1. Arrowtooth flounder (*Atheresthes stomias*)

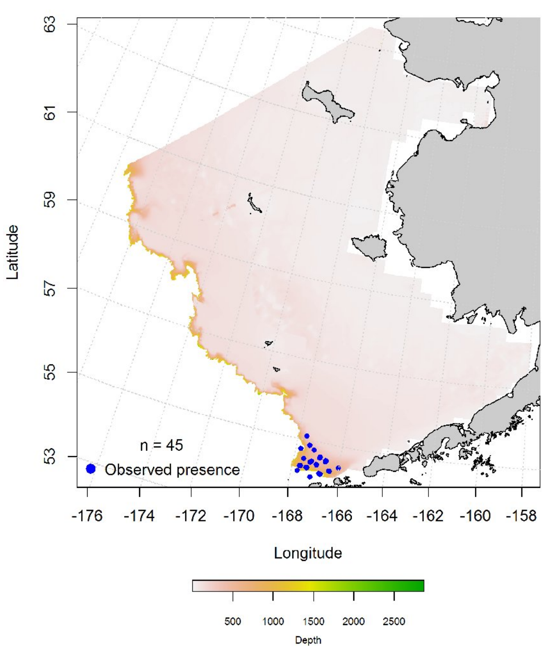
Arrowtooth flounder is widely distributed throughout Alaska and is the flatfish species with the highest biomass in AFSC bottom trawl surveys in the eastern Bering Sea shelf and slope (Lauth 2014, Hoff 2012).

1.1 Seasonal distribution of early life history stages of Atheresthes sp.

Arrowtooth flounder eggs, larvae and early juveniles cannot be distinguished from the other species in the genus, Kamchatka flounder (*Atheresthes evermanni*), so results from the genus *Atheresthes* are presented here. There were only 50 instances of Atheresthes eggs observed in the FOCI database (Figure 1.1), 45 in the winter and 5 in the spring. All observations, except one were found in and around Bering Canyon.

There were catches of Atheresthes larvae in winter, spring and summer months (Figure 1.2). The distribution of larvae was limited to Bering Canyon in the winter (and there were not enough cases for modeling). In the spring, the distribution of larvae extended northward from Bering Canyon along the continental shelf with areas of concentration still within the canyon (Figure 1.3). This distribution was predicted to extend onto the shelf and northward during summer months (Figure 1.3). The most important variables in modeling larval distribution during spring and summer were sea surface temperature (relative importance > 0.55 in both cases) and for both the spring and summer models, the AUC was > 0.95 for the training data and > 0.80 for the testing data, indicating a good model fit.

There were only 13 observations of early juvenile stages of Atheresthes sp. in the FOCI database (Figure 1.4). These were all during summer months and were all observed near the Pribilof Islands.



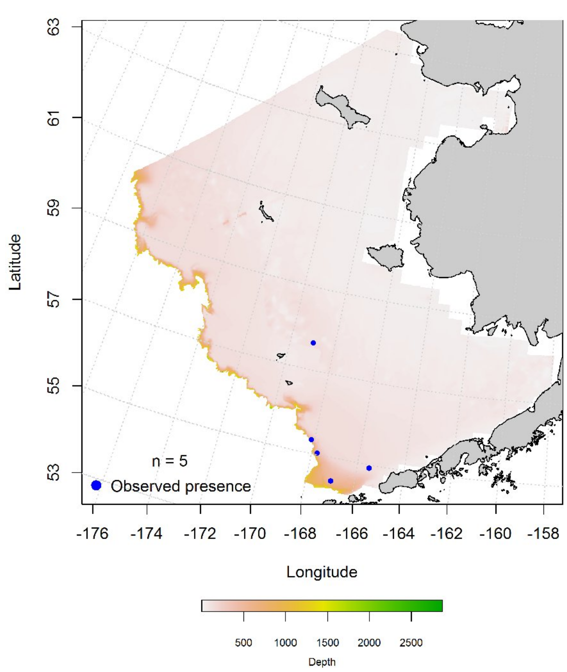


Figure 1.1. Observations of Atheresthes sp. eggs during winter and spring in the eastern Bering Sea from the FOCI database.

