INTERNATIONAL PACIFIC HALIBUT COMMISSION

Report on current and future biological and ecosystem science research activities

Agenda Item 7

IPHC-2021-SRB018-08

Outline

- SRB recommendations and requests from SRB017
- Biological research integration with SA and MSE
- Research updates

SRB recommendations: Rec. 02

SRB017–Rec.02 (para. 31)	***Biological and ecosystem science program research updates*** **NOTING** the improved presentation of the research integration plan, the SRB **RECOMMENDED** that the research planning table shown in the meeting presentation for paper IPHC-2020-SRB017-08, be improved by adding clear prioritization of biological research needs for addressing uncertainties in the stock assessment and MSE programs. Ideally, this would be in the form of ranked biological uncertainties/parameters for the stock assessment and MSE operating model along with an explanation for deviations from this ranked list.	**Completed**: See papers IPHC-2021-SRB018-10 and 08

- Created lists of ranked biological uncertainties and parameters for stock assessment (SA) and for management strategy evaluation (MSE) and their links to research areas and research activities contemplated in the five-year research plan (2017-2021).
- Ranked the biological research needs for addressing uncertainties in the stock assessment and MSE programs.

SRB recommendations: Rec. 02 (SA)

SA Rank	Research outcomes	Relevance for stock assessment	Specific analysis input	Research Area	Research activities
1. Biological input	Updated maturity schedule	Scale biomass and reference point estimates	Will be included in the stock assessment, replacing the current schedule last updated in 2006	Reproduction	Histological maturity assessment
	Incidence of skip spawning		Will be used to adjust the asymptote of the maturity schedule, if/when a time-series is available this will be used as a direct input to the stock assessment		Examination of potential skip spawning
	Fecundity-at-age and -size information		Will be used to move from spawning biomass to egg-output as the metric of reproductive capability in the stock assessment and management reference points		Fecundity assessment
	Revised field maturity classification		Revised time-series of historical (and future) maturity for input to the stock assessment		Examination of accuracy of current field macroscopic maturity classification
2. Biological input	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area	Altered structure of future stock assessments	If 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area	Genetics and Genomics	Population structure
3. Biological input	Assignment of individuals to source populations and assessment of distribution changes	Improve estimates of productivity	Will be used to define management targets for minimum spawning biomass by Biological Region		Distribution
	Improved understanding of larval and juvenile distribution		Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	Migration	Larval and juvenile connectivity studies
1. Assessment data collection and processing	Sex ratio-at-age	Scale biomass and fishing intensity	Annual sex-ratio at age for the commercial fishery fit by the stock assessment	Reproduction	Sex ratio of current commercial landings
	Historical sex ratio-at-age		Annual sex-ratio at age for the commercial fishery fit by the stock assessment		Historical sex ratios based on archived otolith DNA analyses
2. Assessment data collection and processing	New tools for fishery avoidance/deterence; improved estimation of depredation mortality	Improve mortality accounting	May reduce depredation mortality, thereby increasing available yield for directed fisheries. May also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude	Mortality and survival assessment	Whale depredation accounting and tools for avoidance
1. Fishery yield	Physiological and behavioral responses to fishing gear	Reduce incidental mortality	May increase yield available to directed fisheries	Mortality and survival assessment	Biological interactions with fishing gear
2. Fishery yield	Guidelines for reducing discard mortality	Improve estimates of unobserved mortality	May reduce discard mortality, thereby increasing available yield for directed fisheries	Mortality and survival assessment	Best handling practices: recreational fishery

SRB recommendations: Rec. 02 (MSE)

MSE Rank	Research outcomes	Relevance for MSE	Research Area	Research activities
1. Biological parameterization and validation of movement estimates	Improved understanding of larval and juvenile distribution	Improve parametization of the Operating Model	Migration	Larval and juvenile connectivity studies
	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area		Genetics and Genomics	Population structure
2. Biological parameterization and validation of recruitment variability and distribution	Assignment of individuals to source populations and assessment of distribution changes	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model		Distribution
	Establishment of temporal and spatial maturity and spawning patterns	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model	Reproduction	Recruitment strength and variability
3. Biological parameterization and validation for growth projections	Identification and application of markers for growth pattern evaluation	Improve simulation of variability and allow for scenarios investigating climate change	Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age
	Environmental influences on growth patterns			
	Dietary influences on growth patterns and physiological condition			
1. Fishery parameterization	Experimentally-derived DMRs	Improve estimates of stock productivity	Mortality and survival assessment	Discard mortality rate estimate: recreational fishery

SRB recommendations: Rec. 04

SRB017–Rec.04 (para. 53)	***Research integration*** The SRB **RECOMMENDED** that the IPHC Secretariat incorporate prioritization of research activities, as well as the timeline of available research outputs as inputs into the stock assessment and MSE processes.	**Completed**: See paper IPHC-2021-SRB018-10

- Prioritized the biological research needs for addressing uncertainties in the stock assessment and MSE programs.
- Produced a timeline of research outputs and their use as inputs into the stock assessment and MSE processes.

SRB recommendations: Rec. 04 (prioritization)

Research areas	Research activities	Research outcomes	Relevance for stock assessment	Relevance for MSE	Specific analysis input	SA Rank	MSE Rank	Research priorization
Reproduction	Sex ratio of current commercial landings	Sex ratio-at-age	Scale biomass and fishing intensity		Annual sex-ratio at age for the commercial fishery fit by the stock assessment	1. Assessment data collection and processing		1
	Historical sex ratios based on archived otolith DNA analyses	Historical sex ratio-at-age						1
Mortality and survival assessment	Whale depredation accounting and tools for avoidance	New tools for fishery avoidance/deterence; improved estimation of depredation mortality	Improve mortality accounting	Improve estimates of stock productivity	May reduce depredation mortality, thereby increasing available yield for directed fisheries. May also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude	2. Assessment data collection and processing		2
Reproduction	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	Improve simulation of spawning biomass in the Operating Model	Will be included in the stock assessment, replacing the current schedule last updated in 2006	1. Biological input		3
	Examination of potential skip spawning	Incidence of skip spawning			Will be used to adjust the asymptote of the maturity schedule, if/when a time-series is available this will be used as a direct input to the stock assessment			3
	Fecundity assessment	Fecundity-at-age and -size information			Will be used to move from spawning biomass to egg-output as the metric of reproductive capability in the stock assessment and management reference points			3
	Examination of accuracy of current field macroscopic maturity classification	Revised field maturity classification			Revised time-series of historical (and future) maturity for input to the stock assessment			3
Genetics and genomics	Population structure	Population structure in the Convention Area	Altered structure of future stock assessments	Improve parametization of the Operating Model	If 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area	2. Biological input	1. Biological parameterization and validation of movement estimates and recruitment distribution	4
	Distribution	Assignment of individuals to source populations and assessment of distribution changes	Improve estimates of productivity		Will be used to define management targets for minimum spawning biomass by Biological Region	3. Biological input		5
Migration	Larval and juvenile connectivity studies	Improved understanding of larval and juvenile distribution	Improve estimates of productivity	Improve parametization of the Operating Model	Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	3. Biological input	1. Biological parameterization and validation of movement estimates	5
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve trends in unobserved mortality	Improve estimates of stock productivity	Will improve estimates of discard mortality, reducing potential bias in stock assessment results and management of mortality limits	1. Fishery yield	1. Fishery parameterization	6
	Discard mortality rate estimate: recreational fishery				Will improve estimates of discard mortality, reducing potential bias in stock assessment results and management of mortality limits			6
	Best handling and release practices	Guidelines for reducing discard mortality			May reduce discard mortality, thereby increasing available yield for directed fisheries	2. Fishery yield		7
Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age	Identification and application of markers for growth pattern evaluation	Scale stock productivity and reference point estimates	Improve simulation of variability and allow for scenarios investigating climate change	May inform yield-per-recruit and other spatial evaluations of productivity that support mortality limit-setting		3. Biological parameterization and validation for growth projections	8
		Environmental influences on growth patterns			May provide covariates for projecting short-term size-at-age. May help to delineate between effects due to fishing and those due to environment, thereby informing appropriate management response			8
		Dietary influences on growth patterns and physiological condition			May provide covariates for projecting short-term size-at-age. May help to deleineate between effects due to fishing and those due to environment, thereby informing appropriate management response			8

