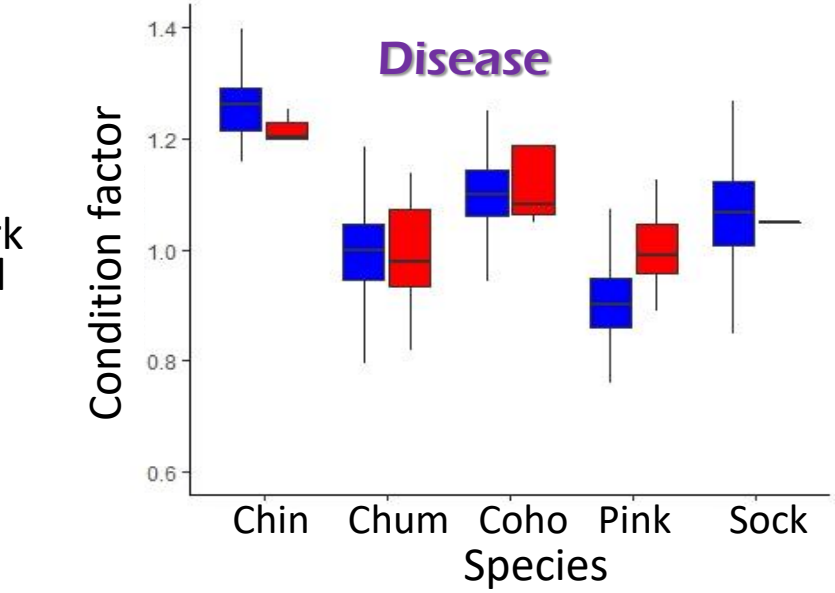
Results: Condition factor and Mark Presence/Absence