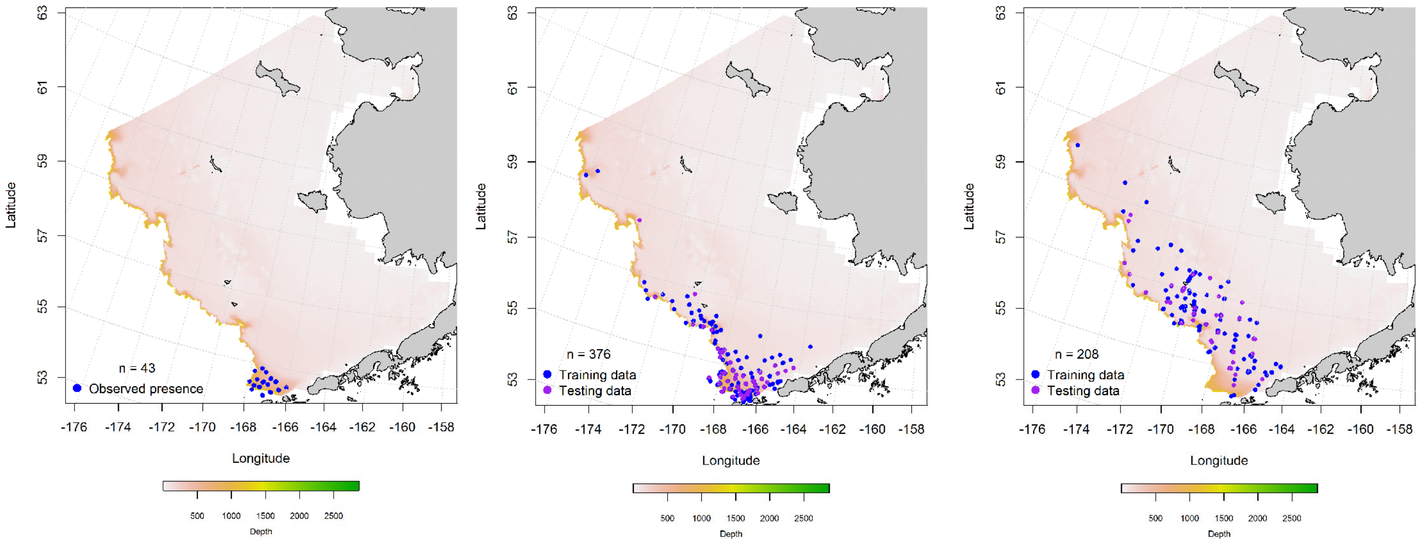


Figure 1.2. Observations of Atheresthes sp. larvae during winter, spring and summer in the eastern Bering Sea from the FOCI database.

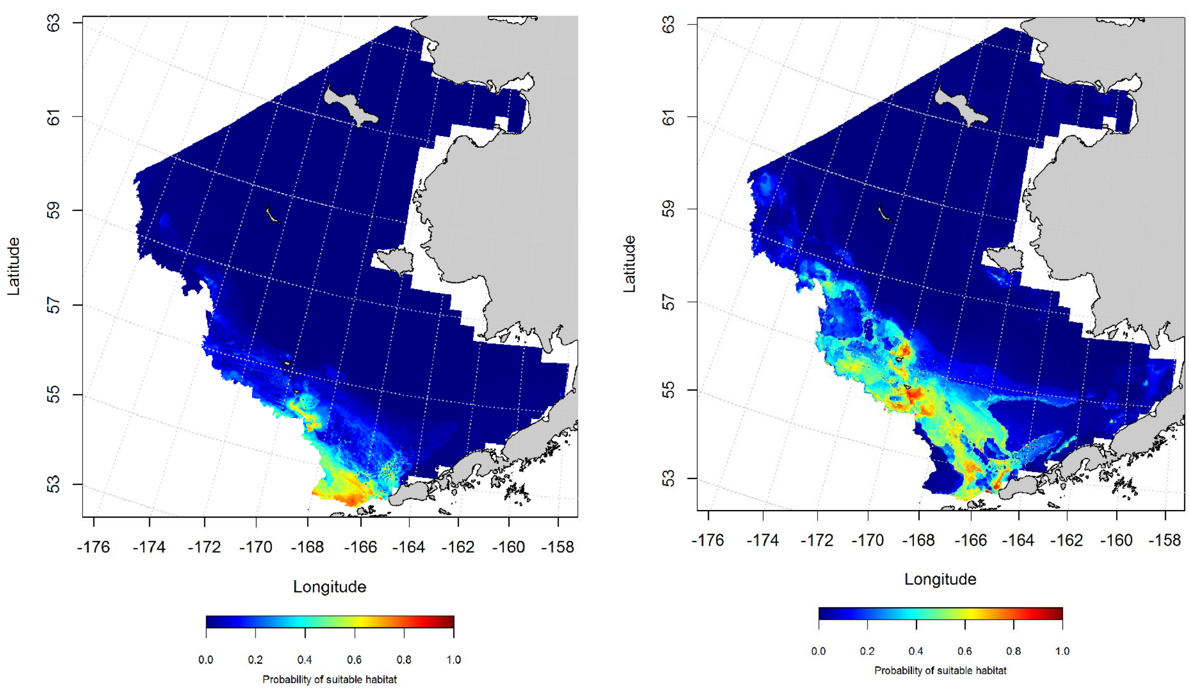


Figure 1.3. Predictions of Atheresthes sp. larvae distribution based on maximum entropy modeling during spring and summer in the eastern Bering Sea from the FOCI database.