SRB recommendations: Rec. 05

SRB017–Rec.05 (para. 54)	The SRB **RECOMMENDED** that the IPHC Secretariat identify those research areas with uncertainty and indicate research questions that would require the SRB to provide input and/or decision in future documentation and presentations provided to the SRB.	**Completed**: See papers IPHC-2021-SRB018-10 and 08

- The Secretariat has identified various research questions related to research areas with uncertainty that would require guidance and input from the SRB:

    1. Genetics and genomics research area
    2. Reproduction research area

Outline

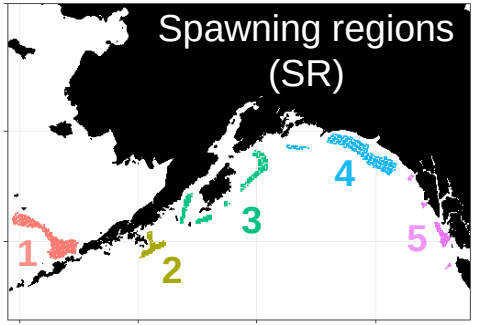
- SRB recommendations and requests from SRB017
- Biological research integration with SA and MSE
- Research updates

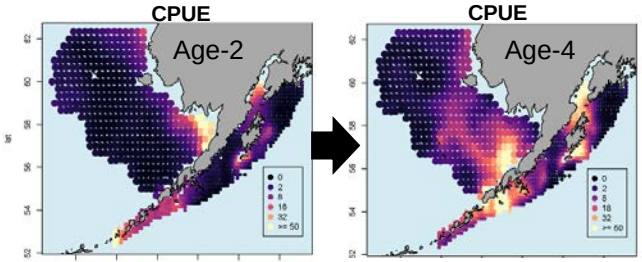
Primary Research Areas	*Main Objectives*	*Management implications*
Migration and Distribution	Improve understanding of migration throughout all life stages (larval, juvenile, adult feeding and reproductive migrations)	Stock distribution, regional management
Reproduction	Information on sex ratios of commercial 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
Mortality and Survival Assessment	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

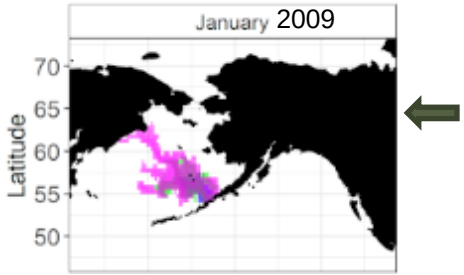
1. Migration and Distribution

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Migration	Larval and juvenile connectivity and early life history studies	Improved understanding of larval and juvenile distribution	Improve estimates of productivity	3. Biological input	Improve parametization of the Operating Model	1. Biological parameterization and validation of movement estimates

- **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







	% larvae reaching BS	
	Warm	Cold
Year	2005	2009
SR 1	100	100
SR 2	58.1	52.7
SR 3	15.2	17.2
SR 4	8.2	4.5
SR 5	0.6	0.08

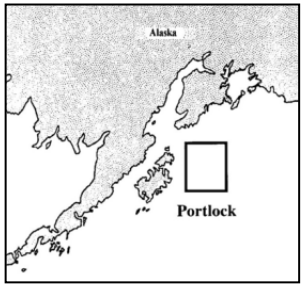
Sadorus et al. 2021. ***Fisheries Oceanography. 30: 174-193,***

2. Reproduction

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE
Reproduction	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	1. Biological input	Improve simulation of spawning biomass in the Operating Model
	Examination of potential skip spawning	Incidence of skip spawning			
	Fecundity assessment	Fecundity-at-age and -size information			
	Examination of accuracy of current field macroscopic maturity classification	Revised field maturity classification			
	Sex ratio of current commercial landings	Sex ratio-at-age	Scale biomass and fishing intensity	1. Assessment data collection and processing	

2. Reproduction

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE
Reproduction	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	1. Biological input	Improve simulation of spawning biomass in the Operating Model
	Examination of potential skip spawning	Incidence of skip spawning			
	Fecundity assessment	Fecundity-at-age and -size information			
	Examination of accuracy of current field macroscopic maturity classification	Revised field maturity classification			



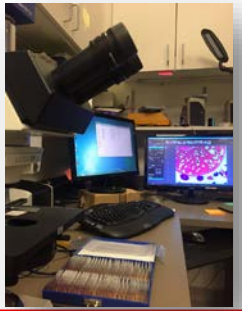
Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

