
INTERNATIONAL PACIFIC
HALIBUT COMMISSION

# IPHC 5-year Biological and Ecosystem Science Research Plan: Update

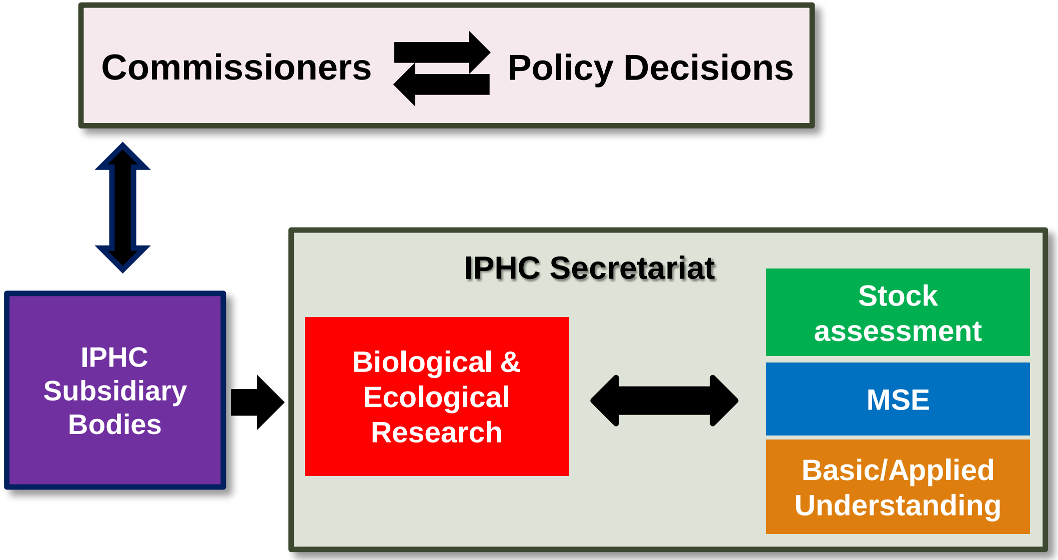
Agenda Item 7.3

IPHC-2020-IM096-10

# Outline

- Five-year biological and ecosystem science research program and management implications
- Progress on ongoing research projects
- Externally-funded collaborative research projects

# Integration of biological research, stock assessment, and policy



# Five-year research program and management implications (2017-2021)

5-Year Biological and Ecosystem Science Research Plan

| *Primary Research Areas* | *Main Objectives* | *Management implications* |
|---|---|---|
| **Migration** | Improve understanding of migration throughout all life stages (larval, juvenile, adult feeding and reproductive migrations) | Stock distribution, regional management |
| **Reproduction** | Information on sex ratios of commercial landings and improved maturity estimates | Female stock spawning biomass |
| **Growth** | Improve understanding of factors responsible for changes in size-at-age and development of tools for monitoring growth and physiological condition | Biomass estimates |
| **DMRs and discard survival** | Improve estimates of DMRs in the directed longline and guided recreational fisheries | Discard mortality estimates |
| **Genetics and genomics** | Improve understanding of the genetic structure of the population and create genomic tools (genome) | Stock distribution, local adaptation |

**Next 5-Year Research Plan (2021-26) in development**

# Outline

- Five-year research program and management implications
- **Progress on ongoing research projects**

1. Migration and Distribution
2. Reproduction
3. Growth
4. DMRs and Survival Assessment
5. Genetics and Genomics

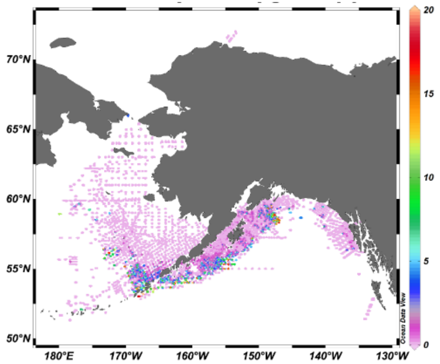
# 1. Migration and Distribution

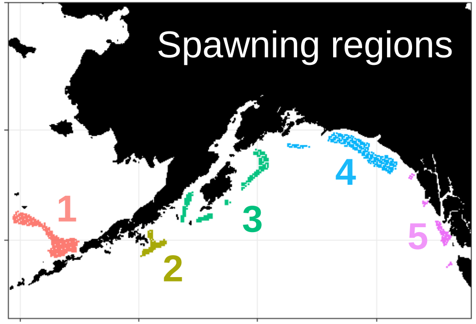
## *1. Larval and early juvenile dispersal*

- **Key findings:**
  - Aleutian Islands constrain connectivity, but large island passes act as conduits between the GOA and Bering Sea
  - Degree of inter-basin larval connectivity is influenced by spawning location.

Percentage of model larvae reaching the **Bering Sea** based on IBM:

| | Spawn region | Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | Warm | | | Cold | | |
| | | 2003 | 2004 | 2005 | 2009 | 2010 | 2011 |
| BS | 1 | 100 | 100 | 100 | 100 | 100 | 100 |
| GOA | 2 | 58.0 | 51.1 | 58.1 | 52.7 | 51.5 | 47.0 |
| GOA | 3 | 17.6 | 19.3 | 15.2 | 17.2 | 17.2 | 20.5 |
| GOA | 4 | 8.6 | 4.5 | 8.2 | 4.5 | 7.0 | 6.5 |
| GOA | 5 | 0.2 | 0.04 | 0.6 | 0.08 | 1.6 | 0.04 |

