Travel: Trip report

Pacific Community
Communauté du Pacifique

Part A: Trip details

Staff Name:	Inna Senina
Division	FAME-OFP-FEMA
Purpose of trip	Travel to Copenhagen DTU Aqua for spatiotemporal tag modelling workshop
Travel Dates	12/5/2025 to 16/5/2025
Where visited	DTU-Aqua, Copenhagen

Key people met	Anders Nielson, Tobias Mildenberger

List of trainees if training provided	

Link to evaluation report analysis if training or workshop with evaluations done	Not yet posted
Links to presentations or other key docs presented.	

Is follow up needed? (if so, then with whom)	See Joe Scutt's report
What was accomplished?	• Better understanding of DTU approach for estimating population movement and mortality rates from tagging datasets • Potential for collaboration including estimation of movement and mortality rates for the WCPFC area and comparisons of methods used in DTU and SPC.
Reflective Observations/Lessons Learned/Conclusions	See below

Part B: Description

The workshop diary is very well described by Joe in his excellent and informative trip report, I don't have more to add in this regard. Since my role was to contribute to better understanding, learning and applying the Mildenberger-Nielson spatio-temporal approach for movement and mortality estimation from tags, starting from skipjack, I'll focus on this part. I will not be talking about Peterson-type model, Joe covered it, or the special case of archival tags, but only about the estimation model for conventional tagging data.

During the workshop Anders and Tobias gave several presentations to explain their approach and shared the results they obtained with the IATTC data. I must admit that I wasn't prepared to present the approach in SEAPODYM, and moreover, to respond to the criticism for not using the fishing effort when treating the recaptured tags. If I knew that we'd want to compare our methods in terms of the theoretical background, data and likelihoods, I would prepare materials and a more detailed overview of the most recent results. However, this criticism and discussions around it gave lots of food for thought and created a motivation to better understand their spatio-temporal approach and its major differences with the method currently implemented in SEAPODYM.

Movement model for conventional tags

The Mildenberger-Nielson movement modelling approach is similar to that described in Thorson et al., 2021 (https://doi.org/10.1111/faf.12592) and relies on the Fokker-Plank advection-diffusion equation (ADE) that describes how the probability density function (PDF) p(x,t) evolves in time, with x being the position of a particle. Thus, it implies solving advection-diffusion equation numerically for each released tag. However, due to the expectedly significant computational loads for solving PDEs, Anders and Tobias don't do that. They tested two methods, first consisting in approximating the movement rates by matrix exponential operator and updating the probability density in time between adjacent grid cells, and second is to use the Kalman filter to get the most probable track of the tagged fish. The Kalman filter runs 300 times faster than matrix-exponential method, so it is retained as the movement state space model and the operating estimation method. One note should be made here. The solution provided by the Kalman filter approximates the solution of the Fokker-Plank equation only and only if the movement rates are constant, which is not the case. It can still be used as an approximation of the ADE solution if the movement fields can be assumed to be smooth and varying only slightly. One clear difference between the ADE solution with variable v and D and the Kalman filter estimated PDF, is that the first one allows multimodal and not normal distributions and the second gives always unimodal and normal distributions.

Environmental fields and movement rates

All released conventional tags are "moved" with the state space model, with drift that is proportional to the gradient of the environmental preference, and with the process noise given by the diffusion coefficient. Both preference and diffusion rate are the functions of environment implemented by splines with three knots. To supply continuous environmental fields to Kalman filter, the authors derive their differentiable representations along each "most probable track" with local regression method involving the weighted average function for all data points within some fixed radius. By the way, the fishing effort is treated the same way as the environmental data. Thus, only local calculations are done for each tag, which makes the method very fast and enables parallelization.

Parameter estimation

Survival of recaptured and non-capture of unrecaptured tags are computed as for the classical Baranov catch equation. The residuals of tag positions (obviously for the recaptured tags only) are computed as the differences between each tag observed position and the position of the PDF mean, divided by its variance, which are both estimated by the Kalman filter. The time residuals are computed for all tags, for times t1, t2, …, tn or 'never' by the inverse uniform within the interval of the observed times. From SAC-14_INF-E, the 'never' time is when the fish age gets to the known species maximum age. To resume, the estimation method works as follows: starting from the release location of each conventional tag (recaptured and non-recaptured), Kalman filter updates each tag position given the drift and error distribution being the normal probability distribution of this unobserved position, doing so with the small enough time step (to ensure the low variability of the movement field), and finally evaluates the likelihoods for 1) the recapture position for recaptured tags, 2) recapture time for recaptured tags, and 3) non-recapture for unobserved tags. Here's why it is important to account for the fishing effort in this method. First, through likelihoods (2) and (3), the fishing effort provides additional information for the estimation of the movement field by allowing the 'never recaptured' tags follow the directions, where they will never be recaptured. Second, fishing effort controls two out of three likelihood components, so without them much less information is provided for the parameter estimation. Third, the model uses all tags, so it must be non-conservative to predict only the fraction of released tags. Hence, the fishing mortality (along with the reporting rates) must be correctly accounted in space and time and the movement correctly captured for the natural mortality rates to be well estimated. Indeed, for the simulation study presented by Anders and in a small demonstration shown by Tobias, we could see that with all likelihoods and the effort data, which is available in the area of tag movements, the method successfully estimates the dynamic rates within their confidence intervals.