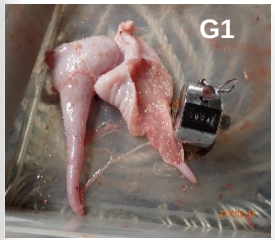
2017 2018

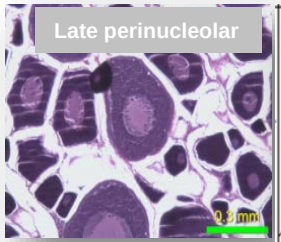
30♀ / 30♂

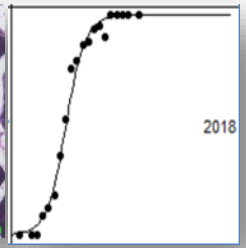
Reproductive cycle

Gonadal growth | **Maturation** | **Spawning**



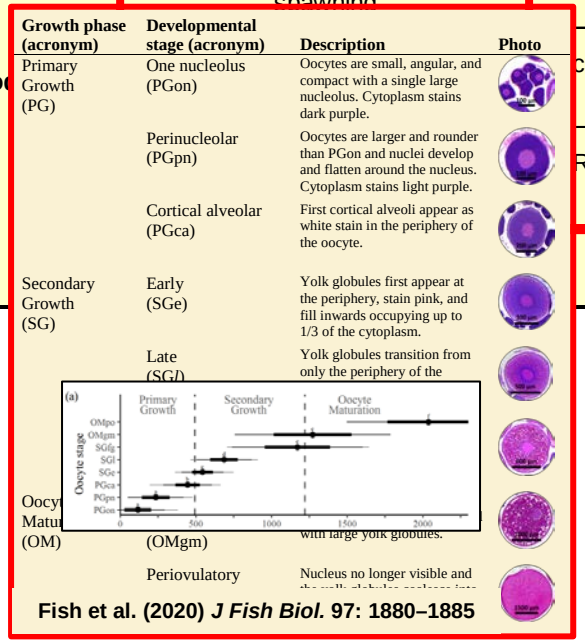






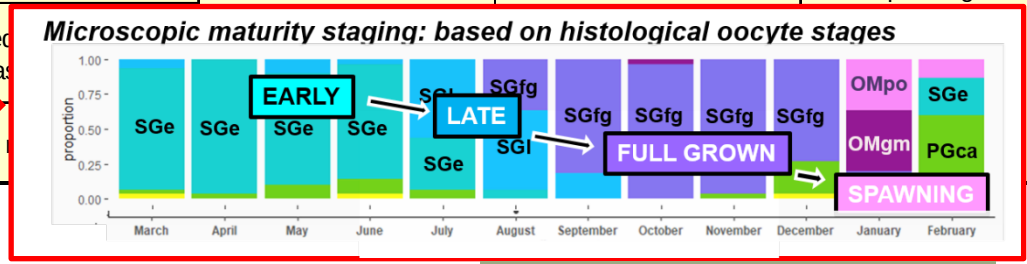
2. Reproduction

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE
Reproc	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	1. Biological input	Improve simulation of spawning biomass in the Operating Model
	Examination of potential skip spawning	Incidence of skip spawning			
		cundity-at-age and -size information			
		Revised clas			
		Sex r			



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 (SGl)	Yolk globules transition from only the periphery of the	
Oocyt Matur (OM)	(OMgm)	with large yolk globules.	
	Periovulatory	Nucleus no longer visible and	

Fish et al. (2020) *J Fish Biol.* 97: 1880–1885

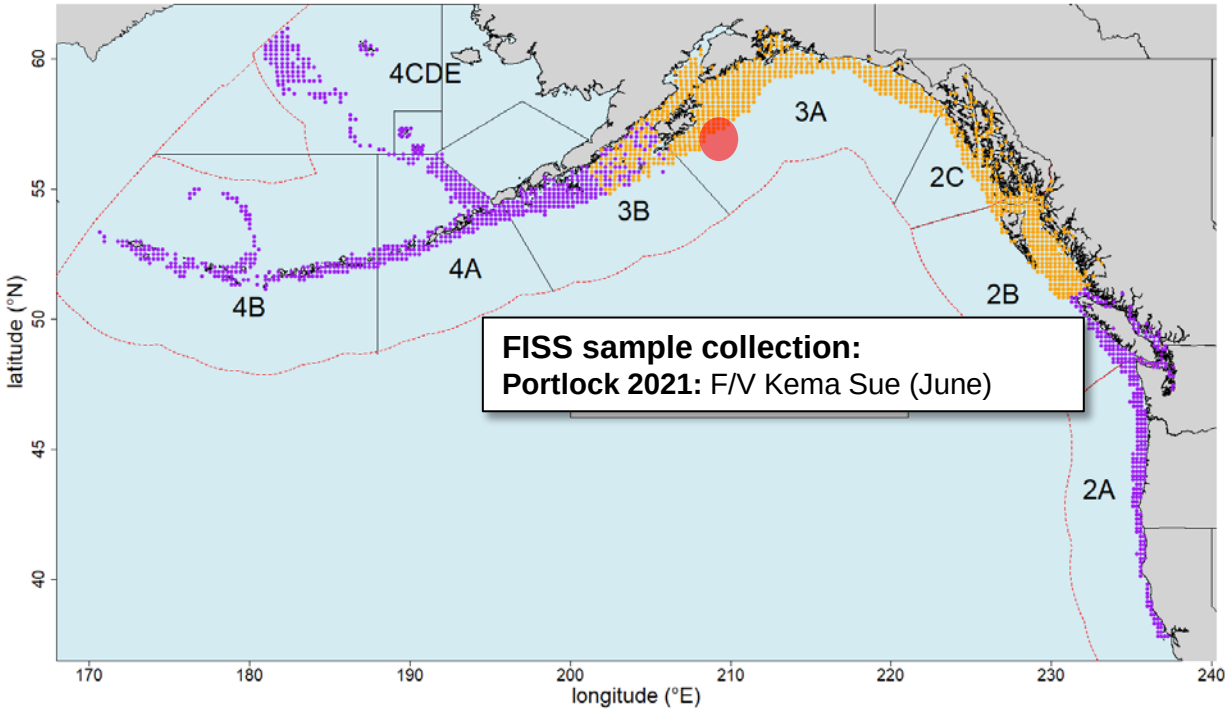


Spawning capable phase

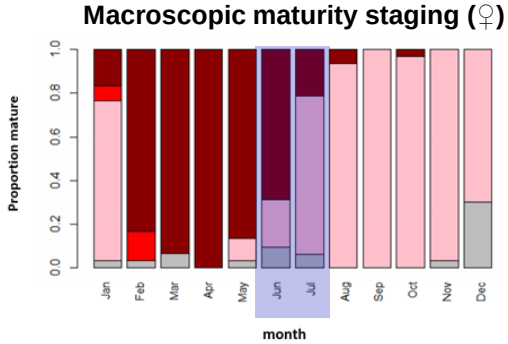
- Relationships among age, size, developmental stage, reproductive phase, GSI, HIS, condition factor, fat content, month of collection, oocyte diameter, depth, etc. are being investigated.

