Modeling to Assess Influence of Water Withdrawals On Estuarine Species in Charlotte Harbor, Florida

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Objectives

To assist with setting minimum flows and levels, the Southwest Florida Water Management District (SWFWMD) is sponsoring research to seasonally assess the influence of changes in environmental conditions on fish and invertebrate species life-stages in Charlotte Harbor, Florida.

The first phase involves habitat mapping and habitat suitability modeling (HSM) to seasonally assess spatial distributions and relative abundances of species life-stages using water quality (WQ) data collected by SWFWMD in the lower Peace River and fish catch rate (CPUE) and WQ data collected by the Florida Fish and Wildlife Conservation Commission (FWC) Fisheries Independent Monitoring (FIM) program in the lower Peace River and Charlotte Harbor from 1996-2013. This creates a baseline for long-term conditions.

The second and third phases involve running “what if” scenarios using HSM to assess short-term impacts on species life-stages of changes in environmental conditions predicted with circulation modeling conducted by SWFWMD over 4 seasons to determine the influence of:

a) Baseline flow conditions .
b) Water withdrawal conditions.

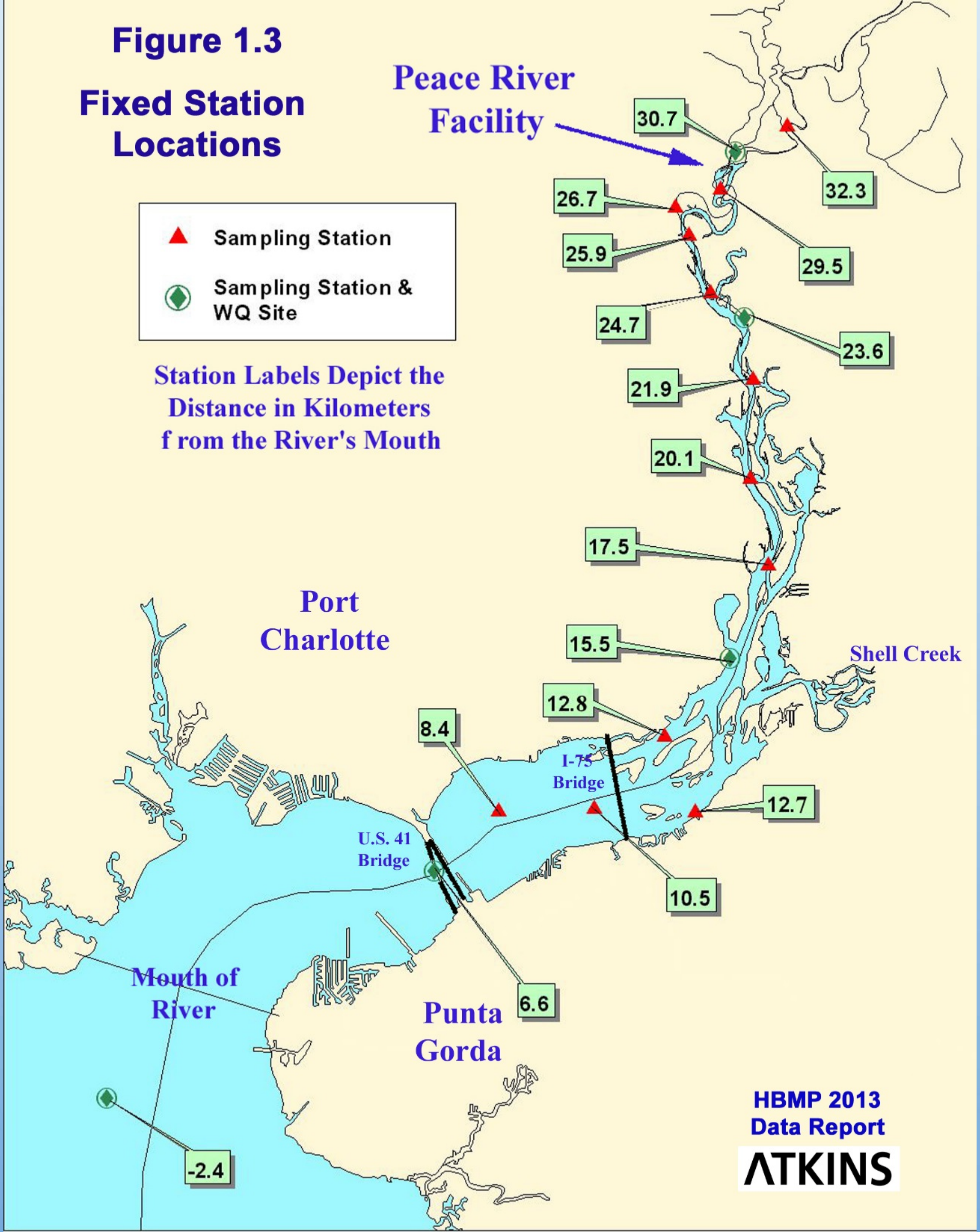
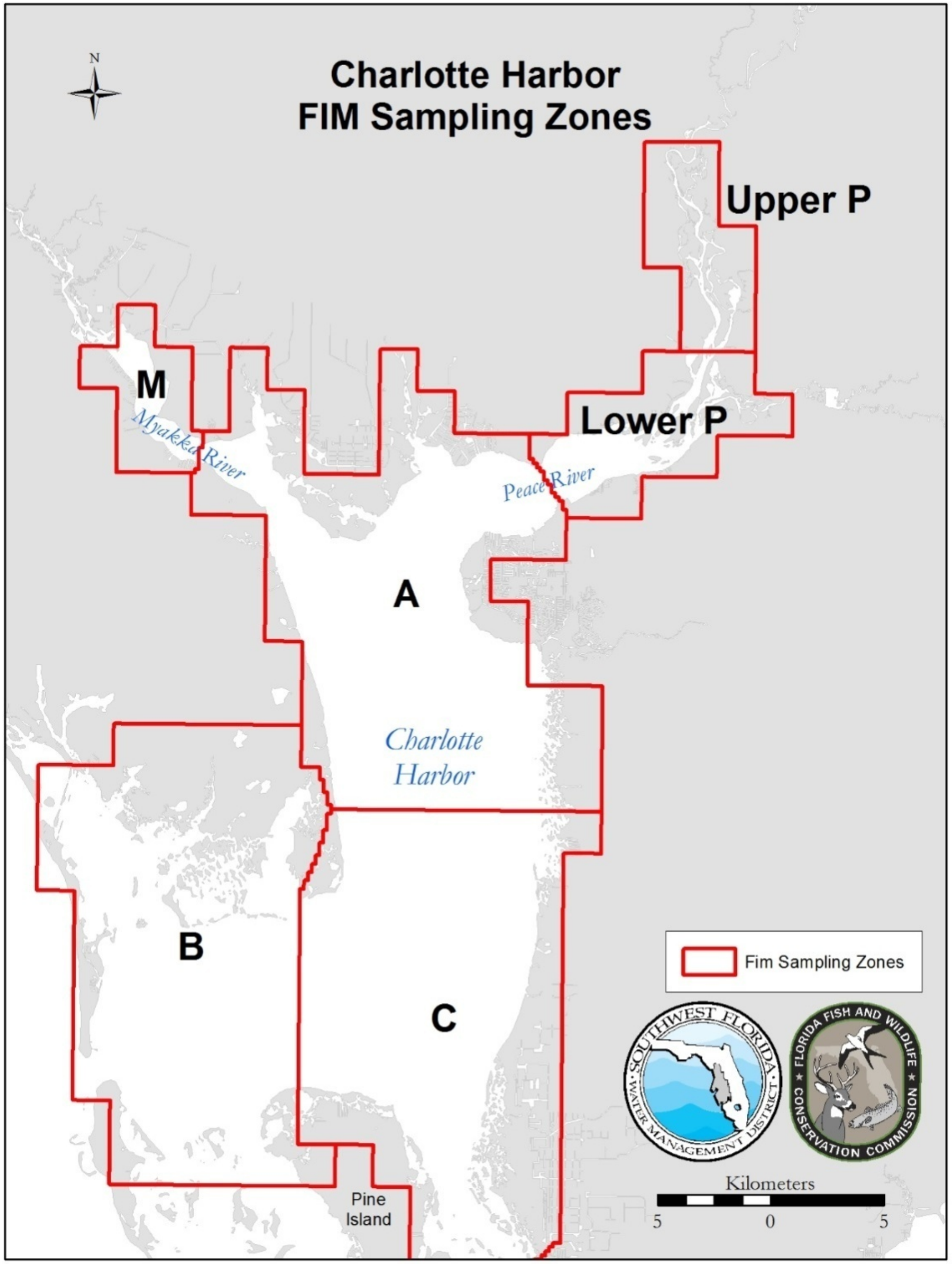
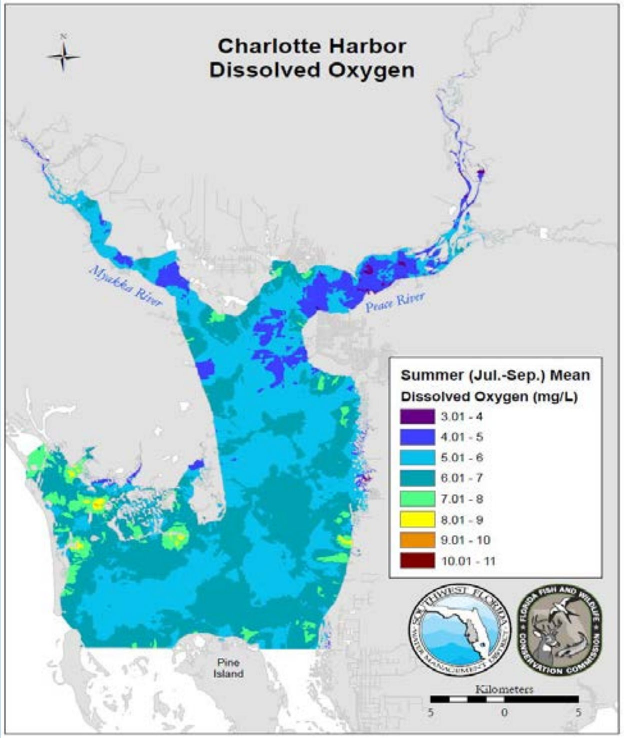
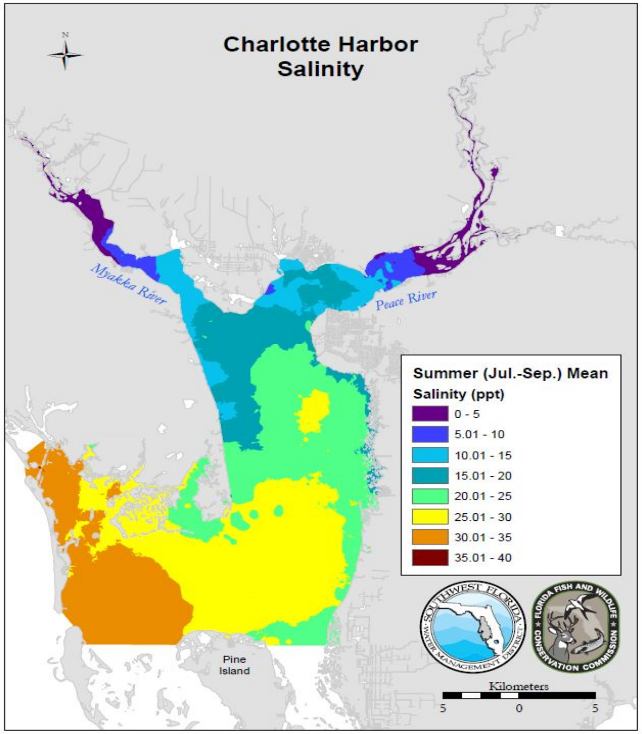