For more details on the method, see reports SAC-13-08, SAC-14_INF-E, and SAV-15_INF-G.

Preliminary estimation with WCPO SKJ conventional tagging data

Typical resolutions of environmental data and model grid in previous studies were 2.5°x2.5° or 5°x5°. For the WCPO case study, we provided environmental fields at 1°x1° resolution from the ocean forcings used in SEAPODYM, and Tobias demonstrated that their method worked and successfully converged in very short times: 0.3 minute with 200 released tags in Bismarck Archipelago and less than a minute with about 2000 releases during 2006-2007 campaigns. Although it converged in both cases, it was hard to understand the results from only the movement fields. The preference temperature function was estimated to be constant within the area of tag displacements, showing spatial heterogeneity only across the Pacific Ocean. But these were technical and preliminary runs. I'm confident that with better parameterization and selection of environmental fields, the results will become more sound and interpretable.

Conclusions and needs for development

The approach developed by Tobias and Anders is comprehensive, computationally efficient, and promising as it is built to estimate movements, mortalities and population abundance from tags, which is essential for improving the stock assessment. It should be noted however that it relies heavily on the fishing effort data and cannot be used without it. It is built on the assumption that individual movement can be predicted, because through the position likelihood (1) it fits the unobserved PDF's mean to the observed position which is a result of stochastic movement with unknown a priori probability for its observed position. Such "believing" that a tag moved to the most probable position may result in the estimation of the biased movement fields, especially when using the spline functions, when only the recapture-conditioned tags are used. In contrast, the approach inbuilt in SEAPODYM relies on the fact that the ADE approximates the distribution of many (the more the better) individuals. So, even if it uses the recapture-conditioned tags, they are treated as density distributions, constructed from several hundreds of tags released in different locations and times and recaptured at the same time in different locations, meaning that it incorporates different movement patterns from multiple tags in one prediction. Finally, the method learns about the movement from tagging, fisheries and scientific data by running simultaneously the ADEs for tags and for the full population dynamics sharing the same movement fields.

In the current Mildenberger-Nielson model the movements and mortality rates are assumed to be constant across age. This might be critical in WCPO where skipjack is tagged at ages when it is rapidly growing. Tobias also indicated the need to revise the boundary conditions because of more complex coastline in the WCPO domain and lots of islands.

Trip highlights

To conclude, I very much enjoyed the workshop at DTU - thanks to Arni for the invitation! I'm grateful to Tobias and Anders for all the questions, answers and stimulating discussions as well as for the wonderful barbecue at Anders's place and farewell beers offered by Tobias; and many thanks to Joe for his friendly support and patience through countless iterations on modeling topics during our afterwork hours at Granny's. Yes, Granny's place was special – and our short walk through Copenhagen to Warpigs, unforgettable!

Part C: Attestation/other stuff

Travel was carried out as planned.

Figure 1. Boarding passes


BOARDING PASS
SENINA/INNA
12. May 2025
norwegian

Flight number: D8 3627
Boarding time: 09:45
Enter aircraft: Front door
Class: Y/Q
Pnr: YCHE78

Area: International
Gate: 9
Seat: 7C
From: TLS TOULOUSE
Departure: 10:15

Terminal:
Boarding group: A B C
Hand baggage:
To: CPH COPENHAGEN
Arrival: 12:40

Security lane: Regular
Group A (PRIORITY)
Max 10 kg:
1 bag under the seat
Seq no: 0046

BOARDING PASS
SENINA/INNA
16. May 2025
norwegian

Flight number: D8 3626
Boarding time: 17:15
Enter aircraft: Front door
Class: Y/P
Pnr: YCHE78

Area: International
Gate: See screens
Seat: 7C
From: CPH COPENHAGEN
Departure: 17:45

Terminal: Terminal 2
Boarding group: A B C
Hand baggage
To: TLS TOULOUSE/BLAGNAC
Arrival: 20:20

Security lane: Regular
Group A (PRIORITY)
Max 10 kg combined:
1 bag under the seat
+1 overhead cabin bag
Seq nr: 100