INTERNATIONAL PACIFIC HALIBUT COMMISSION

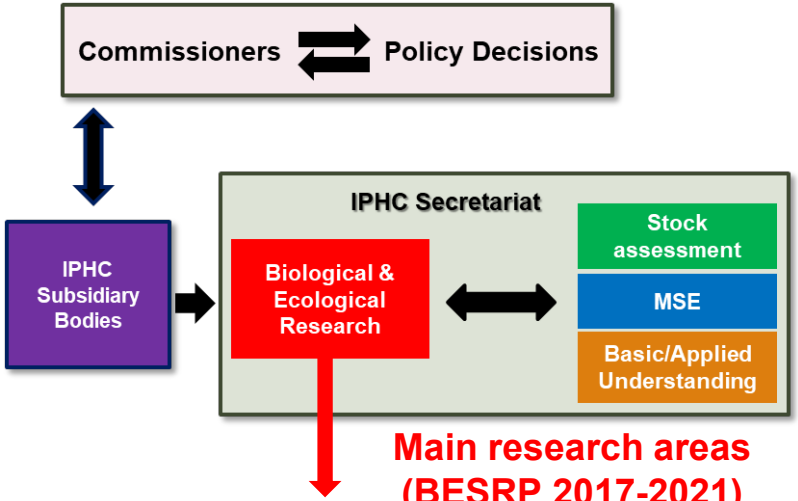
Report on current and future biological and ecosystem science research activities

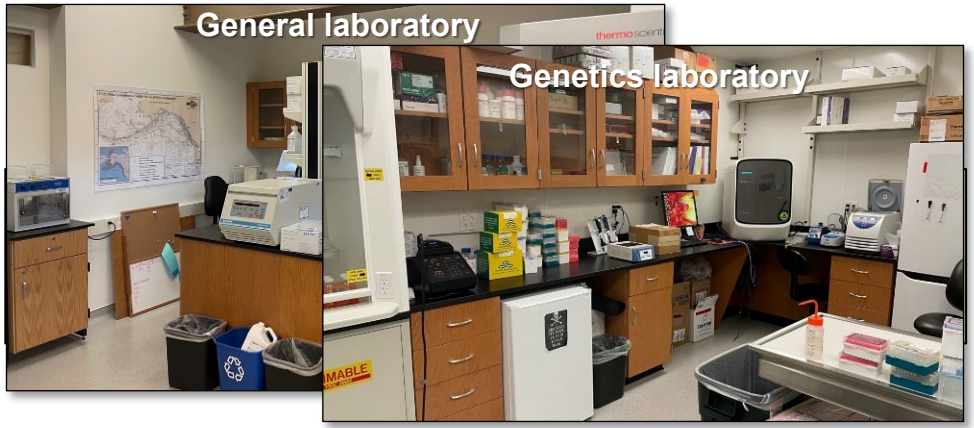
Agenda Item 5.3
IPHC-2022-RAB023-08
(and covering papers 09-12)

Description of IPHC research activities

- **Overview of biological and ecosystem science research activities within the IPHC 5-year Program of Integrated Research and Monitoring (2022-2026)**
- **Core research streams: Updates for key ongoing research activities**

Biological and Ecosystem Sciences





Main research areas (BESRP 2017-2021)

- Migration and distribution
- Reproduction
- Growth
- Discard mortality
- Genetics and genomics

Main research areas (PIRM 2022-2026)

- Migration and Population Dynamics
- Reproduction
- Growth
- Mortality and Survival Assessment
- Fishing technology

5Y-PIRM and management implications

5-Year Five-Year Program of Integrated Research and Monitoring

Primary BES Research Areas	*Main Objectives*	*Management implications*
Migration and population dynamics		
Reproduction		
Growth		
Mortality and survival assessment		
Fishing technology		

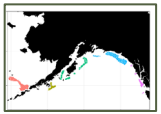
1. Migration and Population Dynamics

5-Yr Research Plan (2017-2021)

Multiple life-stage connectivity

Bering Sea

Gulf of Alaska



Genetic samples of spawning aggregations

Larval connectivity

- Larval catch and effort data
- Individual-based biophysical model
- Hydrographic ROMS model

→ Larval dispersal pathways → Inter-basin and intra-basin larval connectivity

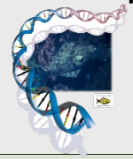
Juvenile connectivity

- NMFS trawl survey data
- Spatiotemporal model

→ Ontogenetic migration

Development and application of genomic approaches

Genome sequence



→ Population structure analyses

PIRM 2022-2026

- Climate effects on larval connectivity
- Connectivity with Russian waters
- Mapping of settlement/nursery areas
- Characterization of genetic composition/mixture of settlement areas
- Establishment of a baseline of genetic diversity
- Delineation of fine-scale stock structure
- Stock composition: mixed stock analyses

1. Migration and Population Dynamics

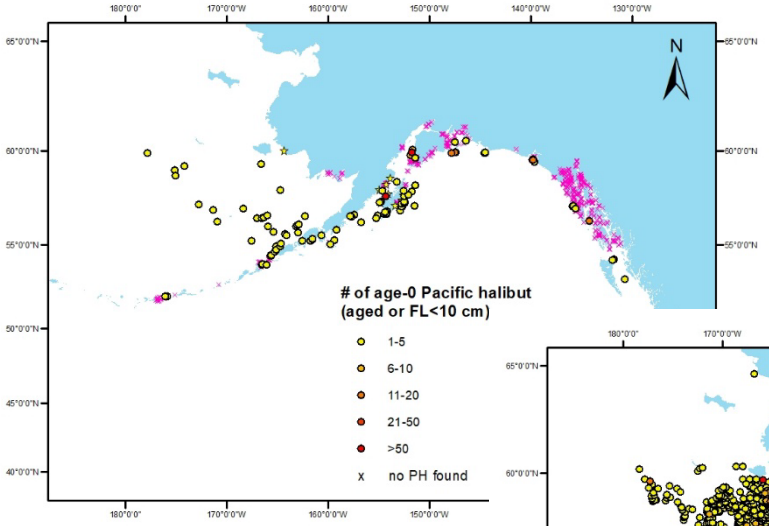
Mapping of Pacific halibut juvenile habitat

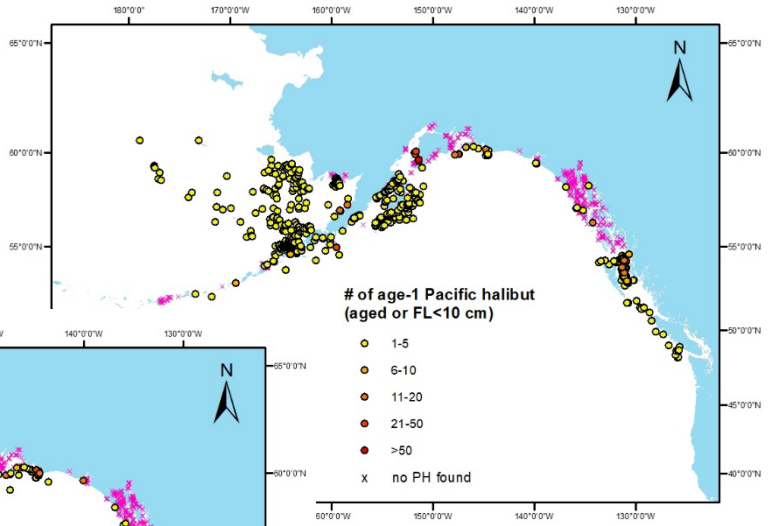
- Compile known datasets into a map of where age-0 to age-2 Pacific halibut are found and not found

