Developing Robust Management Approaches for Hand-Harvested Marine Invertebrates; Review of Manilla Clam Operating Models for Blue Matter Science Contract 2022/2023

Welcome/Introductions:

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Background:

1. Overall goal:
    a. To build a framework for making decisions to ensure FSP requirements and conservation objectives and met for management of hand-harvest marine invert fisheries

2. Timeline:
    a. We are on year 2 of this 3 year project

3. What:
    a. 4 case studies for operating models (geoduck, green urchin, sea cucumber, manila clam); today will focus on geoducks

4. Where we are now in Year 2 of the project:
    a. Refining reference (base case) Oms
    b. Developing robustness (or alternative OMs)
    c. Establishing a range of quantitative performance metrics
    d. Establishing and preliminary testing of alternative management procedures (MPs), including reference points, with management options relevant for marine invertebrates
    e. Determining additional management objectives beyond the FSPs for the four case studies

Agenda:

1. Feedback on the operating models that will be presented
2. Discuss goals for the fishery (i.e. what do you want the fishery to look like in 5 years? 10 years?)
3. Discuss metrics that you think would represent fishery success (i.e. high catches, consistent catches, biomass above a threshold, etc.)
4. Discuss any other management options that you would like to see tested in the simulation framework
5. Discuss any other issues you would like to see addressed with the simulation framework

*This is not meant to be formal but rather a conversation so that the simulation framework can best address the needs for the fishery

Tom's operating model presentation:

Operating Model Purpose Overview:

1. What are our goals/demands with fishery management that we need the OM to meet?
2. We can use OM to show that our current management approach is robust enough despite certain data holes
3. Manila clam doesn't really have enough data to create a bomb proof stock assessment. Therefore OMs are particularly useful for manila clam

Data Updates:

1. General:
    a. Spatial definitions
    b. Age-length observations
    c. Length-weight observations
    d. Length-composition data
    e. Catch curve analysis of Z (total mortality rate)
    f. Annual catch data
    g. Historical survey data
    h. Intertidal clam monitoring program

2. Dataset clarifications:
    a. CMA-A is not in the data set given to Blue Matter Science.
        i. "CMA-A" only exists for razor clams. Agreed upon in discussion to refer to this area as "Central Coast area"
        ii. There should be data available back to the late 90s/early 2000s for this area from the Heiltsuk nation. There needs to be a follow up to see if this data got loaded into our database.
        iii. Their survey followed A manual for Intertidal Clam Surveys (G.E. Gillespie and A. R. Kronlund, 1999). (Includes num-weight data, individual net weight data. Etc.)
        iv. It was questioned how representative Central Coast data would be but Tom said that it's good to represent all areas
3. We should establish how many different CMAs we need to capture the spatial variability for Manilla Clams.
4. The goal is to make the OMs robust enough that they capture all spatial variability
    a. Data plotted is from num weights file beach ID. This might have been just from presence absence surveys so we likely don't have enough data for all the locations plotted
    b. The North Coast region is managed separately and very differently from the South Coast regions.
        i. Different PSPs between regions is a big reason why the two regions are managed separately

5. Dataset outstanding issues:
    a. Tom can't find the length/age, and num weight data for some years
        i. Megan to check that all the data is actually in the Github

6. Previous approach:
    a. Original modeling approach was by beach (last meeting he came with >100 OMs to fit all the beaches); was rectified that it should be my CMAs not beach scale. CMA scale will be a lot more simple
    b. Only length compositions
    c. No catch (scale free)
    d. Weight-Length, Age-Length, by stat area
    e. Assumed an effort trend
    f. Similar to a dynamic LBSPR approach

7. New approach:
    a. By CMA (Weight-Length, Age-Length)
    b. Catch data from 2000 (equilibrium catch before this)
    c. Length composition
    d. No effort assumption this time (to have appropriately interpret length data he had to assume it was stable, but now he doesn't)
    e. Possible reconstructed index from beach surveys
    f. Intertidal clam monitoring plan to be included (Tom needs to know more what's in them)
    g. Need to discuss what Tom can use the density data can be used for (how representative/reliable is it)