2. Reproduction

Temporal analysis of maturity (Portlock region)



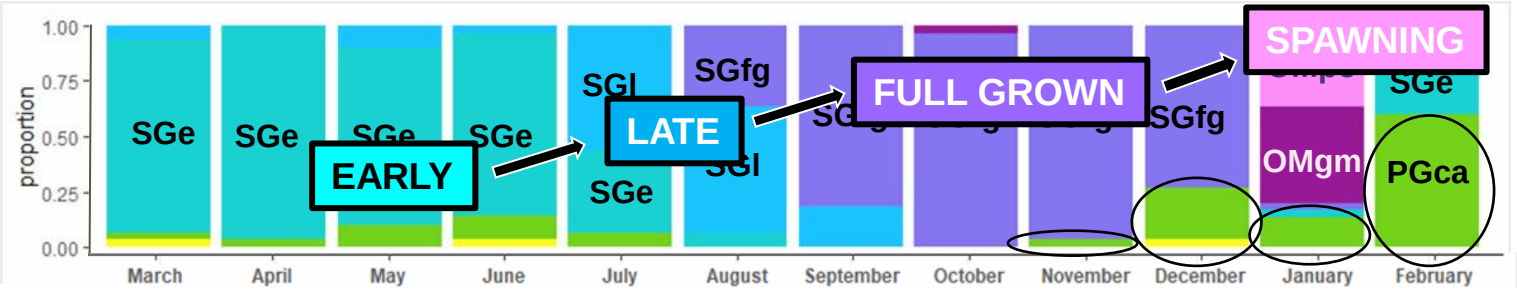
- **Full annual collection**



FISS

- **Ovarian samples for histology (30 females) during June/July (2017-2021).**
- **Whole ovaries from 3 females staged at G2 (for testing methods of fecundity determinations)**

2. Reproduction



Identification of potential skip-spawning females:

1. **Maturity classification prior and during spawning (Nov. – Feb.)**
2. **Histological examination of aged females at primary growth stages:**
   - **Presence or absence of post-ovulatory follicles**
   - **Presence of absence of degenerating follicles**
   - **General structure of ovarian tissue (compacted versus loose)**
3. **Examination of additional reproductive and physiological parameters:**
   - **Gonadosomatic index, condition factor, fat content.**
   - **Endocrine markers in pituitary (luteinizing hormone gene expression) and blood (17β-estradiol and 17α,20β-dihydroxyprogesterone)**

SRB requests: Req. 10

SRB017–Req.10 (para. 43)	***Reproduction*** The SRB **REQUESTED** that the Secretariat should clarify how skip-spawning research contributes to stock assessment and MSE functions. In particular, future research should develop and present: i. models for forecasting or estimating skip-spawning for Pacific halibut taking into account the timing of the sample collection, size / age and potentially condition factor of females; ii. estimates of the potential impact of skip-spawning scenarios on management procedure performance; iii. clear plans for analyses of histological data, including incorporation of age variation and locational variation; iv. details of experimental and sampling designs, as well as expected analyses for “measures of fecundity”	**Completed**: See papers IPHC-2021-SRB018-06 and 08

2. Reproduction: skip spawning

Histological examination of potential skip-spawning females:

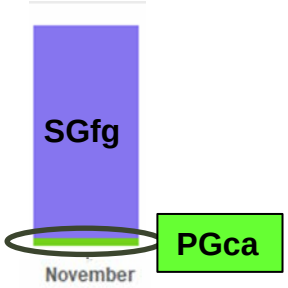
Month	Female #	Weight (kg)	Length (cm)	Age (years)	Oocyte diameter (microns)	Gonadosomatic index (%)	Hepatosomatic index (%)	Fat content (%)	Developmental stage	Reproductive phase
Nov	27	14.73	108	15	394.33	0.71	0.64	2.22	CA	Regenerating
Dec	4	19.08	114	11	348.74	0.43	0.80	1.66	CA	Regenerating
Dec	5	24.13	124	15	328.57	0.51	0.90	1.90	CA	Regenerating
Dec	20	9.56	91	12	316.45	0.46	1.15	1.78	CA	Regenerating
Dec	23	20.72	120	14	336.67	0.47	0.92	2.74	CA	Regenerating
Dec	24	22.81	122	11	418.48	0.49	1.29	2.32	CA	Regenerating
Dec	26	19.65	119	10	438.52	0.55	0.89	1.66	CA	Regenerating
Dec	27	18.91	117	12	354.43	0.51	0.67	1.69	CA	Regenerating
~~Dec~~	~~25~~	~~8.85~~	~~90~~	~~9~~	~~221.90~~	~~0.52~~	~~0.88~~	~~1.21~~	~~PGpn~~	~~Immature~~

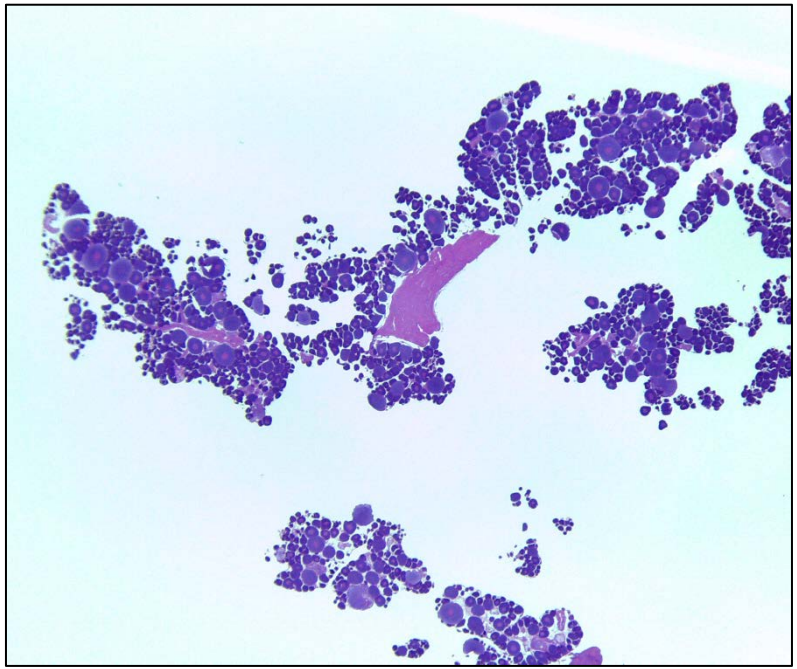
- Developmentally-delayed females: 8/360
- Attempting to distinguish between females arresting prior to first spawning and females skipping a reproductive cycle

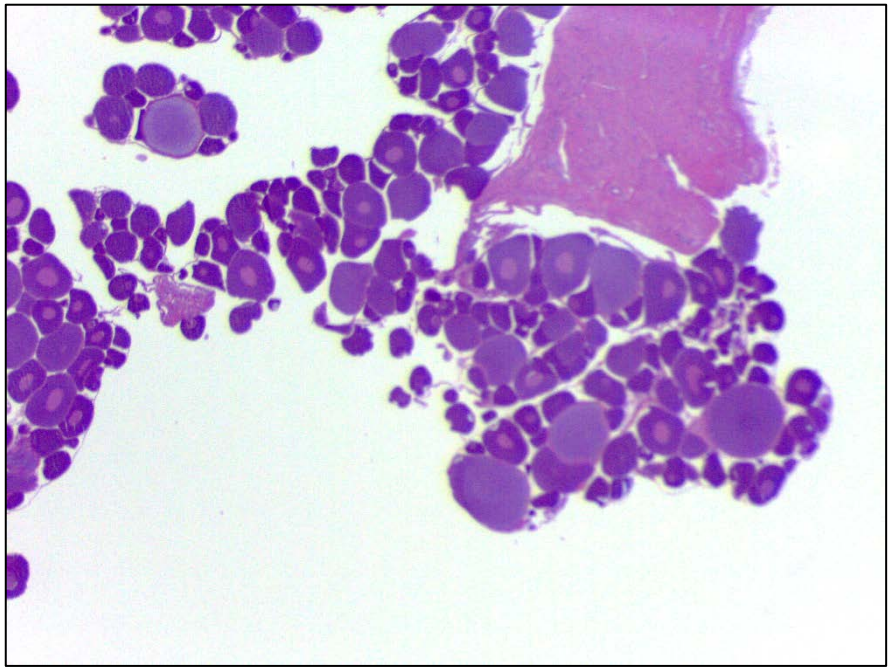
2. Reproduction: skip spawning

Example of potential skip-spawning female

Month of collection: November (only female not with Vtg3 oocytes)
Age: 15
Maturity classification: Primary Growth - Cortical Alveoli Stage