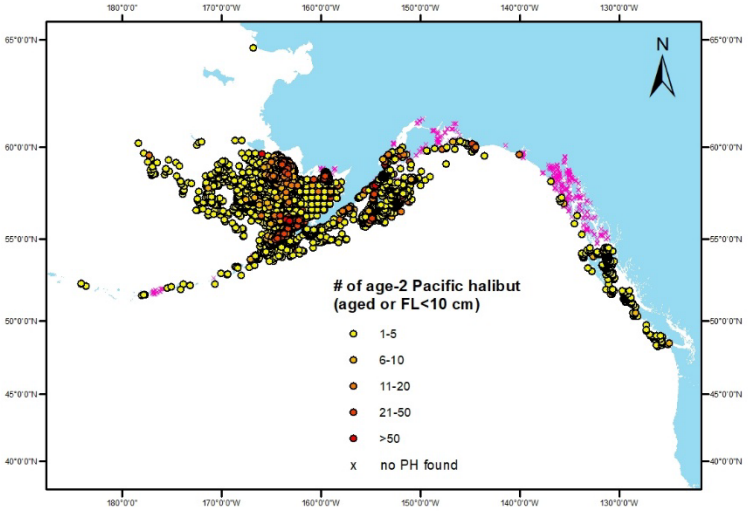
- Identify and define nursery areas that are used by Pacific halibut

- Use this information as a springboard for early life history projects going forward.
  Some examples include:
  - Identify co-variates that help to explain presence/absence and distributions of young Pacific halibut
  - Determine the traveling capabilities of young settled Pacific halibut
  - Explore the genetic composition of groups of young Pacific halibut
  - Explore the connectivity of spawning and nursery grounds through genetics and modeling

1. Migration and Population Dynamics





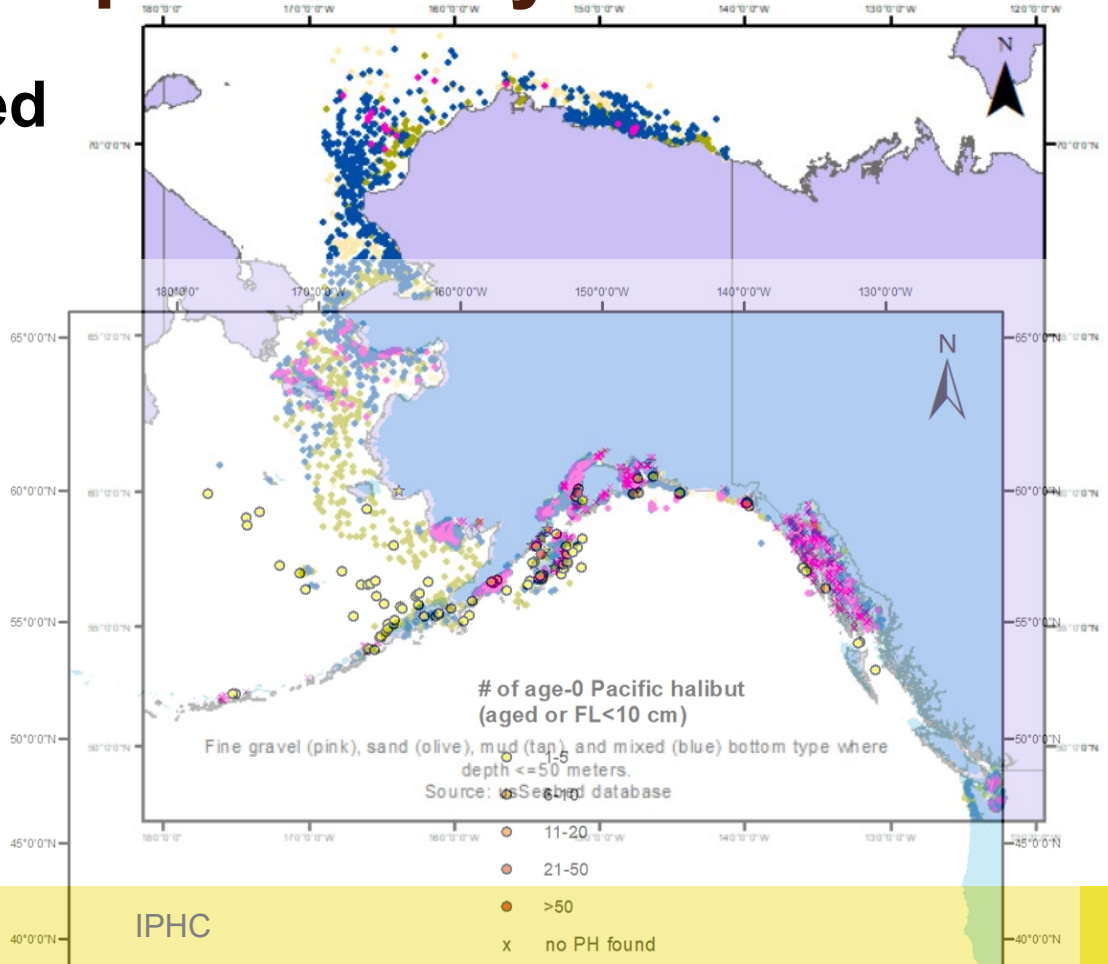


1. Migration and Population Dynamics

Data from the usSeabed database (USGS)

