Abstracts - DRAFT

Coding philosophies, software structure, and underlying language base

Engineering Practices for Maintainable Software

Matthew Supernaw

Software Engineering (SE) provides a systematic and disciplined approach for developing maintainable software. It prescribes a framework, that if followed leads to efficient and highly extensible solutions. Approximately 80 percent of software cost ultimately goes to towards maintenance. This presentation provides an overview of the software engineering process and introduces several key concepts that will help the fisheries community in the pursuit of a generalized stock assessment framework with maintainability and efficiency as a priority from the onset.

Enabling Successful Onboarding of Scientific Tools Via Development Best Practices

Corinne Bassin

Developing scientific software applications for operational usage across scientific and policy organizations can be challenging. The variety of both development processes and user interface preferences for operational tools can create impairments to onboarding the applications for general usage. When considering new tools for operational use it is important to consider strategies to ensure ease of collaboration on tools, ensuring reproducibility of tools and results, scientific integrity, and simplicity of user interfaces. These basic tenants can more easily be ensured by implementing practices from general software development that may be used by developers early in the coding process. As part of the NOAA Fisheries Integrated Toolbox, we are focusing on strategies to help developers think ahead of time about using software development best practices which will make onboarding tools simpler and allow for greater usability and continued development of these tools into the future.

Casal2 - Dynamic Modeling Framework

Scott Rasmussen

This is a talk about the Casal2 modeling platform in development led by NIWA. This is a highly dynamic and scalable modeling platform that allows a wide range of different modeling techniques and styles.

A modular framework for the generic application of fisheries management strategy evaluation.

Ernesto Jardim, Finlay Scott, Paris Vasilakopoulos, Cecilia Pinto, Alessandro Mannini, Christoph Konrad, Iago Mosqueira

Management strategy evaluation (MSE) is a complex simulation and forecasting procedure that takes into account structural and observational uncertainty of both stock dynamics (growth, recruitment, maturity) and exploitation by fishing fleets (selectivity, effort). The MSE paradigm leads to the articulation of a decision-making framework for fisheries management under uncertainty. Within the 'assessment for all' (a4a) initiative, the European Commission's Joint Research Centre has developed a modular MSE, built with the R programming language and implemented in the Fisheries Library in R (FLR) toolbox. The a4a MSE algorithm includes the most common elements of uncertainty and allows, among others, the formulation of alternative management procedures and harvest control rules, testing the robustness of reference points, etc, within a reasonable operational time frame. The a4a MSE has a modular design, meaning that the system components are divided into smaller, independent, parts (modules). These modules link back to the MSE model parts, so that each element of the model refers to a single module. Here, we present the a4a MSE algorithm and describe its application to a range of case studies. These applications illustrate the flexibility of the a4a MSE algorithm and its potential to support the evaluation of multi-annual management plans, identification and testing of management procedures for data poor stocks, development of harvest control rules, etc.

Doing Stock Assessment Using ADMB, Stock Synthesis or TMB? A Case Study on the Queensland Saucer Scallop

Wen-His Yang

The Queensland Government manages fisheries to maintain their sustainability, relying heavily on the results of stock assessments. For future stock assessments, the Queensland Department of Agriculture and Fisheries (DAF) aims to improve the stock assessment process in terms of accessibility, repeatability and swiftness. To address this, DAF organised a Stock Synthesis workshop in August 2019 in Nambour, Queensland with participants consisting of DAF scientists, and mathematicians and statisticians from the Centre for Applications in Natural Resource Mathematics (CARM) at the University of Queensland. The Stock Synthesis package differs from ADMB and TMB which are C++ based languages for optimisation with more flexibility for model development. ADMB has been used for stock assessments of species in

the Queensland waters. In this talk, we present the assessment of the Queensland saucer scallop (Ylistrum balloti) stock using ADMB, Stock Synthesis and TMB, sharing our experiences in using the three programs for the scallop assessment.

Stock assessment model features

Stock assessment model in Japan: past to present

Momoko Ichinokawa, Shota Nishijima, and Hiroshi Okamura

The stock assessment method used in Japanese fisheries stocks have been evolving independently from international standards (such as statistical integrated assessment models). Tuned-VPA with using a spreadsheet application with graphical user interface (such as Microsoft Excel ®) has the long history of the Japanese stock assessment model, being the current majority especially for data-rich and TAC-managed stocks since the introduction of TAC management system of 1998.

This presentation reviews our efforts to break away from Excel to R since 2012 in the stock assessment of Japanese fisheries. Our developed R programs can conduct tuned VPA, calculate biological and empirical reference points, and conduct stochastic future projections. The development of R programs is now fully achieved through some important breakpoints such as complete replication of the past stock assessments by using Excel for TAC species (Ichinokawa and Okamura 2014, Bulletin of Japanese Society of Fisheries Oceanography), incorporation of “ridge-VPA” (Okamura et al 2017, ICES Journal)”, calculation of MSY-based reference points under stochastic simulations with hockey-stick stock-recruitment relationship (Ichinokawa et al 2017, ICES Journal), and shortening the calculation time with TMB (Nishijima, unpubl.). The R programs are (not-officially) available as a R package named by “frasyr” (FRA-sustainable-yield-with-R) in github website.

In conjunction with new Japanese policy on fisheries management toward explicit MSY-based management, “frasyr” will be used as the main software in the future Japanese stock assessment. There are, however, still many operational problems on this R package: “generality”, “usability”, “co-developing”, “authorship”, “efficiency”, and “transparency”. We listed up our current facing problems in this presentation and pass those issues to the next generation’s scientist who can blueprint the framework of next generation stock assessment software in Japan.

Stock assessment model in Japan: future perspective

Akira Hayashi, Junji Kinoshita, Akihiro Manabe

Assuming the next generation stock assessment models are build, how should we utilize it for the actual stock assessment? This presentation will address the desired direction inspired from a concept of

"DevOps": a cultural movement in the field of software business, which enables producing products efficiently in sustainable manner.

The global standard of stock assessment has been improving in terms of development procedure the program for stock calculation; codes are version controlled with automated tests, and programs are distributed as stable package. But the development of stable programs is not the goal of the stock assessment, but only the beginning to achieve our ultimate goal: sustainable fishery with consensus among stakeholders. Until then, researchers routinely have to estimate stock status with programs, write reports, communicate with stakeholders, re-calculate to cope with new requirements, and even write additional reports.

In Japan, the work surrounding stock assessment has various problems in the operational aspect.

Although the component program (frasyr: introduced in the previous presentation) is distributed as a stable package, the current workflow remains vulnerable and slow because of (1) the user-end script which have to be run manually, (2) researcher works on the similar scenarios concurrently with other researchers on different stocks, and (3) errors that may occur in a recurrence manner. To make consensus among stakeholders on stock management, scenarios of stock calculation should be more meticulous, and the number of review-recalculate cycles should be increased. We will encounter too much burden if we lack the operational framework for utilization of the stock assessment software.