Condition factor= measure of long-term fish health



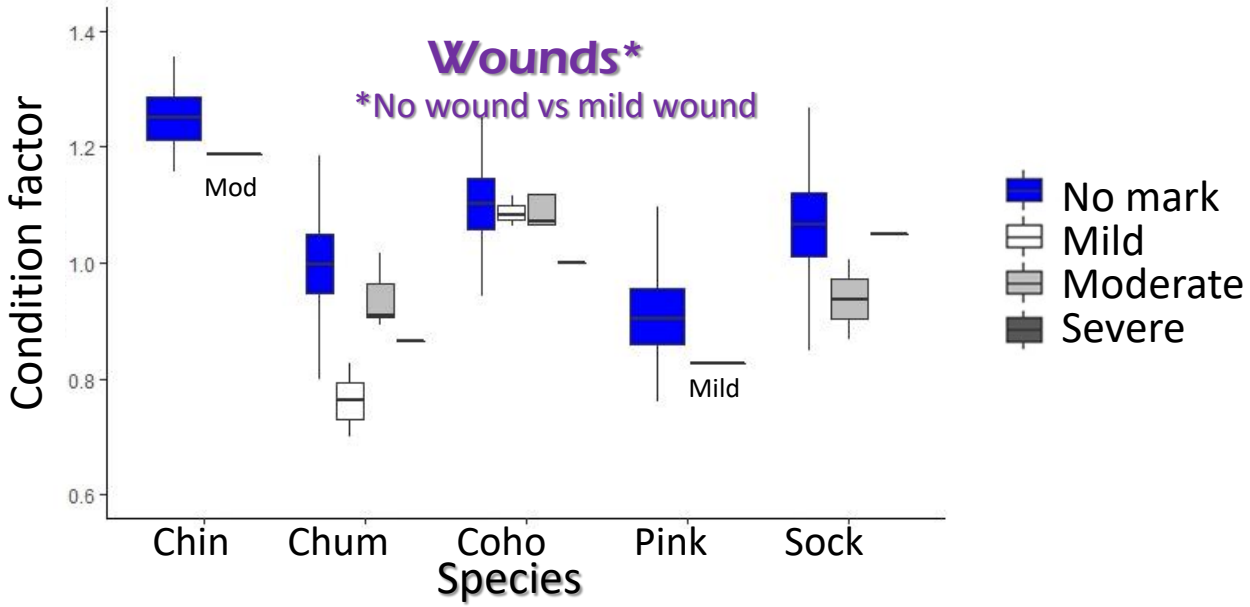




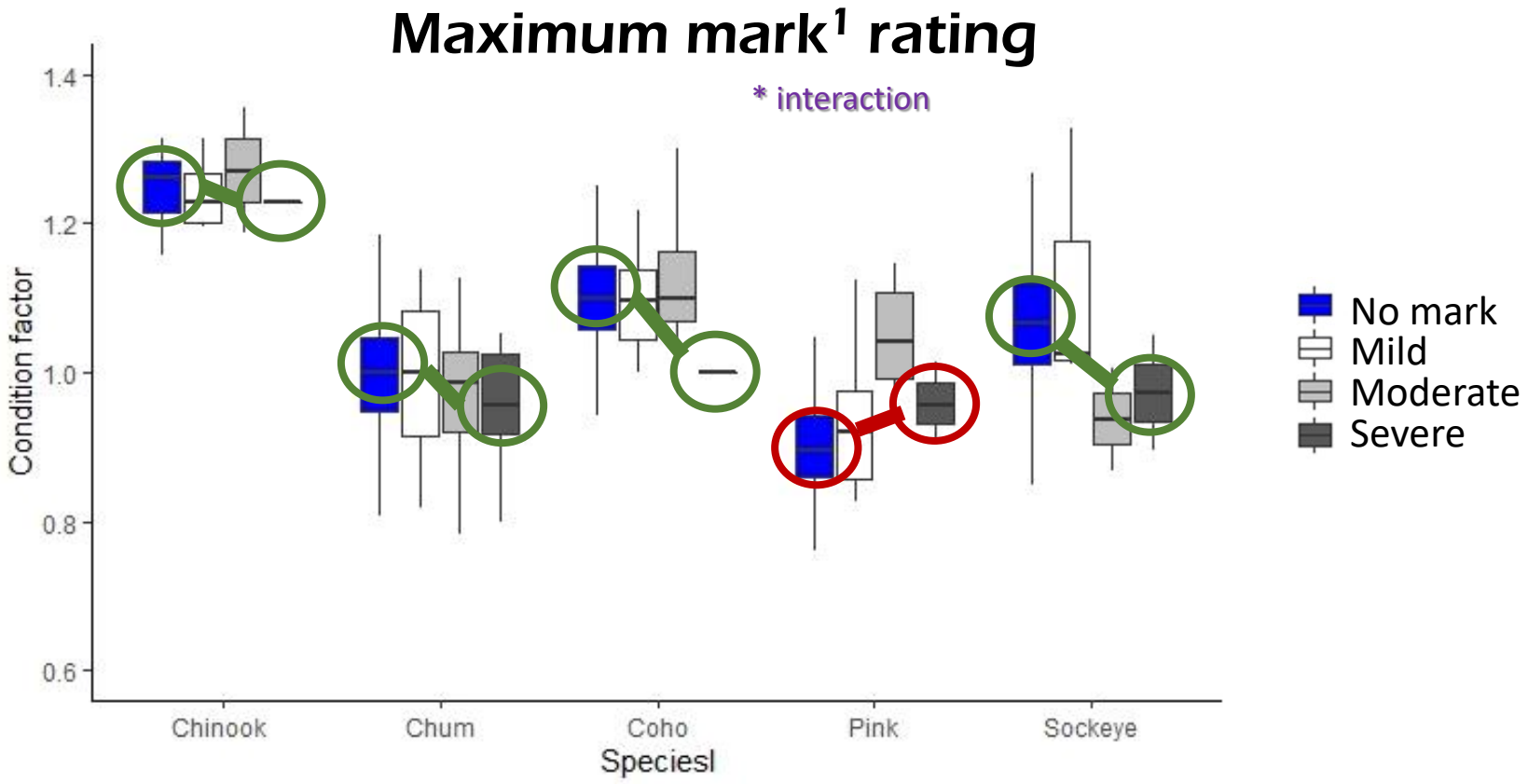


