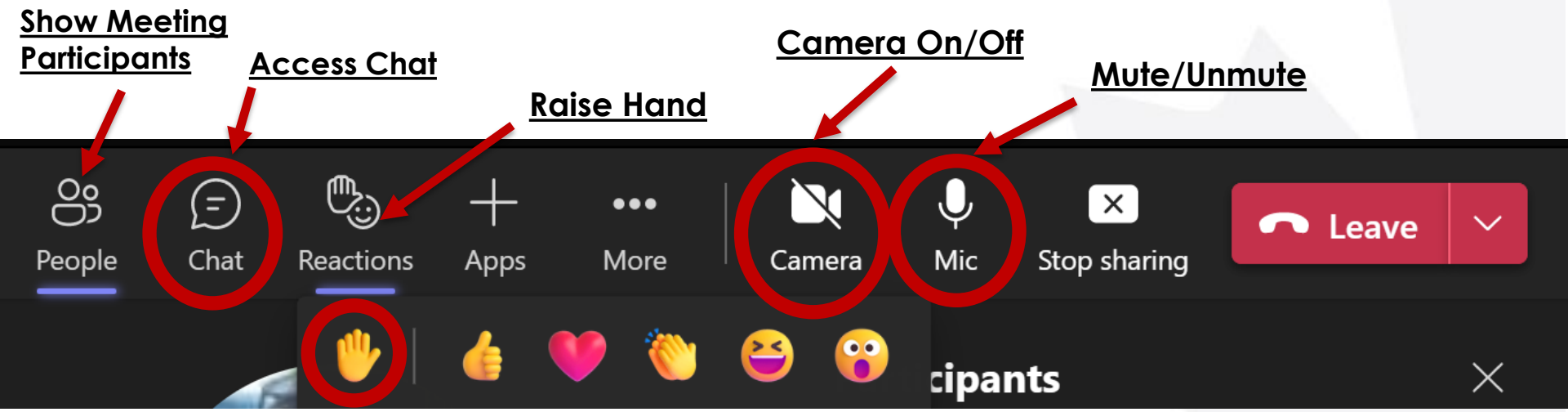
Pacific Salmon Strategy Initiative Mark-Selective Fisheries (MSF) Catch Monitoring Workshop

March 28, 2023

Housekeeping

- One voice at a time
- Respect others that are speaking
- Disagree without being disrespectful, challenge ideas not people
- Unless you are speaking stay on mute by using the mute function
- Use the raise hand function if you wish to speak or have questions
- For individuals calling in note that *5 is the raise/lower hand function and *6 is the mute/unmute function



Workshop Objectives

1. Review key monitoring challenges/gaps identified in the MM/MSF Discussion Paper and the catch monitoring related feedback provided
2. Receive an update on some new advancements on CWT indicator program and FRIM
3. Review and discuss proposed enhanced catch monitoring plan for Chinook mark-selective fisheries.

Please kindly note: Upcoming workshop is being planned for mid-April on data review of the 2021 and 2022 MSF fisheries

Workshop Outline

1. Review MM/MSF Discussion paper and feedback
2. Review recent advancements
   a) Calendar Year Exploitation Rate (CYER) working group recommendations for the Pacific Salmon Commission
   b) Fishery Related Incidental Mortality (FRIM) studies
3. Review and discuss DFO's enhanced MSF monitoring plan for 2023
   a) Expanded creel and overflight coverage
   b) Reference fishery
   c) Supplementary sampling
4. Discuss annual report/review process
5. Discussion/questions

1. Discussion Paper – Key Monitoring Challenges

- **Differential exploitation between CWT indicators and unmarked wild-origin Chinook**
  - New analytical methods developed by PSC CYER Working Group
  - Recommended Transition Plan for Estimating Calendar Year Exploitation Rates for Chinook Salmon Escapement Indicator Stocks Impacted by Mark-Selective Fisheries. https://www.psc.org/download/33/psc-technical-reports/14971/psc-technical-report-no-50.pdf
- **FRIM rates are poorly estimated and may underestimate the real-world rates**
  - New UBC recreational FRIM studies
  - SFI best handling practices educational campaign
- **Uncertainty in estimates of released catch**
  - Creel coverage of MSF pilots
  - Independent verification of releases through reference fishery
  - Stock composition of releases (biological sampling)

1. Discussion paper feedback on impacts to assessment programs

- Impacts to assessment programs (CWT Indicator Program) (Section 2a)
  - *Adequate domestic and bilateral monitoring, data, and assessment systems to plan and evaluate fishery-stock -age specific impacts must be in place prior to MSF implementation. The evaluation of impacts must be transparent and quantitative*
  - *If DITs are planned as an evaluation tool, tagging programs need to be planned years in advance to coordinate with MSFs and need to be considered in the tagging schedule.*
  - *A review of whether CWT exploitation rate indicators stocks are useful proxies for wild Chinook stocks. This will inform discussions on implications of MM and MSF for the CWT program*
  - *Suggestion for the management program to address CWT Chinook exploitation and mortality measurements that may be affected by differential mortality in MSF*
  - *Adequate population and fishery monitoring and enforcement programs need to be in place, including: additional depots for head recovery, development of DIT programs, purchase of electronic tag detection equipment, expansion of catch monitoring and sampling programs, and revision and development of new databases, analytical tools and planning and evaluation models for these tools to be useful for representing fishery impacts under MSF*
  - *Concerns with many uncertainties (FRIM impact from UBC-SFI study, increased fishing efforts, CWT and stock assessment changes)*
- Uncertainty in FRIM (Section 2b)
  - *Concerns over catch and release and related mortality.*
  - *Robust and/or precautionary estimates of FRIM rates;*
  - *Concerns over insufficient data on FRIM impacts to make science-based MSF decisions*
  - *It is critical that FRIM and fishery effort is closely tracked.*

1. Discussion paper feedback on catch monitoring

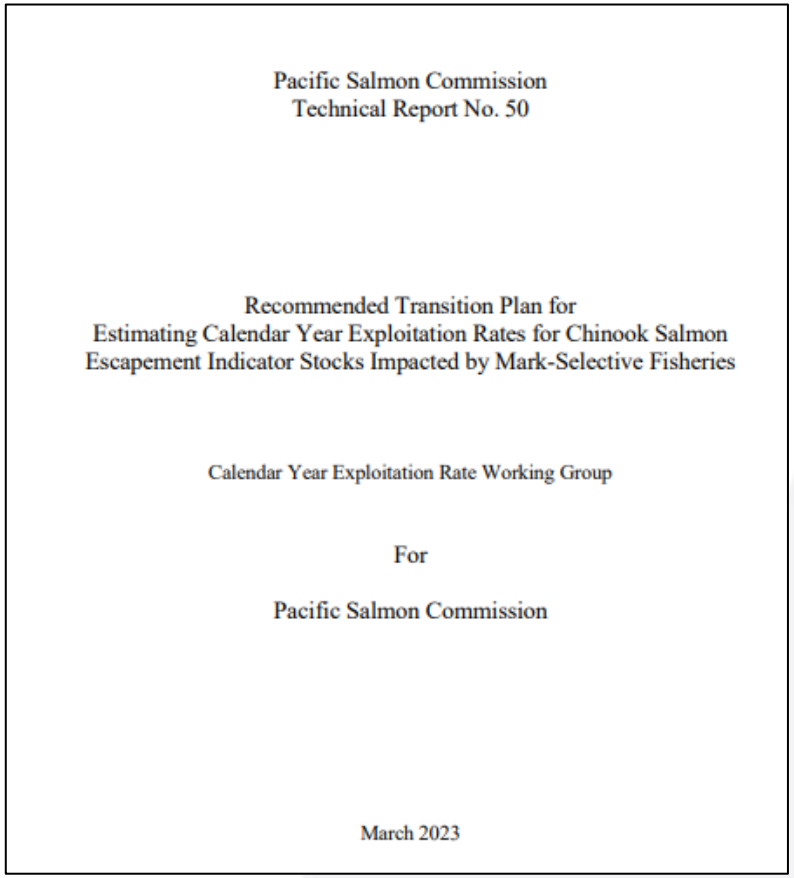
- Monitoring plan/resources should be addressed before proceeding (Section 3)
  - *Monitoring, assessment, and management issues resulting from MSF implementation need to be identified and resolved prior to change in management regime.*
  - *Concerns that DFO staff will be stretch thin further, are there sufficient resource allocated?*
  - *A clear and transparent plan for long-term funding to support monitoring and assessment programs critical to MSFs for assessing impacts to wild Chinook salmon*
  - *Required assessment, monitoring, and enforcement structures are in place, including FRIM.*
- Uncertainty in release estimates (Section 3)
  - *Implementing new MSF may worsen uncertainty in estimate of catch composition and related mortality due to uncooperative recreational fisher.*
  - *Stock composition of released fish at a sufficient resolution (e.g. population or CU);*
- Recommend independent verification of releases/reference fishery (Section 3)
  - *Robust and/or precautionary fishery independent estimates of releases;*
  - *Test fisheries to verify fisher dependent data such as releases, stock composition or*
  - *Long-term funding needs for sufficient and continued independent monitoring of fisheries.*

1. Discussion Paper feedback on catch monitoring (cont.)

- Recommend transparency & review process with catch monitoring data/results (Section 4)
  - *DFO to consider Washington State's example and provide a comprehensive annual public report of verified catch, release, compliance, and stock composition information sourced from both fisher dependent and independent monitoring programs*
  - Programs to provide robust and transparent monitoring and assessment program
  - *A monitoring and assessment framework that provides verifiable, accurate estimates of retained catch, legal releases, sub-legal releases, the stock composition of all encounters, compliance, and Fishery Related Incidental Mortality (FRIM), including MSF; and - Adequate funding to ensure baseline studies are completed and progress fully monitored and reported on*
- Recommend mandatory reporting for guides/new tools
  - *Group recommend that recreational fisheries be closed until opened and guides and lodges be required to report catches.*
  - *The SFAB and groups that represent guides, lodges and charter operators have already confirmed their support for enforced mandatory catch log compliance by guides*
  - *The SFAB has been consistent in its advice to DFO regarding the development of tools that can enhance, supplement, or even replace creel surveys depending on the risk presented by the fishery. These tools include the FishingBC app, Guide Catch Log Program, Avid Angler Program and iREC catch surveys.*

2a. Transition Plan for Estimating ER in MSF

- **Mark Selective Fisheries (MSFs) present a challenge for estimating exploitation rates on unmarked stocks:**
  - they break the underlying assumption that a marked CWT indicator stock experiences the same fishery impacts as associated unmarked stocks.
- **2019 PST Chinook Chapter Update:** New obligations with limits on calendar year exploitation rates (CYERs) in ISBM fisheries.
- **Basic Question**: How do we estimate CYERs on unmarked Chinook salmon that have been impacted by MSFs?