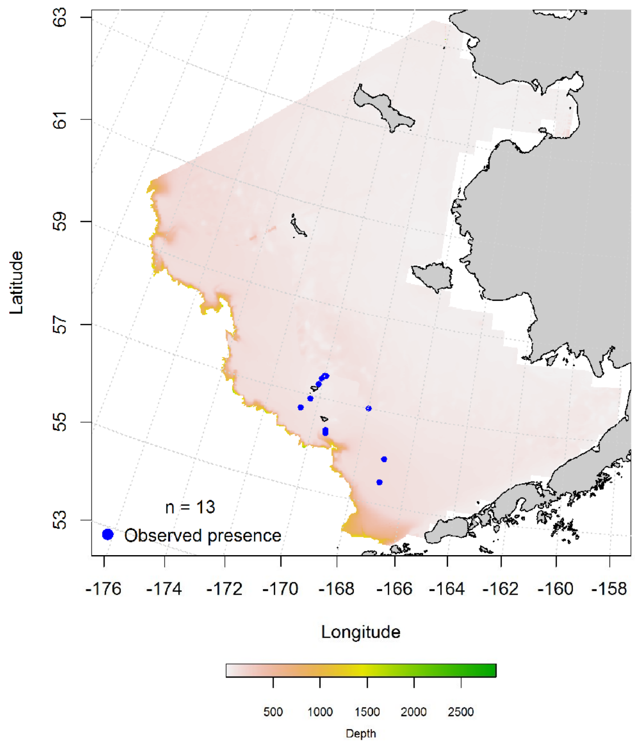


Figure 1.4. Observations of Atheresthes sp. early juvenile catches during the summer in the eastern Bering Sea from the FOCI database.

1.2 Summertime distribution of juvenile and adult Arrowtooth flounder in the EBS

The catch of arrowtooth flounder in summer bottom trawl surveys of the eastern Bering Sea indicates this species is broadly distributed. Generalized additive models predicting the abundance of juvenile arrowtooth flounder explained ??% of the variability in CPUE in the bottom trawl survey. Slope, depth and latitude and longitude were the most important variables explaining the distribution of juvenile arrowtooth flounder. The model fit the test data set as well, explaining ??% of the variability. The areas of predicted highest abundance were on the outer shelf of the eastern Bering Sea near the Alaska penninsula (Figure 1.5).

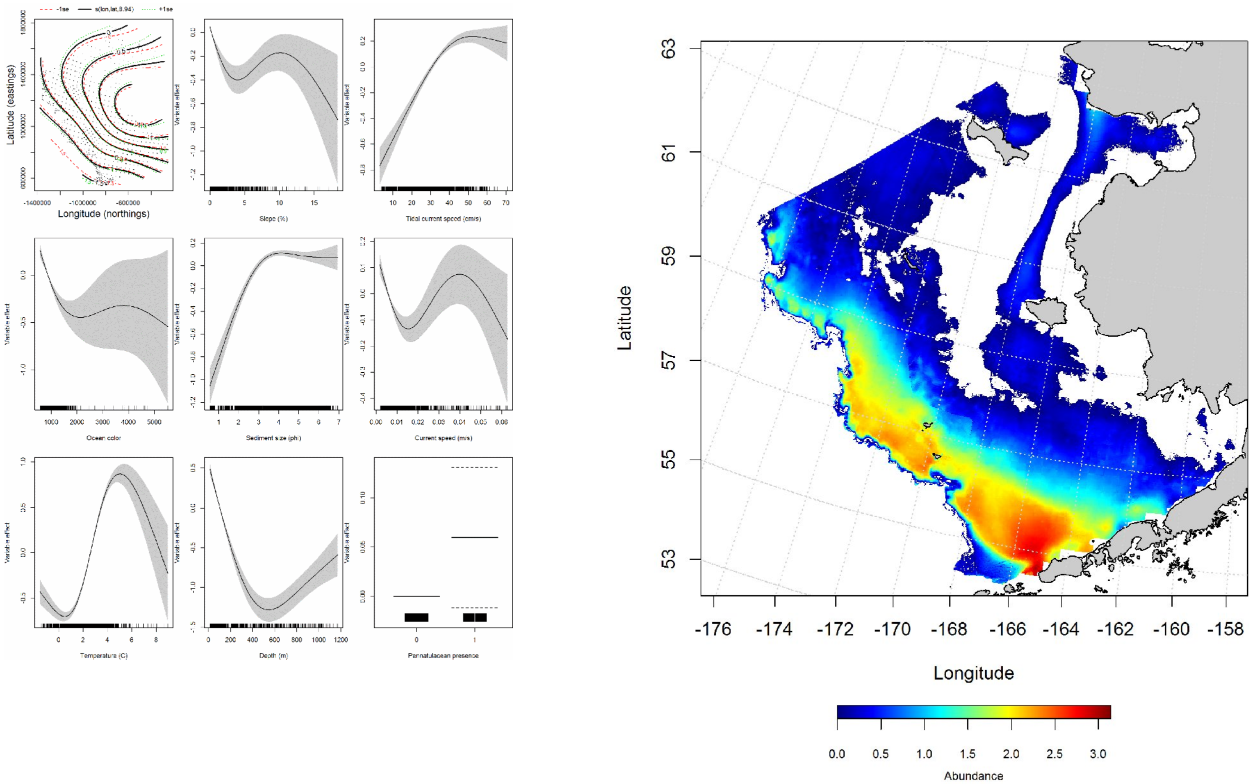


Figure 1.5. Relationships between significant habitat variables and abundance of juvenile arrowtooth flounder during summer bottom trawl surveys of the eastern Bering Sea slope and shelf from the best-fitting generalized additive model (left panel) and predictions of abundance of juvenile arrowtooth flounder based on the best fitting generalized additive model (right panel).