In the world of software business, cycles of development and operations have become harmonized owing to the permeation of "DevOps". The key of their success was rooted in the idea that the most of "Ops" procedures such as running program and making document should be automated and integrated into "Dev" part. In the world of stock assessment, aiming sustainable fishing, how does our "actual" work consist of? Essentially, we have to:

- solve a problem
- calculate outcome from data
- ensure reproducibility of the calculation
- update calculation to meet new requirements

This presentation will translate and link ideas from DevOps into our field, and suggest the operational framework for the next generation stock assessment which allows us to focus on improving customer satisfaction: sustainable fishing with full consensus.

Case studies of the local stock assessment in the Northwest Pacific: difficulties in the stock assessment for seamount bottom fisheries

Kota Sawada

Although the stock assessment is crucial for the sustainable use of biological resources, it is often hindered by various kinds of difficulties. In this presentation, I review the current status of stock assessment/management for bottom fisheries in the Emperor Seamounts area which offers a challenging area of development in the stock assessment models incorporating various difficulties such as life history diversity and limited data quality. I explain why the stock assessment for bottom fisheries resources in the Emperor Seamounts area, especially North Pacific armorhead Pentaceros wheeleri, has not been successful despite the long effort by North Pacific Fisheries Commission (NPFC) and its predecessor.

North Pacific armorhead has a unique life history, consists of long pelagic period, determinate growth and body weight reduction (Kiyota et al. 2016). Length-based methods are inapplicable because they do not grow after recruitment. Catch and stock levels are highly unstable due to recruitment fluctuation and high fishing pressure, and thus difficult to predict by population dynamics models. Unreliability in fine-scale catch data further complicates the analysis. Catch per unit effort may be hyperstable because of aggregative behavior and affected by target shift between primary and alternative stocks. Target shift is more important in CPUE of the alternative target (splendid alfonsino Beryx splendens) rather than that of the primary target (armorhead), as indicated by “directed CPUE” analysis (Biseau 1998).

Several approaches, including De Lury method, surplus production model and yield-per-recruit analysis, has been adopted to assess North Pacific armorhead and splendid alfonsino in the Emperor Seamounts area. Although those approaches succeeded partly, the stock management based on solid assessment has not been implemented by NPFC. Instead, to protect spawning stock and juvenile individuals, flexible catch limitation depending recruitment level and mesh-size regulation started this year, under the name of “adaptive management”, based on the limited scientific knowledges and no quantitative evaluation of stock status. Finding a way to deal with such data-poor and atypical stocks and to reconcile with adaptive approach will be an important task for future studies on stock assessments.

Case studies of the local stock assessment in the Northwest Pacific: application of robust regression in estimating stock-recruitment relationship (15)

Shin Fukui

Fisheries stock assessment data sometimes have strong year classes of recruitment that can often give a significant impact on population dynamics of fisheries resources. The strong year class can also affect the estimation of stock-recruitment relationship when using Least Mean Squares (LMS) method with a

log-normal distribution of recruitment deviations if the year classes are unusual strong like as outliers. In such a case, the stock assessment using LMS becomes biased due to the unusual strong year class.

To avoid stock-recruitment relationship being sensitive to extraordinarily strong year classes, it could be preferred to estimate SR relationship by reducing the weight on the information of outstanding recruitment. Least Absolute Deviation (LAD) method is the parameter estimation method by minimizing the sum of absolute values of deviations. LAD assumes a Laplace distribution as the error structure and has been used as the common method for robust regression even when extreme outliers exist in data.

In this talk, we show some simulation results to demonstrate usability of LAD compared with LMS when there are outliers of recruitment deviations. Also, we introduce case studies in Japanese fisheries stocks when LAD method is applied to estimate SR relationship in the stock assessment.

Stock assessment issues in South Eastern Australia

Jemery Day

Australia's Southern and Eastern Scalefish and Shark Fishery (SESSF) is a multi-sector, multi-species fishery covering almost half of the Australian Fishing Zone, managed by limiting catch (TAC), restricting the number of boats and regulating gear. There are 34 different species managed under a quota system, with around 13 Tier 1 (data rich) assessments. These were all assessed using bespoke models up until 2006, when most assessments were transferred to Stock Synthesis (SS). With assistance and training from the stock synthesis team at NOAA, we now have 13 stocks assessed in SS (all non-shark Tier 1 stocks). These assessments range from some which are relatively straightforward, to others using little used features in SS, including cohort dependent growth, productivity shifts and projections with low recruitment scenarios. To provide management advice, the Australian Harvest Control Rules were coded within SS so that Recommended Biological Catches (RBCs) are explicitly calculated within the software. Incorporating Australian Harvest Control Rules within the software was essential to allow us to adopt this package and is an important requirement for future general stock assessment models. There are advantages with a common framework, through consistent presentation of assessments across species to both managers and industry (due to the r4ss output package), and a much easier process of review, collegial work within our team and transferring assessments between different assessment scientists. In contrast to this move towards adopting a common package in the SESSF, the Macquarie Island Patagonian Toothfish assessment has recently moved from an assessment using a modified version of SS (a spatial model with tagging data where the age and sex at first tagging is unknown), into TMB to allow the tagging component to be modelled more accurately and more efficiently and to potentially allow the use of close kin mark-recapture in future. General stock assessment models have been useful in Australia, but they currently do not satisfy all objectives required from such tools.

Essential Features of the Next-Gen Integrated Assessment

André E. Punt

Integrated (or statistical/ stage-space) methods have been the preferred approach for conducting stock assessments and providing the basis for management advice for fish and invertebrate stocks off South Africa, Australia, New Zealand and the west coast of North America since the publication of seminal paper by Fournier and Archibald in 1982, and now most assessments worldwide have adopted this approach. Methods to assess stocks based on single-species, single-area age-structured models are now standard, with the major debates associated with these models related to data choice and data weighting. The major challenges for next-gen stock assessments are the extensions needed to assess stocks that do not satisfy the 'single-stock fish' paradigm, and sadly it is increasingly becoming obvious that many stocks fall into this category. My talk will highlight the following areas: (a) spatial models, and in particular modelling multiple populations (e.g. stocks that exhibit a cline in density and population structure over their range), (b) models that are able to capture the age and length dynamics of populations simultaneously yet computationally efficiently, and (c) models that can scale from data-rich to data poor (and include as special cases the many bespoke approaches to data-poor assessment). In relation to data, there is a need to ensure that the next-gen stock assessment methods better handle tagging data (age-length models may help in this regard), in particular to be able to use genetic mark-recapture data (next-gen-x-2 stock assessments may be built around such data), and to assess multiple stocks simultaneously (satisfying the promise of 'Robin Hood' paradigm). Some challenges that have plagued stock assessment for decades warrant continued attention (at the theoretical and applied level) such automatic data weighting and tuning, improved coding to facilitate application of state-of-the-art methods for quantifying uncertainty, and adoption of true state-space formulations to allow more parameters to be treated as random effects.