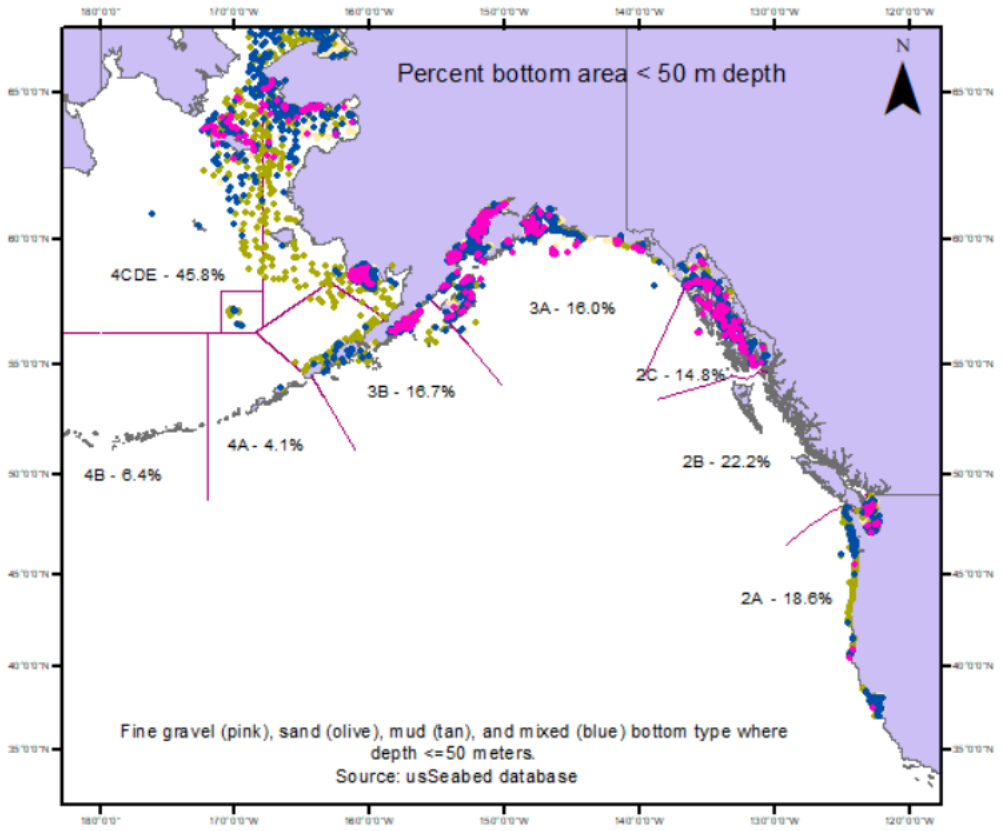
- Filtered to include:
  - mud
  - Sand
  - Fine gravel
  - mixed substrate
  - depth <=50 meters

These characteristics align with what we know about Pacific halibut nursery habitat.



1. Migration and Population Dynamics

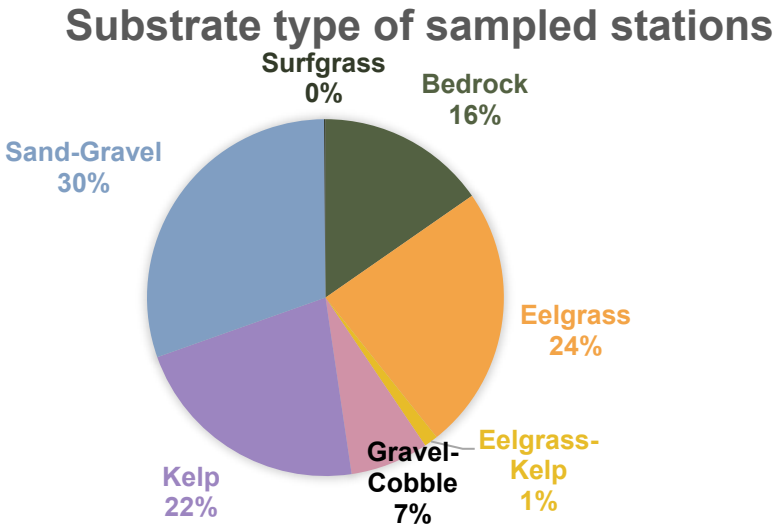
Percent bottom area for each Regulatory Area that is < 50 m depth

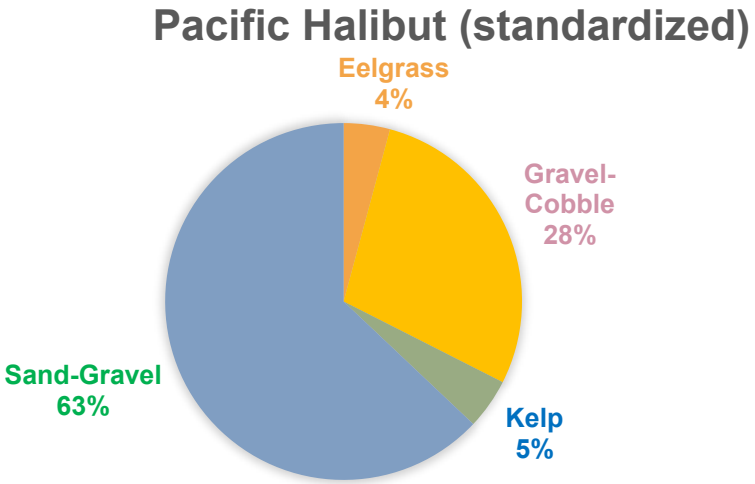


1. Migration and Population Dynamics

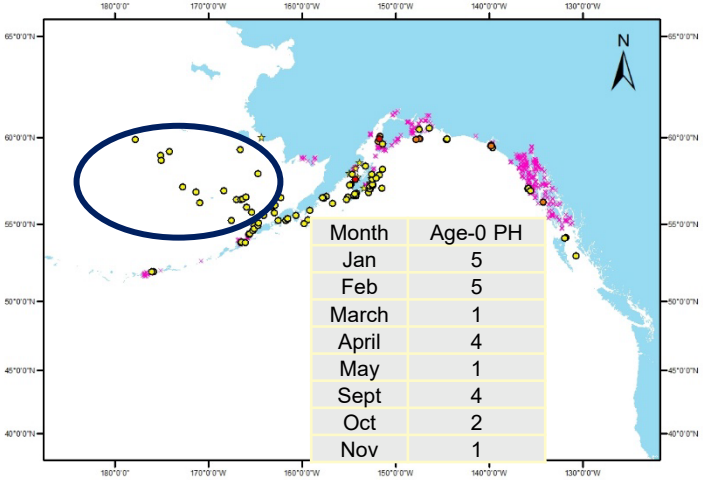
Substrate type – Fish Atlas

Total possible nursery sites: 789
Sites where Pacific halibut were found: 23

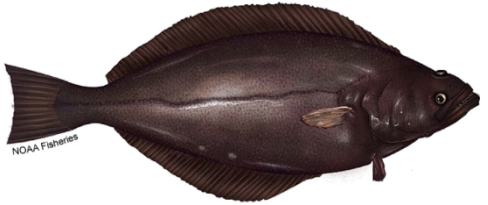




1. Migration and Population Dynamics



Month	Age-0 PH
Jan	5
Feb	5
March	1
April	4
May	1
Sept	4
Oct	2
Nov	1



Mis-identification?