Pacific Salmon Commission
Technical Report No. 50

Recommended Transition Plan for
Estimating Calendar Year Exploitation Rates for Chinook Salmon
Escapement Indicator Stocks Impacted by Mark-Selective Fisheries

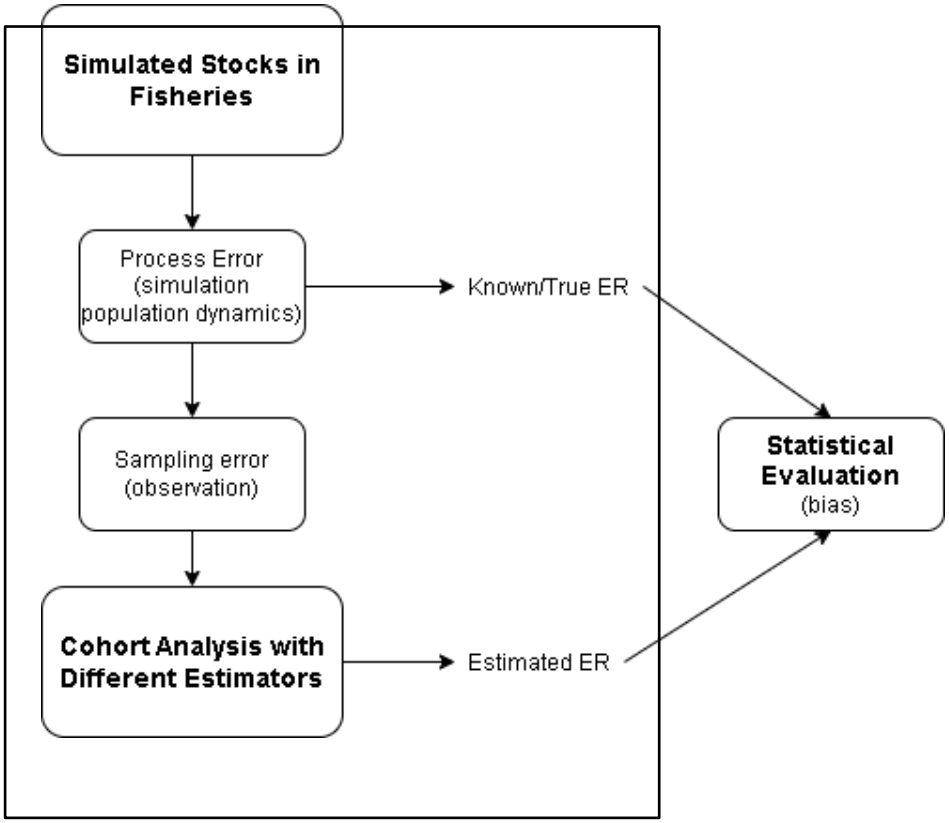
Calendar Year Exploitation Rate Working Group

For

Pacific Salmon Commission

March 2023

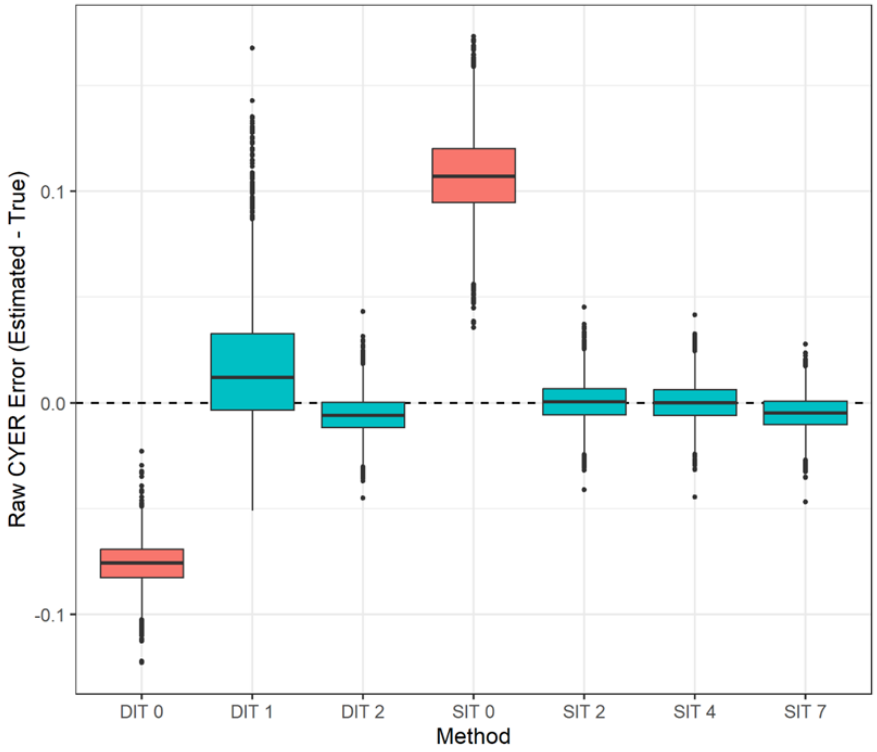
2a. Transition Plan for Estimating ER in MSF



Repeat many times for a scenario
Repeat for ~20 simulated scenarios

- **Define alternative estimators**
- **Single Index Tag (SIT) – one CWT group, marked**
  - SIT 2: backward cohort analysis (i.e., starts with spawners)
  - SIT 4: forward cohort analysis (i.e., starts with recruits)
  - SIT 7: forward cohort analysis with MSF "savings" passed to escapement
- **Double Index Tag (DIT) - two CWT groups, one marked, one unmarked**
  - DIT 1: MSF fishery mortalities estimated by subtraction of paired CWT codes
  - DIT 2: MSF fishery mortalities estimated from adjacent fishery

2a. Transition Plan for Estimating ER in MSF

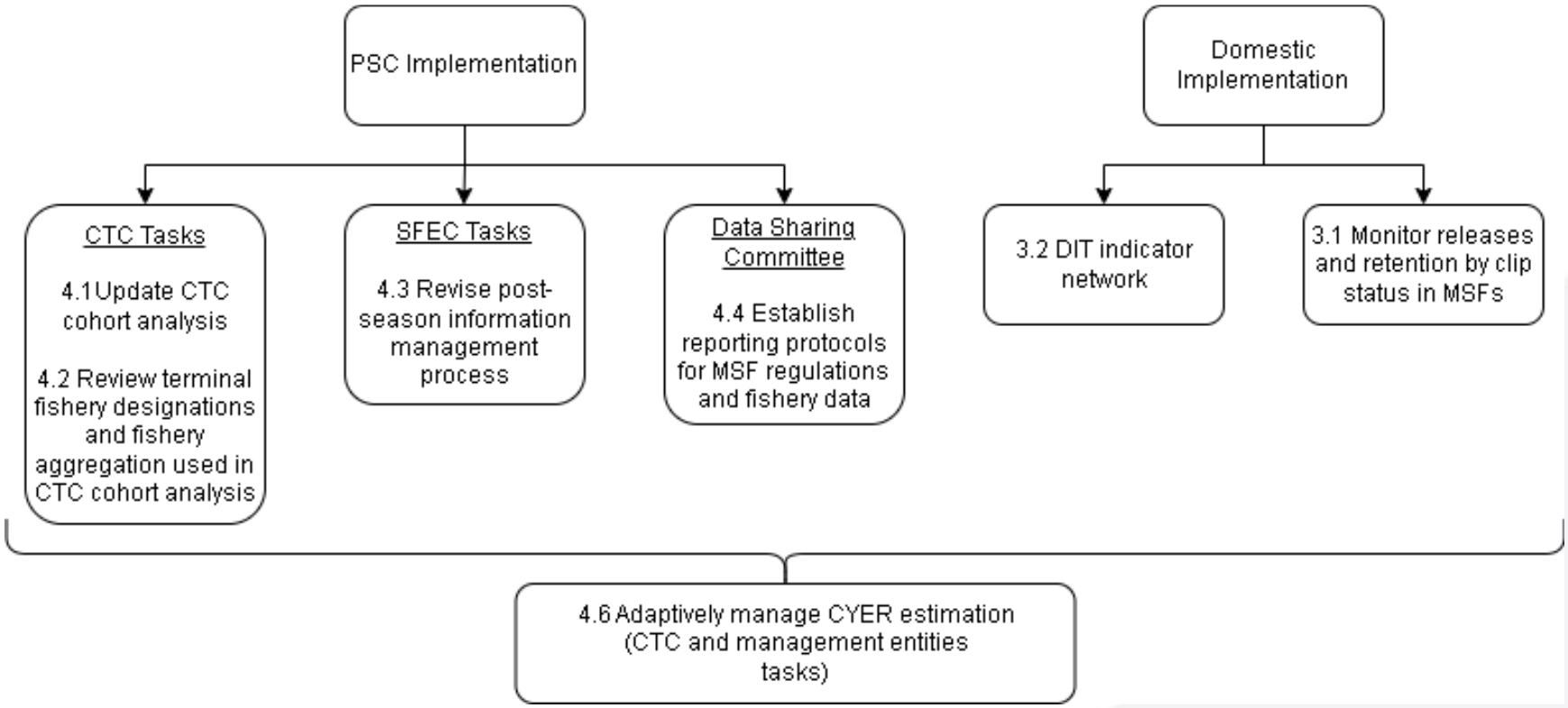


SIT 2 and SIT 4 performed the best of the methods evaluated, across all scenarios we simulated.

CYER WG recommended conducting future exploitation rate analyses using either SIT 2 or SIT 4 (the choice between them will be based on considerations such as ease of implementation).