Adult arrowtooth flounder were more evenly distributed, although they were also more abundant on the outer shelf in the southern part of the eastern Bering Sea (Figure 1.6). The best-fitting GAM model indicated that slope, tidal current and latitude and longitude were the most important factors controlling adult arrowtooth distribution and the model explained ??% of the variability in bottom trawl CPUE. The model fit the test data set very well, explaining ??% of the variability in that data.

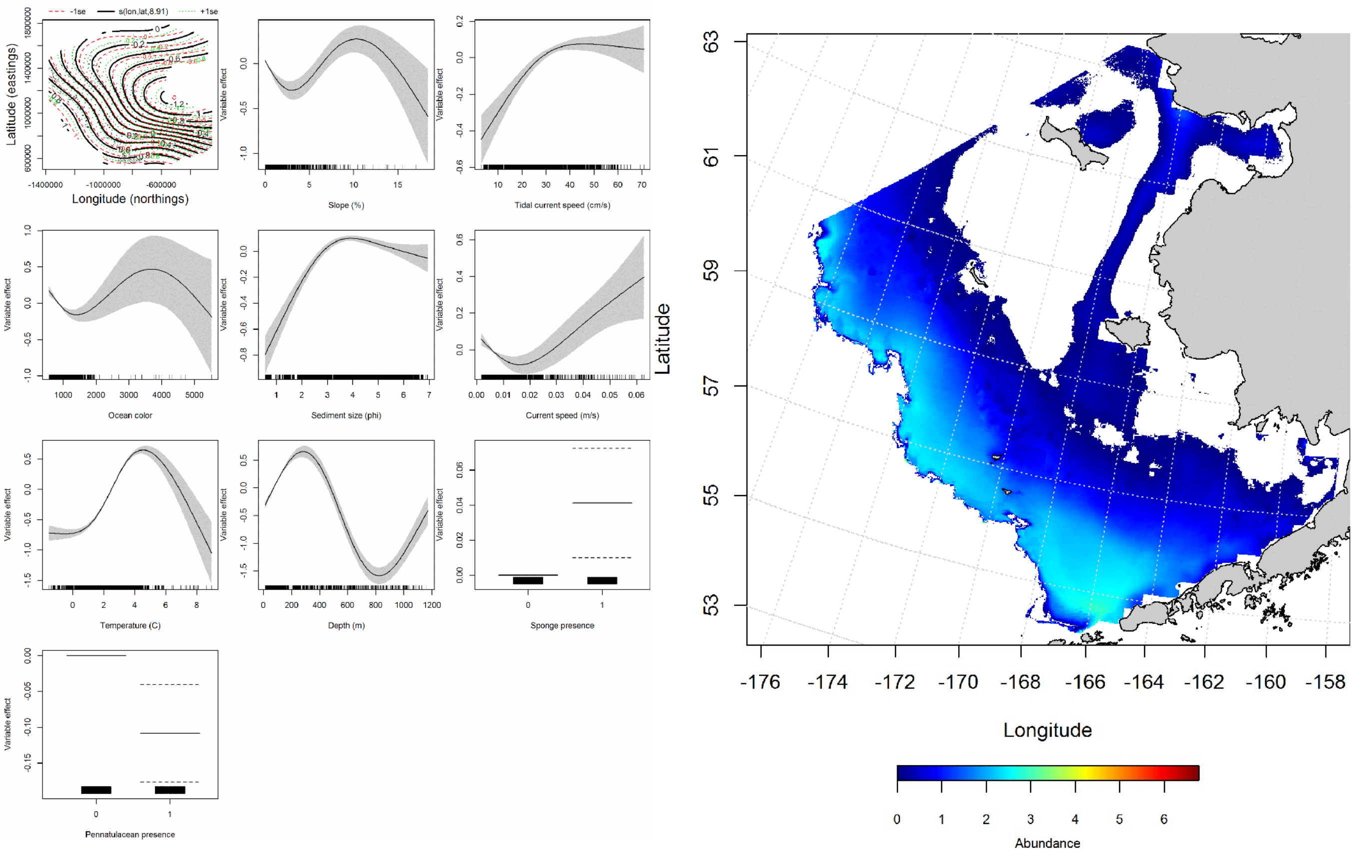


Figure 1.6. Relationships between significant habitat variables and abundance of adult arrowtooth flounder during summer bottom trawl surveys of the eastern Bering Sea slope and shelf from the best-fitting generalized additive model (left panel) and predictions of abundance of adult arrowtooth flounder based on the best fitting generalized additive model (right panel).