Annulus data set:

1. There's not much data observed past age 10, but has a complete distribution
2. Estimates of growth curve of large Linf
3. Data set has some pretty large length data, questionable whether believable

Biomass data set

1. Has a much lower Linf than the annulus data set.
    a. It is unexpected/concerning why the annulus and biomass data sets are so different
2. Lower catches on bigger clams might influence the fit lowering near the end
3. Conclusions that this data set makes more sense intuitively than the annulus dataset
    a. When model is fit with bio data it gives a picture of the fishery that doesn't agree with the age data that exists. So Tom questions why there are two totally different conclusions depending on whether the growth is from the annulus data or the somatic growth data from the bio data set.
4. Shows high fishery selectivity to clams of a specific size (shows attrition); could this be due to skewed sample?

Concerns about age data:

1. The age data is older than some would expect. Discussion that 8-12 years is usually posed as their age span but there's 15-year old clams on these graphs.
    a. Tom did a quick calculation and it supports the thought that the 15-year old clam data points seem unlikely
    b. The reliability of the age data has been in question lately; two people can age the same clam differently

Biological data: L-W

1. Comparable among CMAs
2. Some differences in condition factor among CMAs
    a. Discussion whether this is credible that we're seeing different weights for same size shells among CMAs. Suggested that it could be possible as it has been found that different feeding conditions can impact weights among same lengths in scallops.

Length composition by CMA (frequency vs length) (all years):

1. Some distributions have 2 modes (for example, CMA B and G). Discussion on what would cause 2 modes:
    a. There could be really good recruitment in one area in a particular year. Given uncertainty in age data this could show up in these graphs with just a few strong recruitment years.
    b. There is a low level of sampling/frequency so the data could be influenced by small sample size and strong cohorts.
2. CMA-E is better sampled in all aspects

Conventional stock assessment model:

1. Will try to make sense of various data inputs
2. Do those estimated exploitation rates impact age and other curves in a way you would expect

Catch curve by CMA-Annulus

1. Age data should be analyzed for how quickly is that age data composition declining before anything else is done with it.
    a. The curve will work out the percentage of decline which gives the total mortality rate you'd expect.
        i. This matters because the model is going to look at the Z (instantaneous mortality/curve) inferred by the data and subtract the M you give the model.
2. The Z estimated by the curve is usually quite high.
        i. We can look to see if there's an age composition that is consistent with high exploitation.
3. Our age data says we're fishing (20-50%; that's a lot!) but the length-compositions from the biological data says we're not fishing at all.
    a. Don't take these data too seriously, there just an early snapshot.

Catch curve by CMA-biodata

1. Z's are generally higher than in annulus data
2. Interpreting a very high exploitation rate
3. The M that is selected will impact the OM greatly
    a. M is linearly related to what fraction we can take.
    b. Do we have beds that are underexploited we could compare to overexploited beds to infer M?
    c. Do we have age data already by CMA that could tell us M. Or could we find a place in each region that represents a baseline.
        i. *Tom thinks this is one of the next most important things to prioritize for sampling/surveying.

        ii. Discussion whether data from the decontamination fishery could be used. Some beaches aren't always being harvested but have the biomass surveys. Could this be used to help mortality estimates?

4. Other notes:
    a. It's unknown how much 'winter kills' (extreme low temperatures coinciding with extreme low tides resulting in mass mortality), would impact M. Most information about winter kills in the literature is only anecdotal, not data based.
    b. It's also unknown how heat waves would impact M.
        i. Could the fact that Manilla Clams bury in the sand help protect them against heat waves?
    c. Spatial resolution for this fishery is poor

Catch data:

1. There is catch data from two different data files that don't overlap (both from commercial catch only though). The two data sets are close but not identical. In theory, they should be identical as the information is from the same people.
1. Manilla fishery data: 2000-2010
    a. Comment that this data should be available from 2000-2023
    b. This dataset is based on data from fish slips
2. Manilla buyer data: 2015-2022
    a. The buyer data is from buyers and has no QA/QC (data sent to province not to us) performed on it; data is very raw.
    b. The data exists before 2000, so Tom should be able to request it
2. This fishery has commercial, FSC, and recreational catches but this catch data is only on commercial data
3. Catches will give the models scale
4. We can assume an equilibrium catch (spool up catches) as one option for missing years or we can reconstruct catch for missing years. For this OM Tom assumed equilibrium catch
5. FSC catches have not been tracked at all and recreational catches are also largely unknown
6. There's no data for CMA-A, and only 3 data points for CMA-G. Therefore, we can only use CMA B-F for OMs.
    a. Comment that CMA-G mostly targets butter clams so this might not be a big loss of information
7. If there's a very large non-managed catch that is highly variable could impact OMs

Recreational Catches

1. Likely highly variable between beaches.
2. In the recreational fishery, some people get randomly selected to fill out their catch (IREC);
    a. Species ID is not accurate by fishermen
    b. This has only been mandatory for a few years
        1. Even though it's mandatory now if you get selected some people don't comply
        2. Information about recreational reporting: [Report your effort and catch | Pacific Region | Fisheries and Oceans Canada (dfo-mpo.gc.ca)]
3. Recreational fishery has been increasing over time
4. Has a different size limit than the commercial fishery (35 mm for recreational, and 38 mm for commercial)
    a. Size limit has only been mandatory for a few years in the recreational fishery

5. Recreational is open all year round and has a daily possession limit (60/day combined manila and littleneck clams);
    a. In contrast, the commercial fishery has no catch limit but is only open a few certain tides per year.
    b. Harvesters are often wildly over their limits.
    c. A lot of illegal harvesting being done on closed beaches (could impact virgin biomass estimates)
8. ****We need to put a range on recreational data harvesting (Tom will put in 10-50% as a place holder).**
    a. If the fishery is set on size limit then recreational estimate isn't too consequential.
    b. If you put a TAC on the fishery then this estimate will become very consequential
9. Much higher recreational harvest rates to road accessible beaches expected
10. If there's a very large non-managed catch that is highly variable it could impact OMs

Historical Surveys:

1. There has been inconsistent survey effort among CMAs
2. Beaches with just one year of data were not used for the OMs (doesn't tell him trend data)
3. Every year you could linearly interpolate the data to see if you construct an overall biomass series.
4. Combined (imputed) index. Can we use the survey density to tell us anything at all. The imputed data shows the biomass was roughly consistent/stable. The 1997-2008 imputed data trend could be used, but only for CMA E.
5. Density RP established in depuration fishery back in 2002ish.
6. We're not going to get to a point where we can survey every beach for biomass. Ergo we're not likely to ever have a biomass estimate for Manilla Clams.
7. Probability of being above LRP, TLP, upper stock reference; can be challenging to get through FSP. We can run the most extreme parameter estimates and show how big of a decline that causes in stock, therefore showing the 'risk' *possibilities* **(not predictions)** in the fishery.

ICMP

1. Clam monitoring program (tom hasn't seen data yet): numweights, net weights, length-weight data, but no age samples
2. We have density estimates for certain beaches but we don't have an estimate for total habitat
    a. We could look at what is the area of open and classified areas.
        i. Classified areas= where PSP and water quality sampling are overlapping. Based off inventory of clam beaches that were done 30 years ago
        ii. There's a map that shows all these areas
            1. Commercial fisheries harvest selected only from these areas
            2. Recreational and FSC are advised to harvest in these areas but are not complied to
    b. If we need beach area per CMA we could look at this information and calculate minimum harvestable habitat per CMA.
        i. This could show relative biomass at best
        ii. We could use biomass data to create spatial heterogeneity by beach and create data on that scale in the future
        iii. Might be more tactical to look at management at a beach level
3. The 2021-2022 data is available but not yet on Github
    a. Data whereabouts still uncertain. Mackenzie to double check.