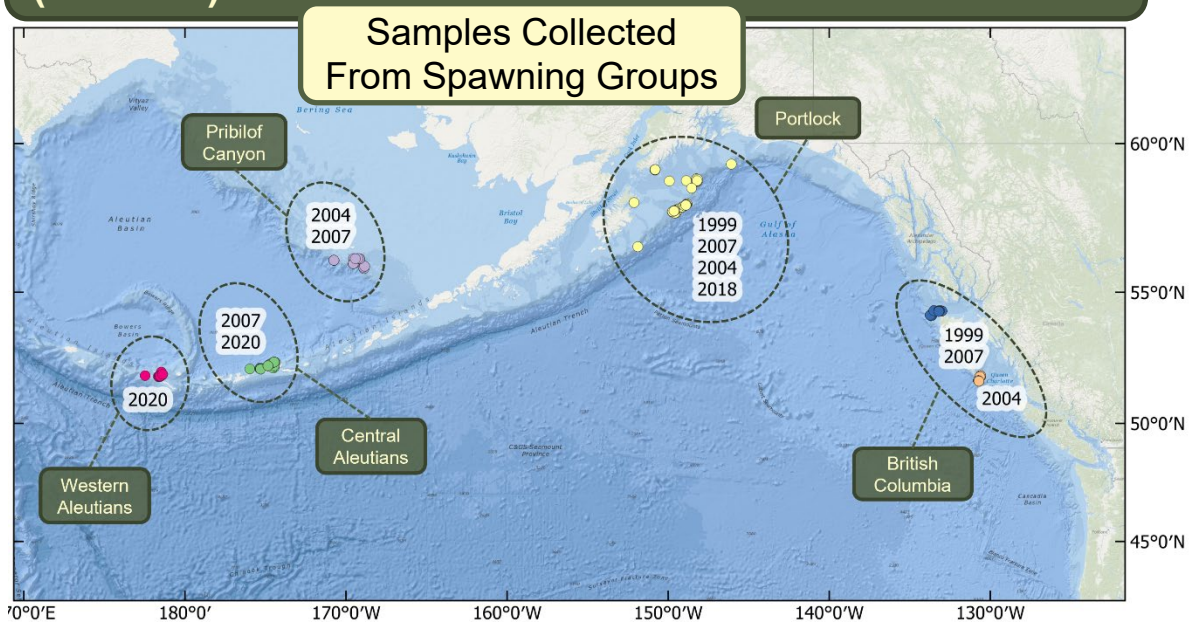
Seasonality?

Something else?

1. Migration and Population Dynamics

Population Genomics

Re-evaluate previous findings of population structure (Area 4B)



- **L**ow-**c**overage **w**hole-**g**enome **r**esequencing (lcWGR)
  - Interrogate genomic variation at very high resolution

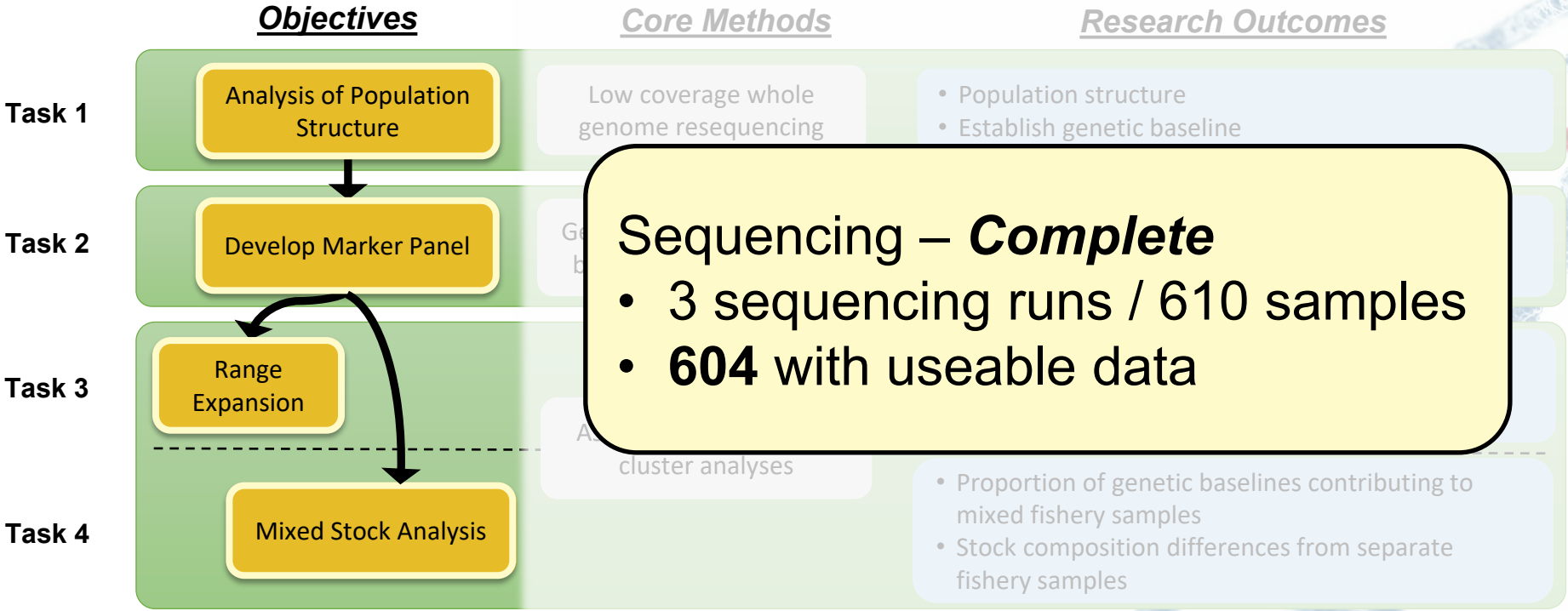
Pacific Halibut Genome

- Version 2 – March 2022
- Identify potential local and/or environmental adaptations.
- Provide genetic basis for life-history traits (e.g. growth, maturity, migratory behavior, etc.).

Establish Genetic Baseline

1. Migration and Population Dynamics

NPRB Project 2110: *Collaboration with NOAA AFSC*



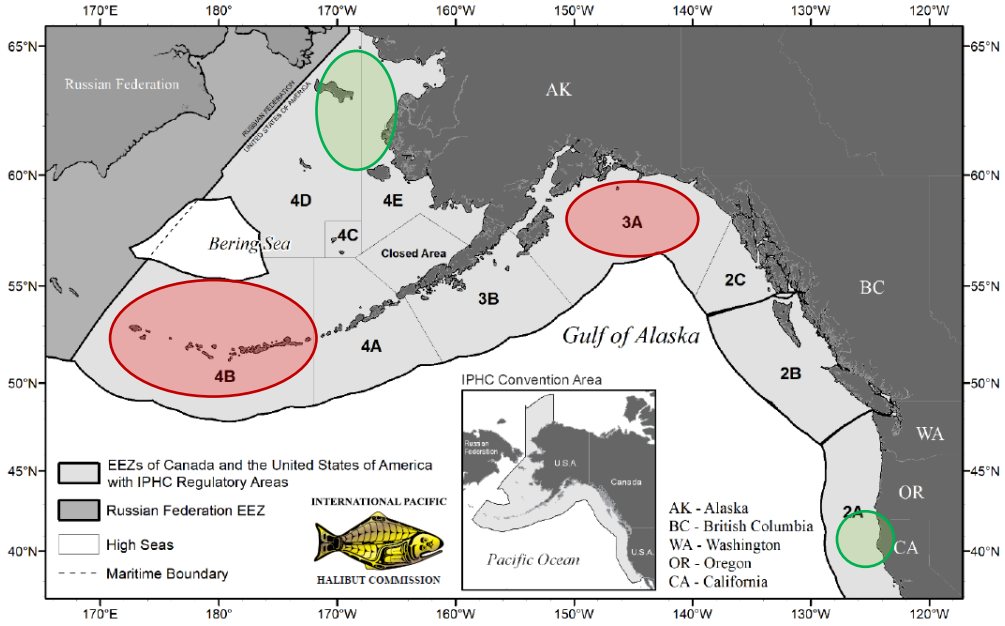
Sequencing – ***Complete***

- 3 sequencing runs / 610 samples
- **604** with useable data

1. Migration and Population Dynamics

Application of Genetic Baseline

Development of genetic marker panel (~500 SNPs)
Identify the population of origin for samples collected outside of spawning season