Beaufort Assessment Model (BAM): Lessons Learned From Twenty Years of Software Development

Erik H. Williams and Kyle W. Shertzer

The Beaufort Assessment Model (BAM) was developed out of necessity during the early years of AD Model Builder in 2001. Named for the NOAA Beaufort Lab in North Carolina, USA, BAM was developed for stock assessment analyses of fish species within the South Atlantic Fisheries Management Council jurisdiction and coincided with the beginning of the SouthEast Data, Assessment and Review (SEDAR) process. These developments coincided with a shift in this region from VPA models to forward projecting statistical catch-at-age models (now called, integrated models). The BAM system went through much evolution to reach its current form. Currently it consists of code and packages written in R, ADMB, C++, and LaTex for reading in data, running assessment models and forecasts, processing output, and generating reports. Feedback from long time and new users of the BAM system have provided insights into important features for a successful next generation stock assessment system.

Needs from a next generation general modelling framework to support the future of stock assessment and MSE at IPHC

Allan C. Hicks, Ian J. Stewart, Piera Carpi, David T. Wilson, Steve Berukoff

The International Pacific Halibut Commission (IPHC) manages the Pacific halibut (Hippoglossus stenolepis) resource for the governments of Canada and the United States of America, and a major responsibility is providing scientific support for setting annual catch limits. Advice from the annual stock assessment is provided by an ensemble of four stock synthesis (SS) models presented in the form of a decision table reporting the risks to (probabilities) of stock and fishery performance metrics given projected catch levels. Results can be integrated via MCMC samples or Monte Carlo generation of distributions with MLE, but to properly integrate MLE results, the variances and covariances of specific quantities are needed, some of which are not available in SS (e.g., dynamic biomass reference points).

A Management Strategy Evaluation (MSE) is underway at IPHC with the development of a simulation framework and spatially-explicit operating model for Pacific halibut. An initial framework used SS as an operating model by writing R code as a wrapper to condition the OM and perform closed-loop simulations to compare among management procedures. Other agencies have performed MSE simulations using SS (e.g., Pacific hake), and many others are also interested in a general framework to conduct MSE. Challenges in transforming a generalized stock assessment model into an MSE framework include: 1) conditioning the OM, 2) producing multiple starting points from which to simulate future trajectories, 3) incorporating a management procedure in a closed-loop simulation, 4) using the OM to simulate into the future with variability on both parameters and processes, 5) access to population quantities to simulate observations, and 6) outputs that can be transformed into performance metrics.

In the future IPHC needs a general modelling framework that can 1) be used to develop multiple structurally differing models with consistent outputs for use in both an ensemble and computationally efficient sensitivity analyses, 2) incorporate a range of modern fisheries stock assessment techniques and provide options to compare between them (e.g., data weighting, functional forms), 3) output dynamic reference points (time-series and equilibrium), 4) provide variances and covariances of both parameters and derived quantities, 5) provide options for various time-efficient MCMC algorithms, 6) be used in a simulation framework to rapidly examine estimation performance, explore alternative hypotheses about dynamics and observation processes, and perform closed-loop simulations for use in MSE., 7) allow for expansion and incorporation of new data sources, modelling assumptions, parameters, and outputs, 8) provide standardized outputs that foster collaboration between agencies and efficient review processes, and 9) easily link with software to visualize and summarize results (e.g., r4ss). We discuss how IPHC has recently utilized general stock assessment software, some of the challenges experienced, and specific needs for a future generalized modelling platform.

Hybrid – a modelling framework to sidestep structural uncertainty in models

Divya Varkey, Jonathan Babyn , Paul Regular, Rajeev Kumar

The fisheries stock assessment modelling community has made a lot of headway in ways to present and evaluate different types of uncertainties in state-space stock-assessment models. Yet, we have limited opportunity to evaluate structural uncertainty stemming from model structure and parameterization. In recent years, there are several papers where authors have presented and compared alternate models for assessment of a stock with a. different parameterizations of selectivity, natural mortality, and catchability (Rossi et al., 2019); b. different approaches to model natural mortality (Miller and Hyun 2017); c. likelihood choice (Albertsen et al. 2016) and others. Yet, often in these comparisons, the structure of the base model remains unchanged (Rossi et al 2019) (not always—Miller and Hyun compare SCAA and state-space models). We present 'HYBRID', a modelling framework which allows different choices about the underlying model structure wherein the differently structured models (like Nielsen and Berg 2014; Cadigan 2015) are realizations within the same modelling framework. Features can be turned an off depending on user choice. The first and most prominent is different options for modelling F: a logistic flat topped or dome selectivity with year effects, a correlated random-walk, or a correlated auto-regressive structure over age or year; additionally it is possible to break the processes for F in years where important events (like a moratorium) might have happened in the fishery. Other choices built into the model are (i) alternate parameterization of M, (ii) choice of modelling recruitment, (iii) choice of using censored likelihoods for missing data points, (iv) choice of fitting to catch numbers at age or fitting to catch proportions and landings, (v) censored fitting of landings data when there is uncertainty about landings in different time periods in the landings, (viii) year effects in survey where needed, and (ix) use of correlated likelihoods in fitting catch-at-age or index-at-age. Further, a flexdashboard mechanism allows comparison of residual patterns and stock status between models. We expect that this modelling framework can support researchers in fisheries stock assessment when testing out new models for a stock especially in new model evaluations like 'Benchmark' processes at ICES; 'Assessment frameworks' in Canada; and 'SEDAR' in the US, and other similar endeavours elsewhere.

Albertsen, C. M., Nielsen, A., & Thygesen, U. H. (2016). Choosing the observational likelihood in state-space stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences, 74(5), 779-789.

Cadigan, N. G. (2015). A state-space stock assessment model for northern cod, including under-reported catches and variable natural mortality rates. Canadian Journal of Fisheries and Aquatic Sciences, 73(2), 296-308.

Miller, T. J., & Hyun, S. Y. (2017). Evaluating evidence for alternative natural mortality and process error assumptions using a state-space, age-structured assessment model. Canadian Journal of Fisheries and Aquatic Sciences, 75(5), 691-703.

Nielsen, A., & Berg, C. W. (2014). Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research, 158, 96-101.

Rossi, S. P., Cox, S. P., Benoît, H. P., & Swain, D. P. (2019). Inferring fisheries stock status from competing hypotheses. Fisheries Research, 216, 155-166.

12:00 Chantel Wetzel - Moving up the assessment ladder: A flexible and integrated approach to modelling data-limited stock assessments (30)

Groups / partitions

Partitioning in MULTIFAN-CL in respect of space, tagged populations, species, stocks, and gender – coding implementation and recommendations