1.3. Seasonal distribution of adult Arrowtooth flounder in the EBS

Distribution of adult arrowtooth flounder in the eastern Bering Sea in commercial fisheries catches was generally consistent throughout all seasons. In the fall, depth and bottom temperature were the most important variables determining the distribution of arrowtooth flounder (relative importance = 69.8 and 21.6 respectively). The AUC of the fall model was 0.88 for the training data and 0.79 for the test data and 79% of the cases in both the test and training data sets were predicted correctly. The distribution of arrowtooth flounder catches were distributed mostly on the outer shelf and the southern half of the middle shelf of the EBS (Figure 1.7).

In the winter, depth and bottom temperature were the most important variables determining the distribution of arrowtooth flounder (relative importance = 60.0 and 34.5 respectively). The AUC of the fall model was 0.92 for the training data and 0.84 for the test data and 84% of the cases in both the test and training data sets were predicted correctly. As with the fall, the distribution of arrowtooth flounder catches were distributed mostly on the outer shelf and the southern half of the middle shelf of the EBS, although there was more predicted suitable habitat in Bristol Bay (Figure 1.8).

In the spring, depth and bottom temperature were also the most important variables determining the distribution of arrowtooth flounder (relative importance = 53.7 and 32.2 respectively). The AUC of the fall model was 0.92 for the training data and 0.85 for the test data. As with the fall and winter the distribution of arrowtooth flounder catches were distributed mostly on the outer shelf and the southern half of the middle shelf of the EBS (Figure 1.8).

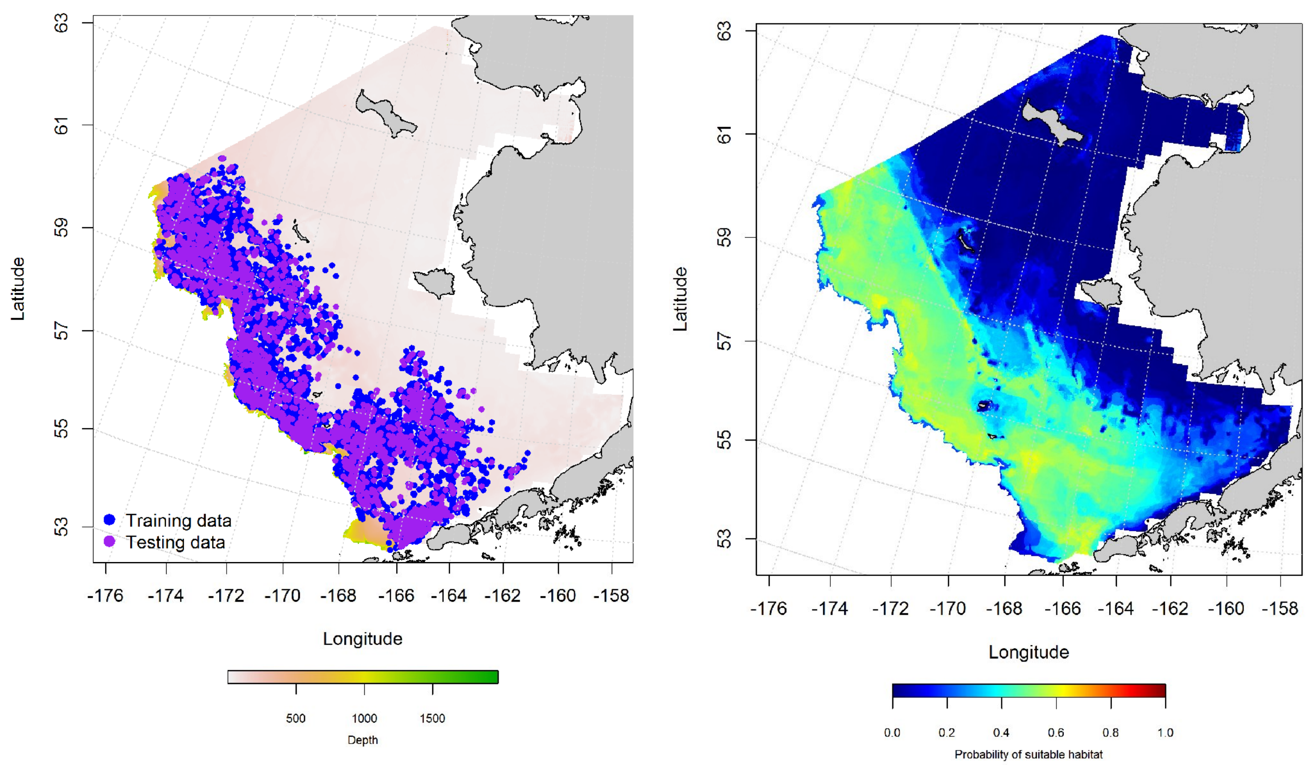


Figure 1.7. Locations of observed catches of Arrowtooth flounder in commercial fisheries (left panel) for fall months (September-November) and resulting predicted distribution of Arrowtooth flounder from maximum entropy modeling of commercial fishery catches. The points in blue were used for training the model and the points in purple were used for testing the model.