2. Reproduction: fecundity

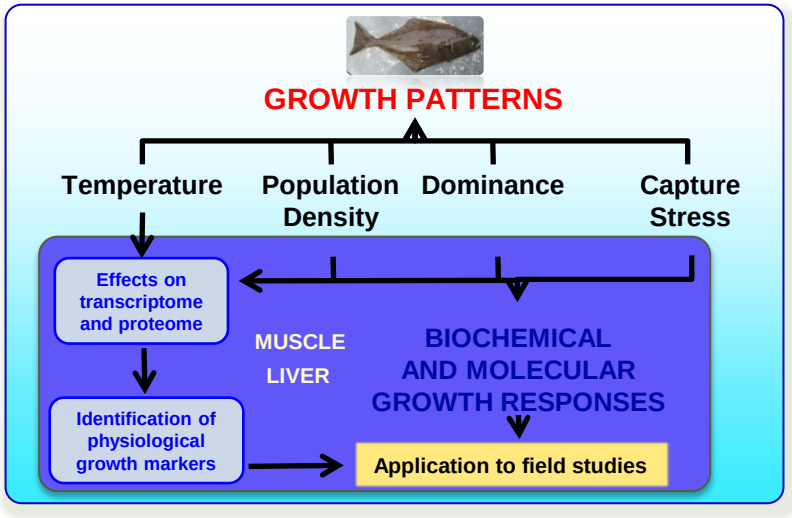
- Objective: establish a fecundity –size (length/weight/age) relationship
- Measure: potential annual fecundity as a measure of annual egg production.
- Important considerations:
    a) Time of sampling. Important to complete annual maturation cycle to select time when individuals are in pre-spawning conditions.
    b) Location of sampling and sample size.
    c) Method: gavimetric versus auto-diametric methods.
- Method testing with ovarian samples collected planned for FISS 2021.
- Planned implementation of ovarian collection starting in 2022.

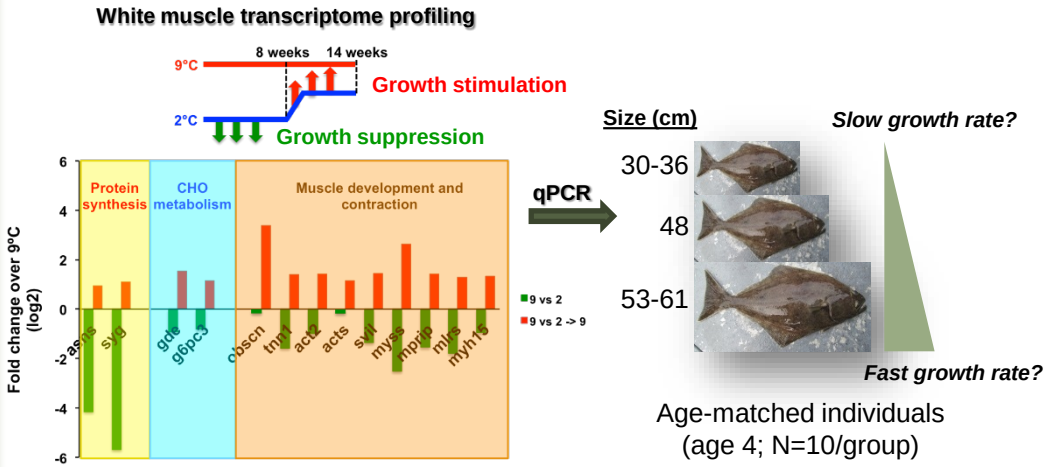
SRB input requested on:

1. Ovarian sample collection designs to assess maturity and fecundity at temporal and spatial scales.
2. Strategies to scale maturity and fecundity information at the population level.
3. Need for long-term monitoring of maturity and fecundity

3. Growth

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Growth	Identification and application of markers for growth pattern evaluation	Identification and application of markers for growth pattern evaluation	Scale stock productivity and reference point estimates		Improve simulation of variability and allow for scenarios investigating climate change	3. Biological parameterization and validation for growth projections
	Environmental influences on growth patterns	Environmental influences on growth patterns				
	Dietary influences on growth patterns and physiological condition	Dietary influences on growth patterns and physiological condition				





4. Mortality and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Directed longline fishery***

NOAA FISHERIES Saltonstall – Kennedy Grant NA17NMF4270240 (2017-2020)

ALASKA PACIFIC UNIVERSITY

DMR
Best predictors of mortality
Best practices

4. Mortality and Survival Assessment

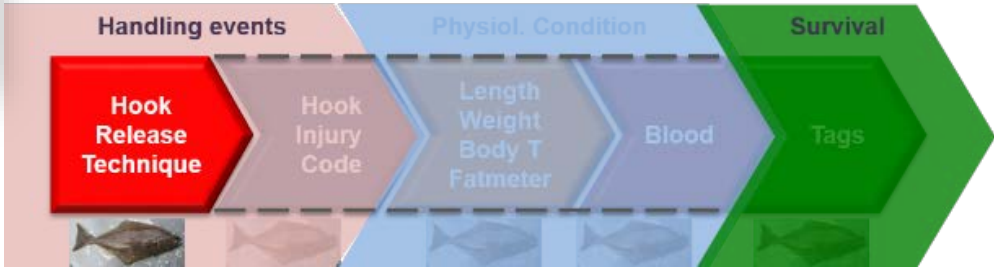
Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Directed longline fishery***

NOAA FISHERIES **Saltonstall – Kennedy Grant NA17NMF4270240 (2017-2020)**

ALASKA PACIFIC UNIVERSITY

Electronic Monitoring



4. DMRs and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Guided recreational fishery*** NFWF National Fish and Wildlife Foundation UAF University of Alaska Fairbanks Alaska Pacific University ACA Alaska Charter Association

1. Collect information on hook types and sizes and handling practices
2. **Investigate the relationship between gear types and capture conditions and size composition of captured fish**
3. **Injury profiles and physiological stress levels of captured fish**
4. **Assessment of mortality of discarded fish**

- Sitka: 21 – 27 May 2021
- Seward: 11 – 17 June 2021

4. DMRs and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Guided recreational fishery***

National Fish and Wildlife Foundation

1. Collect information on hook types and sizes and handling practices
2. **Investigate the relationship between gear types and capture conditions and size composition of captured fish**
3. **Injury profiles and physiological stress levels of captured fish**
4. **Assessment of mortality of discarded fish**