2a. Transition Plan for Estimating ER in MSF

- Technical review required at multiple stages
- Recommendation numbers align with PSC Technical Report 50



2a. Transition Plan for Estimating ER in MSF

Proposed Next Steps

Approach

- ✓ Statistically Evaluate Alternative CYER Estimation Methods
- ✓ Identify Monitoring and Data Management Requirements
- ✓ Develop Recommended Transition Plan (PSC Technical Report 50)
- Draft technical report for May 2023
- Agency implementation of recommended processes
- Integration into PSC processes

2b. New FRIM Studies

Multi-year tagging study in the PACIFIC SALMON ECOLOGY & CONSERVATION LABORATORY

British Columbia Salmon Restoration and Innovation Fund

Enhancing the sustainability of capture and release marine recreational Pacific salmon fisheries using new tools and novel technologies

Involves 3 PhD students:

- **Steve Johnston** (Chinook, marine migration)
- **Katie Zinn** (Chinook, marine to freshwater)
- **Emma Cooke** (Coho, marine migration)

- Generate measures of **post-release mortality**
- Provide validation of current and new **fishing methods** to **enhance survival**
- Examine sub-lethal, infectious agent, and **cumulative effects**
- Produce a science-based **Best Practices Guidebook**

2b. New FRIM Studies

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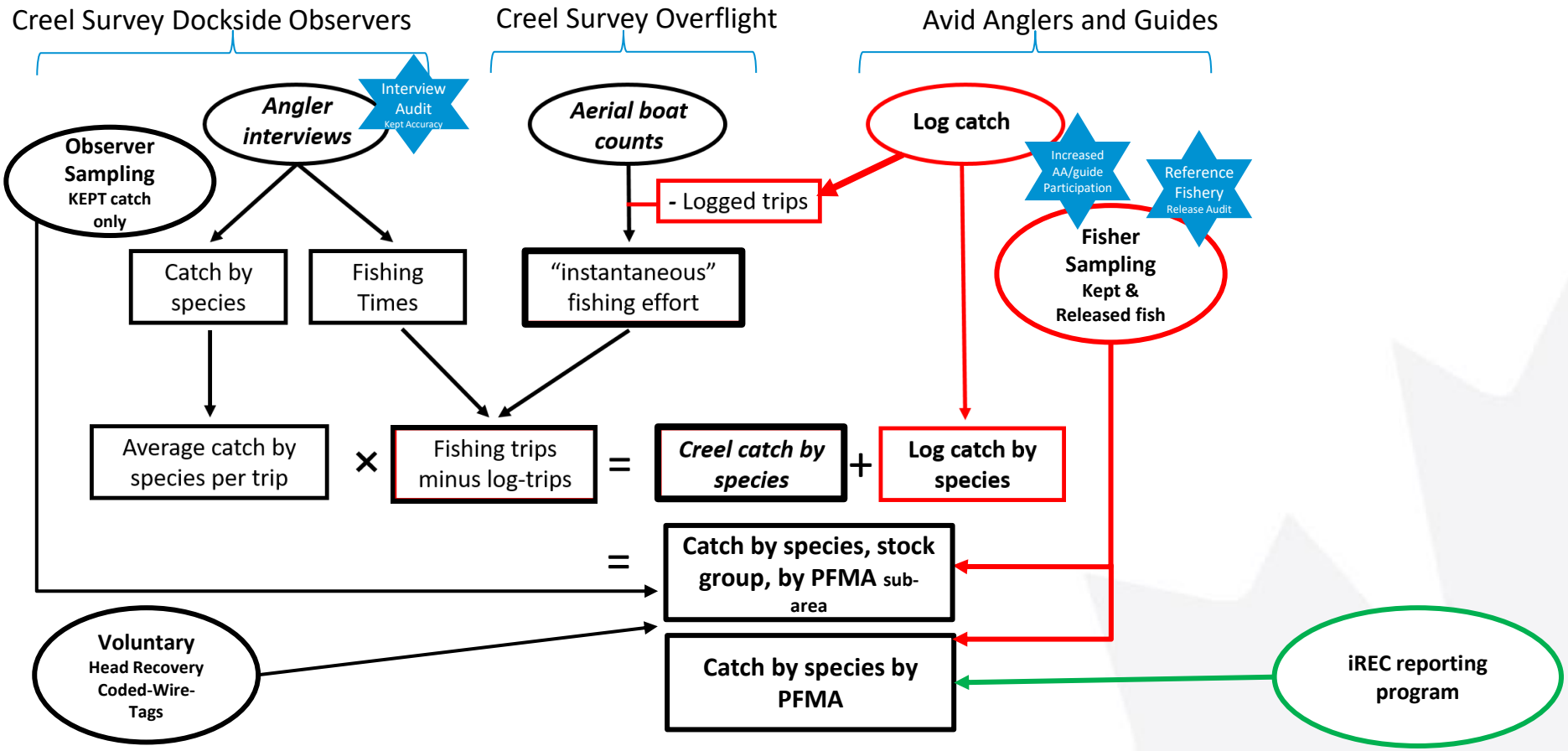
3. Enhanced MSF Monitoring Plan for 2023

a) Expand creel survey coverage to potential Chinook mark-selective fisheries
   - Overflights
   - Dockside interviews
   - Biological sampling of retained catch

b) DFO-led Reference fishery (trial)
   - Independent verification of at-sea releases
   - Biological sampling of releases

c) Supplementary sampling
   - Avid Anglers program
   - First Nation's support

3. MSF Enhanced Monitoring Plan



3. Recreational Catch Monitoring

Fisher-independent data

SC Marine Creel program:

- Landing site surveys
  - CPUE by species
  - Activity Profiles
  - Biological sampling
  - Target interview rate of 10%
- Overflight Effort Counts
  - Instantaneous effort counts

Fisher-dependent data

Logbook Program:

- Daily catch and effort by Creel Subarea
- Typically, Guided effort
- Includes bio-sampling component

Avid Angler Program:

- Combination logbook program with more emphasis of both landed and release bio-sampling
- Better compliance

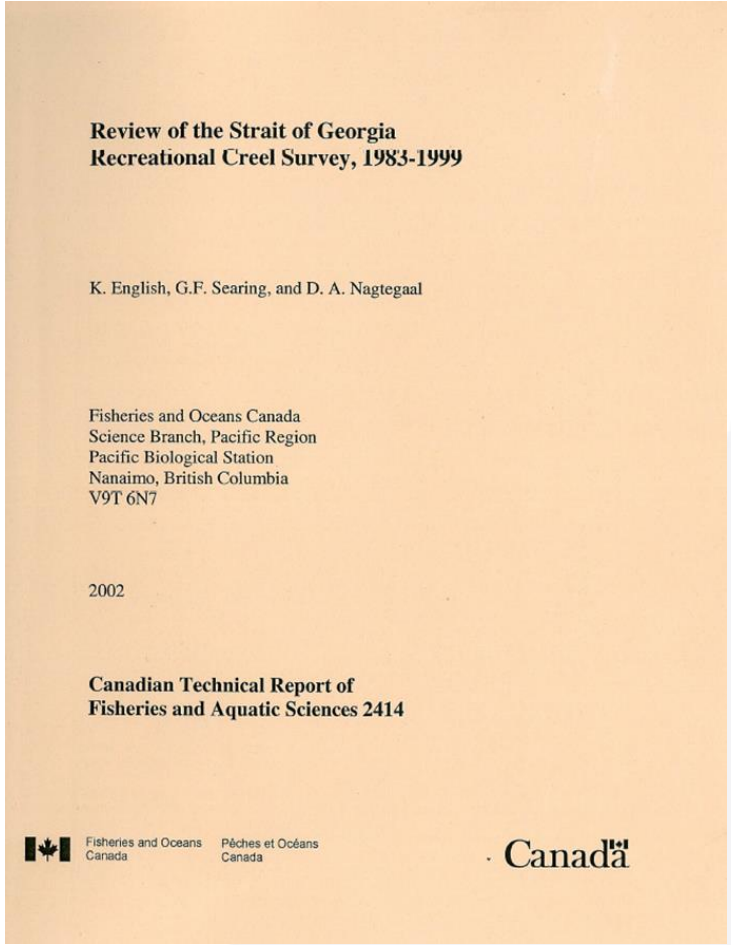
Internet Recreational Catch and Effort (IREC):

- License based program to help fill in gaps of the existing creel program

3. Creel Survey – History and Methods

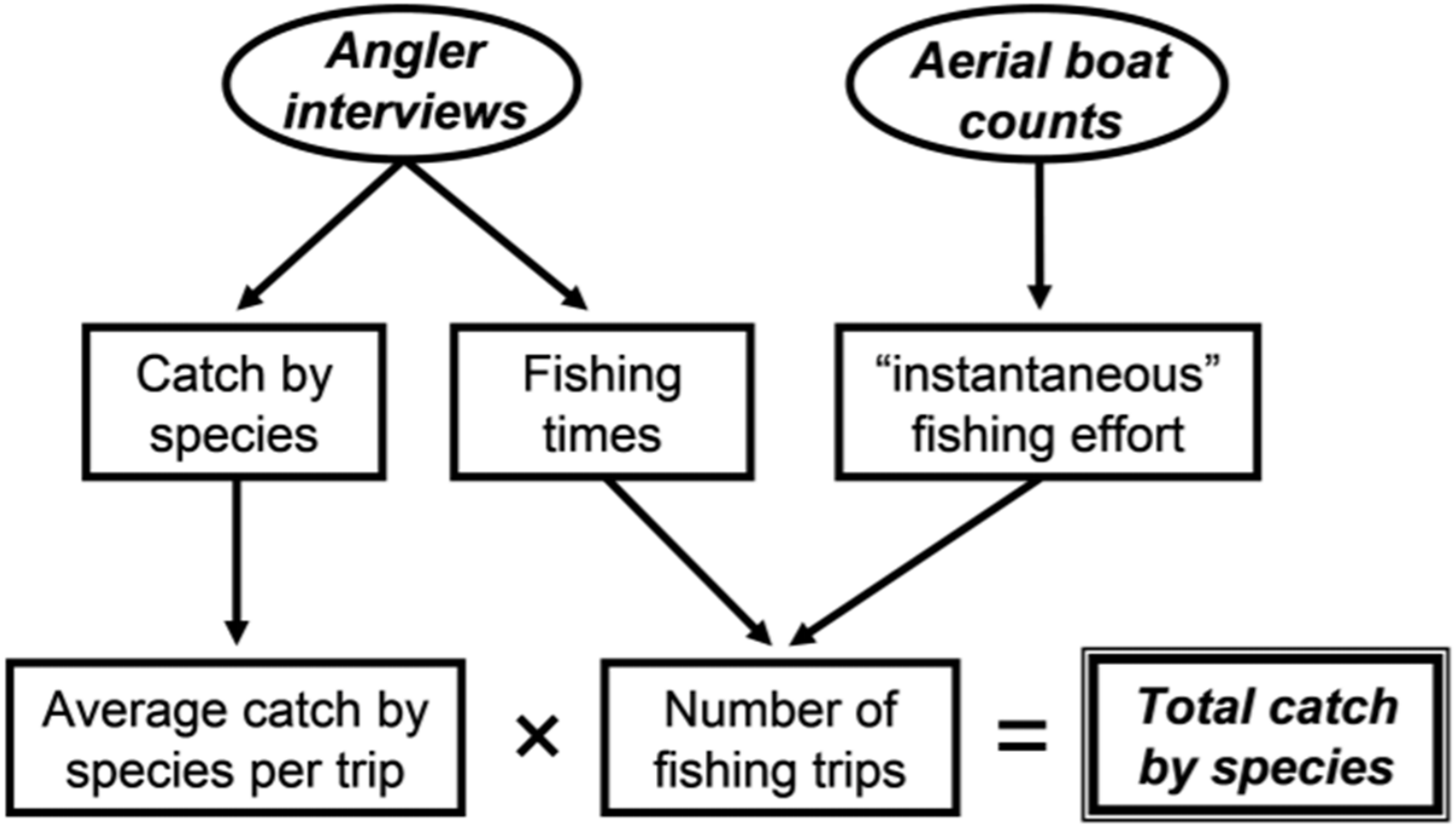
- The recreational creel survey began in the Strait of Georgia in 1980 and expanded to Alberni Inlet/Barkley Sound (1984), WCVI (1991) and Johnstone Strait (1998).