Nick Davies, Dave Fournier, John Hampton

MULTIFAN-CL is an integrated, statistical, age-structured, length-based model that has routinely been used for stock assessments of tuna and other pelagic species since the 1990's. It is typically fitted to total catch, relative abundance, size-frequency and tagging data stratified by fishery, region and time period. The implementation of partitions for gender, space, tagging, and species or stocks in MULTIFAN-CL is presented, offering an example for generic fisheries software. The spatial partition is a core data structure, being the primary dimension of the population state matrix: by region, time period, and age class. Movement among regions may be parameterized with independent transfer coefficients or with orthogonal-polynomial coefficients, that may be constant or age-specific. Similarly, the tagged partition is implemented as a "parallel" core data structure having four dimensions: release event, region, time period, and age class. While separate from the untagged partition in respect of recruitment (being the initial tag release samples), it shares the fundamental processes and parameters for natural and fisheries mortality, movement, and growth. Partitions for species, stocks and gender were recently added by means of an adaptation of the spatial partition in respect of regions, to create "mirrored" regions for the additional partitions. Code development began in 2011 and was largely completed by 2014. Initial development was in respect of species, that was later adapted for stocks and sexes being special cases of "species". While the simultaneous implementation of the species-sex, or stocks-sex partitions is technically possible, this has not yet been attempted with real examples. The creation of mirrored regions for additional species is described, and, also the processes and parameters that may be mirrored, shared, or estimated as unique in each region corresponding to each species/stock/sex. The regional structure for these partitions readily allows for the partitioning of tagged populations among species/stocks/sexes, because tagging events are themselves partitioned in respect of regions. Data may be aggregated among each species/stock/sex. Tagging events are mirrored in the regions for the additional species, and the proportions assigned to each species is assumed to be as estimated for the untagged population, thus creating multiple tagged populations, one for each species/stock/sex, from the single release event. Similarly, apportioning aggregated tag release groups among sexes must take account of the sex-specific growth rates and sex ratios. Examples for each case of multiple species/stocks/sexes are presented to demonstrate the implementation of the partitions.

Coding considerations when developing new partitions within existing code are discussed, including validation methods. For example, it needs to be ensured that a multi-species model is capable of reproducing the results of the two single-species models fitted to each species' data separately. Ensuring the code's integrity throughout the development process is critical, and the validation procedures used for MULTIFAN-CL are described. This aims to prevent new features being developed for a single species case "breaking" the code when used in the context of a multi-species/stock/sex model. Benchmark testing therefore includes a range of single- and multi-species/sexes test data sets. Based on our experience, recommendations are offered for future developers in respect of coding a multi-partitioned generic model, perhaps beginning with the first rule: establish the correct data structures at the outset.

Will age-and-length based modelling permit broader application of the next-generation fishery assessment model?

Richard McGarvey, Richard D. Methot, Ian G. Taylor, André E. Punt, John E. Feenstra, Janet M. Matthews

One of the questions for a next-gen model is whether to make population numbers dynamically dependent on both age and length-within-age. A second question is whether such an age-and-length based formalism can be applied to both age-based assessments (where otoliths are read) and to length-only assessments. If so, only a single set of software would need to be developed and supported. We compare two current methods for age-and-length-based fishery models (platoons in Stock Synthesis and slice partition). Simulated data from an individual-based model that is independent of these two approaches will be generated for model testing. We also discuss the relative advantages and disadvantages of the two methods.

Assessment developments including climate enhanced multi-species models from the North Pacific.

James Ianelli, Kirstin Holsman, James T. Thorson

We note that flexible mechanistic models linking physical and biological dynamics to fisheries problems continue to be developed and link to the future climate change scenarios. In the North Pacific, part of this effort includes scaling simple single- and multi-species within these dynamics. We start with a survey of innovative developments within single species models to better account for observed changes in species distribution and treatment of survey data. We expand some of these approaches to trophically linked key species with an example from the eastern Bering Sea. Options to feed time and age-varying predation mortality into simpler single species models are presented and discussed. rFinally, we project under alternative climate scenarios given linked spatio-temporal predictions of environmental conditions. The attributes and trade-offs of integrating more complicated models into clear tactical and strategic management advice will require transparency to be effective.

Are Agent-Based Approaches the Future of Fishery Management? – applying the Poseidon model to the Eastern Pacific Tropical Tuna Fishery.

Katyana A. Vert-pre, Nicholas Payette, Ernesto Carrella, Michael Drexler, Jens Koed Madsen, Steven E. Saul, Richard M. Bailey, Aarthi Ananthanarayanan, Chris Dorsett

Fisheries are complex, adaptive, coupled social-ecological systems. The behavioral and social responses of individual and groups of fishers to fisheries management interventions remain a critical knowledge gap in developing robust management solutions. Management and implementation uncertainty can dramatically undermine an adaptive management paradigm. Therefore, research to understand and forecast human systems are needed, but hypothesis-driven, controlled experiments are difficult or impossible to conduct in complex systems like fisheries. Agent-based models (ABMs) are well suited to address these challenges in the human system as they capture the motives of individual actors in the system but emphasize the emergent, grouplevel, properties which are relevant to management. Furthermore, fully coupled social-ecological models can extract additional information about the fishery system that may not be captured from either the biological, social, or economic dimensions individually. An implementation of an agent-based model framework, “POSEIDON” is in development. It allows to evaluate management alternatives when using fish aggregating devices (FADs) in the Eastern Pacific. The coupled social-ecological model represents the biologies of three tropical tuna species and draws the dynamics of purse seine vessels and fish aggregating devices using adaptive agents. Once fully developed and calibrated, this model can be used to evaluate the tradeoffs associated with management alternatives for the FAD fishery across a spectrum of biological, ecological, and economic criteria. While powerful, Poseidon requires expertise in multiple fields between project managers, social scientists, computer scientist, and fishery scientists. We explore the strengths and challenges brought by working with such a diverse group of scientists on a complex systems model.

Observation models

A framework for multi-year Leslie-Davis depletion modelling and its use as a stock assessment model feature.

John Feenstra, André E. Punt, Richard McGarvey.

An overview is provided of the multi-year Leslie-Davis depletion modelling framework of Feenstra et al. (2017), referred to as "EDM", followed by representations of it within integrated modelling. EDM estimates yearly total recruitment numbers, as well as exploitable population at the start of each time step within a part of the fishing season ("fitted depletion period" or "FDP"). Data requirements of EDM consists of total fishery catch in number for all of the season, but catch rates for only the FDP, which may be much shorter than the entire fishing season. The basic assumptions of the Leslie-Davis model of constant catchability and no recruitment apply for the FDP for each season. EDM hence does not require data on total fishing effort during a season, nor does it make assumptions about catchability during the

non-FDP. The basic ("base") EDM version estimates a parameter for the population in the initial fishing season, a recruitment parameter for each season, and a single catchability parameter shared among all seasons. It may also be used to estimate exploitable biomass (instead of population numbers) for fisheries that only have catch rate data and catches in weight, but the recruitment parameters in this case estimate total positive production similar to the "production function" in surplus production models. EDM here is applied to the Southern Zone rock lobster fishery of South Australia, as per Feenstra et al. (2017) but the time series of data is extended by four seasons ending in calendar year 2018. Sensitivity analyses comparing standalone EDM results with those from standalone runs of a length-based and catch-conditioned integrated stock assessment model used for rock lobster in South Australia ("LenMod") reveal that selectivity configuration in the latter determine strongly the level of congruence for exploitable abundance (but not recruitment to legal size). Adding EDM functionality as a feature to a general stock assessment model either by providing it as a standalone option, or as an influence when fitting an integrated model to diverse data. Requirements for integration of EDM within a more general model include that it allows: catch-conditioning, homogeneous catchability over specified contiguous time steps within a fishing season during which substantial depletion occurs and catch rate is fit (i.e. FDP), recruitment to occur outside of the FDP, weighting values for likelihood components. Fitting to length composition data may complement EDM by better modelling of exploitable abundance through informing on selectivity, the latter implicitly assumed to be uniform in standalone EDM. Similarly, setting catchability to be homogeneous for some time steps (when deemed realistic) in integrated models alters estimates and configuration of length selectivity. EDM functionality may be beneficial in data-limited (or –moderate) fisheries to estimate abundance/biomass, and in more data-rich fisheries by enabling the possibility of detecting yearly changes in catchability or by providing an alternative set of abundance/biomass estimates.