- Sitka: 21 – 27 May 2021

Size classes (cm)				
≤ 68	69-77	78-93	≥ 94	Total
63	**75**	**66**	**39**	**243**

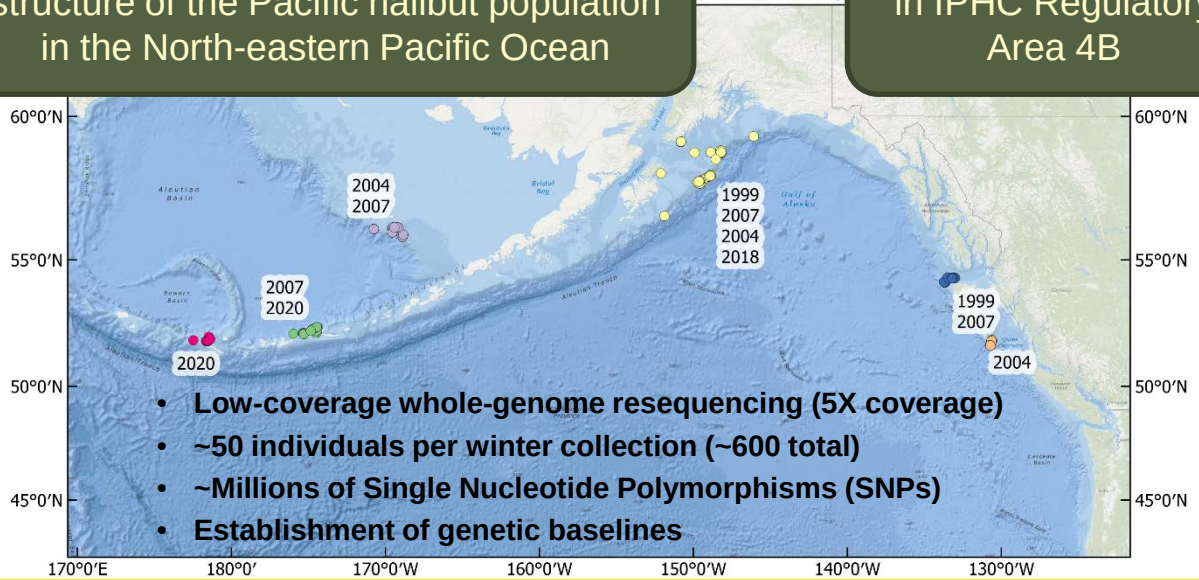
- Two gear sizes: 12/0 and 16/0 hooks
- Observations and samples: hooking time, time on deck, weight, length, hook injury type and picture, viability, fat content, fish temperature, blood sample, fin clip, wire tag.

5. Genetics and Genomics

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Genetics and genomics	Population structure	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area	Altered structure of future stock assessments	2. Biological input	Improve parametization of the Operating Model	1. Biological parameterization and validation of movement estimates. 2. Biological parameterization and validation of recruitment distribution
		Assignment of individuals to				

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



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

SRB recommendations: Rec. 03

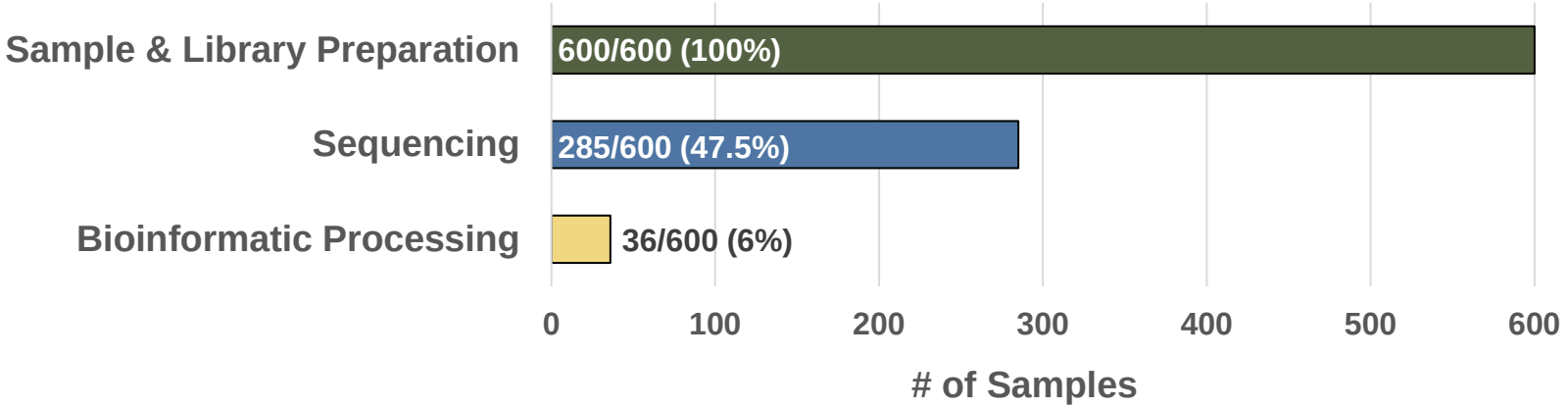
SRB017–Rec.03 (para. 49)	***Genetics and Genomics*** **NOTING** IPHC Secretariat responses to SRB016-Req. 15 that requested additional methodological detail pertaining to ongoing genomics research, the SRB **RECOMMENDED** that the IPHC Secretariat work with collectors to develop a series of benchmark summary statistics that characterize the quality of the Pacific halibut genome developed.	**Completed**: See paper IPHC-2021-SRB018-08

- The Secretariat completed in 2020 the first chromosome-level assembly of the Pacific halibut genome (https://www.ncbi.nlm.nih.gov/assembly/GCF_013339905.1) and was annotated by the NCBI Eukaryotic Genome Annotation Pipeline (NCBI Hippoglossus stenolepis Annotation Release 100; https://www.ncbi.nlm.nih.gov/genome/annotation_euk/Hippoglossus_stenolepis/100/).
- A table with summary statistics of the genome assembly is provided.