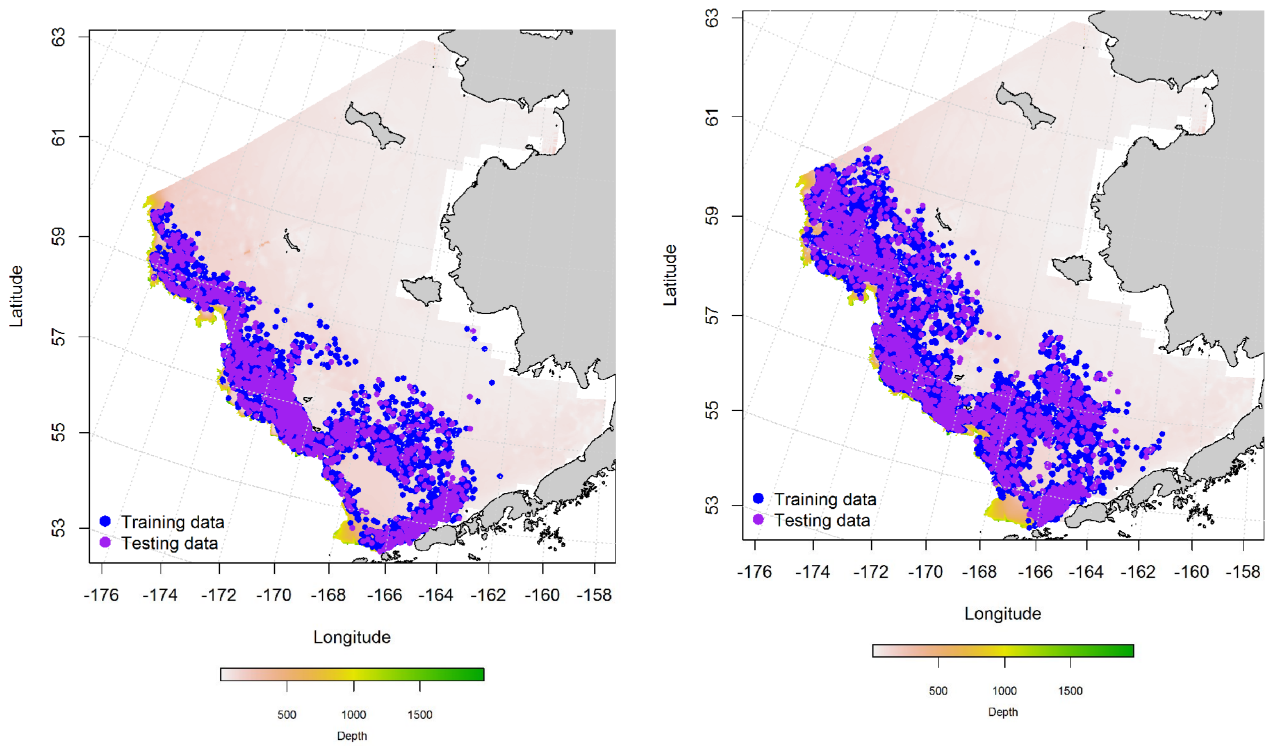


Figure 1.8. Locations of observed catches of Arrowtooth flounder in commercial fisheries (left panel) for winter months (December-February) and resulting predicted distribution of Arrowtooth flounder from maximum entropy modeling of commercial fishery catches. The points in blue were used for training the model and the points in purple were used for testing the model.