- The main components of a creel survey are **catch and effort**
- **Angler Interviews** produce an estimate of catch by species per boat
- **Boat counts** provide an estimate of effort



English, K., Searing, G.F., and Nagtegaal D.A. 2002. Review of the Strait of Georgia Recreational Creel Survey, 1983-1999. Canadian Technical Report of Fisheries and Aquatic Sciences 2414

Basic Creel Program Flow Chart



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Online Creel Survey - iREC

Français

Government of Canada | Gouvernement du Canada

Search DFO

MENU

Canada.ca > Fisheries and Oceans Canada > Pacific Region > Recreational fishing > Report your effort and catch

Information about completing the Internet Recreational Effort and Catch reporting program

By completing the Internet Recreational Effort and Catch (iREC) report, you are providing essential effort and catch information for months, areas, and types of fishing in order to help us make management decisions to support sustainable fisheries in the long-term.

Creel Heat Maps and iREC

"...but the creel survey is only run in peak months; what about the rest of the year?"

- The following chart shows example of **iREC** based Chinook catch distribution within the Pacific Region marine area.
- The cells with dark outline have creel survey or logbook monitoring….**approximately 90% coverage for Chinook and halibut**. Feb-March in Victoria area are often added depending on available funding.

The remaining cells (comprising 10% of total catch and effort) would use calibrated **iREC** catch and effort

Logistical Area	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Grand Total
Prince Rupert	0.02%	0.21%	1.75%	1.24%	0.62%	0.23%	0.02%	0.05%	0.01%	0.09%	0.03%	0.04%	4.31%
Central Coast	0.02%	0.16%	1.57%	2.06%	1.94%	0.16%	0.02%	0.00%	0.01%	0.00%	0.00%	0.03%	5.98%
Haida Gwaii	0.01%	0.55%	4.33%	3.69%	4.29%	0.91%	0.01%	0.00%	0.00%	0.14%	0.01%	0.02%	13.96%
Port Hardy	0.02%	0.06%	0.80%	1.86%	1.46%	0.15%	0.01%	0.00%	0.00%	0.14%	0.00%	0.02%	4.52%
Campbell River	0.18%	0.90%	2.28%	2.05%	2.59%	0.94%	0.08%	0.01%	0.07%	0.22%	0.06%	0.11%	9.49%
Nanaimo	0.14%	0.86%	0.50%	0.30%	0.47%	0.21%	0.01%	0.00%	0.05%	0.02%	0.06%	0.11%	2.73%
Sunshine Coast	0.07%	0.42%	0.61%	0.43%	0.33%	0.16%	0.00%	0.00%	0.01%	0.06%	0.01%	0.03%	2.13%
Vancouver	0.19%	0.41%	0.24%	0.15%	0.63%	0.73%	0.18%	0.02%	0.05%	0.06%	0.06%	0.30%	3.03%
Victoria	0.36%	0.65%	1.54%	1.95%	3.68%	1.53%	0.39%	0.25%	0.49%	0.71%	0.47%	0.44%	12.47%
Barkley	0.10%	0.45%	2.20%	3.70%	6.75%	1.27%	0.01%	0.00%	0.03%	0.04%	0.01%	0.12%	14.68%
Kyuquot		0.02%	0.37%	1.30%	1.26%	0.09%	0.00%				0.00%	0.02%	3.06%
Port Alberni	0.02%	0.02%	0.16%	0.28%	1.41%	0.38%	0.00%			0.02%	0.01%	0.01%	2.30%
Port Renfrew	0.01%	0.09%	0.66%	0.93%	1.33%	0.16%	0.04%	0.00%	0.05%	0.02%	0.01%	0.02%	3.32%
Tahsis/Nootka	0.01%	0.06%	0.81%	4.80%	5.43%	0.24%	0.05%	0.00%	0.07%	0.00%		0.00%	11.46%
Tofino	0.01%	0.13%	0.50%	1.30%	1.20%	0.20%	0.00%	0.00%		0.00%	0.00%	0.05%	3.40%
Winter Harbour	0.01%	0.05%	0.59%	1.19%	1.09%	0.08%	0.03%		0.01%	0.00%	0.00%	0.04%	3.08%
Lower Fraser River	0.00%	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%	0.00%	0.01%				0.06%
	1.18%	**5.04%**	**18.92%**	**27.23%**	**34.49%**	**7.45%**	**0.85%**	**0.34%**	**0.87%**	**1.53%**	**0.73%**	**1.38%**	**100.00%**

Allocation of observers is based on risk within each fishery stratum. Risk is based on

1) Overall effort
2) Catch of key species such as chinook, halibut, sockeye
3) Prevalence of stocks of concern
4) Data are needed for in-season management
5) Vicinity to Pacific Salmon Treaty indicator stocks. Funds for monitoring are allocated based on this risk.

Stratified random sample design

"...but more people fish on weekends than weekdays."

"...but everyone avoids Tuesdays and Saturdays because that is when they are at the dock."

Strata

WD = weekday

WE= weekend

Interview Shifts

2020 August Sunshine Coast Scheduling

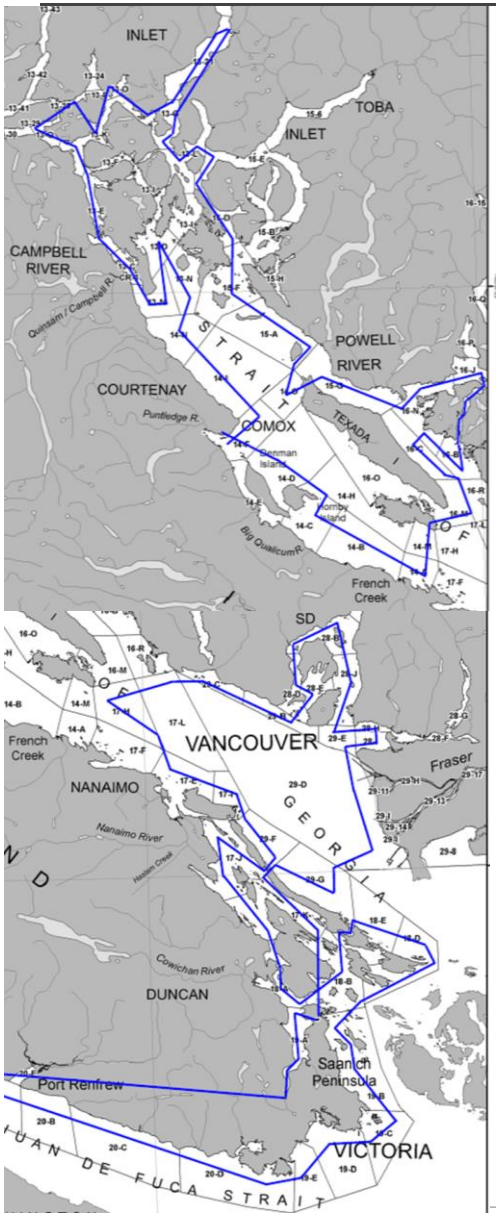
					11 we
Gibsons	**1**	weighted shifts	Shifts	WD	WE
413	Egmont	3.0	2	3	2
418	Cooper's Green	3.0	5	3	2
420	Pender Harbour Resort	6.0	5	3	2
430	Bucaneer	6.0	5	3	2
423	Gibsons Marina	6.0	5	3	2
409	Madeira Park	6.0	5	3	2
		30	27	18	12
Powell River	**1**	weighted shifts	Shifts	WD	WE
410	Westview	4.8	10	6	4
412	Lund	12.8	10	6	4
447	Saltery Bay	12.5	10	6	4
		30	30	18	12

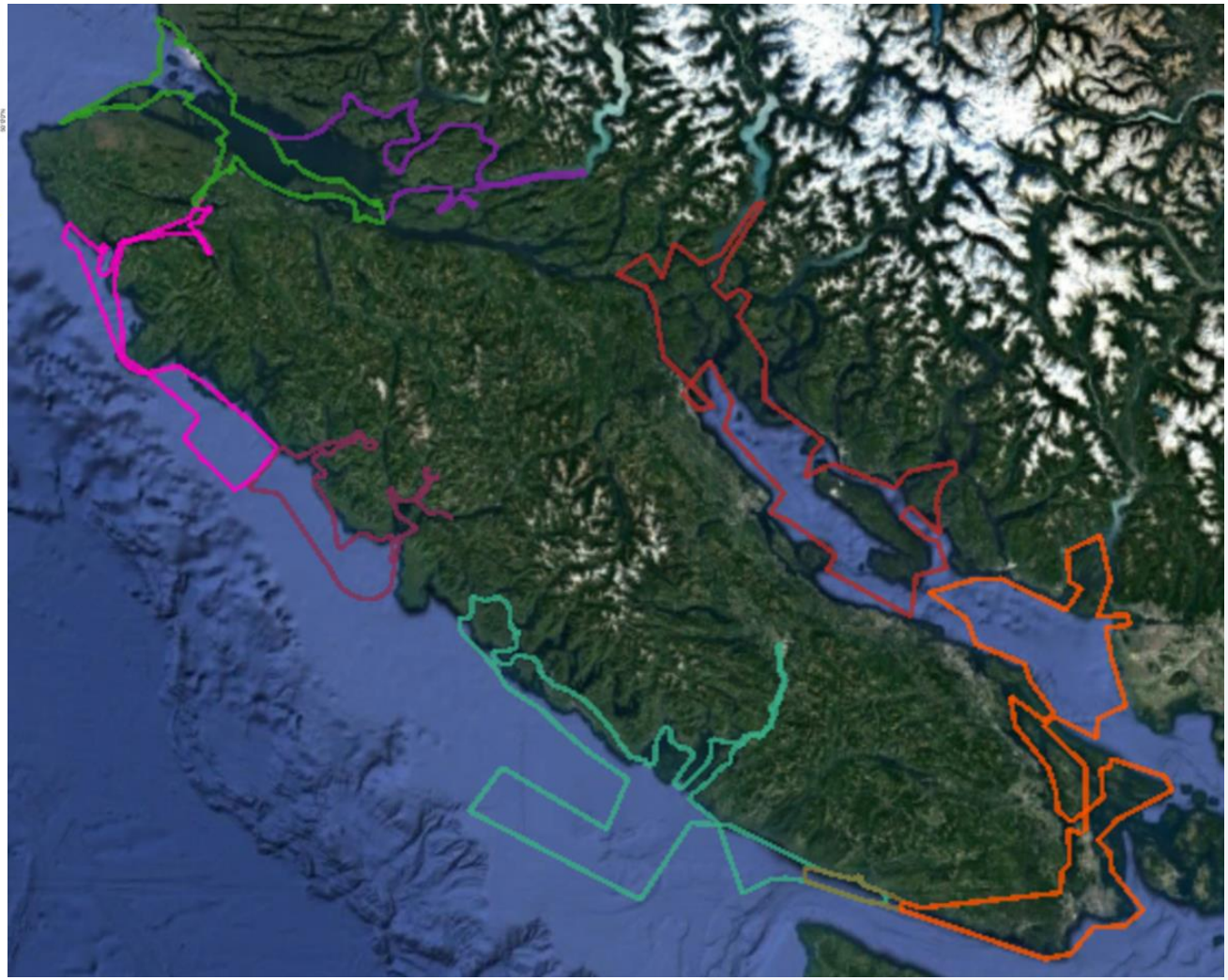
Schedules generated **randomly** pre-season