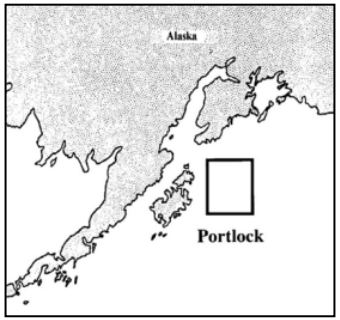


Two proof of concept applications

- Stock composition of commercial fishery landings
  - IPHC Areas 3A & 4B
  - N=640 samples
- Compare stock composition at latitudinal extremes of the species' range
  - California & Northern Bering Sea
  - N=~600 samples

2. Reproductive Assessment

Objective: Revise and improve accuracy of maturity estimates for female Pacific halibut

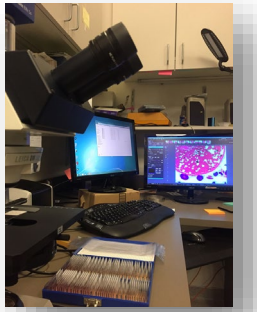


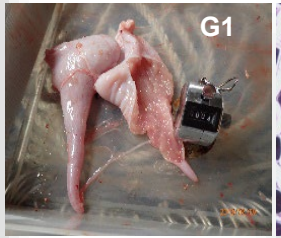
Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

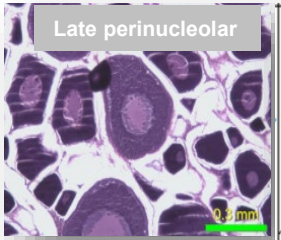
2017 2018

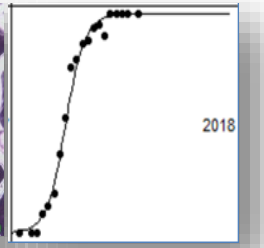
30♀ / 30♂

Reproductive cycle









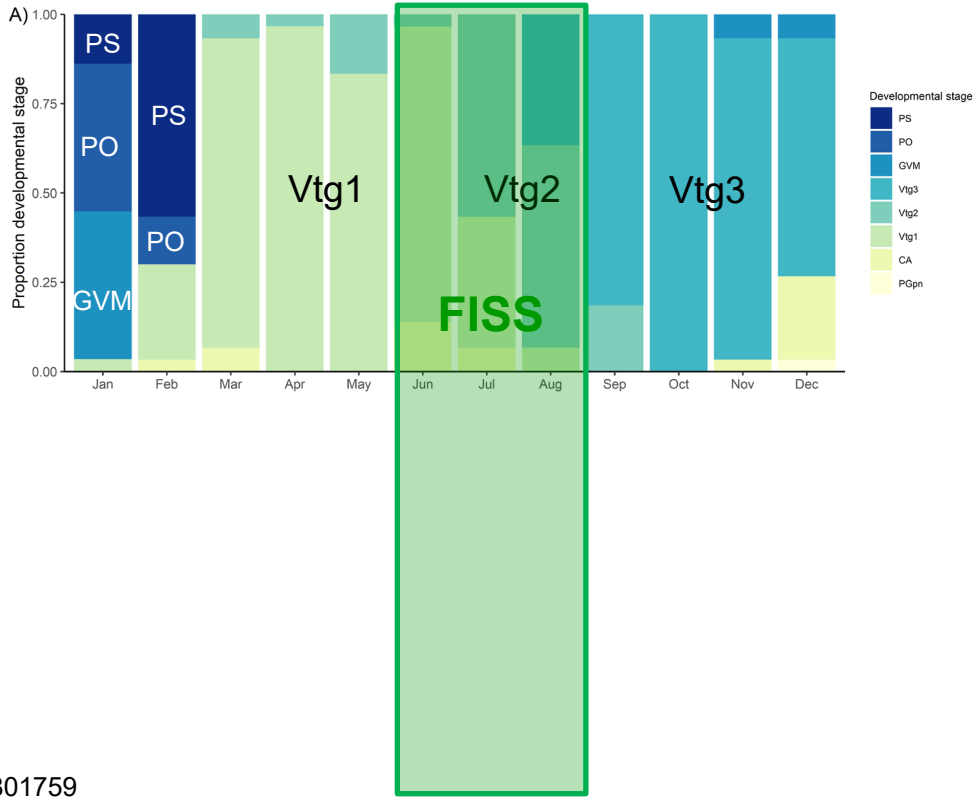
Deliverables:

- Accurate staging of reproductive status
- Updated maturity-at-age estimates
- Fecundity estimations

2. Reproductive Assessment

Microscopic maturity staging: based on histological oocyte stages

Female developmental stages



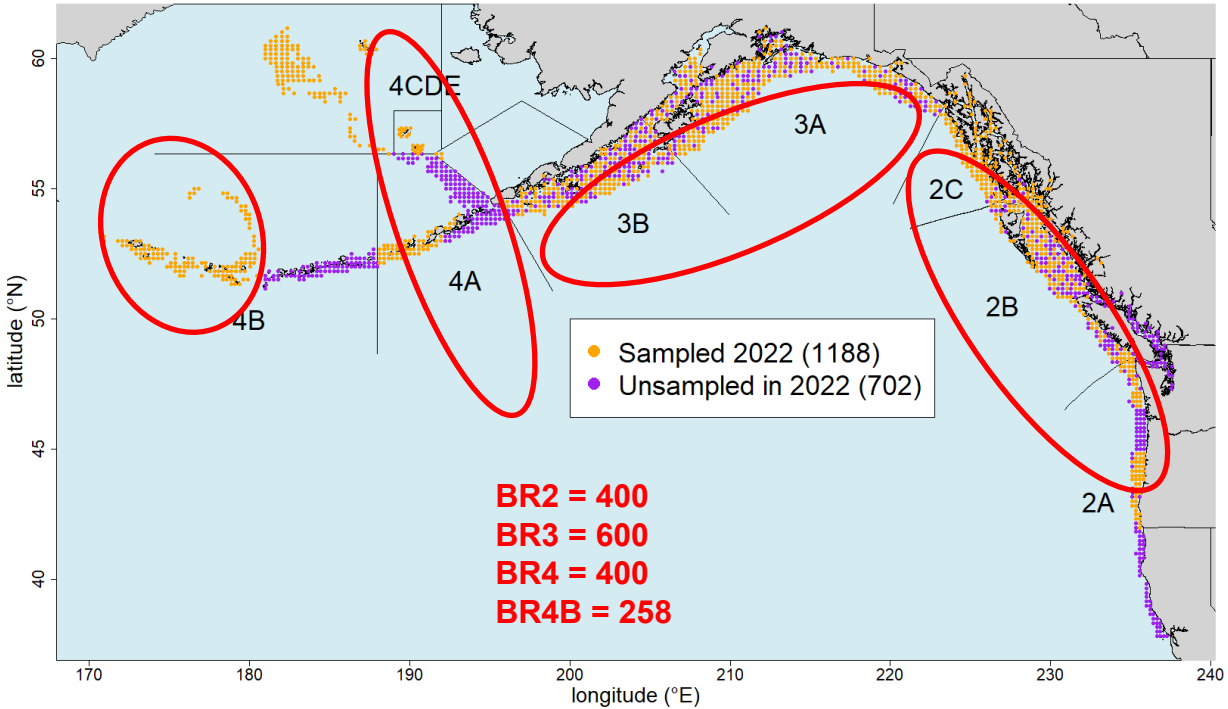
Vtg1 (Vitellogenic 1)
↓
Vtg2
↓
Vtg3
↓
GVM
(Germinal vesicle migration)
↓
PO (Periovulatory)
↓
PS (Post-spawning)