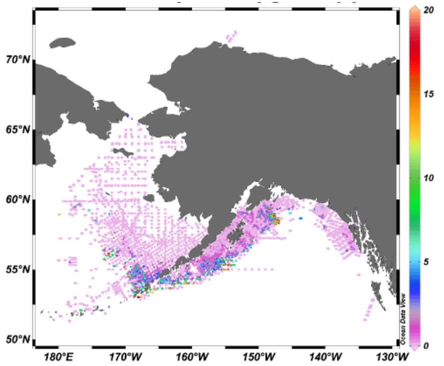


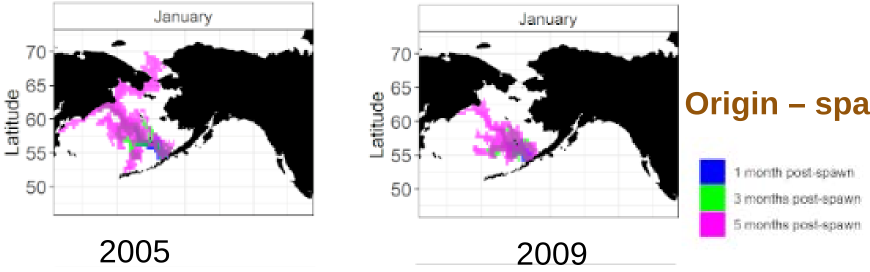



# 1. Migration and Distribution

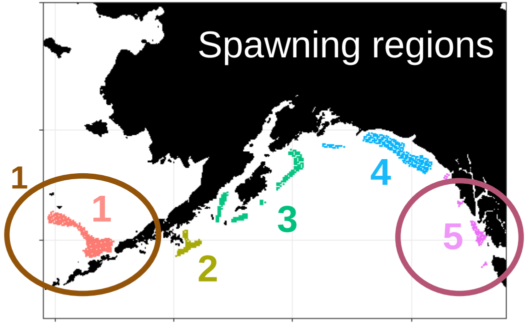
## *1. Larval and early juvenile dispersal*

- **Key findings:**
    - Aleutian Islands constrain connectivity, but large island passes act as conduits between the GOA and Bering Sea
    - Degree of inter-basin larval connectivity is influenced by spawning location
    - Large degree of intra-basin connectivity



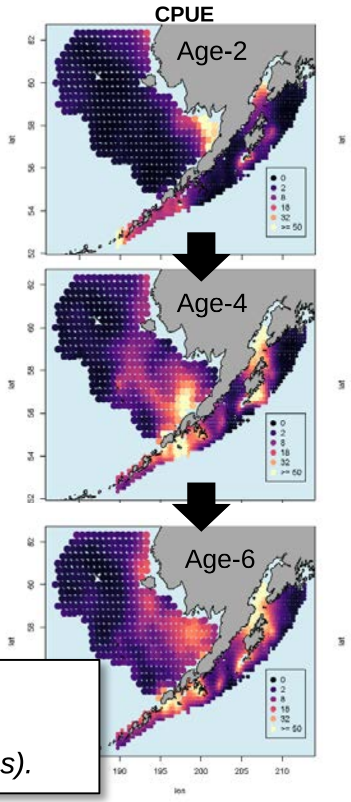

Origin – spawning region 1



# 1. Migration and Distribution

## *1. Larval and early juvenile dispersal*

- **Key findings:**
  - Aleutian Islands constrain connectivity, but large island passes act as conduits between the GOA and Bering Sea
  - Degree of inter-basin larval connectivity is influenced by spawning location.
  - Large degree of within-basin connectivity
  - Demersal stage fish in the Bering Sea migrate outward from Bristol Bay and reach Unimak Pass by age-4, widely dispersed by age-6



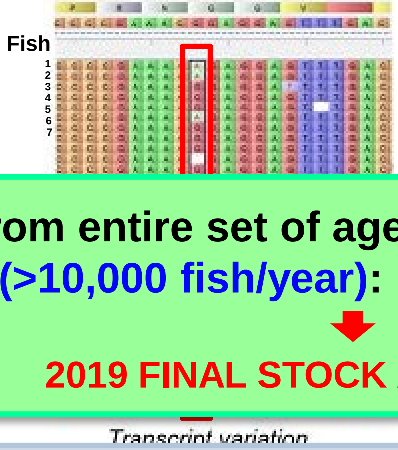

Sadorus, L. L., Goldstein, E., Webster, R. A., Stockhausen, W. T., Planas, J. V., and Duffy-Anderson, J. 2020. **Multiple life-stage connectivity of Pacific halibut (*Hippoglossus stenolepis*) across the Bering Sea and Gulf of Alaska**. *Fisheries Oceanography. (In Press).*

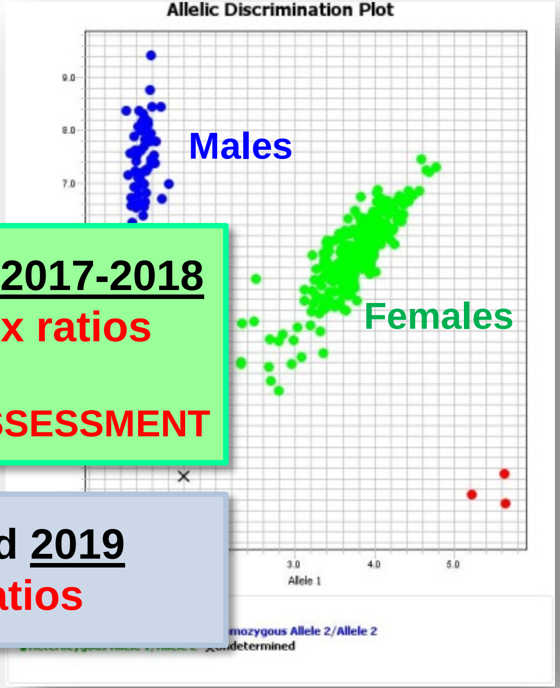
# 2. Reproduction

## *1. Identification of sex in the commercial landings*

**To generate sex-ratio data for use in assessment and policy analysis**

**Application of genetic techniques (SNPs)**


- **Completed: Fin clips from entire set of aged __2017-2018__ commercial samples (>10,000 fish/year): sex ratios**

**2019 FINAL STOCK ASSESSMENT**

- **Completed: Fin clips from entire set of aged __2019__ commercial samples (>10,000 fish) : sex ratios**

# 2. Reproduction

## *1. Identification of sex in historical commercial landings*

## ***DNA Extraction from Archived Otoliths: Current Progress***

| **Storage Type** | **n** | **# Successful Genotypes** |
| --- | --- | --- |
| Dry | 7 | 7 |
| Glycerin | 10 | 0 |