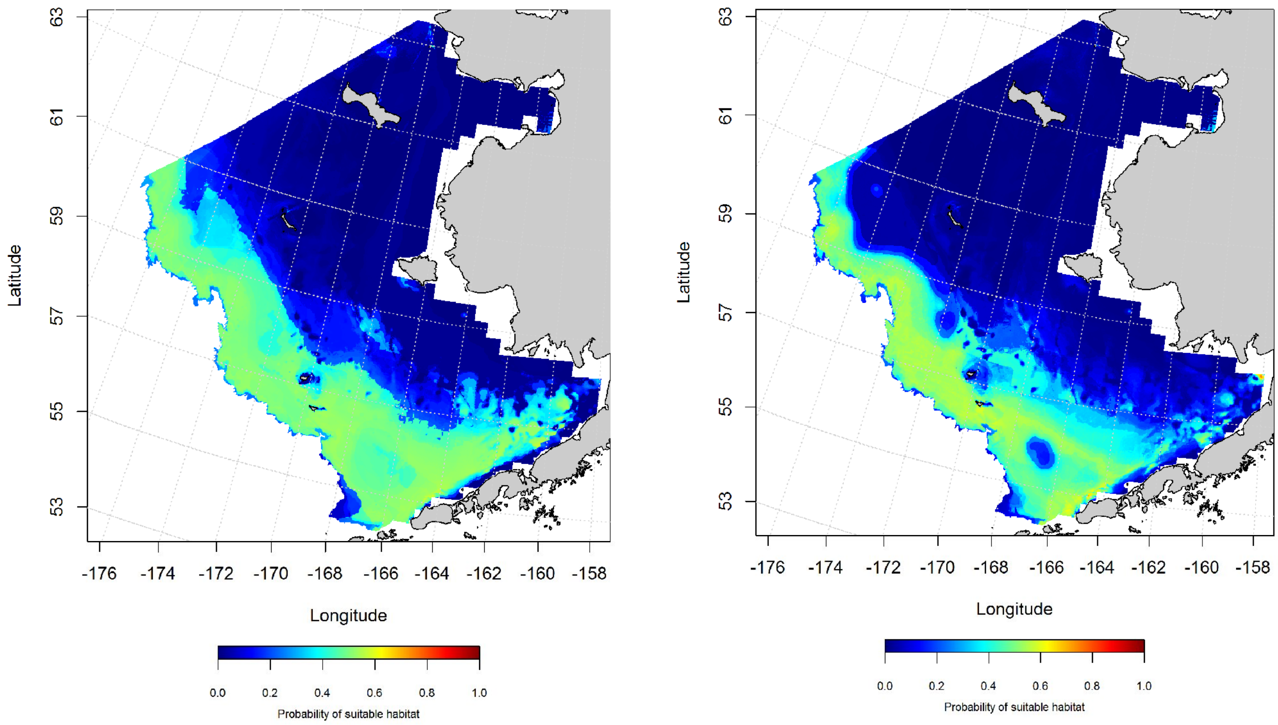


Figure 1.9. Locations of observed catches of Arrowtooth flounder in commercial fisheries (left panel) for spring months (March-May) and resulting predicted distribution of Arrowtooth flounder from maximum entropy modeling of commercial fishery catches. The points in blue were used for training the model and the points in purple were used for testing the model.

1.4. Arrowtooth flounder EFH maps and Conclusions

Arrowtooth flounder essential fish habitat predicted by the modeling is extensively distributed across the eastern Bering Sea outer shelf and southern regions for most life history stages. EFH for larval stages predicted in the spring and summer was in Bering Canyon and the outer shelf (Figure 1.10). Egg and early juvenile EFH could not be predicted.

Summertime EFH of arrowtooth flounder juveniles and adults was also distributed across the outer shelf, to a larger degree in the south. Juvenile EFH was very similar to the adult.

The fall, winter and spring distribution of arrowtooth flounder EFH was essentially the same as the summer, with EFH distributed on the outer shelf.

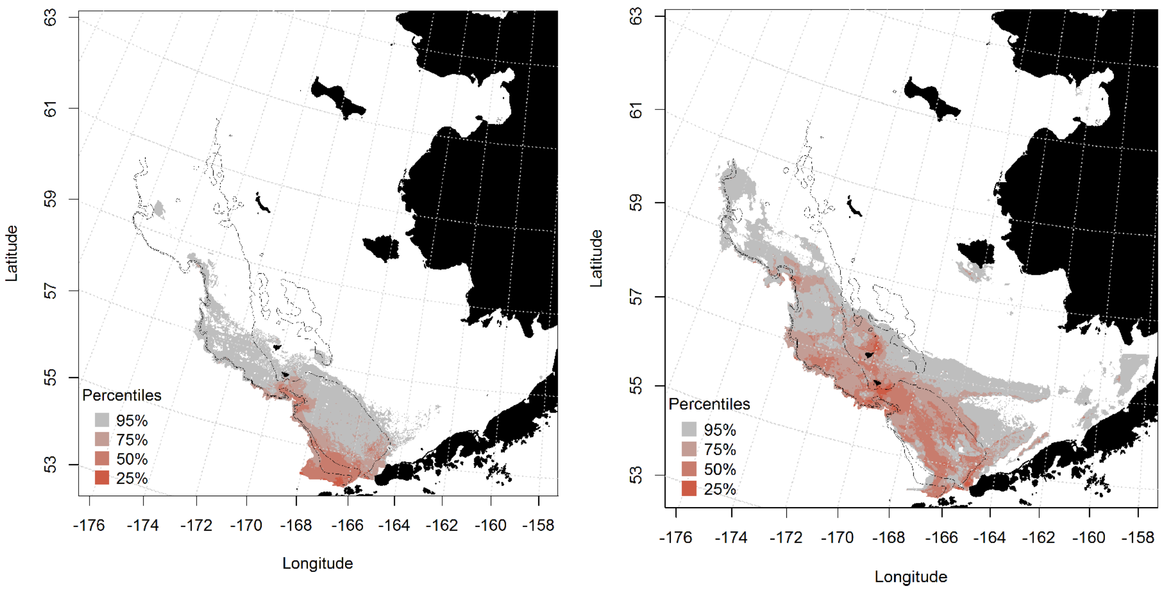


Figure 1.10. Predicted EFH for arrowtooth flounder larvae in the spring (right panel) and summer (left panel). based on FOCI data.