SRB recommendations: Rec. 03

Genome summary statistics		Complete assembly	Chromosomes only
Assembly metrics	Number of scaffolds	120	24
	Total size of scaffolds	594,269,479	585,884,243
	Longest scaffold	32,413,955	32,413,955
	Shortest scaffold	4,965	11,318,318
	Mean scaffold size	4,952,246	24,411,843
	Median scaffold size	13,681	24,662,186
	N50 scaffold length	24,986,857	24,986,857
	L50 scaffold count	11	11
	% of assembly in chromosomes	-	98.6 %
	% of assembly in unanchored scaffolds	-	1.4 %
Assembly completeness	Complete BUSCOs (C)	4,472 (97.6%)	
	C and single-copy BUSCOs	4,345 (94.8%)	
	C and duplicated BUSCOs	127 (2.8%)	
	Fragmented BUSCOs	33 (0.7%)	
	Missing BUSCOs	79 (1.7%)	

5. Genetics and Genomics



Sample & Library Preparation

- DNA Extraction: ***All samples***
- lcWGR libraries (Therkildsen & Palumbi 2017): ***All samples***

Sequencing

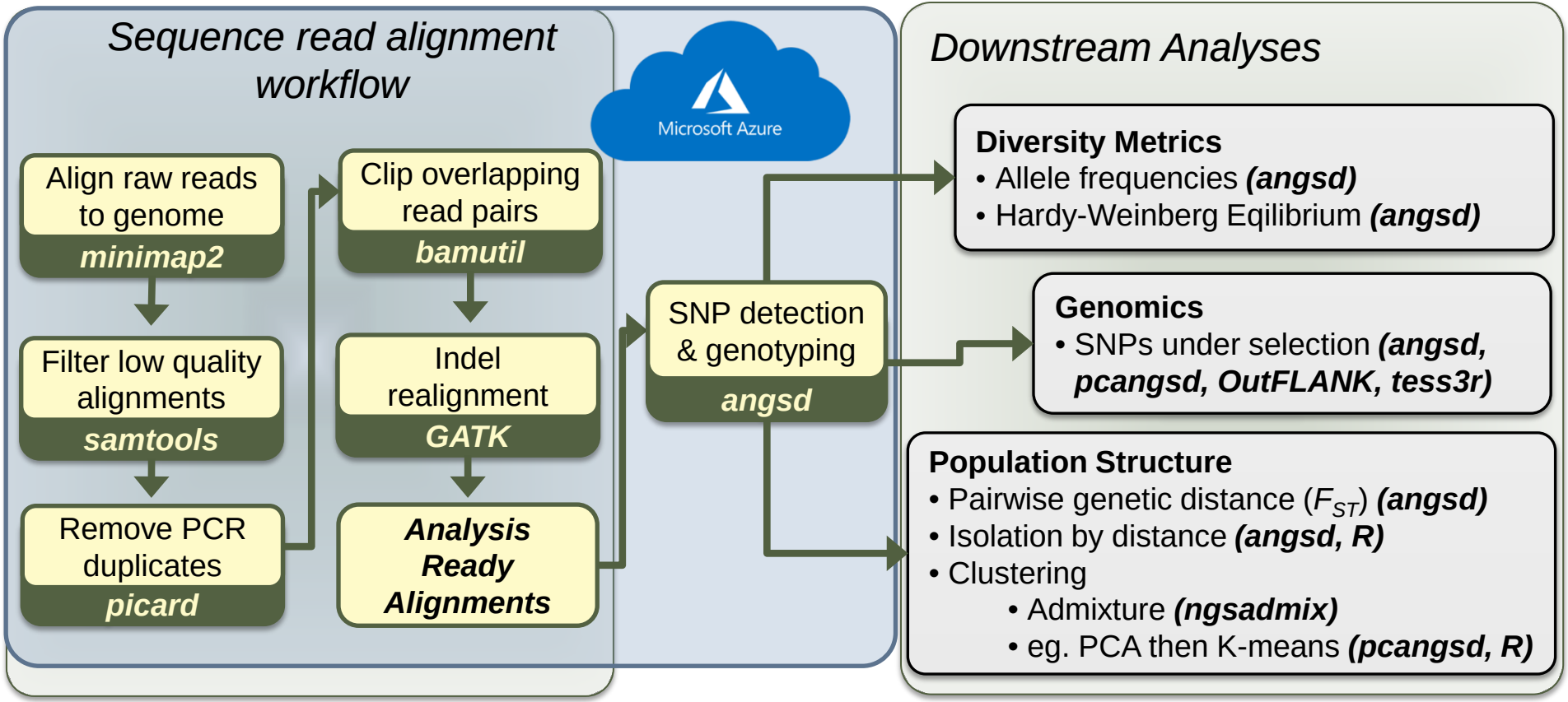
- ***285 samples*** (no data for 1)

Bioinformatic processing

- Sequence read alignments: ***36 samples***

Therkildsen, N. O., & Palumbi, S. R. (2017). Practical low-coverage genomewide sequencing of hundreds of individually barcoded samples for population and evolutionary genomics in nonmodel species. Molecular Ecology Resources, 17(2), 194–208. doi: 10.1111/1755-0998.12593