Reference

Feenstra, J., Punt, A.E., McGarvey, R., 2017. Inferring absolute recruitment and legal size population numbers of southern rock lobster (Jasus edwardsii) in South Australia's Southern Zone fishery using extended forms of depletion modelling. Fish. Res. 191, 164–178.

Integrating conventional and electronic tagging data into the next generation of stock assessment models

J. P. Eveson, R. M. Hillary, T. A. Patterson,

The job of assessing the status of a given fish stock is often hard enough for a single spatial area. When one cannot really ignore the spatial distribution and/or migratory dynamics of the population being assessed it only gets harder. The most common information defecit is data that can meaningfully inform on spatial dynamics, and mark-recapture data have always been the most likely general data stream that could solve this problem, though they present significant challenges when modelling the full suite of release and repcature data. Several stock assessment packages already have tagging data modules within their general structure, but not for the kinds of electronic tagging data platforms (e.g. archival,

satellite, acoustic) that have been increasingly developed and implemented for a variety of species – particularly for pelagic species like tunas, billfish, and sharks. This talk uses two examples (southern bluefun tuna and striped marlin in the South Pacific) to demonstrate how we can go about integrating conventional recapture data only (not releases and recpatures), and the current suite of possible electronic tagging data for the purposes of movement estimation within integrated stock assessment models.

Towards Close-Kin Mark-Recapture software

Hans J. Skaug

Mark-recapture methods are commonly used to study wildlife populations. Taking advantage of modern genetics one can generalize from “recapture of an individual” to “recapture of a closely-related kin”, and thereby the name Close-Kin Mark-Recapture (CKMR). The basic logic is: if your sample contains many close relatives (genetically determined) then your population is small, and wise versa. The method has been successfully applied to some fish populations, and there is also interest in applying CKMR to terrestrial populations. I will explain basic principles of CKMR and discuss to which extent it is possible to develop generic CKMR software. Part of the conclusion will be that every target organism have their own peculiar life history, which must be accounted for when calculating “recapture probabilities”, and this makes it hard to write generic software.

Application of Close-Kin Mark-Recapture

Robin Thomson, Mark Bravington and Rich Hillary

Close-Kin Mark-Recapture (CKMR) is an exciting new method that can provide precise time-series estimates of absolute abundance, as well as independent estimates of mortality rate (fishing and/or natural), relative-fecundity-at-size, and population age structure. There is no need for fishing effort or CPUE data, and no need to worry about time-varying catchability or selectivity.

Operationally, CKMR entails collecting many tissue samples together with associated length and (at least some) age measurements, followed by genetic sequencing and the identification of close relative pairs, specifically parent-offspring and half-sibling. Although sample size requirements can be high, costs can be kept low because it is generally sufficient simply to sample from the catch, since the method is not susceptible to vagaries of fishery behaviour. A model that uses CKMR data needs little else besides a catch-at-length time series.

CKMR estimation uses a standard age-structured population dynamics model, combined with special-purpose log-likelihood code that has a clear logical structure. While there is real value to running purely-CKMR models, eg to check the reliability of conventional but suspect data such as CPUE, it is also straightforward in principle to embed the CKMR log-likelihood alongside other data within a classical

age-structured integrated stock assessment model framework; at CSIRO, we have used both approaches in the course of addressing Southern Bluefin Tuna, school shark, and several endangered sharks. We present some principles for how this exceptionally powerful technique should--- and should not--- be incorporated into stock assessment software.

Implications of entrainment for fisheries stock assessment

Mark Chambers

There are many examples of the collapse of fisheries exhibiting population dynamics that contrast sharply with stock assessment models. Petitgas et al. (2010) argue collapsed populations, distinct from depleted ones, have suffered disruption to population memory of traditional migratory routes. The social transmission of traditional migratory routes, or "entrainment", has been taken most seriously for Atlantic herring whose seasonal migrations have been documented for centuries. However, attempts to simulate entrainment dynamics are yet to demonstrate its "survival value". I show using a simulation loosely based on juvenile southern bluefin tuna that entrainment can lead to increased fitness over fixed probability migration choices in the usual case when mortality varies over space. I also demonstrate how entrainment can contribute to fishery collapse and delayed recovery.

A New Approach to Generating Spatial Age-Length Keys. Based on Using a Gaussian Field Approximation with Support for Physical Barriers

Jonathan Babyn

Estimating the age composition of a fish population is an important first step in the stock assessment process. Often this is done through the use of an Age Length Key (ALK), which links a subsample of fish that have had their ages determined to those that have only had their lengths measured in order to obtain an estimate of the age structure of the entire sample. ALKs can suffer from data gaps and sampling artifacts and are limited in how the ways spatial information can be incorporated. We propose a novel spatial ALK model that uses an approximation of a Gaussian Field and has the ability to account for physical barriers (e.g. coastlines) in the study area. Our approach is compared with a previously suggested spatial ALK model as well as non-spatial approaches using both real and simulated survey data. We find that using a spatial ALK approach can reduce the error for stratified estimates of abundance at age.

Management quantities

Stock Synthesis Completes the Cycle: Assessment - Management Quantities – Projections – MSE

Richard D. Methot

The Stock Synthesis (SS) assessment approach links age-structured assessment of a stock's exploitation history, with calculation of reference points and then with projections. Movement, seasonality, growth, fleet selectivities, etc. are estimated from maximum likelihood fits to data in the time series, then applied equivalently in equilibrium and projection calculations. A target F, say F35% or Fmsy, calculated in the reference point phase can be used as the F for the projections. This approach preserves parameter gradient information through these linked modules and propagates variance of parameters estimated for the time series onto the equilibrium calculations and projections. The capabilities of the projection module are extensive to deal with real-world fishery management situations such as uncontrolled bycatch by other fisheries, fixed allocations between sets of fleets, caps on total catch, etc. A novel aspect of projections with SS is its three phased approach. The first phase calculates future catch if fishing was according to Fmsy; the second phase applies fixed input catches, catch constraints and allocations, and biomass-linked control rules including a buffer below Fmsy. Catches from the second phase are save as if they are a time series of future fixed catch quotas. Then the third phase uses these saved catches to calculate future realized F's taking into account stochastic recruitment and implementation error. New work is wrapping the SS framework within a R-based system to conduct Management Strategy Evaluation.

Management strategy evaluation made operational with Stock Synthesis

Nathan Vaughan, Kathryn Doering, John Walter, Rick Methot, Matthew Smith, Nancie Cummings, and Nick Farmer.