Other potential issues:

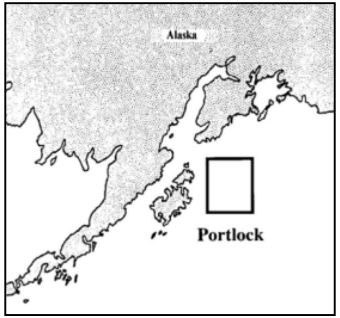
- All otoliths collected prior to 2003 stored in glycerin in batches, not individually
- Glycerin solution sometimes reused
- Some otoliths cleaned in muriatic acid

- Extractions via Qiagen column kits w/ DTT added, low elution volume
- PCR performed w/ BSA, extended cycle number
- No nanodrop signature present for glycerin-stored samples

# 2. Reproduction

## *2. Full characterization of the annual reproductive cycle to improve current estimates of maturity*

**Objective:** Revise maturity estimates for male and female Pacific halibut



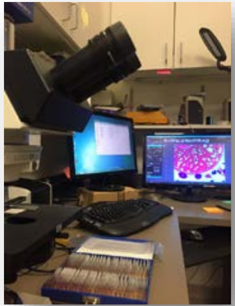

Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

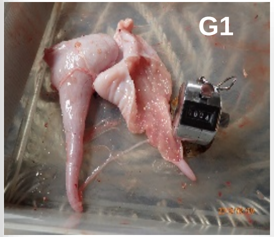
2017 2018

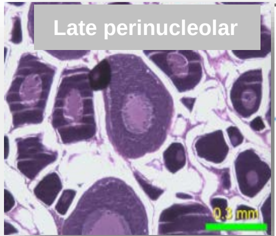
30♀ / 30♂

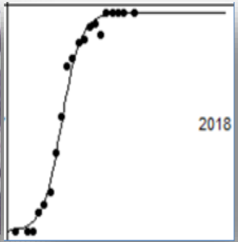
**Reproductive cycle**

| | | | | |
|---|---|---|---|---|
| | Gonadal growth | Maturation | Spawning | |





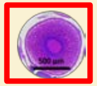



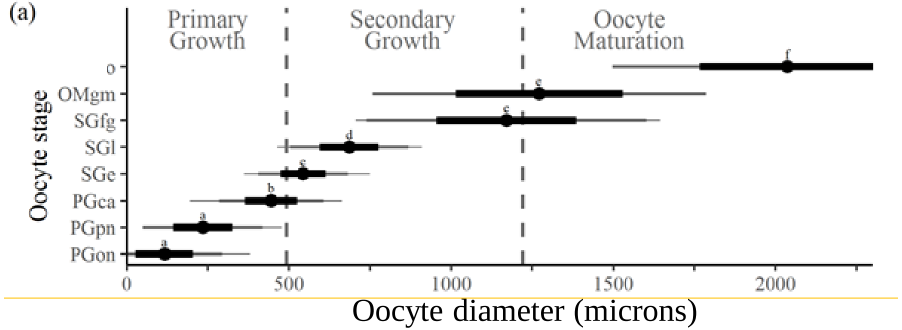




**Deliverables:**
- Accurate staging of reproductive status
- Updated maturity-at-age estimates
- Information on fecundity and skip-spawning

# 2. Reproduction

## *Microscopic maturity staging: Oocyte stage classification by histology*

| Growth phase (acronym) | Developmental stage (acronym) | Description | Photo |
|---|---|---|---|
| Primary Growth (PG) | One nucleolus (PGon) | Oocytes are small, angular, and compact with a single large nucleolus. Cytoplasm stains dark purple. |  |
| | Perinucleolar (PGpn) | Oocytes are larger and rounder than PGon and nuclei develop and flatten around the nucleus. Cytoplasm stains light purple. |  |
| | Cortical alveolar (PGca) | First cortical alveoli appear as white stain in the periphery of the oocyte. |  |
| Secondary Growth (SG) | Early (SGe) | Yolk globules first appear at the periphery, stain pink, and fill inwards occupying up to 1/3 of the cytoplasm. |  |
| | Late (SG*l*) | Yolk globules transition from only the periphery of the ooplasm and fill inwards to the nucleus. |  |
| | Full Grown (SGfg) | Yolk globules completely fill the ooplasm to the central nucleus and coalesce into larger yolk globules. |  |
| Oocyte Maturation (OM) | Germinal vesicle migration (OMgm) | The nucleus begins to migrate through a cytoplasm fully filled with large yolk globules. |  |
| | Periovulatory (OMpo) | Nucleus no longer visible and the yolk globules coalesce int a central yolk mass. Oocyte is still within the follicle wall. | |



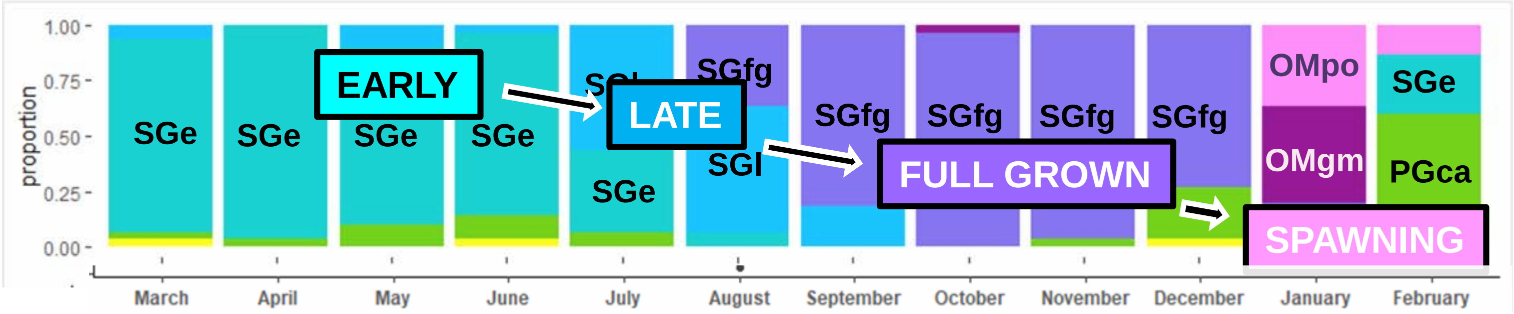

**Female reproductive phase determined based on the stage of the most advanced oocytes**

- **Pacific halibut is a batch-spawner with a group-synchronous ovarian developmental pattern**