Updates since Feb:

1. All modeling by CMA
2. Added survey (clamnumwgts.csv)
3. Added historical catches
4. ICMP data from the new intertidal Clam Monitoring Program for the 2021 and 2022 field seasons has been QAQC'd and entered into the 'Shellfish_Bio_Other' database
5. M=0.381 (CV 15%)

More on data inputs:

1. Burton's approach to hierarchal modelling of Linf? (possibility, but need to adjust priors possibly)
2. Concluded that we will use a count of fish slips per year on a CMA-level to create an effort time series
    i. Comment that Jenny had asked for slip data before and they said they only have data back to 1996. 1951-1995 are just a pdf they've uploaded online.
    ii. Brittany volunteered to acquire/count slip data
    iii. Discussion that what data sources we have for slips needs to be discussed/evaluated and we need to make sure they all get collated before submitting the data to Tom
3. Other thoughts from Tom;
    i. Drag equilibrium catches back to use earlier survey data (fishery ramp up from 1961-1990)
    ii. Can we pull IREC or creel data as a minimum estimate for rec fishery?
    iii. Effort is a metric of fishing mortality rate and therefore the fishing mortality will have to follow that pattern or we need to calculate a nominal catch rate
    iv. Turn on/off the catch/slip metric of commercial CPUE
        a. The number of licenses have declined by ~800 to ~600 licenses between 1990 and now.
4. Less than 200 of these licenses are fished each year. Licenses couldn't be transferred until recently, instead they just got retired; therefore many harvesters would renew just to retain their licenses
5. Ageing Data;
    i. Concerns about how inconsistent age data is
    ii. Suggested by Tom that we take the current age data even if it's not great and just run it in the model to see if the data is worth using with the error in ageing methods. Tom said it's better to do this and show why there's ageing data issues than doing nothing at all because we don't have faith in ageing data.
    iii. Uncertainty of age data likely goes up with age (rings become less accurate)
        a. If Tom has time he'll do an age error analysis for growth and catch-curve
    iv. We might have more reliable age data in the future but currently doing isotope comparison to validate ring ageing method

Operating model condition approach

1. Statistical catch-length using the rapid condition model (RCM, of openMSE)
2. Somatic growth and weight-length parameters taken from empirical data by CMA
3. Age and time invariant M specified and sampled from a lognormal distribution mean=0.381, cv=0.15, 95%CI [0.283, 0.511]--> CI seems wide
4. Commercial selectivity was assumed to be fixed: 5% at 35 mm and fully selected and asymptotic from 39 mm.
5. New for this round:
    a. Catch series
    b. Optional survey biomass index (can probably drop this)
    c. Depletion prior (reveals informative the data area)

Model assumptions/specified parameters:

1. Past DFO paper and IFMP report that maturation occurs at around 25 mm and 1-3 years.
    a. Maturation age and size can be traced back to 2 documents:
        i. IFMP report update (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/345640.pdf)
        ii. Gillespie et al. 2012 (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/347145.pdf)
    b. This produces a length distribution that's very wide in the OM.
    c. The legal size limit is much higher than 25 mm as Manilla Clam don't always reproduce in the first couple years.
    d. Is there any evidence that age of maturity is different across regions?
    e. Inquiry posed on how climate change, etc. will impact size limit and maturity
    f. Razor clam maturity is around 87mm. A study done in 1930 shows ~83% of 87mm were mature, but a 2001 a study showed only 50% of 87 mm were mature.
        i. Should we be conducting a survey on size at maturity more regularly to assess if we're using models appropriately?
        ii. Rebut that these type of surveys are big undertaking which is why it doesn't really get done
    g. More information sourced from literature by Amy on maturity/growth:
        i. From the Gillespie et al. 2012 paper:

        "Growth Rate and Lifespan

        Bourne (1982) calculated growth rates for Manila clams in different areas of BC. Growth was most rapid in the Strait of Georgia, followed by the west coast of Vancouver Island, the Central Coast and Queen Charlotte Strait. Manila clams reached the legal size limit (38 mm TL) in 3.5 years in the Strait of Georgia, 4.0 years on the west coast of Vancouver Island, 5.0 years in the Central Coast and 5.5 years in Queen Charlotte Strait. Growth rates calculated from recent exploratory surveys provide similar information; legal size (38 mm TL) was attained after 3.5-6.0 years in PFMA 6 and 7, after 3.0-4.5 years in PFMA 8 through 11, after 3.5-6.5 years in Johnstone Strait (PFMA 12 and portions of 13), and 3.5-5.5 years on the west coast of Vancouver Island with growth being somewhat slower in some northern locations (Winter Harbour, Quatsino Sound and Ououkinsh Inlet) (Table 8). For comparative purposes, age to legal size was approximately 4.0-5.0 years in Clayoquot Sound (Bourne and Farlinger 1982), 3.5-5.3 for four beaches in southern Strait of Georgia (Gillespie and Bond 1997)

and 4.0-6.5 years for Savary Island in the northern Strait of Georgia (Gillespie et al. 1998a).
Growth is rapid for the first 4-5 years and slower thereafter. Growth is dependent on substrate type and tidal height occupied on the beach, so growth rates often vary within populations on a given beach depending on where on the beach the clams are found.
Maximum size reported from BC is 79 mm TL, although most clams in a population are considerably smaller. Maximum age reported from BC is 14 years (Bourne 1987).
Under culture conditions, growth is much more rapid; Manila clams reached sizes of 38 mm TL in 13 months in an upwelling system in the US Virgin Islands (Rodde et al. 1976) and 30-35 mm TL in 16-18 months in a tray system in Israel (Shpigel and Fridman 1990).“

ii. More size limit info here: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/103707.pdf, page 130 of the .pdf.

2. Age selectivity that’s estimated by length;
    a. This shows that they’re already matured and reproduced before they start getting selected for harvest.
    b. This also shows that size limits are intensely precautionary. (50% mature (spawning fraction) long before they are fully selected
    c. Suggested that there is no size selectivity in harvesting practice as harvesters don’t see the clam until they dig them up and digging is hard so why would they throw them back
        i. The Recreational fleet might have a lot more undersized harvest because they take whatever they dig and often don’t know there’s a size limit
3. These curves show our exploitation rate currently are very sustainable because we’re taking them at such a large size/maturation age

Mode fit for CMA-E, length composition:

1. Data from 1999-2011
2. Quite often Tom says if he uses length error from fit to somatic growth curve the model line is way too dispersed compared to data. He had to half error to get the model to fit the observed length composition data. Could mean the CV is wrong. Tom needs to look into this as he thinks something isn’t quite right.
3. Some change in mean length over time (small amount)
4. Length data; some people think that large sizes are an indicator of good stock status but this is often not true
5. This rendition doesn’t have fit by CMA by age because he forgot
6. Management is interested in conversations about what the size limit should be and if we can say anything about risk due to size limit

Model fit for CMA-E, annual catches:

1. Catch data were assigned a CV of 20% which is very high compared with your typical statistical catch at length or age model (I.e. 2.5% for most stock synthesis assessments)
2. What were the catches before the year 2000:
    a. Dom found a paper (Gillespie & Bond 1997) (Gillespie et al. 1999) with trends from 1951-1995 that said;

i. Under 500 tonnes until 1981, bumped up to 4000 tones 1988, and bumped back up to 1000 tonnes by 1991
https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/230049.pdf
https://publications.gc.ca/collections/collection_2015/mpo-dfo/Fs70-1-1999-197-eng.pdf

3. **How would we sketch catch?;**
    a. **Do we have any experts that worked commercial fisheries over than time period or anecdotal evidence?**
    b. **Can someone ask G. Gillespie where he got the data from for the tonnes of catch 1951-1995 paper mentioned above?**
4. If super big clams are extra fecund, how would creating an upper size limit impact the population?
5. Catches are likely to be larger than reported.
6. **Someone needs to make a reasonable estimate on approximate recreational catch.**
    a. Mackenzie says rec overage is likely increasing so it would be good to have a scenario that shows the increase. Tom says he doesn't have enough info to sketch it.