Developing
↓
Spawning capable
↓
Regressing

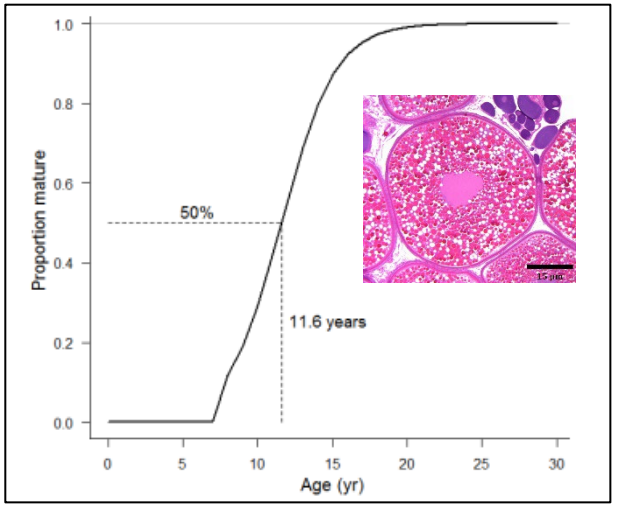
Fish et al. (2022) *Front. Mar. Sci.* **9**:801759

2. Reproductive Assessment

FISS 2022: ovarian sample collection for histology

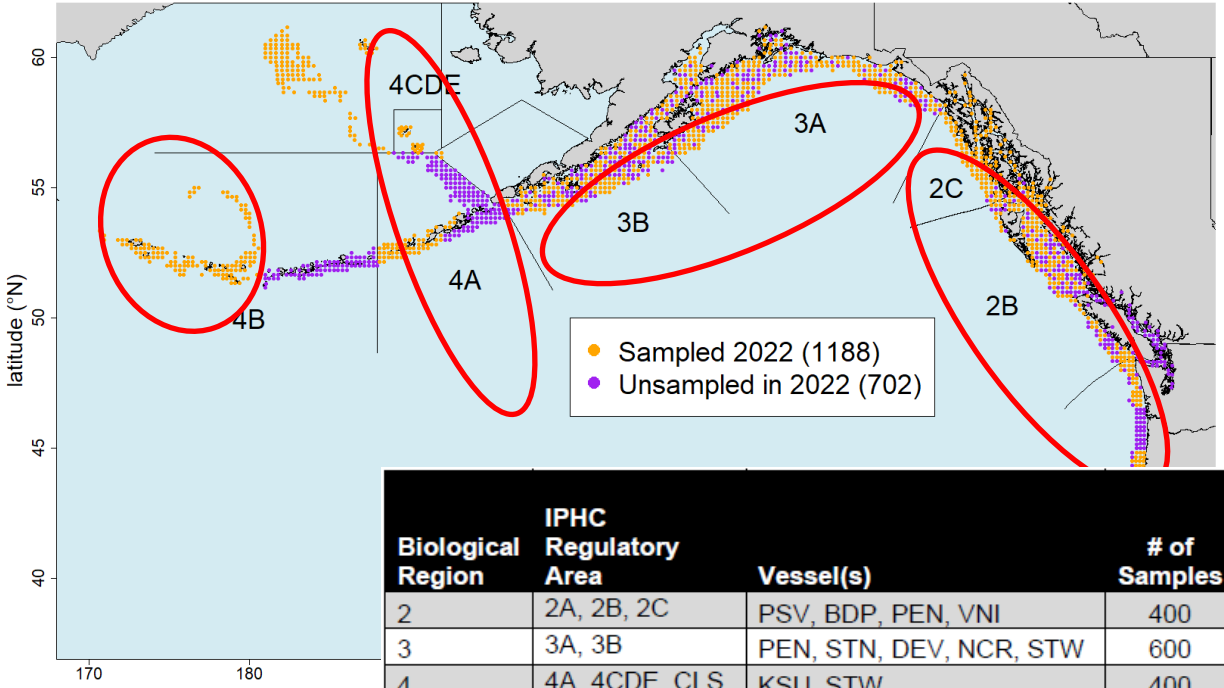


- **Revise maturity estimates per biological region by histological staging**



2. Reproductive Assessment

FISS 2022: ovarian sample collection for histology



Biological Region	IPHC Regulatory Area	Vessel(s)	# of Samples	Maturity Sampling Rate
2	2A, 2B, 2C	PSV, BDP, PEN, VNI	400	1/8
3	3A, 3B	PEN, STN, DEV, NCR, STW	600	1/5
4	4A, 4CDE, CLS	KSU, STW	400	1/5
4B	4B	KSU	258	1

3. Mortality and Survival Assessment

Discard mortality rates in the Pacific halibut charter fishery

A. Industry Survey:Gear and Handling Practices (AK, USA: Ketchikan, Juneau, Homer, Seward)

- 75-100 % use circle hooks (followed by jigs).
- Hook size: primarily 16/0, variety of others
- Captured fish generally pulled up with hook and line (larger fish brought aboard with a net)
- Hook release method: reversing the hook (54%), gaff twist (40%)
- Fish release method: support head and tail (65%)

3. Mortality and Survival Assessment

Discard mortality rates in the Pacific halibut charter fishery

B. Experimental fishing

Objective

- Conduct experimental fishing in which Pacific halibut are subjected to typical recreational gear and handling practices, to:
    - Investigate relationships between hook size and catch size
    - Develop injury and physiological stress profiles.
    - Quantify and characterize survival