5. Genetics and Genomics

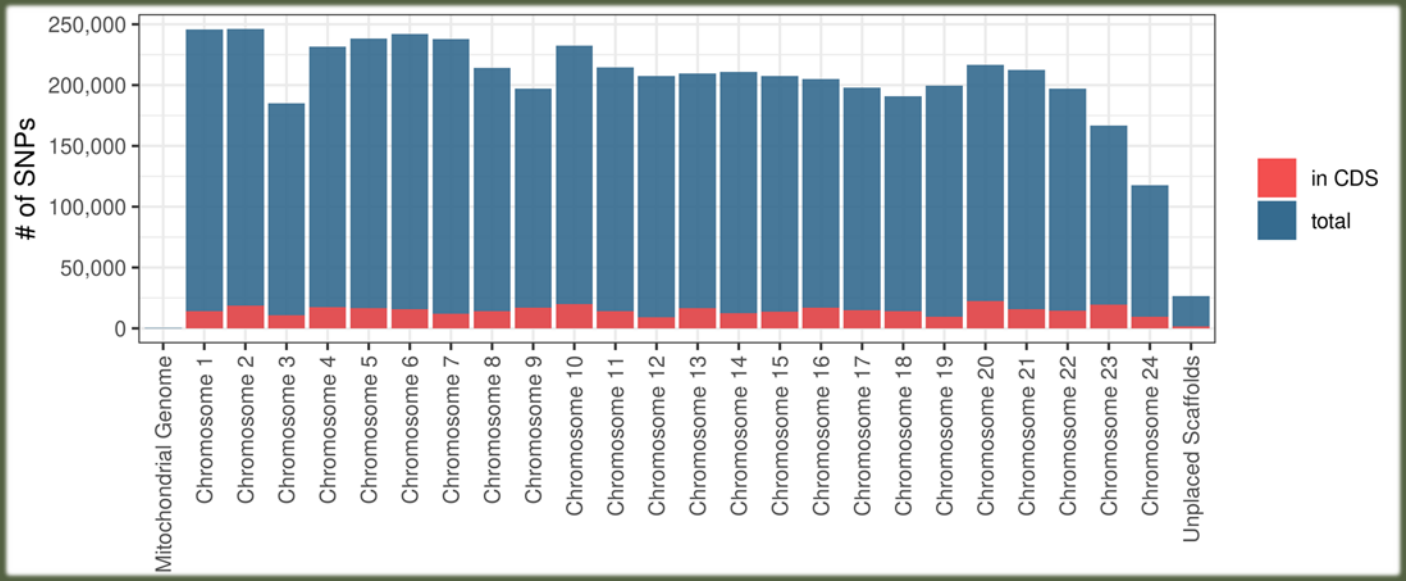


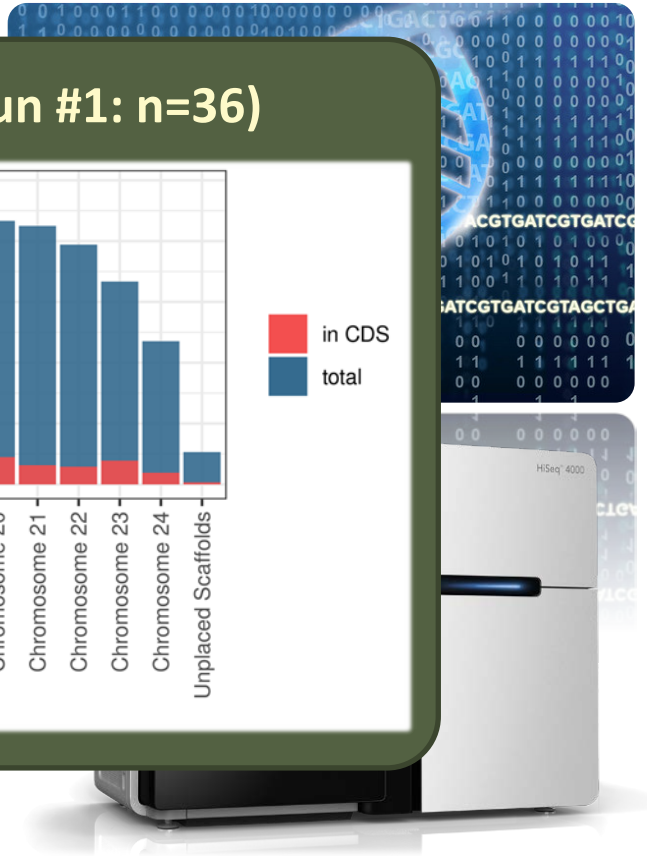
5. Genetics and Genomics

Complete

Raw Rea Per Samp
Reads Retaine
Coverag Per Samp

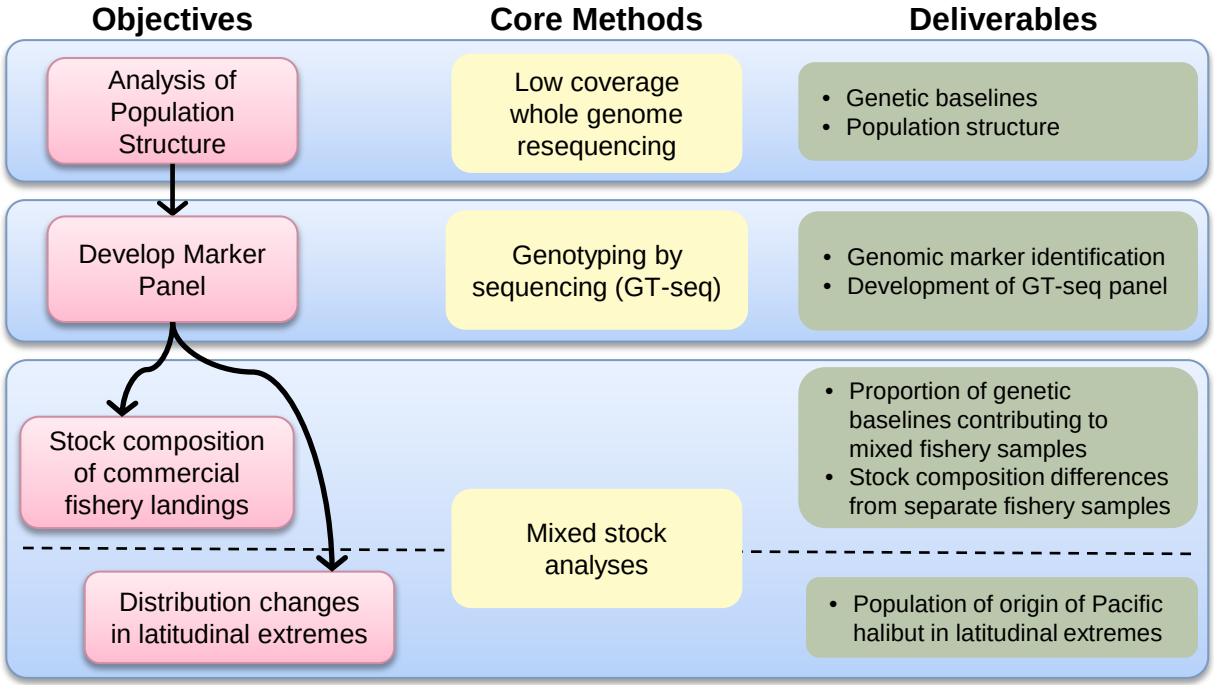
5,051,577 SNPs identified using ANGSD (Run #1: n=36)





5. Genetics and Genomics

Proposed summary workplan



SRB recommendations: Rec. 05

SRB017–Rec.05 (para. 54)	The SRB **RECOMMENDED** that the IPHC Secretariat identify those research areas with uncertainty and indicate research questions that would require the SRB to provide input and/or decision in future documentation and presentations provided to the SRB.	**Completed**: See papers IPHC-2021-SRB018-10 and 08

1. Genetics and Genomics Research Area. Research questions:

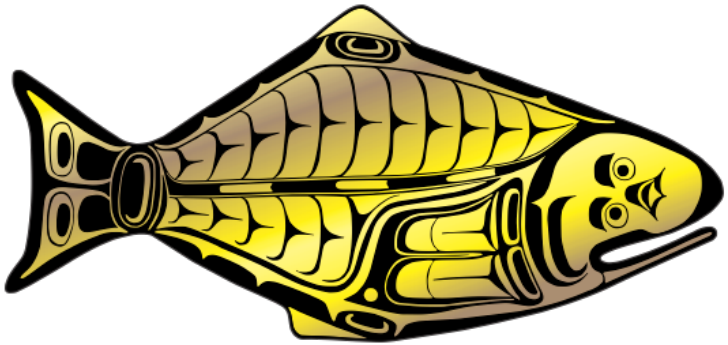
   - Review proposed development of a genetic marker panel (GT-seq) for downstream applications (e.g. individual population assignments).
   - Review proposed population assignment methods to inform on distribution with particular emphasis in IPHC Regulatory Area 4B.
   - Discuss potential interest and fishery sample collection designs for planning future coastwide assessment of stock composition with the use of a genetic marker panel.
   - Discuss potential interest and study design considerations for planning future close-kin mark recapture studies to provide estimates of population size, connectivity, fecundity, etc.

Recommendation

That the SRB:

- **NOTE** paper IPHC-2021-SRB018-08 which outlines progress on the IPHC's 5-year Biological and Ecosystem Science Research Plan (2017-21).
- **REQUEST** specific items for further discussion at SRB019 in September 2021.

INTERNATIONAL PACIFIC



HALIBUT COMMISSION