Flight Schedule

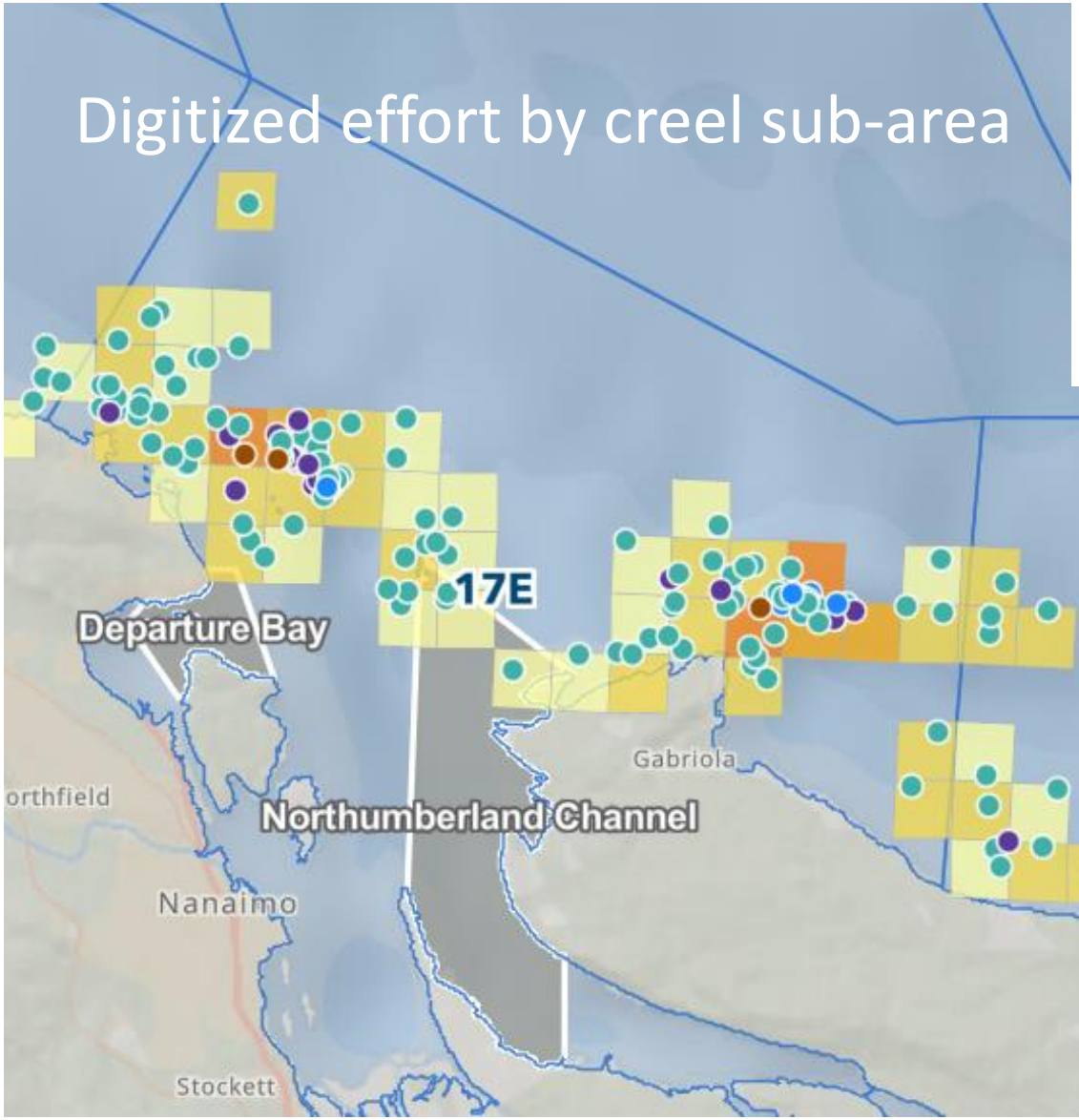
Final August Schedule	Departure Time	Path
Saturday, August 1, 2020	800	Full North
Wednesday, August 5, 2020	800	Full North
Sunday, August 9, 2020	800	Full North
Tuesday, August 11, 2020	800	Full North
Saturday, August 15, 2020	800	Full North
Thursday, August 20, 2020	800	Full North
Saturday, August 22, 2020	800	Full North
Thursday, August 27, 2020	800	Full North
Friday, August 28, 2020	800	Full North
Saturday, August 29, 2020	800	Full North