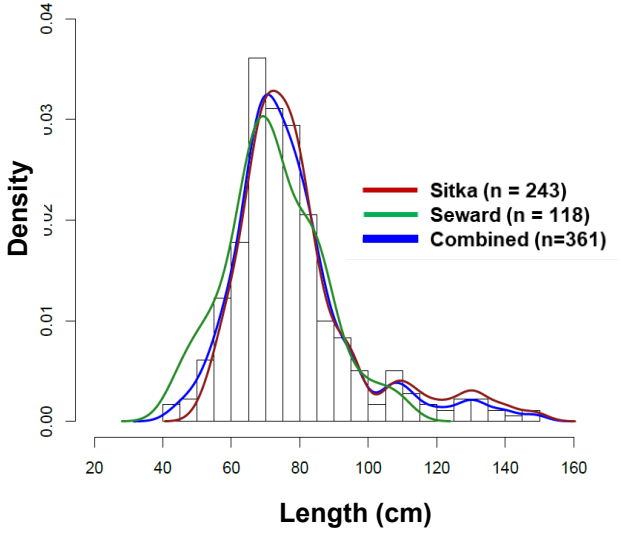

3. Mortality and Survival Assessment

Discard mortality rates in the Pacific halibut charter fishery

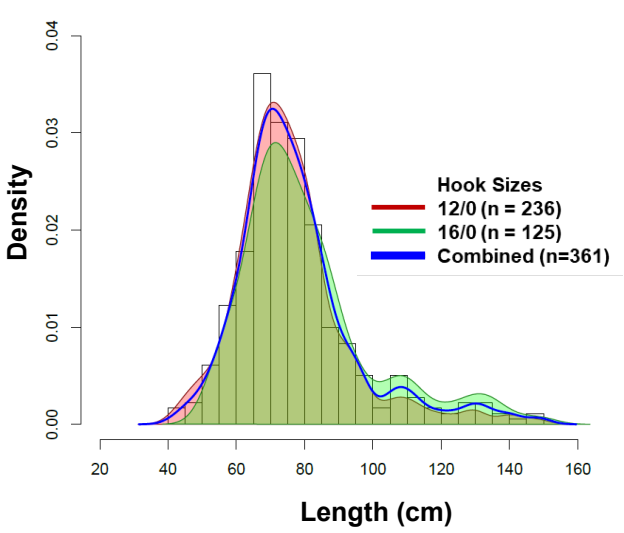
B. Experimental fishing

Results: Hook size and relation to fish size and injuries

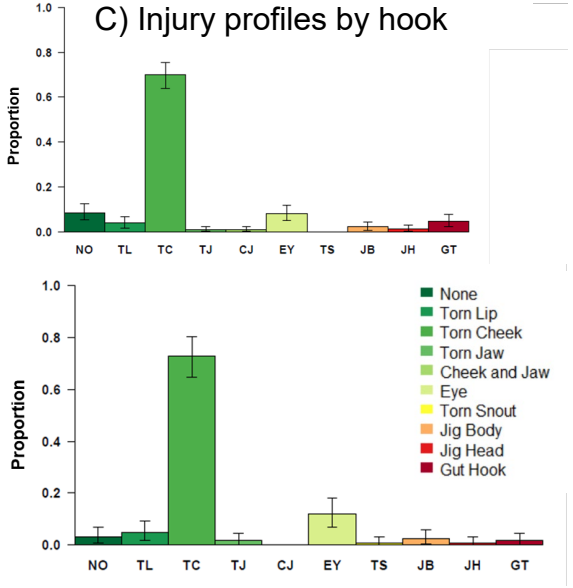
A) Length distributions by port



B) Length distributions by hook size



C) Injury profiles by hook



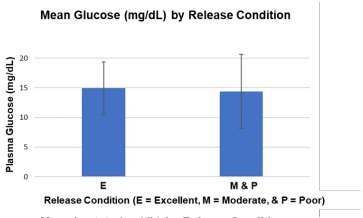
3. Mortality and Survival Assessment

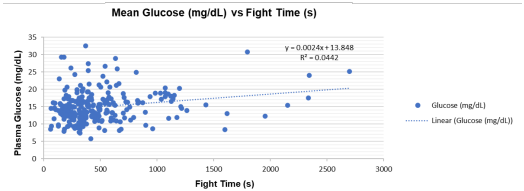
Discard mortality rates in the Pacific halibut charter fishery

B. Experimental fishing

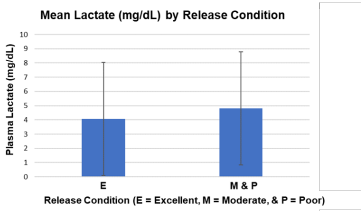
Results: Blood stress indicators (glucose, lactate, cortisol)

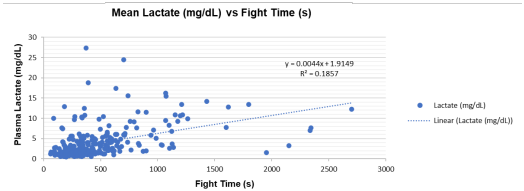
Glucose



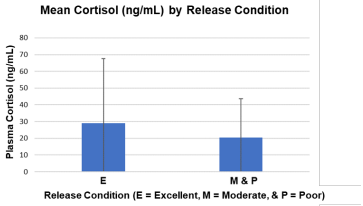


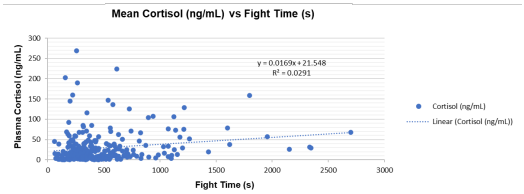
Lactate





Cortisol





3. Mortality and Survival Assessment

Discard mortality rates in the Pacific halibut charter fishery

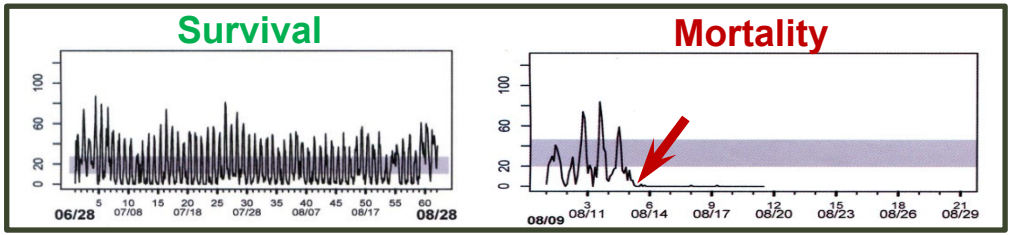
B. Experimental fishing

Results: Quantify and Characterize Survival

- Tags
  - Wire = 281 (243 Sitka, 38 Seward) – 28 recovered to date
  - sPAT = 80 (Seward) – 76 provided functional data
    - 7 fishery recoveries, 21 premature release, 48 full duration