Management Strategy Evaluation (MSE) is designed to holistically evaluate alternative management strategies, data collection approaches, and modeling structures. It iteratively simulates the stock assessment, management, and population & fishery processes to evaluate uncertainty and determine which components could be improved to achieve performance. While MSE is becoming routine, the task of conducting it is currently limited by the challenge of creating realistic operating models (OMs) for the population and fishery processes. The stock assessment software package Stock Synthesis (SS) currently represents one of the most complete, generalizable population assessment models available, which is why it is used for a large number of stock assessments around the world. The structure of SS models provides the necessary architecture for MSE OMs, while the stock assessment process formalizes the parameterizing, fitting, and evaluating of models. Pre-existing stock synthesis assessment models therefore represent a potential pool of excellent operating models. Attempts that have been made to

utilize this existing resource for MSE are often simplified versions of the original SS model itself. We propose an alternative path to MSE functionality using the parameterized SS model itself as the OM. The goal of this project is to build the capacity to easily turn any SS model into an operating model with as much of the OM engine as possible operating within SS, thereby making OM output an innate capacity of SS. Additional parts of the MSE control logic will be developed as an R package called SSMSE. This approach would allow the complexity of the MSE to grow with SS, leveraging its future development, and innately linking the MSE and stock assessment processes. Our purpose in this presentation is to describe the project, elicit input on desirable outputs and properties of OMs and to solicit a review panel of likely users and previous/existing MSE/SS developers to suggest important features, beta test software developments, and review the final products.

The role of simulation modelling in fisheries research: future needs and requirements

Jeremy McKenzie

Simulation modelling is important to fisheries management and research in two key areas: management strategy evaluation (MSE); estimation-model performance evaluation. Although most of the common stock assessment modelling platforms can be configured for data simulation, greater insight into estimation model performance is gained when the simulated assessment data has been generated by a computationally different, and more “real world” complex, operating modelling platform. In this talk I will discuss some of the key roles and feature requirements of operating model simulators in fisheries research. I will compare the pros and cons of two currently in-use simulation modelling platforms: a partition modelling platform (SPM) and an agent-based modelling platform and pose the question: how much simulation capacity should we build into the next generation of fisheries models?

Insights on dynamic reference points and their importance for next generation stock assessment models.

Piera Carpi, Allan C. Hicks, Ian J. Stewart, David T. Wilson

Non-anthropogenic influences on a fish population are important drivers of both dynamics and productivity, and are often a major cause for changes in recruitment strength, growth, and natural mortality. However, there are only few examples where environmental components are formally included in fisheries management: for many stocks, the current management relies on reference points based on a theoretical unfished equilibrium stock size, which may lead to an inconsistency between the current potential of the stock and the management objectives. A dynamic reference points approach, on the other hand, will help to disentangle the effect of fishing from the effect of environmental forcing, given that the underlying mechanisms for the main changes in growth or productivity have been identified.

In recent years, the International Pacific Halibut Commission (IPHC) has revised its harvest strategy policy to use a dynamic measure of stock status rather than assuming a static unfished equilibrium biomass defined for a specific recruitment regime and growth pattern.

We first discuss the differences between candidate dynamic reference points: 1) “dynamic time-series reference points”, calculated for each year of the stock assessment using the past observations of recruitment deviations (and comprising a special case of the ‘moving window’ approach), and 2) “dynamic equilibrium reference points”, calculated using constant equilibrium recruitment and constant productivity. Then, the Pacific halibut stock is used as an example to i) investigate the variability of reference points, such as Maximum Sustainable Yield (MSY), over time, ii) understand the influence of different types of uncertainty on dynamic reference points, and iii) discuss the importance of incorporating dynamic reference points as part of a general stock assessment framework. Three different approaches were implemented. First, an equilibrium model was used to investigate changes in dynamic equilibrium reference points given different assumptions about virgin recruitment, steepness, weight at age, selectivity and natural mortality. The stock synthesis framework was then used to investigate estimates of past and current dynamic equilibrium reference points. Finally, a simulation framework was implemented to investigate the variability in dynamic equilibrium reference points given variability in parameters, productivity, fisheries, and structural assumptions.

Given the potential benefits of dynamic reference points, we suggest that a clear characterization of candidate methodologies is important to ensure analysts are comparing the same quantities. Further investigation into how best to incorporate dynamic reference points calculations into stock assessment models and which are most appropriate will rely on next-generation models capable of calculating a range of alternatives.

A decision support tool for incorporating management impacts into stock assessment projections

Nathan Vaughan

We present a stock assessment decision support tool (DST) that extends the existing projection capabilities of the stock synthesis integrated assessment model (SS). The DST provides a simple graphical user interface that automates the incorporation of recent landings data and future management changes into the calculation of equilibrium sustainability benchmarks and annual overfishing limits. Specifically, DST users can: input recent catch history; adjust allocations between fleets; assign equilibrium benchmark targets; and change future fleet selectivity parameters. The ability to incorporate proposed management actions in the estimation of overfishing limits (OFLs) is a first step towards full dynamic feedback between the assessment and management processes. Coupling the implementation of management with the estimation of OFLs will: improve the robustness of OFL estimates; provide best scientific advice regarding the expected impacts of management actions; and improve managers and stakeholders understanding of the complex tradeoffs inherent to all management options. Allowing non-experts to easily explore the impacts of different management actions could increase public trust and engagement in the stock assessment process. The DST has been

utilized within the U.S. to inform management decisions for Gulf of Mexico fisheries and internationally by assessment scientists at ICCAT to produce Bigeye and Yellowfin tuna projections. Future development goals include: additional data inputs such as indices of abundance to enable simplified interim assessment advice to be produced from partial data; and utilizing the DSTs projection interface capabilities to develop an SS based management strategy evaluation package. The DST project represents an ongoing attempt to integrate the stock assessment and management/regulation processes; achieving this goal should be a desired feature of future advanced stock assessment methods.

Operationalizing model ensembles to provide scientific advice for fisheries management.

Ernesto Jardim, Manuela Azevedo, Jon Brodziak, Liz Brooks, Kelli Faye Johnson, Nikolai Klibansky, Coilin Minto, Colin Millar, Iago Mosqueira, Richard Nash, Paris Vasilakopoulos, Brian Wells

Providing scientific advice to fisheries managers can be a risky activity! It's not uncommon that a model which was working perfectly fails to properly fit an additional year of data, or to find that projections made in the past did not materialise when new information was made available. Furthermore, when fitting a model it is common to deal with conflicting pieces of information or data revisions. All of these have the insidious tendency to ruin a seemingly good assessment model. Scientists deal with very complex systems, with many unknown or poorly understood processes and limited information, which make advisory tools sensitive to alternative system representations, model assumptions or new data. Our approach to mitigate the potential lack of robustness and instability of fisheries advice is to expand its basis to integrate structural uncertainty using model ensembles. There are two main reasons to use model ensembles (i) to include structural uncertainty captured by differences across models of the same system; and (ii) to integrate across initial conditions and process errors in projections or sensitivity runs. This paper discusses and speculates about the utility and implementation of model ensembles for scientific advice to fisheries management. We discuss ensemble utilization, ensemble types, weighting metrics, model space and model expansion. We make the case for using ensembles in three main situations: (i) to estimate stock status, (ii) to set future fishing opportunities, and (iii) to build operating models for management strategy evaluation.