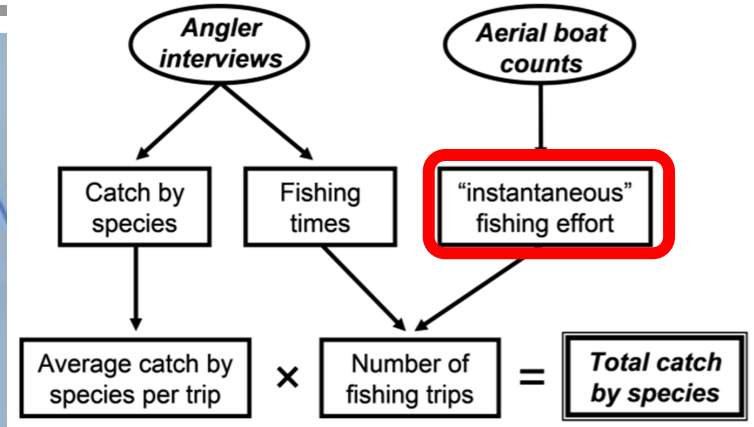
Creel Overflight Routes



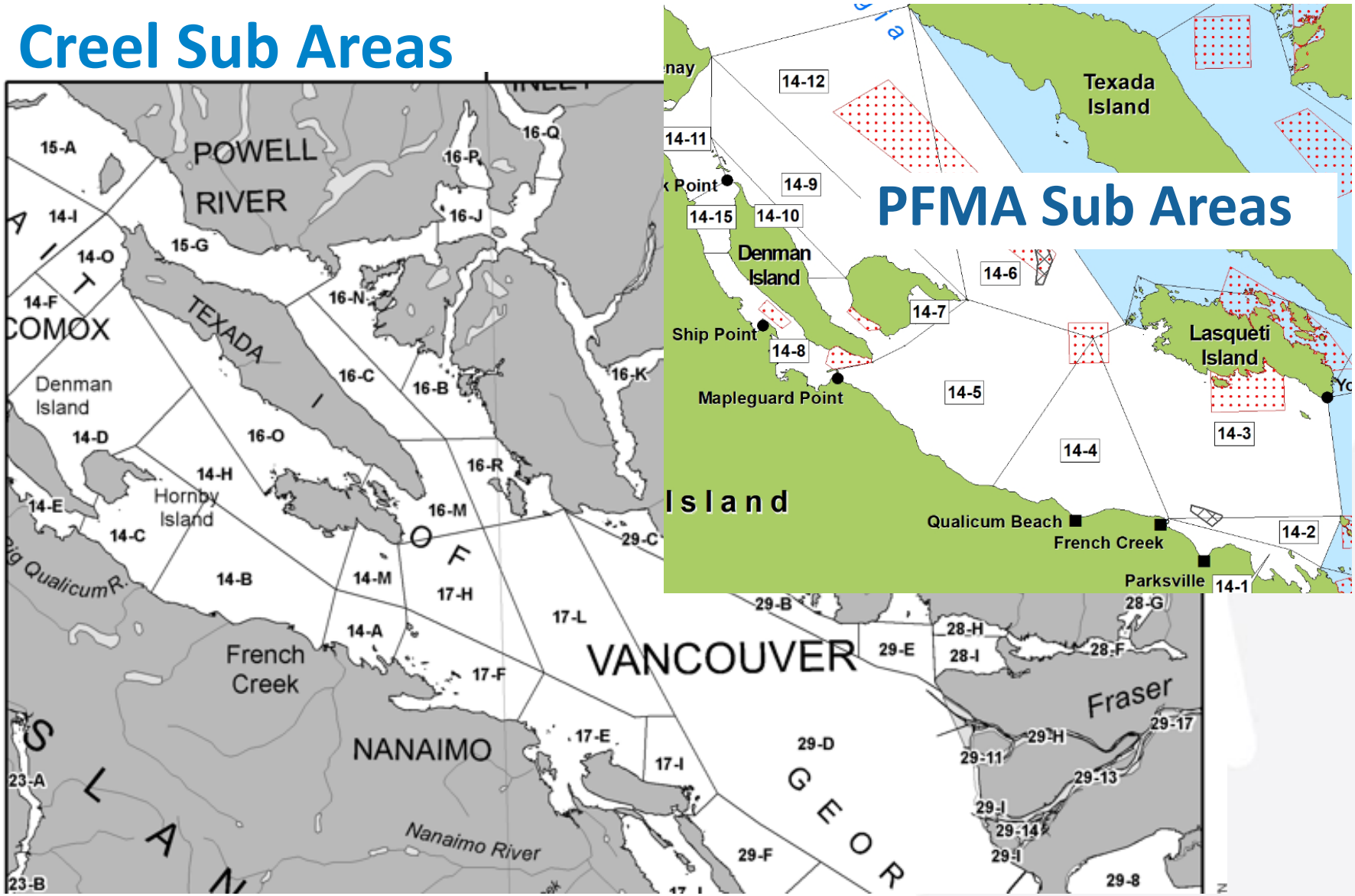


Digitized effort by creel sub-area



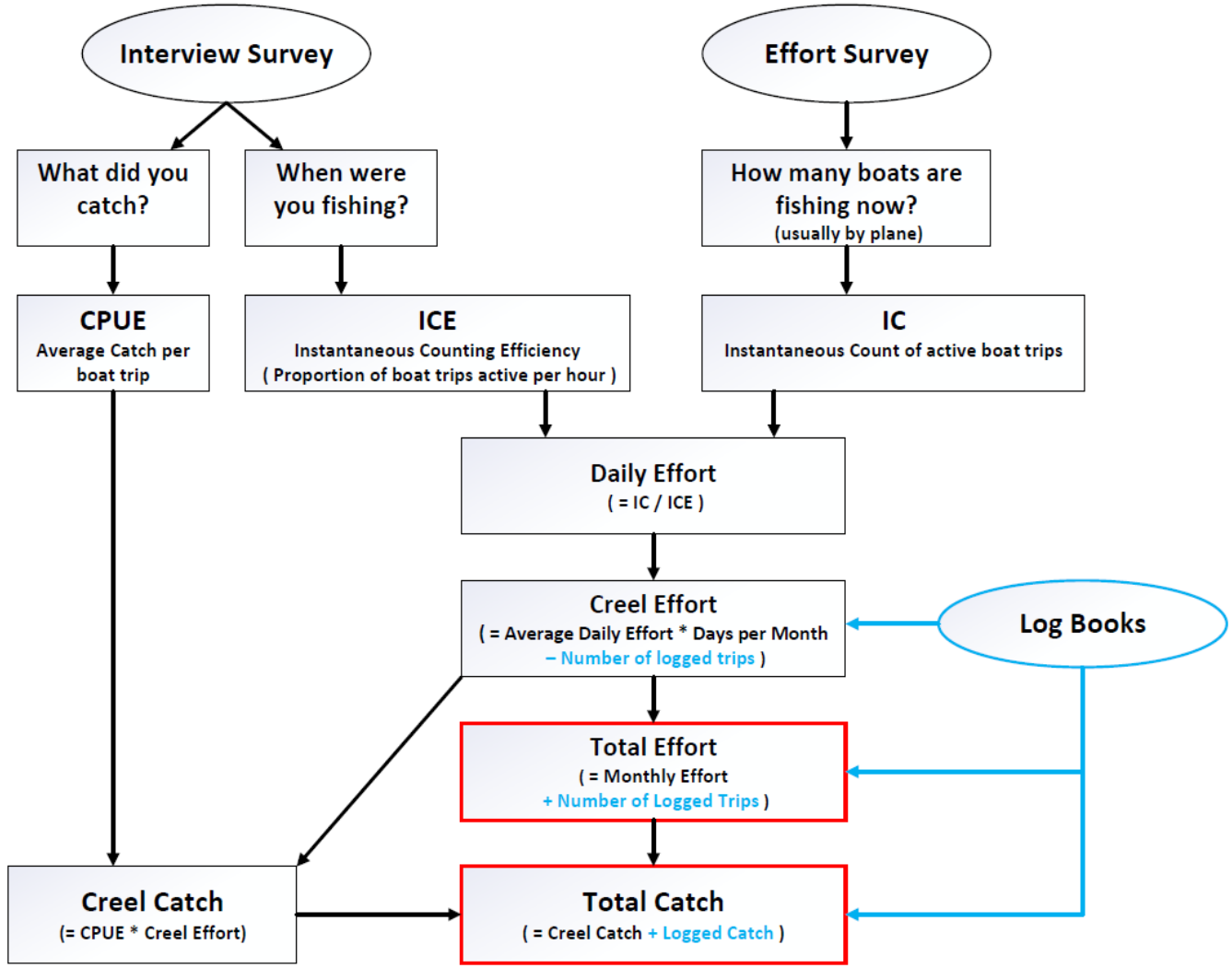


Creel Sub Areas



PFMA Sub Areas

Detailed Creel Flow Chart



Final Product

Fisheries and Oceans Canada | Pêches et Océans Canada

South Coast Assessment Bulletin
2021 Final Creel Survey Update
Recreational Fishery South Coast Tidal Waters

https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41048192.pdf

Table 5: Final recreational Kept Chinook catch estimates (number of fish) by Pacific Fishery Management Area (PFMA), 2021

	January		February		March		April		May		June		July		August		September		October		November		December		Total		5 Yr. Avg
PFMA	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.	%SE	Est.
Area 11									11[1]		324	(45%)	1211	(33%)	824	(18%)	6[1]								2376	(19%)	3994
Area 111									9[1]		1157	(32%)	1246	(26%)	686	(44%)	3[1]								3101	(19%)	1369
Area 12									15[1]		2		1478	(11%)	1257	(12%)	237[1]								2989	(8%)	6070
Area 13									25		507	(18%)	9382	(9%)	7460	(8%)	1941	(17%)							19315	(6%)	19862
Area 14											1		6927	(12%)	5710	(11%)	1439	(20%)	92	(33%)					14169	(7%)	9627
Area 15									314[1]		1384	(27%)	2870	(19%)	1319	(20%)	166	(28%)							6053	(13%)	4555
Area 16									114[1]		512	(30%)	3624	(15%)	972	(23%)	310	(35%)							5532	(11%)	2883
Area 17													1422	(18%)	735	(23%)	280[1]								2437	(14%)	4091
Area 18															157	(30%)	123[1]								280	(30%)	878

Total Estimate for creel months

Uncertainty expressed as percent standard error = SE/Estimate
Objective is 10% SE on annual estimates at PFMA level

3b. Reference Fishery - Purpose

- Independent verification of at-sea releases
  - Address concern that release estimates are from fisher-dependent data only
  - Increase public confidence
- Audit function only
  - Used to compare against estimates generated from Creel and/or iREC
  - Estimates from Creel and iREC will remain the official estimates
  - Focus on potential MSF pilots
  - Not necessary to cover all times/areas
- Biological samples
  - Compare mark:unmark ratios and legal:sublegal sizes ratios
  - Understand stock composition of releases
- Fishery Impacts by stock
  - Releases multiplied by stock proportion

3b. Reference Fishery vs Commercial Test Fishery

Commercial Test Fishery	Recreational Reference Fishery
Unselective gear – represents fish present	Recreational gear/techniques – must reflect fish encountered in the recreational fishery
CPUE's used to estimate abundance	CPUE's expected to be higher than average – not representative of general recreational fishery
Operates consistently through the season – run timing	Audit function – occurs at selected times/areas – focus on MSF pilots in 2023
Scientific licence	Recreational licence
Requires all-sector approval of test fishery allocation	Part of recreational fishery
Biological samples represent true stock composition	Biological samples represent recreational fishery encounters
	Mark:Unmarked ratio and length category ratios are the key data!

3b. Reference Fishery – vs WA "test" fishery

- No overflights
  - Effort determined from landing site fraction sampled by creel interviews
  - At-sea interviews determine intended landing sites
- Interviews for landed catch only
  - Releases not asked for in interview questions
- Release estimates from test fishery
  - Ratio of legal:illegal
  - Expanded from landed catch estimate
  - Also Voluntary Trip Reports

Test Fishery Data

	# Fish	Proportion
Legal-AD	50	0.50
Legal-UM	20	0.20
Sublegal-AD	20	0.20
Sublegal-UM	10	0.10
Total	100	

3b. Reference Fishery – Prioritization

- Where/when to implement Reference Fishery?
  - Chinook MSF focus for 2023
  - Pure (marked only) vs hybrid (some unmarked retention permitted)
  - Times/areas with most effort anticipated
  - Times/areas with encounters of stocks of concern anticipated
  - Match spatial/temporal strata of creel/iREC program estimates
  - Other priority metrics?

3c. Supplementary biological sampling

- Creel survey
  - Retained fish only
- Avid Angler program
  - Continue to collect samples from retained and released fish
  - Times/areas with reference fishery and without reference fishery
  - Results can be compared to reference fishery
- First Nations sampling

4. Annual Report/Review Process

- Recommendations for a transparent review process for MSF catch monitoring programs
  - Creel survey data
  - Avid Angler data
  - Reference fishery data
  - IREC data
- What should the review process look like?
  - Who, what, where, when?
  - Privacy issues
  - Timeliness issues
- Annual report

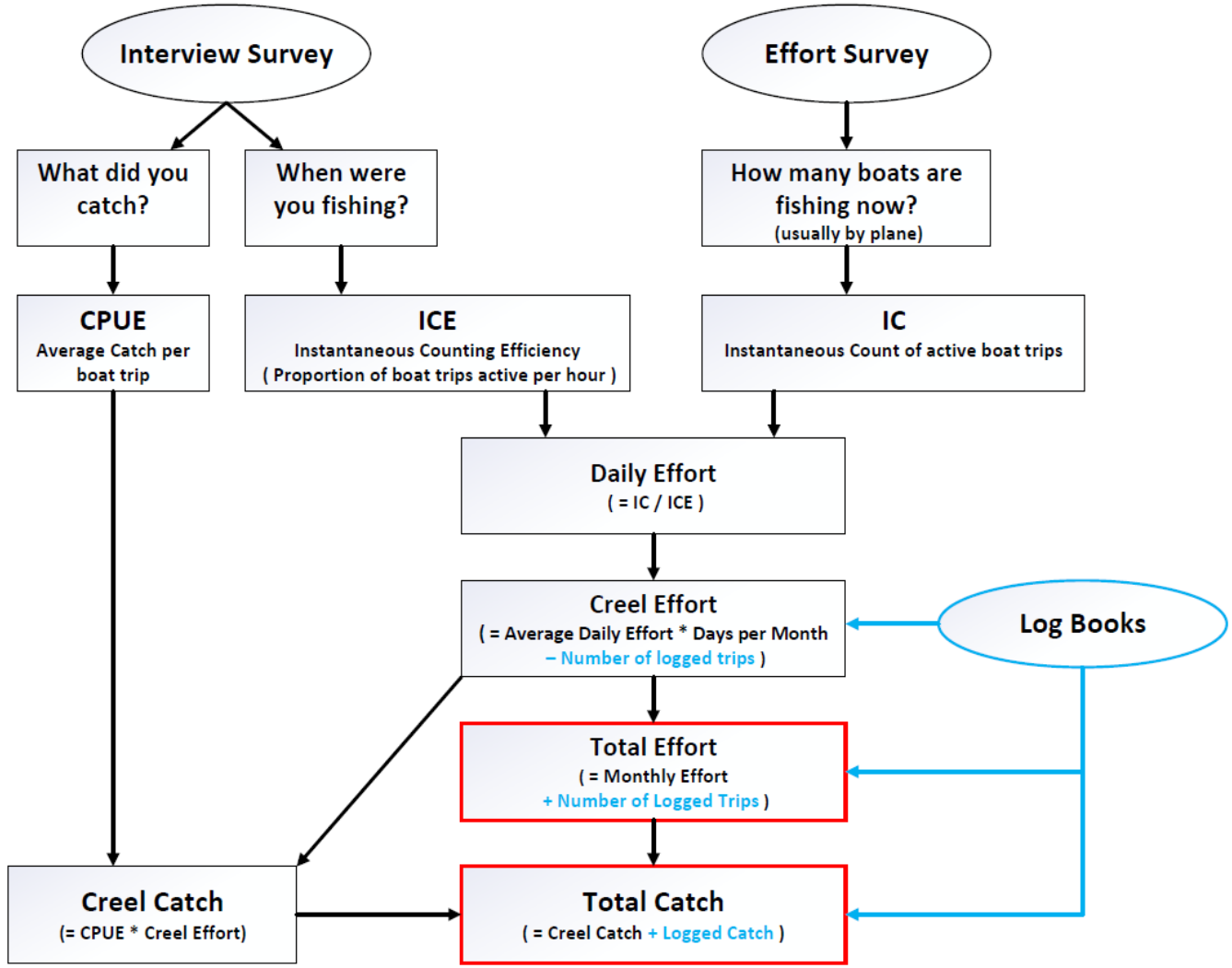
5. Discussion/Questions for attendees:

- Any other technical considerations?
- Other assessment approaches that should be considered?

Appendix

- Additional creel slides with formulas for total catch and effort including:
  - Instantaneous counting efficiency profiles
  - Expanded fishing effort
  - Catch per unit effort (CPUE)
  - Estimates of uncertainty

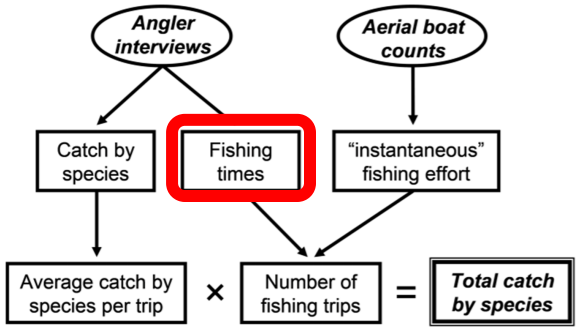
Detailed Creel Flow Chart

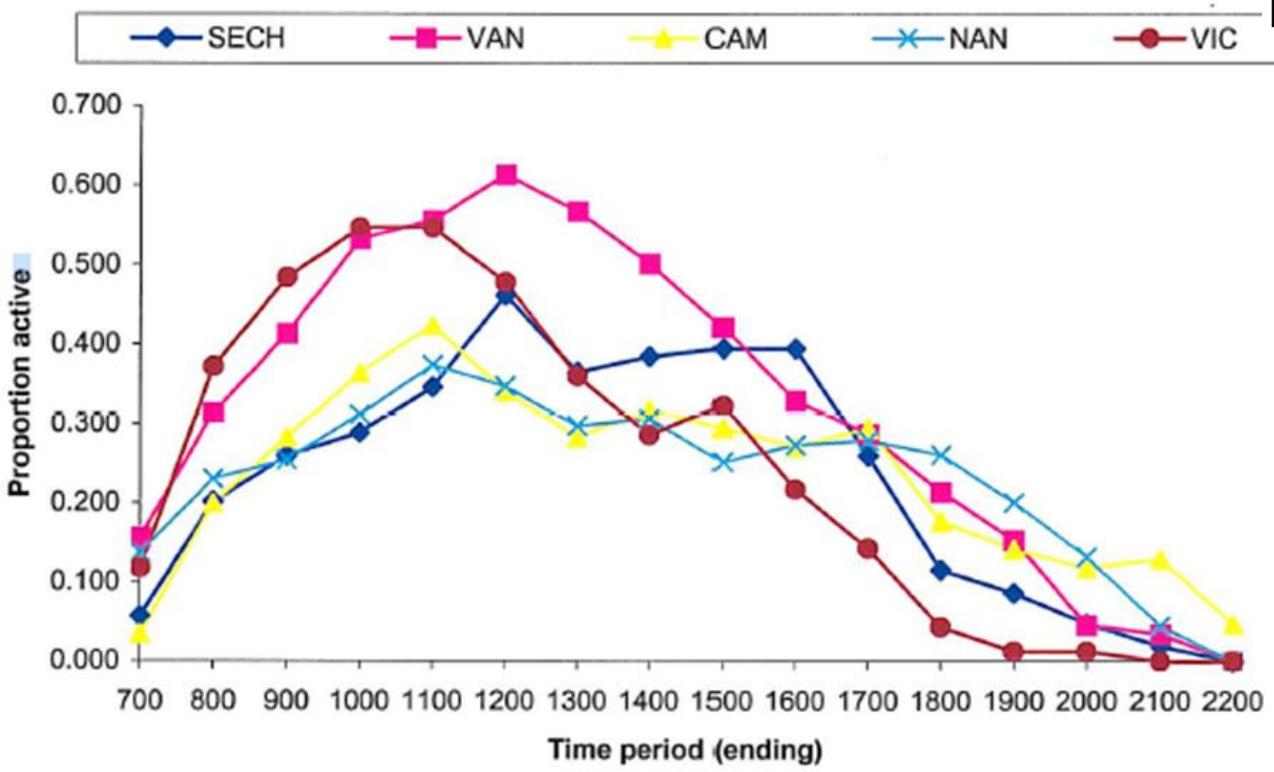


Instantaneous Counting Efficiency (ICE) Profiles

"...but what about the boats that launched after the plane flew over."

ICE used to expand the instantaneous count to the full day





ICE = proportion of total fishing boats actively fishing each time block (hour)

Generating ICE Profiles Part 1 (W1)

"...but the creel survey doesn't operate every day."

W1 accounts for differences in the number of days sampled across Landing Timeblocks and sites

$$W1_{dij} = \frac{N_d}{n_{dij}}$$

Where:

- N_d = number of type *d* days in month
- *n* = number times sampled
- *d* = daytype (weekday / weekend)
- *i* = landing site,
- *j* = landing time block

2b. Effort: Instantaneous Counting Efficiency (ICE) = **W1**

Example: *d* = daytype = weekend
N_d = 10
Time period = June

Landing Site (*i*)	Landing timeblock (*j*)	Times sampled (*n*)	Boats fishing (*F*)	W1	Adjusted boats fishing
Big W	6	10	200	1	200
Big W	7	5	100	2	200

Generating ICE Profiles – Part 2 (W2)

"...but the creel surveyor missed a bunch of boats during the rush."

W2 accounts for interviewer saturation

$$W2_{dijk} = \frac{L_{dijk}}{I_{dijk}}$$

Where:

- *L* = total number of boats landed
- *I* = total number of interviews
- *d* = daytype (weekday / weekend)
- *i* = landing site,
- *j* = landing time block
- *k* = stint (work shift by date)

$$\frac{Fishing\ Boats}{Fishing\ Ints} = \frac{Total\ Boats}{Total\ Ints}$$

2b. Effort: Instantaneous Counting Efficiency (ICE) = **W2**

Example (just pretend):

- *d* = Daytype = weekend
- *k* = stint = June 6
- *i* = landing site = "Big Wharf"

Landing timeblock (*j*)	**Fishing intvs. (*F*)**	**Not fishing intvs.**	**Boats missed**	**Total boats (*L*)**	**Total intvs. (*I*)**	**W2**	**Adj. boats fishing**
6	10	0	10	20	10	2	20
7	5	5	0	10	10	1	5

Generating ICE Profiles – Part 3 (W1 + W2)

2b. Effort: Instantaneous Counting Efficiency (ICE) = **Total fishing boats**

$$T_{gd} = \sum_i \sum_j \left[W1_{dij} \sum_k (W2_{dijk} F_{dijk}) \right]$$

Where:

- T_{gd} = Total boats fishing by group of landing sites and daytype
- *W1* = corrects for uneven timeblock samples
- *W2* = corrects for missed interviews
- *F* = number of fishing interviews
- *g* = group of landing sites
- *d* = daytype (weekday / weekend)
- *i* = landing site
- *j* = landing time block
- *k* = stint (work shift by date)

"...but not every boat interviewed was fishing which lowers average catch."

Example:
d = daytype - weekend
8 weekend days in June

Landing Site (*i*)	Landing timeblock (*j*)	Stint (*k*)	Fishing Interviews (*F*)	W2	Adjusted W2	W1	Adjusted boats fishing (*T*)
Big W	6	June 6	10	2	80	2	400
Big W	6	June 13	10	2			
Big W	6	June 14	10	2			
Big W	6	June 20	10	2			
Little D	6	June 6	10	2	40	4	
Little D	6	June 20	10	2			
Big W	7	June 6	5	1	10	4	
Big W	7	June 13	5	1			
Little D	7	June 6	5	1	10	4	
Little D	7	June 20	5	1			

Generating ICE Profiles – Part 4

2b. Effort: Instantaneous Counting Efficiency (ICE) = **Total fishing boats per timeblock**

$$A_{gdt} = \sum_i \sum_j \left[W1_{dij} \sum_k (W2_{dijk} F_{dtijk}) \right]$$

Where:

- *A* = fishing activity
- *W1* = corrects for uneven timeblock samples
- *W2* = corrects for missed interviews
- *F* = number of boats interviewed as fishing during each fishing timeblock
- *g* = group of landing sites
- *d* = daytype (weekday / weekend)
- *t* = fishing time block
- *i* = landing site,
- *j* = landing time block
- *k* = stint (work shift by date)

"...but more people fish in the morning and the surveyor was here in the afternoon."