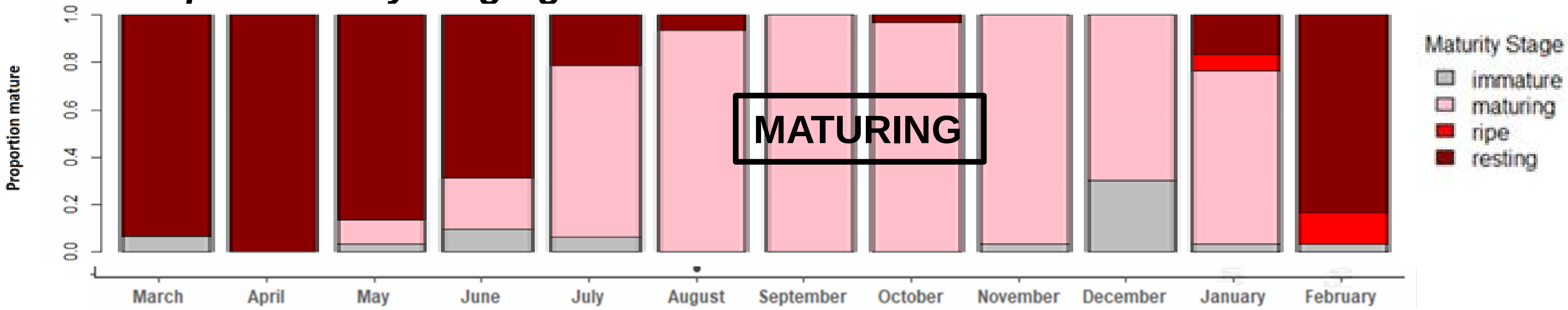

Fish, T., Wolf, N., Harris, B. P. , and Planas, J. V. 2020. **A comprehensive description of oocyte developmental stages in Pacific halibut, *Hippoglossus stenolepis*.** *Journal of Fish Biology. (In Press).*