A) Wire Tag

B) sPAT Tag



C) Typical acceleration patterns for fish that survive and fish that die

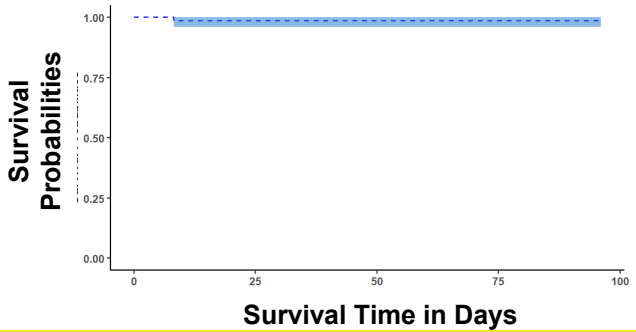
3. Mortality and Survival Assessment

Discard mortality rates in the Pacific halibut charter fishery

B. Experimental fishing

Results: Quantify and Characterize Survival

- sPAT Survival Analysis (R package ‘survival’ – time to event)
  - Preliminary mortality rate of 1.35% (95% CI of 0.0 – 3.95%) for excellent viability fish
  - Consistent with the currently applied DMR of 3.5%



4. Fishing technology

Reducing whale depredation by protecting longline catches

Background:

- Depredation of catch an increasing problem in hook and line fisheries.
- Auditory deterrents, and spatial or temporal avoidance – variable success.
- Terminal gear modification and catch protection - highest likelihood of ‘breaking the reward cycle’ in depredation

Project Goals:

1. Identify effective methods for protecting hook captured fish from depredation
2. Develop and Pilot several designs

NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Bycatch Reduction Engineering Program
(BREP) NA21NMF4720534

DEEP SEA
FISHERMEN'S UNION

4. Fishing technology

Reducing whale depredation by protecting longline catches

1. International Workshop on Protecting Fishery Catches from Whale Depredation (2/9/2022):

- Virtual workshop - 74 participants from 6 countries
- Presentations on different strategies for protecting the catch from longlines:
  - Shuttles – Sago Solutions (Norway),
  - Shrouds – INFREMER, IRD, MARBEC, (France)
  - Slinky Pots – Cod Coil (US)

Common Outcomes / Ideas:

- Cover the catch – shroud/cachalotera or via shuttle
- Small size for smaller vessels (slinky pots don't require reconfiguration or large stowage concerns)
- Branchlines to break gear into smaller manageable subunits
- Short gangions to keep catch near a mainline /reduce fouling/keep within the reach of the shroud
- Minimize fiddling with release mechanisms or repacking of shrouds

4. Fishing technology

Reducing whale depredation by protecting longline catches

2. Field testing of catch protection devices (Spring 2023 in the Gulf of Alaska)

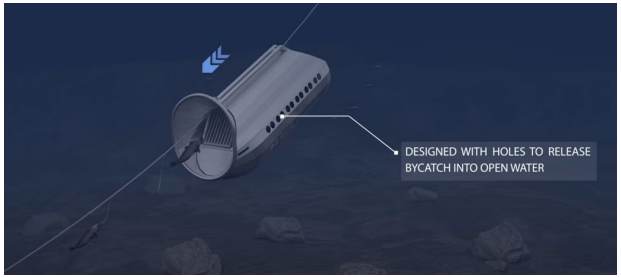
1. **Underwater Shuttle – enclose and transport**
2. **Underwater Shroud – cover the catch**

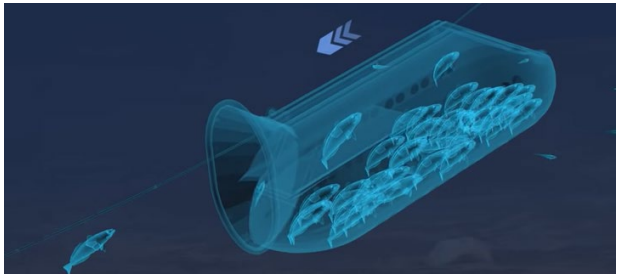
4. Fishing technology

Reducing whale depredation by protecting longline catches

2. Field testing of catch protection devices (Spring 2023 in the Gulf of Alaska)

1. **Underwater Shuttle** – enclose and transport (modeled after Sago Extreme: Sago Extreme – YouTube)
   - Unit dimensions:
     - 2.6 m (8.5’) long x 0.80 m (2.6’) diameter
     - 100 kg (220 lbs)
   - Fixed (stuck) gear
   - Open vessel deck, with crane capability
   - Deck space / cradle





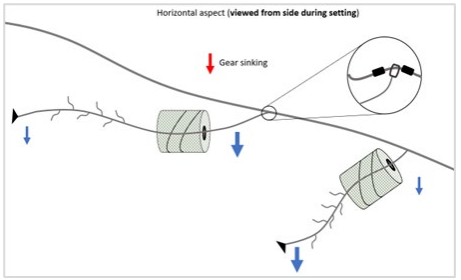
4. Fishing technology

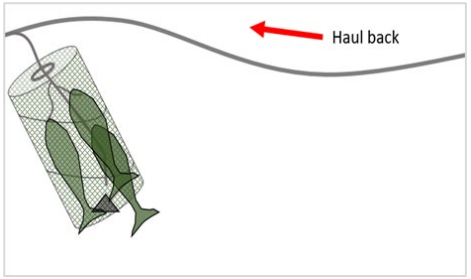
Reducing whale depredation by protecting longline catches

2. Field testing of catch protection devices (Spring 2023 in the Gulf of Alaska)

2. **Underwater Shroud** – cover the catch

- Unit dimensions:
  - 2 m (6.6’) long x 1.0 m (3.3’) diameter
  - 12 kg (26 lbs)
- Snap gear attached to branch lines
- 1 shroud / 10 hooks





4. Fishing technology

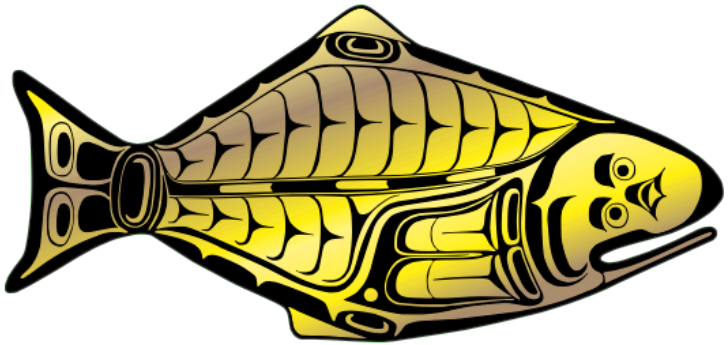
Reducing whale depredation by protecting longline catches

2. Field testing of catch protection devices (Spring 2023 in the Gulf of Alaska)

1. Underwater Shuttle – enclose and transport
2. Underwater Shroud – cover the catch

- Deployment / Retrieval logistics
  - Equipment, manpower, time budget
- Optimal configurations (weighting, attachments)
  - Deck space, minimize fouling
- Basic performance (species/sizes)
  - Target, bycatch, injuries, catch quality considerations

INTERNATIONAL PACIFIC



HALIBUT COMMISSION