Fishing timeblock (t)	Landing Site (i)	Landing timeblock (j)	Stint (k)	Fishing Interviews (F)	W2	Adjusted W2	W1	Adjusted boats fishing (T)
4	Big W	6	June 6	8	2	68	2	372
4	Big W	6	June 13	8	2			
4	Big W	6	June 14	8	2			
4	Big W	6	June 20	10	2			
4	Little D	6	June 6	10	2	40	4	
4	Little D	6	June 20	10	2			
4	Big W	7	June 6	4	1	9	4	
4	Big W	7	June 13	5	1			
4	Little D	7	June 6	5	1	10	4	
4	Little D	7	June 20	5	1			
5	Big W	6	June 6	10	2	70	2	364
5	Big W	6	June 13	5	2			
5	Big W	6	June 14	10	2			
5	Big W	6	June 20	10	2			
5	Little D	6	June 6	10	2	40	4	
5	Little D	6	June 20	10	2			
5	Big W	7	June 6	5	1	10	4	
5	Big W	7	June 13	5	1			
5	Little D	7	June 6	5	1	6	4	
5	Little D	7	June 20	1	1			

Converting Boat Counts to Daily Effort

Total estimated boats for the day

$$B_{sdu} = \frac{B_{sdut}}{P_{dgt}}$$

Raw boat count

All that work on ICE profiles ends up here

Where:

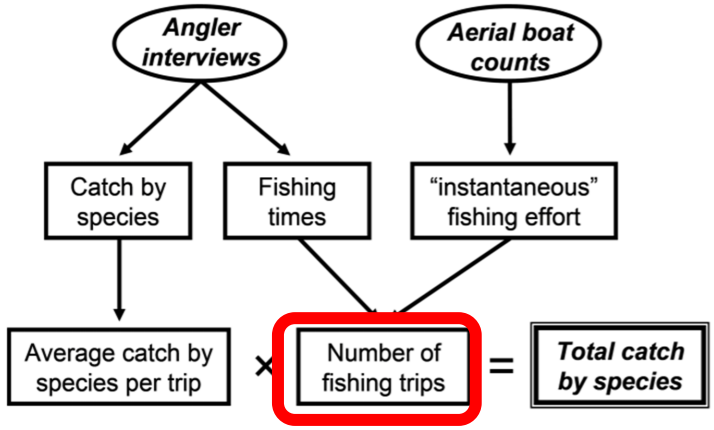
- B_{sdu} = estimated number of boats fishing on day of flight
- B_{sdut} = IC (number of boats observed in flight)
- P_{dgt} = ICE at time of flight
- *d* = daytype (weekday / weekend)
- *s* = subarea
- *u* = day of survey
- *t* = fishing time block
- *P* = proportion of fishing activity
- *g* = group of landing sites

2c. Effort: Daily Effort

Example:
d = daytype = weekend
s = subarea = 23B

Flight (*u*)	Observed boats fishing (effort) B_{sdut}	Time of flight (*t*)	ICE P_{dgt}	Daily effort B_{sdu}
June 2	25	10:08 am	0.5	50
June 9	35	11:15 am	0.6	58.3
June 24	9	10:15 am	0.5	18

Boat counts to total monthly effort per sub area



2d. Effort: Total Effort

$$E_{sd} = \frac{\sum_u B_{sdu}}{n_{sd}} N_d$$

Where:

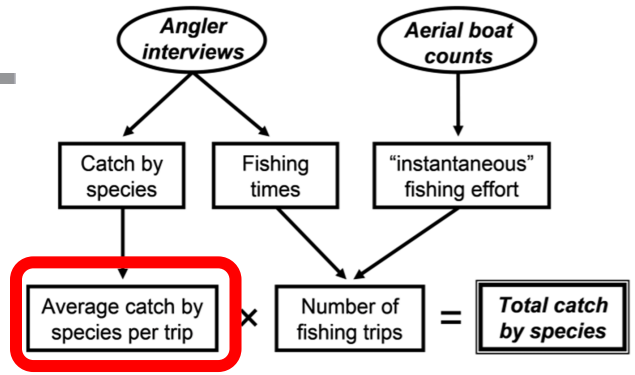
- E_{ds} = total monthly fishing effort
- B_{sdu} = estimated number of boats fishing on day of flight
- n_{ds} = total number of flights
- N_d = number of type *d* days in month
- *s* = subarea
- *d* = daytype (weekday / weekend)
- *u* = day of survey

$$E_{ds} = \frac{(50 + 58.3 + 18)}{3} 10 = 421$$

Example:
d = daytype = weekend
s = subarea = 23B
N_d = 10

Flight (*u*)	Observed boats fishing (effort) B_{dsut}	Time of flight (*t*)	ICE P_{dgt}	Daily effort B_{dsu}
June 2	25	10:08 am	0.5	50
June 9	35	11:15 am	0.6	58.3
June 24	9	10:15 am	0.5	18

Average Catch per Boat Trip - CPUE



1. Catch per Unit Effort (CPUE)

$$(CPUE)_{sdr} = {\sum_q C_{sdrq}}/{\sum_q F_{sdq}}$$

Where:
- *CPUE* = catch per unit effort
- *C* = catch
- *F* = interviewed boat trips
- *s* = creel subarea
- *d* = daytype (weekday / weekend)
- *r* = species
- *q* = boat trip

Example:
s = subarea = 23B
d = daytype = weekend

Trip (F_q)	Species (*r*)	Catch (C)
1	Chinook	2
2	Chinook	0
3	Chinook	3

5 Chinook

Chinook/boat trip by creel sub area by weekday/weekend

$$(CPUE)_{sdr} = {(2+0+3)}/{(1+1+1)} = 1.67$$

3 boat trips

Converting Effort and CPUE to Catch

sum of weekend/weekday estimates

Catch

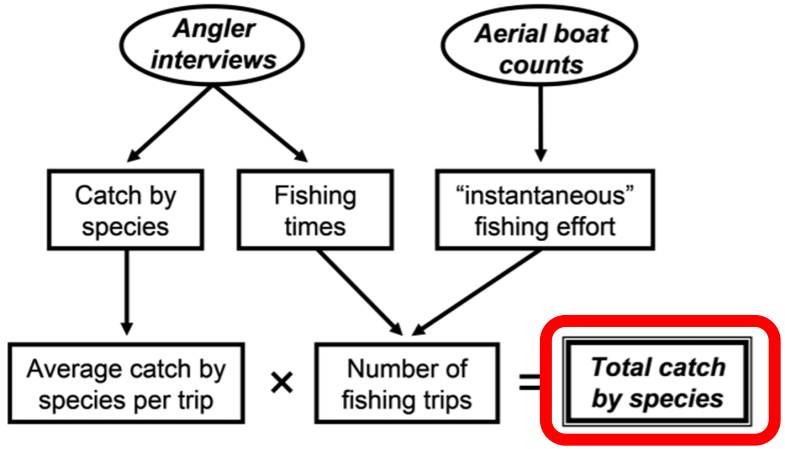
Total (expanded) Effort

Catch per boat trip/sub area/species/WD/WE

$$C_{sr} = \sum_{d} (E_{sd}\ (CPUE)_{sdr})$$

Where:

- C_{sr} = total catch per subarea and species
- E_{ds}= total effort
- $(CPUE)_{dsr}$ = catch per unit effort
- *s* = subarea
- *r* = species
- *d* = daytype (weekday / weekend)



Example:

s = subarea = 23B

$C_{weekend} = 421 * 2 = 842$

$C_{weekday} = 200 * 4 = 800$

C_{sr} = 842 + 800 = 1642

PFMA Catch by size, mark status, kept/released

sum of sub-areas (17a + 17b + 17c....)

PFMA Catch (Area 17)

sum of weekend/weekday estimates

Total (expanded) Effort

Catch per boat trip/sub area/species/WD/WE/size/adipose/disposition

$$C_{(PFMA)r} = \sum_{s} \sum_{d} (E_{sd} \, (CPUE)_{sdr})$$

Where:

- $C_{(PFMA)r}$ = total catch per PFMA and species...**AND size, adipose, disposition**
- E_{sd}= total effort
- $(CPUE)_{sdr}$ = catch per unit effort
- s = subarea
- r = species
- d = daytype (weekday / weekend)

***Disposition = kept/released**

Estimate of Uncertainty
Part 1 - Variance in **CPUE**

$$(CPUE)_{sdr} = \sum_q C_{sdrq} \Big/ \sum_q F_{sdq}$$

Where:
- C = catch
- F = interviewed boats
- s = creel subarea
- d = daytype (weekday / weekend)
- r = species
- q = boat trip

$$S^2_{(CPUE)_{sdr}} = \frac{\sum_q C^2_{sdrq} - \frac{(\sum_q C_{sdrq})^2}{F_{sd}}}{(F_{sd} - 1)}$$

Where:
S^2 = variance of the sample

Which is a rearrangement of the general formula:

$$S^2 = \frac{\sum_{i=1}^{n}(x - \bar{x})^2}{n - 1}$$

Estimate of Uncertainty
Part 2 - Variance in **Daily Effort**

$$B_{sdu} = \frac{B_{sdut}}{P_{dgt}}$$

Where:

- B_{dsu} = estimated number of boats fishing on day of flight
- B_{dsut} = IC (number of boats observed in flight)
- P_{dgt} = ICE at time of flight
- *P* = proportion of fishing activity
- *g* = group of landing sites
- *d* = daytype (weekday / weekend)
- *s* = subarea
- *u* = day of survey
- *t* = fishing time block

Part 1 Part 2

$$S^2_{B_{sd}} = \frac{\sum_u B^2_{sdu} - \frac{\left(\sum_q B_{sdu}\right)^2}{n_{sd}}}{(n_{sd} - 1)} * \left[\frac{N_d - n_{sd}}{N_d - 1}\right]$$

Where:

S^2 = variance of the sample

n = number of boat trips = $\sum_q T_{sdq}$

Part 1 = Rearrangement of general formula

Part 2 = Correction for small sample size

Estimate of Uncertainty
Part 3 - Variance in **Total Effort**

$$E_{sd} = \frac{\sum_u B_{sdu}}{n_{sd}} N_d$$

Where:

- E_{sd} = total monthly fishing effort
- B_{sdu} = estimated number of boats fishing on day of flight
- n_{sd} = total number of flights
- N_d = number of type *d* days in month
- *d* = daytype (weekday / weekend)
- *s* = subarea
- *u* = day of survey

$$S^2_{E_{sd}} = N^2_d S^2_{B_{sdu}}$$

Estimate of Uncertainty

Part 4 - **Standard Error of Total Catch**

$$C_{sr} = \sum_{d} (E_{sd}\ (CPUE)_{sdr})$$

$$SE_{C_{sr}} = \sqrt{\sum_{d} \left(E_{sd}^2 \frac{S^2_{(CPUE)_{srd}}}{F_{sd}} + (CPUE)^2_{sdr} \frac{S^2_{E_{sd}}}{n_{sd}} + \frac{S^2_{(CPUE)_{srd}}}{F_{sd}} \frac{S^2_{E_{sd}}}{n_{sd}} \right)}$$

Standard formula for the product of random variables

Where:

- C_{sr} = total catch per subarea and species
- s = subarea
- r = species
- d = daytype (weekday / weekend)
- E_{ds}= total effort
- $(CPUE)_{dsr}$ = catch per unit effort