Model fit for CMA-E: imputed density (CV·3, precision 1/8)

1. In current formula we have very little info about stock depletion without age data
2. Biomass depletion prior (0.75, CV 0.4), CMA-E:
    a. Despite down-weighting the imputed index and including a very vague prior on the biomass depletion, the model reliably estimates depletion values that closely match the prior mean (albeit flatter through the specified points)
3. No information about stock depletion trend in the composition data for the most data rich of the CMA (CMA-E) (the x-axis of the DFO default harvest control rule)

CMA E estimates/assumptions:

1. Fishing mortality rates were estimated to be high; some years they took ~45% of harvestable biomass according to model. Brittany/Jenny confirmed that this is possible
2. Very high uncertainty in the fishing rate (somewhere between 5-20% catch); this is because biomass magnitude isn't given to the model therefore we have very little scale to go off of
3. We forced models to be stable with historical data (no change in F); when we forced model to decline it couldn't be with catches so the only way the model could do it was with recruitment. Therefore graph shows recruitment drop near 2015
4. Tom says to drop imputed index and use commercial average catch/slip and make it vague/uncertain; would likely be more representative
5. The model fits the length-comp data currently
6. There's been a decrease in fishermen going out over time so it would be interesting to see if the slip data corresponds

Model Estimates:

1. Only data from CMA C, E, and F could be fit for now
    a. The fraction that we were taking in 2022 was about 10% for each of those areas
    b. Says the stock is depleted 40-50%
    c. Biomass F=591.017, E=1323.16, C=1679.588
2. We can estimate RPs from these models but how certain are we of these estimates
3. Reference Points: (not very good for now as we don't have enough data/informed parameters yet)

a. Tom thinks it could be quite hard to defend RPs from these model estimates to the FSP but maybe it will improve with more data and future OM renditions

Reference Points

Br = SSBMSY / SSBo UMSY = MSY / VBMSY Us = U(2022) / UMSY Bs = SSB(2022) / SSBMSY

CMA	Br	Br_025	Br_975	UMSY	UMSY_025	UMSY_975	Us	Us_025	Us_975	Bs	Bs_025	Bs_975
C	**0.368**	0.343	0.385	**0.391**	0.302	0.534	**0.242**	0.168	0.329	**2.161**	1.235	2.757
E	**0.394**	0.352	0.484	**0.526**	0.332	0.643	**0.17**	0.053	0.395	**3.404**	2.182	5.108
F	**0.366**	0.35	0.384	**0.263**	0.201	0.389	**0.154**	0.001	0.438	**6.256**	3.464	9.871

4. M is a key determinant of UMSY and U status (Us):
    a. Where we think M is greatly impacts a sustainable harvest rate
    b. You could be capturing a tenth to 50% of your sustainable catch if you don't know you M

Results:

1. Highly variable and dependent on M input and stock depletion prior
2. Very hard to evaluate stock status and stock size
3. Model requires longer trend information (indices or effort)
4. Age data would further inform current Z (combined mortality)
5. **Slip data will be super helpful

More on model fit and configuration:

1. What is the maturity schedule for Manilla Clam?
    a. Changes in maturity; 12˚C for reaching maturity, and 15˚C for spawning (Gillespie et al. 2012)
2. Early catches available BC wide (Gillespie paper?) can these be broken down into CMA?
3. Additional rec recreational catch (changing?- rec increasing, com effort decreasing)
4. Value of information on maturity/more current age survey
5. See info WRT fecundity with length
6. Slot limits (what about a 'very large' class)
7. Age error analysis (what is the impact on Z estimation and somatic growth estimation)?
8. Ageing for 'underexploited' beds for M calculation
9. Winter kill as a robustness test?
10. **Use the IREC survey to get at recreational magnitude.**
    a. There's a bunch of caveats that go a long with this data.
        i. Not everybody fills it out when its mandatory
        ii. Only at the PMFA level for location
        iii. Fisherman unreliable at species ID
    b. Brittany to request data and see if it's useful.
11. Possible analysis would be to (acknowledging that obtaining absolute biomass limit reference point- in kg-are not practical):
    a. Use CMA level models to demonstrate the theoretical sustainability subject to robustness tests (catches, M, growth)
    b. Use specific well informed, high exploitation rate beaches to validate
    c. Conclude coast-wide status and management performance
12. Tom will be focusing on scale free reporting to FSP.
13. Selectivity is so far after maturity that Tom thinks beach data would just tell us that we are nowhere near our LRP in biomass
14. Practically managing a fishery vs meeting a regulation influences what scale we manage at
    a. Tom suggests demonstrating at CMA level that management practices are sustainable on a wide range of uncertainty and then conclude on a coast wide F scale that the practices are sustainable.
15. how much does aquaculture encompass what we're not accounting for?

Example used of the framework

1. Projecting size limits from 25-35mm:
    a. The difference on the biomass trend is smaller than on the catch trend
    b. The level of variability is extremely high
    c. Tells us it's underfished
    d. This particular model says you could have much lower size limits

2. Size limits by stock depletion in 2022:
    a. The biomass isn't tanking
    b. Can do a risk assessment: simulating depletion rates base on different size limits and recovery rates
    c. Tom recommends using fraction of LRP not absolute biomass for our analysis end

Other possibilities:

1. Could disaggregate CMA into beaches:
    a. For example, CMA E as multiple surveys by beach
2. Testing of bio-economic closure (no fishing below X catch rate for example)
3. Beach-level closure rules (shut below x kg/m2)
4. Tom recommends: overall size limit evaluation at CMA-level, and then where we have enough beach data show tactical beach level management.
    a. Tactical beach level management could be possible and that this is the direction where a lot of harvesters want to go.
    b. Brittany uses buyer data (poundage off the beach) for closures but usually at CMA level.
5. Use of buyer data to test opening/closing rules (opening by week) at resolution of subarea
6. Opening 'green' areas (defined areas that have both biotoxin/water quality monitoring)- in theory beach level
7. Landings trend/size.
8. Tactical advice based on CPUE, ratio of legals/sublegals
9. Evaluation by yield, consistency in yield, ratio of legals to sublegals

Open discussion on management ideas:

1. Current management decision process:
    a. Decisions made on catching legals versus sublegals, and catching a sustainable amount based on previous year's harvest. Sometimes advice is based off of verbal information from the province.
        i. **Tom requested Brittany lay out the decision tree of clam closures.**
2. Harvesters want:
    a. Competitive quota per management area
        i. ** History of competitive quotas has shown to be dangerous for fisheries.
    b. Beaches removed from openings that they claim are being "hit too hard" (some beach concerns are due to commercial fishing and some due to recreational and illegal recreational)
    c. They want to move away from the 2 day openings
        i. The problem with having it open all the time would be the market.
        ii. If it was open all year round the harvest might spread to more beaches (once they exploit to a certain extent it becomes inefficient to keep harvesting a beach)
        iii. Biotoxin testing is also a limiting factor (sometimes the testing is only good for 3 days unless you have samples continually coming in)

2. This is likely more of a limiting factor in the North Coast where CFI will only pay for the testing not the sampling. In the South Coast, CFI pays for both
3. We could Estimate the LRP as a biomass density and find the catch rate cut off.
4. Managing the fishery with size limits according to the models Tom presented.
5. Concern that if we wanted to go with individual quota that we would need scale which we don't seem to have. Tom said we can set a catch based on the previous catch and then we don't need scale. Where are the control points in the CPUE?
    a. A problem pointed out with IQ is that not everyone is going to fish every year and then you have a bunch of unexploited resources
6. The cost of travel to harvest is quite high in comparison to harvest profits in the recreational fishery. Thus, biomass minimum that would be economical to harvest is likely before the point the minimum biomass that is biologically harmful
    a. Knowing the minimum density that is worth harvesting at an accessible beach would be valuable.
        i. Proposition to use slip data to infer this
            1. Rebute that there's a lot of social and economic factors masking which beaches aren't being harvested due to lower legal size catch
7. RP for depuration fishery; limit = 30 legals/m^2, threshold= 130 legals/m^2 (Gillespie 2000) Pacific Scientific Advice (dfo-mpo.gc.ca)
8. Factoring in climate change would be interesting for environmental regulations and that spawning is temp dependent