# 2. Reproduction

***Microscopic maturity staging: based on histological oocyte stages***

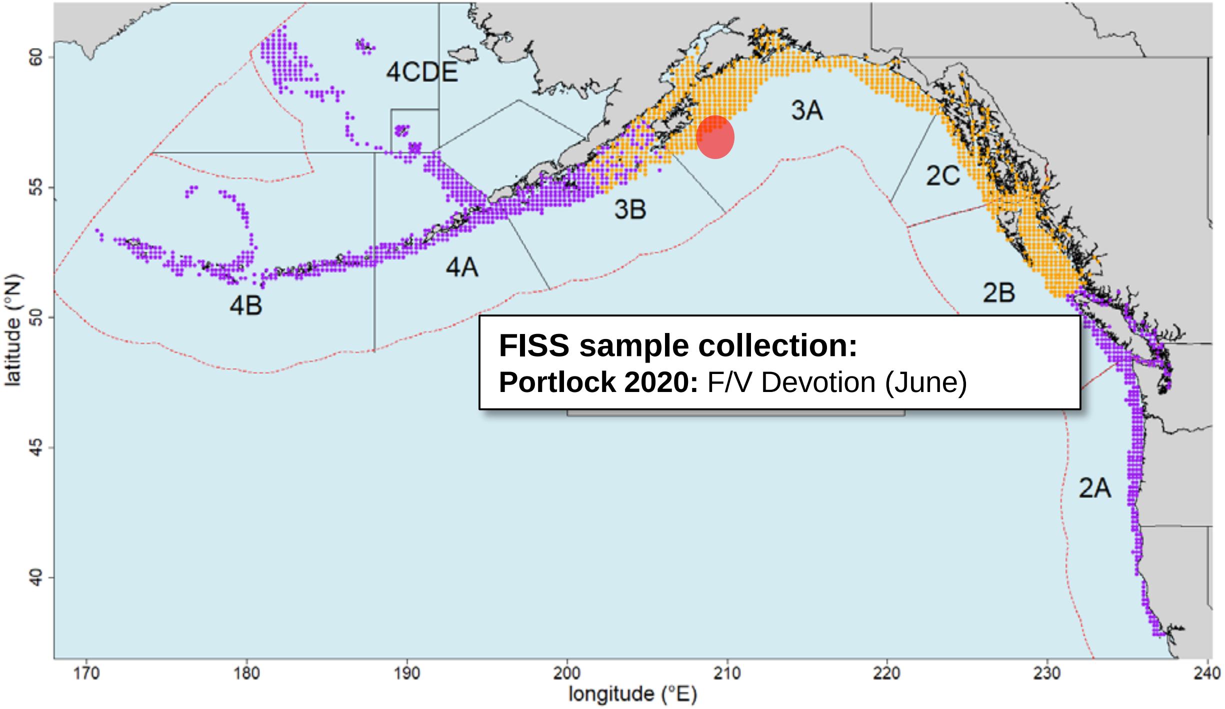



***Macroscopic maturity staging: based on field visual observation***



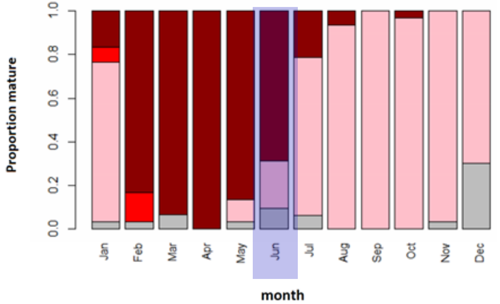
# 2. Reproduction

## 2017-2020: Temporal analysis of maturity (Portlock region)




- **Full annual collection (2018)**

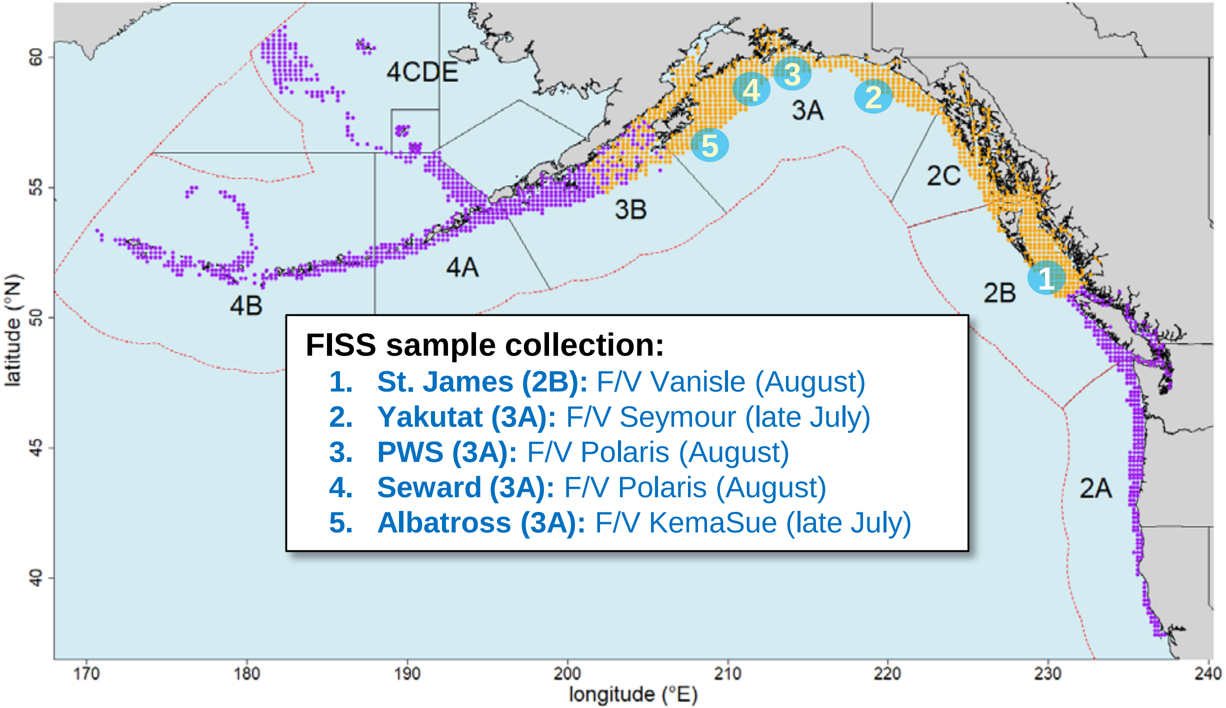
**Macroscopic maturity staging (♀)**




- **Interannual collection**
  **June 2017, 2018, 2019, 2020**

# 2. Reproduction

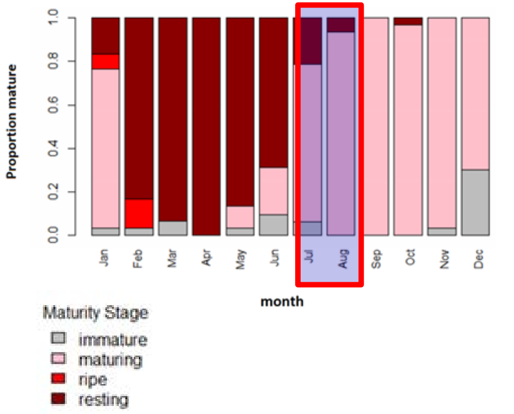
## 2020: Spatial analysis of maturity (Gulf of Alaska)




**FISS sample collection:**

1. **St. James (2B):** F/V Vanisle (August)
2. **Yakutat (3A):** F/V Seymour (late July)
3. **PWS (3A):** F/V Polaris (August)
4. **Seward (3A):** F/V Polaris (August)
5. **Albatross (3A):** F/V KemaSue (late July)