Results: Condition factor and Mark Ratings

Condition factor= measure of long-term fish health

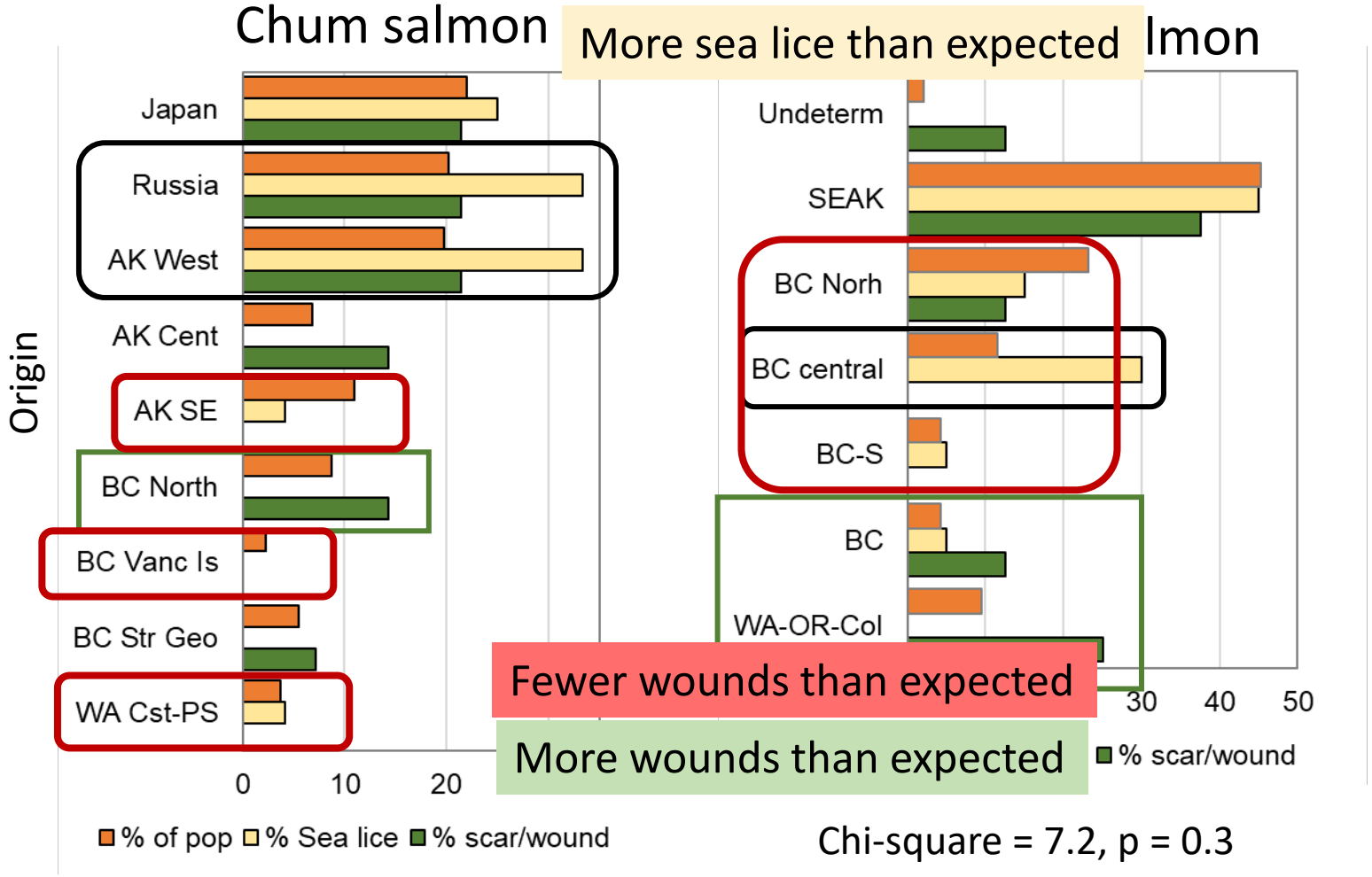


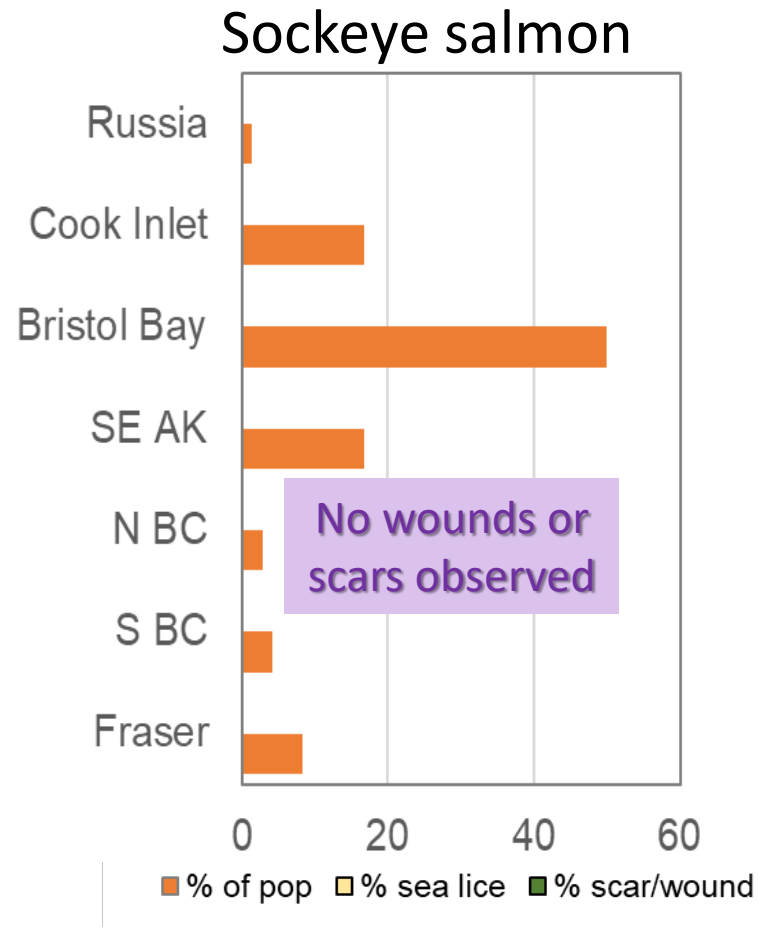
Results: Condition factor and Mark Ratings



[1]Any type of mark (wound, scar, sea lice, disease)

Wounds/scar & sea lice by origins (2019)