Diagnostics

A cookbook for using model diagnostics in integrated stock assessments.

Felipe Carvalho, Henning Winker, Laurence Kell, Dean Courtney, Massimiliano Cardinale, Dawit Ghebrehiwet, Michael Schirripa, Maia Kapur, Kevin R. Piner, and Mark N. Maunder.

This study provides practical guidelines for implementing selected diagnostic tools that identify data conflicts and predictive skills in integrated age-structured stock assessment models. Conflicting signals are a major issue when attempting to integrate diverse data series within a complex model structure. Conflicts among data sets are often a symptom of model misspecification, evident as poor model fits, and can affect the estimates of important parameters and their derived quantities. Consequently, diagnostics that identify inadequate fits to data or conflicts among data components can be used as starting points to identify potential model misspecification and possibly inform alternative model formulations. Here we explore the utility of implementing a suite of diagnostic tools simultaneously in an integrated flow diagram prior to drawing any conclusions about model misspecification and before any data sets or models are removed from consideration. Particular emphasis is placed on evaluating predictive skills by incorporating retrospective analysis and hind cast cross-validation techniques as important diagnostic steps. By first implementing a complete set of diagnostics, one can get a much better sense of the interactions between them, more so than examining individual results in isolation. Example applications are provided from recent Regional Fishery Management Organization (RFMO) data-moderate length- and age-structured stock assessments using Stock synthesis. We use the Stock Synthesis modeling framework as a case study because of the availability of the r4ss package, a collection of R functions that automates visualizations of model summaries. The proposed suite of diagnostics comes with a generic set of R diagnostic tools and graphical visualizations.

Parameter estimation

The role of random effects in next-generation stock assessment models

Anders Nielsen

For most of the long history of fish stock assessment models, random effects have not explicitly been part of the model formulation.

The obvious question is therefore if it is important to implement next-generation stock assessment models to support random effects at all?

State-space models are models where random effects are used to formulate stochastic processes which are unobservable but related to the observed quantities. From a theoretical point of view, the state-space framework is a perfect match to the typical assessment problem. However, in practice, the size and complexity of the applied assessment models, combined with the fast run times required for them to be operational, has in the past hindered the widespread use of state-space assessment models.

Recent advances in algorithms, software, and computing power has greatly reduced the practical concerns w.r.t. using state-space assessment models and they are increasingly being applied.

Here I will present some information about what random effects are used for in current assessment models (e.g.~missing observations, time-varying quantities, and defining correlations) and outline where we can expect to see them further used in next-generation assessment models (e.g.~prediction, linking stocks, and including spatial data).

I will argue that random effects simplify and generalizes many aspects of formulating assessment models and opens up promising paths to further advance assessment models, and hence that good support for random effects should be high on the feature list for next-generation assessment models.

The Woods Hole Assessment Model (WHAM): a generalized state-space age-structured stock assessment model that can include environmental effects on population processes

Brian C. Stock and Timothy J. Miller

The Northeast Fisheries Science Center (NEFSC) is developing the Woods Hole Assessment Model (WHAM), which builds off ASAP, its ADMB-based statistical catch-at-age (SCAA) model. WHAM has many similarities to ASAP, including the input data file structure, and many of the plotting functions for input data, results, and diagnostics are modified from ASAP code. WHAM is written in TMB and can be configured to estimate a range of assessment models, from a traditional SCAA model with recruitments as (possibly penalized) fixed effects, SCAA with recruitments as random effects, or a full state-space model with abundance at all ages treated as random effects. We have distributed WHAM as an R package on GitHub with the intent to follow guidelines for free and open-source software of the NOAA Fisheries Toolbox and the Linux Foundation Core Infrastructure Initiative. R functions allow users to load input data files, specify model options, fit the model in TMB, conduct retrospective and one-step-ahead residual analysis, check convergence, plot diagnostics and results, and compare alternative models.

The primary factors motivating WHAM development are the state-space formulation and incorporation of environmental covariates on time-varying population processes. Several recent applications to Northwest Atlantic stocks have shown that these models can outperform traditional SCAA models in terms of reduced bias, retrospective pattern, AIC, and uncertainty in reference points. In addition, large changes in oceanographic conditions are occurring on the Northeast U.S. shelf, and WHAM has been designed to evaluate how these changes may affect productivity of the commercially important stocks in the region. While standard assessment models can account for environmentally-driven shifts in productivity by estimating time-varying population parameters, WHAM explicitly models the environmental drivers, which can reduce uncertainty and refine projections of stock status. We describe case studies highlighting WHAM's capabilities and share plans for future development.

Approaches for modelling landings and catch age composition information in state-space stock assessment models

Noel Cadigan

I propose that landings information should be modelled using a different likelihood function than catch age composition information in an integrated state-space stock assessment model. This is important for some Northwest Atlantic stocks with international fisheries where uncertainty about landings levels may be high in some time-periods. However, we have little knowledge about the accuracy of landings, and in this case I suggest that a catch bounds approach using a censored likelihood is a reasonable strategy for modelling this type of information. For catch age composition information, I investigate several approaches that depend on whether information on age composition sample sizes is available (i.e. Multinomial, Dirichlet-Multinomial, Log-Gaussian Cox Process - LGCP) or not (Additive and Multiplicative Logistic Normal-LN distribution). Heuristic results favor the LGCP when sample sizes are approximately known, and the Multiplicative LN otherwise.

Size-based and state-space production models for a fish stock assessment

Saang-Yoon Hyun, Jinwoo Gim, and Kyuhan Kim

Although an age-structured model is most appreciated in fish stock assessments, it cannot be applied to a fish stock whose age information is not available. Alternative models range from a production model to a size-based model, depending on available data. When body size data such as lengths or weights from a temporal range are available with fishery catch and effort data, a size-based model would be an excellent option. On an extreme case when available data are limited only to fishery catch and effort data, a production model should be applicable. Given data about the Korean chub mackerel stock (Scomber japonicus) whose body lengths from 2000 to 2017 and fishery catches and efforts from 1996 to 2017 were available, we implemented size-based and production models in ADMB and ADMB-RE (Random Effect module). We extended the evolution of size-based models from Cohen and Fisherman (1980), Deriso and Parma (1988) to Quinn et al. (1998) for the former while we applied a Bayesian state-space production for the latter. We will present detailed methods of those two approaches, and discuss results from them, also seeking workshop participants' ideas about how to systematically synthesize those two approaches.

My Biased experience of using the generalised packages CASAL & Casal2 vs standalone ADMB and STAN models for stock assessments.

Craig Marsh

My background has been as an applied statistician pretending to be a coder, and convincing myself I knew how to help modify and enhance the generalized package Casal2. So I am fairly proficient at

setting up and debugging stock assessments using Casal2 (biased). Which actually made me the worst tester for Casal2!!!

I want to talk about my experience with interfaces when setting up and running assessments, comparing the generalised package Casal2 with standalone programs like ADMB/STAN.

The topics I want to talk about regard, input configurations, error messages, tweaking models from working group recommendations, user community and more. I will spend a little bit of time going over the Casal2 user interface to demonstrate its capabilities, which will hopefully lead into a discuss whether people think that is a useful interface, too much, not enough etc.