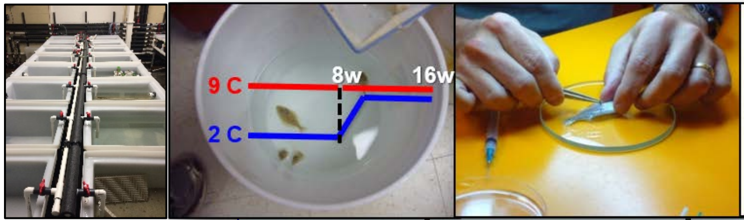
**Macroscopic maturity staging (♀)**

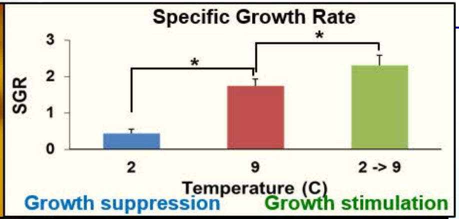



- **July-August collection in FISS: 75-90% maturing (30 females/region)**

# 3. Growth

## *1. Identification and validation of physiological markers for growth*




**Temperature** | **Population Density** | **Dominance** | **Capture Stress**

**Effects on transcriptome and proteome**

**MUSCLE**

**LIVER**

**BIOCHEMICAL AND MOLECULAR GROWTH RESPONSES**

**Identification of physiological growth markers**

**Application to field studies**

**White muscle:**

- **Transcriptomics**
- **Proteomics**

**IPHC / AFSC-NOAA (Newport, OR)**

**Dr. Josep Planas (PI)**

**Dr. Thomas Hurst**


**NPRB Grant 1704 (2017-2020)**

# 3. Growth

## *1. Identification and validation of physiological markers for growth*

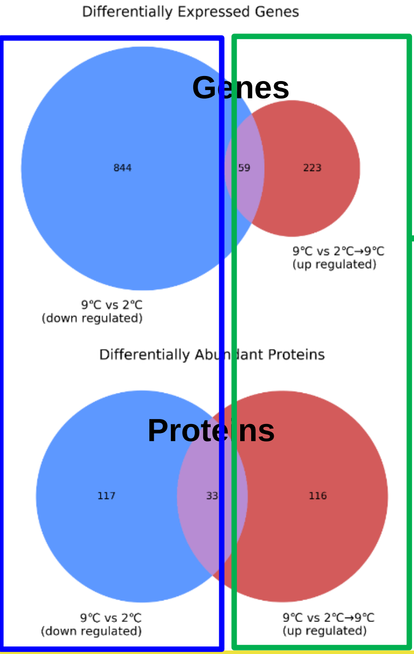
**↓ Growth Markers**

Arginine--tRNA ligase, cytoplasmic OS=Rattus norvegi
Asparagine synthetase [glutamine-hydrolyzing] OS=Ra
ATP-binding cassette sub-family E member 1 OS=Mus
Carboxypeptidase A5 OS=Mus musculus GN=Cpa5 PE=
Collagen alpha-1(V) chain OS=Mus musculus GN=Col5a
Collagen alpha-2(I) chain (Fragments) OS=Gallus gallu
Collagen alpha-6(VI) chain OS=Homo sapiens GN=COL
Coronin-1A OS=Homo sapiens GN=CORO1A PE=1 SV=4
Elongation factor 1-delta OS=Xenopus laevis GN=eef1
Eukaryotic translation initiation factor 2 subunit 2 OS=
Eukaryotic translation initiation factor 3 subunit J-A O
Eukaryotic translation initiation factor 4 gamma 2 OS=
Glycine--tRNA ligase OS=Homo sapiens GN=GARS PE=
Heat shock 70 kDa protein 4 OS=Canis lupus familiaris
Heat shock protein beta-11 OS=Danio rerio GN=hspb1
Histone-lysine N-methyltransferase SETD7 OS=Danio
Importin-13 OS=Pongo abelii GN=IPO13 PE=2 SV=1
Influenza virus NS1A-binding protein homolog A OS=
Kelch-like protein 10 OS=Homo sapiens GN=KLHL10 PE
Myozenin-2 OS=Pongo abelii GN=MYOZ2 PE=2 SV=1
N-alpha-acetyltransferase 38, NatC auxiliary subunit
Ornithine carbamoyltransferase, mitochondrial OS=H
Peptidyl-prolyl cis-trans isomerase FKBP7 OS=Mus mu
Phenylalanine--tRNA ligase alpha subunit OS=Danio r
Phosphoserine aminotransferase OS=Mus musculus G
Protein BCCIP homolog OS=Danio rerio GN=bccip PE=2
Troponin I, fast skeletal muscle OS=Oryctolagus cunic
Ubiquitin carboxyl-terminal hydrolase isozyme L1 OS=
Unconventional myosin-VI OS=Homo sapiens GN=MY

**23**

**Decreased growth rate**

**Increased growth rate**




**10**

- **Identify common genes and proteins in muscle that change with changes in growth rate**

**↑ Growth Markers**

60S ribosomal protein L22 OS=Ictalurus punctatus GN=rpl22 PE=2 SV=3
Asparagine synthetase [glutamine-hydrolyzing] OS=Gallus gallus GN=ASNS
Collagen alpha-3(VI) chain OS=Gallus gallus GN=COL6A3 PE=2 SV=2
Immunoglobulin-like and fibronectin type III domain-containing protein 1
Leucine-rich repeat-containing protein 2 OS=Homo sapiens GN=LRRC2 PE=2
Methionine aminopeptidase 2 OS=Homo sapiens GN=METAP2 PE=1 SV=1
Ornithine carbamoyltransferase, mitochondrial OS=Homo sapiens GN=OTC
Prolyl 4-hydroxylase subunit alpha-2 OS=Caenorhabditis elegans GN=phy-2
Titin OS=Homo sapiens GN=TTN PE=1 SV=4
Ubiquitin carboxyl-terminal hydrolase 25 OS=Homo sapiens GN=USP25 PE=

# 3. Growth

Physiological growth markers → Application to field studies

## *1. Identification and validation of physiological growth markers for adult Pacific halibut*

- **44 adult Pacific halibut in captivity in Seward, AK (collaboration with Alaska Pacific University)**
- **Establishment of different growth rates through dietary manipulation**
- **Validation of physiological growth markers to infer growth patterns (slow versus fast growth) in adult Pacific halibut**

***Slow growth rate?***

***Fast growth rate?***

# 4. DMRs and Survival Assessment

## 1. <u>Directed longline fishery</u>: *A. Relationship between handling practices and injury levels and physiological condition of released Pacific halibut*

- Assessed *injuries* and *release condition* associated with release techniques (careful shake, gangion cut, hook stripping).
  - Injury evaluation




- *Physiological condition* of released fish
  - Condition factor indices



- *Capture conditions*
  - Time



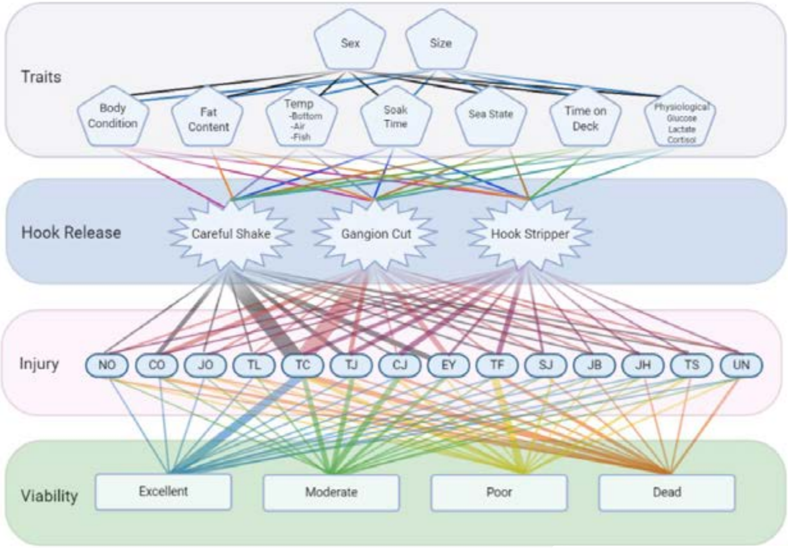
NOAA FISHERIES Saltonstall – Kennedy Grant NA17NMF4270240