Importance of age data:

1. In most fisheries age data is the most valuable data to inform models. If we could assess whether the age data was reliable that would be majorly helpful
2. **Conclude that we need to be taking age data on surveys still**
3. **Heiltsuk have collected age data. All their data should go through to AFS. Coral to let them know that age data is still valuable.**

Next Steps

1. Age data fit
2. Effort (slips/year/CMA)
3. CMA-E biomass surveys for overlapping years only
4. ICMP data (biomass density, lengths)
5. **Hierarchical estimates of asymptotic length (Linf) (Meghan Burton)**
6. More tactical beach-level management options to test (i.e. open/closure rules, index rat MPS, etc.)
7. Developing OMs at varying spatial scales
8. Develop robustness tests (catches, M, selectivity, depletion- i.e. performance from LRP, predators?, climate-maturity?)
9. Sea otters would only be able to harvest at high tides. Possible impact in Area F and G

Performance metrics:

1. Yield
2. Stability in yield
3. Legal/sublegal ratio
4. Conservation (LRP)
5. Accessibility (i.e. in relation to the location of open/closed areas)
6. Economic viability (density- depletion paper has RPs, price of fuel)

7. Harvest rate (efficiency)
8. Some performance metric of clam monitoring program

Other analyses:

1. ICMP goals?
2. ICMP as an input to an exceptional circumstances protocol
3. ECP vs precision/power
4. ICMP precision as an input to an HCR
5. ICMP as basis for informing the LRP

Action Items:

1. **Central Coast data is not in the data set given to Blue Matter Science.**
    a. **There should be data available back to the late 90s/early 2000s for this area from the Heltsik nation. There needs to be a follow up to see if this data got loaded into our database. (volunteer not identified)**
2. **Tom can't find the length/age, and numweight data for some years**
    a. **Megan to check that all the data is actually in the Github**
3. **Tom only presented Manilla buyer data from 2015-2022**
    a. **The data exists before 2000, so Tom should be able to request it**
4. **Someone needs to volunteer to estimate a harvesting range for the recreational fishery. Tom says it's not appropriate for him to come up with this number given that DFO staff have more expertise in the area. (volunteer not identified)**
5. **ICMP 2021-2022 data is available but not yet on Github**
    a. **Data whereabouts still uncertain. Mackenzie to double check.**
6. **Brittany volunteered to acquire/count slip data for the CPUE proxy estimate**
    a. **What data sources we have for slips needs to be discussed/evaluated and we need to make sure they all get collated before submitting the data to Tom (volunteers not identified)**
7. **Uncertainty of age data likely goes up with age (rings become less accurate)**
    a. **If Tom has time he'll do an age error analysis for growth and catch-curve**
8. **How would we sketch catch?;**
    a. **Do we have any experts that worked commercial fisheries over than time period or anecdotal evidence? (volunteer not identified)**
    b. **Can someone ask G. Gillespie where he got the data from for the tonnes of catch 1951-1995 paper mentioned above? (volunteer not identified)**
9. **Use the IREC survey to get at recreational magnitude?**
    a. **Brittany to request data and see if it's useful.**
10. **Tom requested Brittany lay out the decision tree of clam closures.**
11. **Concluded that we need to be taking age data on surveys still (Dom and Alex?)**
12. **Heiltsuk have collected age data. All their data should go through to AFS. Coral to let them know that age data is still valuable.**
13. **Hierarchical estimates of asymptotic length (Linf) (Meghan to acquire and share)**