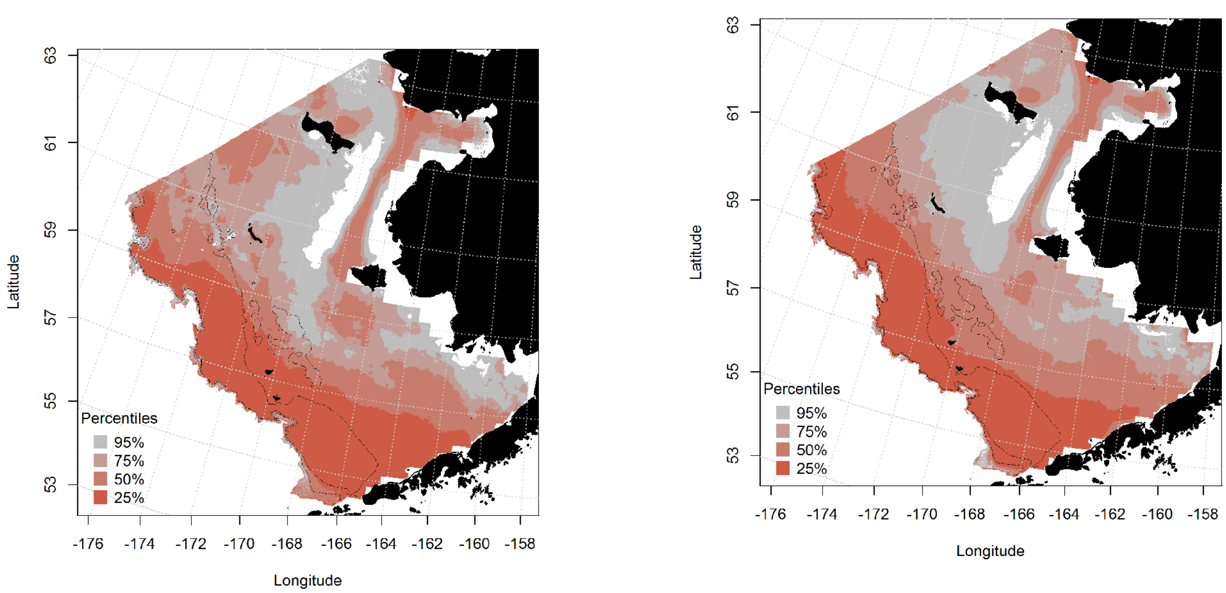


Figure 1.11. Predicted summer EFH for arrowtooth flounder juveniles (left panel) and adults (right panel) based on summertime bottom trawl survey data.

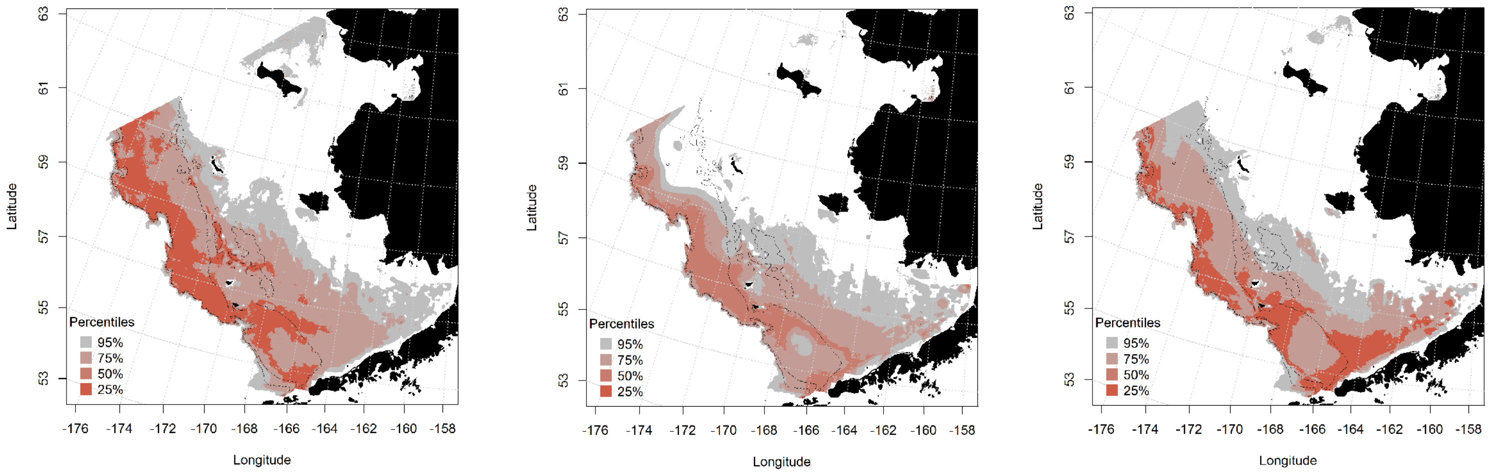


Figure 1.12. Predicted EFH for arrowtooth flounder during fall (left panel), winter (middle panel) and spring (right panel) based on summertime commercial catch data.