ALASKA PACIFIC UNIVERSITY

# 4. DMRs and Survival Assessment

***1. <u>Directed longline fishery</u>: A. Relationship between handling practices and injury levels and physiological condition of released Pacific halibut***

- ***Continuing Analysis:*** **Relationships of individual (physiological, fitness) and environmental (time out of water, soak time, temperature differences etc.) traits on release viability**



# 4. DMRs and Survival Assessment

## 2. Guided recreational fishery: Estimation of DMRs

**Objectives:**

2019

1. Collect information on hook types and sizes and handling practices

➡ Survey: Dock-side interviews (n=51)
- Reg. Area 2C: Sitka (n=16), Juneau (n=8)
- Reg. Area 3A: Homer (n=12), Seward (n=15)

**Results:**

1. 75% Circle Hooks / 25% Jigs (J-hook)
2. Hook removal: 54% reverse the hook
   40% twist with gaff
3. Fish Handling upon release:
   a) Body and tail supported (65%)
   b) Operculum (10%
   c) Tail only (10%)

Guided recreational

Captured Pacific halibut

NFWF National Fish and Wildlife Foundation

UAF University of Alaska Fairbanks | Alaska Pacific University | ACA Alaska Charter Association

# 4. DMRs and Survival Assessment

## 2. *Guided recreational fishery: Estimation of DMRs*

– Project initiated in 2019

**Objectives (cont'd):**

**2021**
Field Experiment

1. Investigate the relationship between gear types and capture conditions and size composition of captured fish
2. Injury profiles and physiological stress levels of captured fish
3. Assessment of mortality of discarded fish

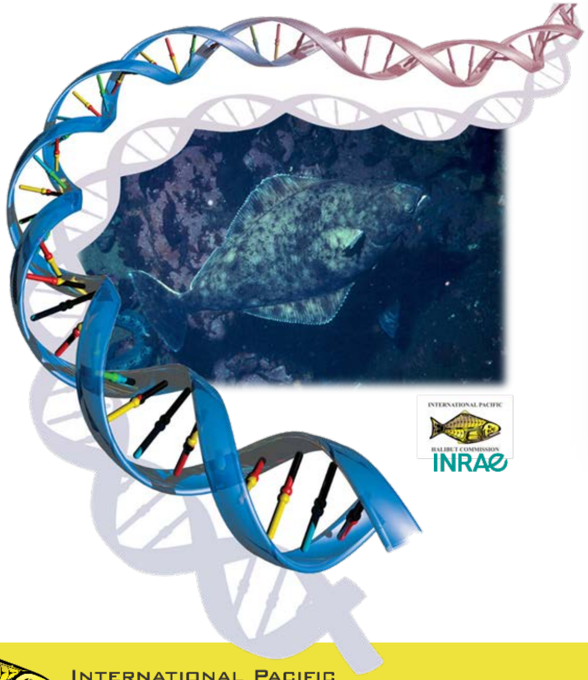
Hook injury assessment

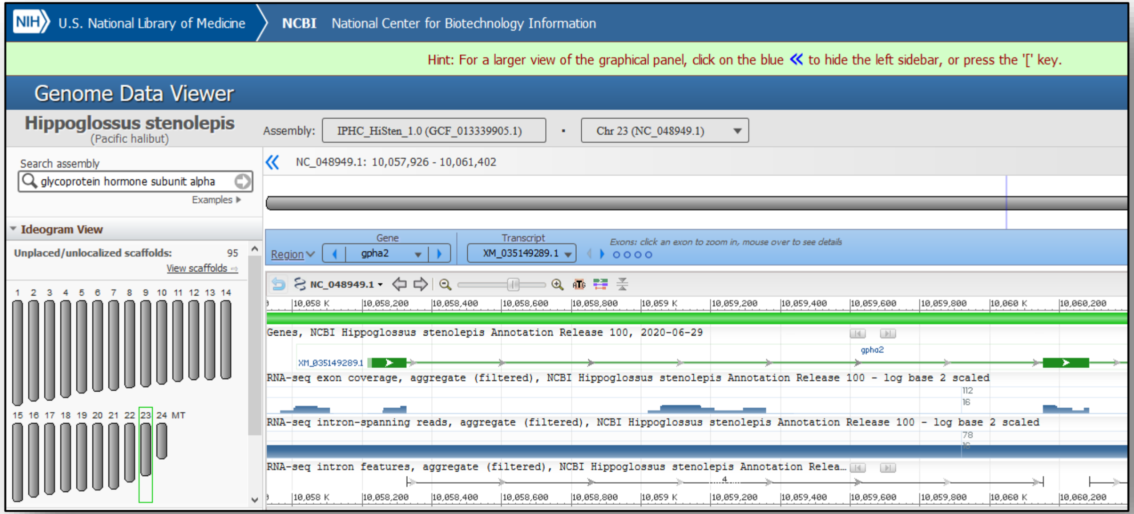
National Fish and Wildlife Foundation

# 5. Genetics and Genomics

## Completed sequence of the Pacific halibut genome

- **Size: 594 million base pairs**
- **24 chromosomes**
- **27,422 genes**
- **91 X coverage**