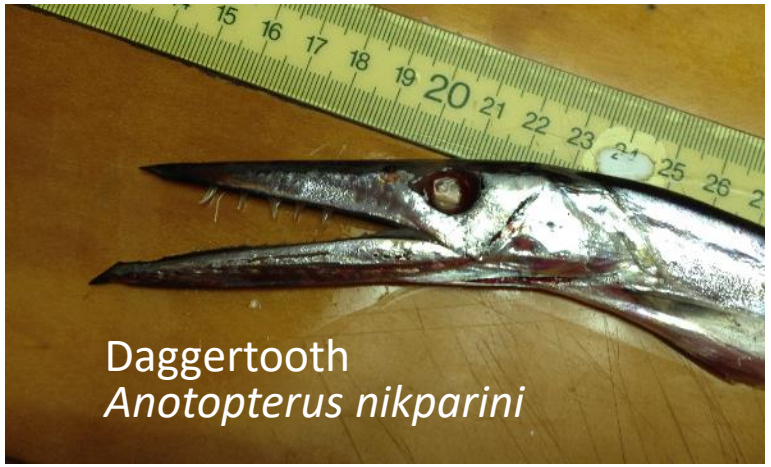
Summary and Conclusions

- Caught more salmon with sea lice (9%) than wounds (2%) or scars (3%). No obvious pattern of one species having more marks than any other.
  - Naydenk & Temnykh (2016) report 0.5% of fish with wounds in winter, but 6-20x higher rates in summer.
- Individuals with wounds, scars, and sea lice were larger and fish with disease were smaller than unmarked salmon, for reasons largely unknown
  - Did smaller fish die in predator attacks? Do older or larger fish have more battle scars or get attacked more often? Do diseased fish eventually succumb to disease?
- Wounded salmon had statistically lower condition factor (CF) than unwounded fish
  - Fish with mild wounds had lower CF than unwounded fish ($p < 0.05$)
  - Fish with extreme marks generally had lower condition factor than unmarked fish (not statistically significant but low statistical power)
- Unclear why fish with sea lice had higher stomach fullness overall (2019 only)
- Fish originating from particular regions did not have consistently low or high frequency of wounds, scars or sea lice (2019 only)

Include 2020 data when available

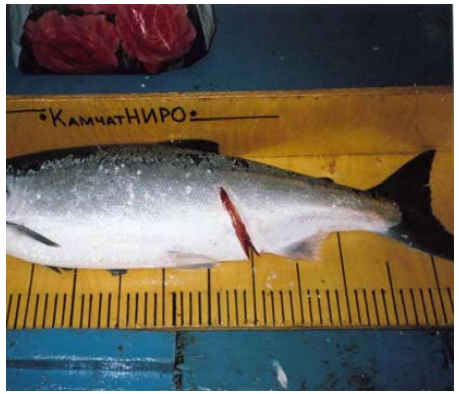
Recommendations for 2022

- Better descriptions & photos of ALL external marks
  - Count sea lice or blackspots
  - Size, severity & location of wounds
  - Include haul & fish number in all photos
- Better guestimates of origins of wounds and marks
  - e.g., daggertooth, sharks, lamprey, pinnipeds?



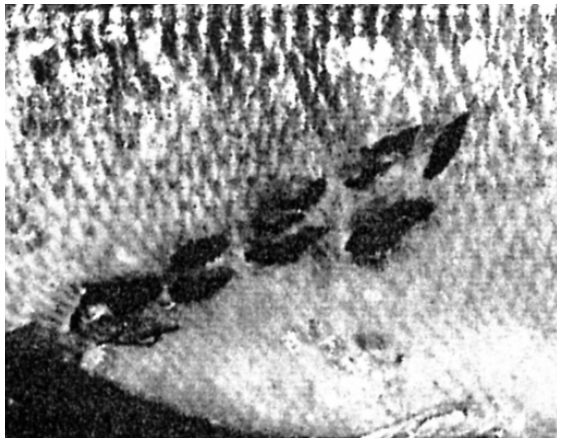
Examples of predator marks (Bugaev et al. 2007, NPAFC Bull 4:145-154)

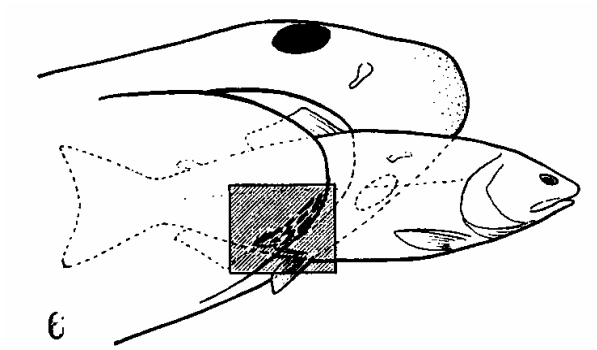
Lancetfish and daggertooth



Lamprey

Salmon shark





Pinnipeds

Acknowledgements

- Captain and crews of R/V *Professor Kaganovskiy* and F/V *Pacific Legacy*
- All the scientists who participated in Winter 2019 and 2020 cruises
- Funding sources
- Dick Beamish and Brian Riddell


Questions?