User interface and good practices defaults

The RGadget environment: A tidyverse inspired approach to model development work flow

Bjarki Þór Elvarsson, Jamie Lentin and Pamela J. Woods

Various frameworks and software packages have been developed in recent years to aid in the process of assessing marine resources. One in particular, the Gadget framework, allows for the development of statistically testable models of marine multi-species ecosystems. Gadget allows for the definition of age- and length-structured models that are capable of taking multi-fleet and mixed fisheries into account. Gadget has proven to be useful in cases where data on the resource is scarce or has notable gaps. Gadget's flexibility does however allow the user to define a quite varied set of models and output, making it cumbersome to manage and compare different model versions.

This has lead to the development of two related R-packages, Rgadget and MFDB, that compose the Rgadget environment. RGadget is an R-package built to aid in the development and testing of models built using the Gadget framework, whereas the MFDB package is a database tool that stores data needed for ecosystem models in a minimally aggregated format that can be extracted in the form required for a Gadget model. The aim of these packages is to facilitate rapid model development, and as such, it includes a number of tools useful for the model developer. These include functions to build models and flexibly extract data, a heuristic to assign weights to disparate datasets used by a typical Gadget model and routines that organize output and provide model diagnostic figures. Model variants can be created relatively easily by simple update commands, thus allowing for better project management and traceability.

This presentation will briefly introduce Gadget and how one can set up a Gadget model using the Rgadget environment.

Processing and exploring assessment model output: lessons learned from a decade of work on the r4ss package

Ian Taylor

The r4ss package is a widely used collection of R functions that has been developed in parallel with Stock Synthesis for more than 10 years. Thanks to a long history of improvements, contributions from 27 people, and feedback from the large user base, it has become a powerful tool to efficiently explore assessment model results, illustrate assessment reports, and manipulate model inputs. The choice of R, which is so widely used by fisheries scientists, has been instrumental to its success. However, behind the scenes the package is a bit of a mess. The accumulated technical debt of years worth of edits to aging code have made adapting to evolving uses of the package more difficult. I will discuss lessons learned from a decade of work on this project for processing output from the next generation of assessment models.

Coordination, project planning, hosting, and funding.

Agile Software Development – What is it and do we want it?

Jennifer Ferreira

Agile software development is an umbrella term for a set of frameworks and practices that are built on the values and principles expressed in the Manifesto for Agile Software Development. In the 12 years that I have been working with Agile teams, I have seen successes and failures in organisations big and small, here in New Zealand and abroad. In this talk I will highlight some of those experiences alongside industry best-practices. I will address some of the challenges and opportunities facing teams who are new to Agile or who have yet to embark on their Agile journey.

Satisfaction, Practices, and Influences in Agile Software Development

Craig Anslow

The principles behind the Agile Manifesto begin with “Our highest priority is to satisfy the customer. . . ”. It also states that Agile projects should be build around motivated and self-organized teams, which might also lead to more satisfied developers. Several studies indeed report an increased job satisfaction by anecdotal evidence. In this talk we address the topic of satisfaction by in-depth analysis of the results of a nationwide survey about software development in Switzerland. We wanted to find out if satisfaction depends on the applied development method, and, more concrete, how satisfaction relates to other elements in the development process, including the use of various practices, and the influences on business, team and software issues. We found that higher satisfaction is reported more by those

using Agile development than with plan-driven processes. We explored the different perspectives of developers and those with a management role and found a high consistency of satisfaction between Agile developers and Agile management, and big differences with using working plan-driven methods. We found that certain practices and influences have high correlations to satisfaction, and that collaborative processes are closely related to satisfaction, especially when combined with technical practices. Applying recursive partitioning, we found which elements were most important for satisfaction, and gained insight about how practices and influences work in combination. We also explored the relationship between satisfaction and personal experience with Agile development. Our results in this analysis are principally descriptive, but we think they can be a relevant contribution to understand the challenges for everyone involved in Agile development, and can help in the transformation to Agile.

The Cylc Workflow Engine: Sustaining a Collaborative Scientific Software Project

Hilary Oliver

Cylc is a workflow orchestration engine for complex cycling systems. Since its release by NIWA on an Open Source license 8 years ago it has been widely adopted to drive environmental forecasting applications around the world, and the project is still evolving rapidly. Cylc has precious little to do with fish, so Hilary Oliver (Cylc project lead) will try to focus on general aspects of collaborative scientific software development, and what it takes to successfully grow and sustain a project like this over time.

ADMB Project Infrastructure and the Next Steps

Johnoel Ancheta

Automatic Differentiation Model Builder (ADMB) software is used for developing and fitting general nonlinear statistical models to analyze data. The software was developed by Dr. Dave Fournier who formed Otter Research Ltd to commercially develop ADMB. Eventually, ADMB became open-source and was made freely available to the public. The ADMB Project was created to continue the development and maintenance of ADMB as an open-source project. The user and developers for ADMB are worldwide. An open-source infrastructure was needed to support the community for collaboration and information gathering. The presentation will describe the ADMB Project infrastructure, tools, and services, and explain how and why they are used for the project. Results from the ADMB user survey administered at the CAPAM workshop will also be presented. As the software and hardware systems continue to change, the next steps will describe the future goals and tasks for the ADMB Project.

Journey of an open source software for fisheries acoustics

Yoann Ladroit

ESP3 is an open-source software package for visualizing and processing fisheries acoustics data with attention to reproducibility, consistency and efficiency. It was started at sea during a trip to Antarctica in 2015 and its first version was released under MIT license in 2017. It has reached a significant number of people since then and has been popular with students and researchers due to the availability of the code. It is scientific software and its outputs are used to produce absolute or relative biomass indices for stock assessment models or spatio-temporal ecosystem studies, making it critical to have rigorous testing procedures in place. The project itself was started “accidentally” due to the difficulty of reproducing results obtained by our previous generation of software using commercially available tools. From this point, it grew organically at first with minimal planning, until it became evident that a strategy had to be put in place to make it a viable long-term project and in order to better manage its growing source code. We moved forward by relying heavily on organized direct feedback from a small number of key users and by using modern code versioning and sharing tools. The interaction with users has proven key to help us introduce, test and document new features successfully, and has led to very fruitful ongoing collaborations.

Lessons learned from the ss3sim project on sharing, hosting, and maintaining simulation code

Kelli Johnson

Code to simulation test stock assessment models is plentiful but is often generated for a specific project or stock assessment, leading to a lack of sharing and maintenance. Thus, ss3sim was created to facilitate reproducible, flexible, and rapid end-to-end simulation testing of stock assessment models that utilize the Stock Synthesis framework. As the code base for ss3sim grew so did demands for maintenance and development. Implementing automated testing procedures using the testthat package was helpful, but the package benefited the most from user feedback. Through the use of github, users provided valuable insight regarding the helpfulness, or lack thereof, of warning messages; functions that weren’t quite doing what they were intended to do or better ways to get the job done; and suggestions to ease the learning curve for new users. We highlight some of the choices that were made regarding its initial simplicity that still seem like good ideas, mistakes that could have been avoided had we known better, and future avenues of development.