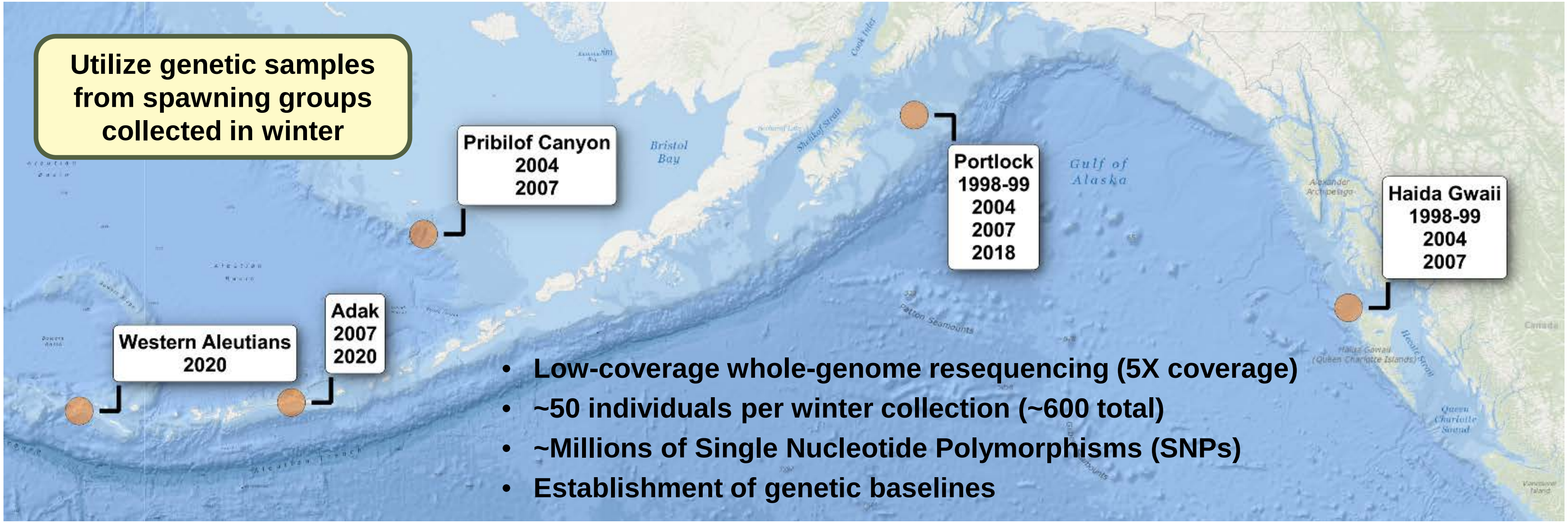

https://www.ncbi.nlm.nih.gov/assembly/GCA_013339905.1

# 5. Genetics and Genomics

**Revise our understanding of genetic structure of the Pacific halibut population in the North-eastern Pacific Ocean**

**Analysis of structure in IPHC Regulatory Area 4B**

**Utilize genetic samples from spawning groups collected in winter**

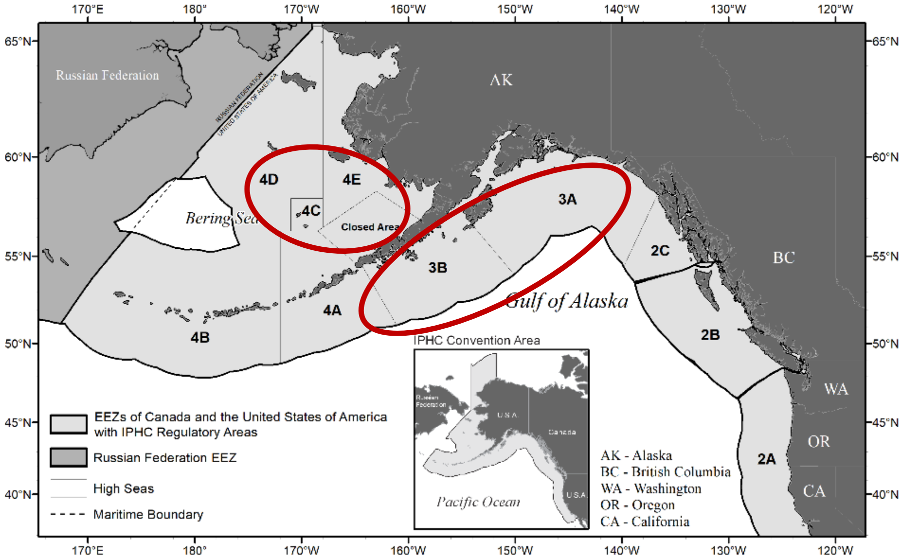



- Low-coverage whole-genome resequencing (5X coverage)
- ~50 individuals per winter collection (~600 total)
- ~Millions of Single Nucleotide Polymorphisms (SNPs)
- Establishment of genetic baselines

# 5. Genetics and Genomics

## Analysis of genetic variability among juvenile Pacific halibut in the Bering Sea and the Gulf of Alaska

- ***Infer the potential contribution of fish spawned in different areas to the Gulf of Alaska (GOA) and Bering Sea (BS)***
- Fin clips collected during NMFS trawl surveys
  - Gulf of Alaska (2015, 2017, 2019)
  - Bering Sea (2015-2019)
- Compare genetic diversity metrics between GOA & BS
- Estimate admixture proportions



# Outline

- Five-year research program and management implications
- Progress on ongoing research projects
- **Externally-funded collaborative research projects**

# Externally-funded collaborative research

| Project # | Grant agency | Project name | PI | Partners | IPHC Budget ($US) | Management implications | Grant period |
|---|---|---|---|---|---|---|---|
| 1 | Saltonstall-Kennedy NOAA | **Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival (*Award No. NA17NMF4270240*)** | **IPHC** | Alaska Pacific University | $286,121 | Discard estimates | September 2017 – August 2020 |
| 2 | North Pacific Research Board | **Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects (*NPRB Award No. 1704*)** | **IPHC** | AFSC-NOAA-Newport, OR | $131,891 | Changes in biomass/size-at-age | September 2017 – February 2020 |
| 3 | National Fish and Wildlife Foundation | **Discard mortality rate characterization in the Pacific halibut recreational fishery (*NFWF Award No. 61484)*** | **IPHC** | UA Fairbanks, APU, Grey Light Fisheries, Alaska Charter Association | $98,901 | Discard estimates | April 2019 - June 2021 |
| | | | | **Total awarded ($)** | **$516,913** | | |

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