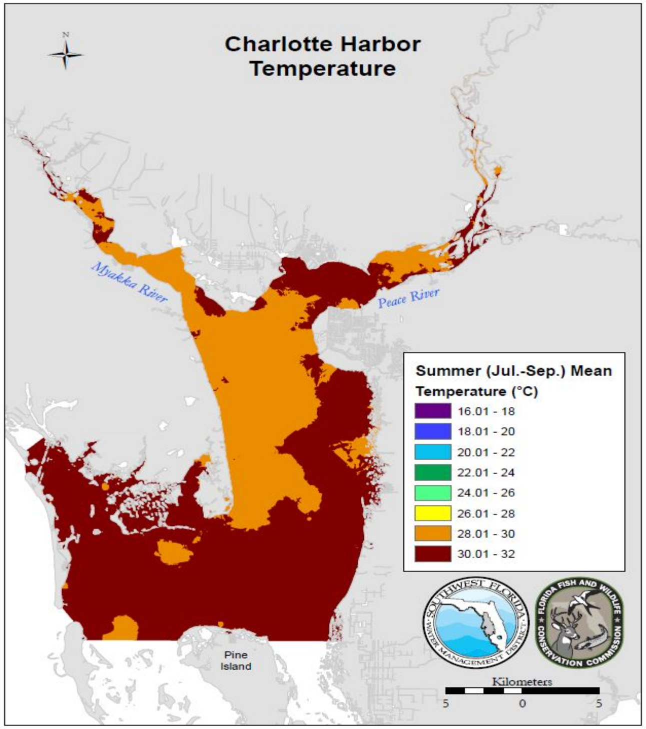
Figure 1.3
Fixed Station Locations
Peace River Facility
Sampling Station
Sampling Station & WQ Site
Station Labels Depict the Distance in Kilometers f rom the River's Mouth
30.7
32.3
26.7
29.5
25.9
24.7
23.6
21.9
20.1
17.5
15.5
Shell Creek
12.8
8.4
I-75 Bridge
12.7
U.S. 41 Bridge
10.5
Port Charlotte
Mouth of River
Punta Gorda
6.6
-2.4
HBMP 2013 Data Report
ATKINS

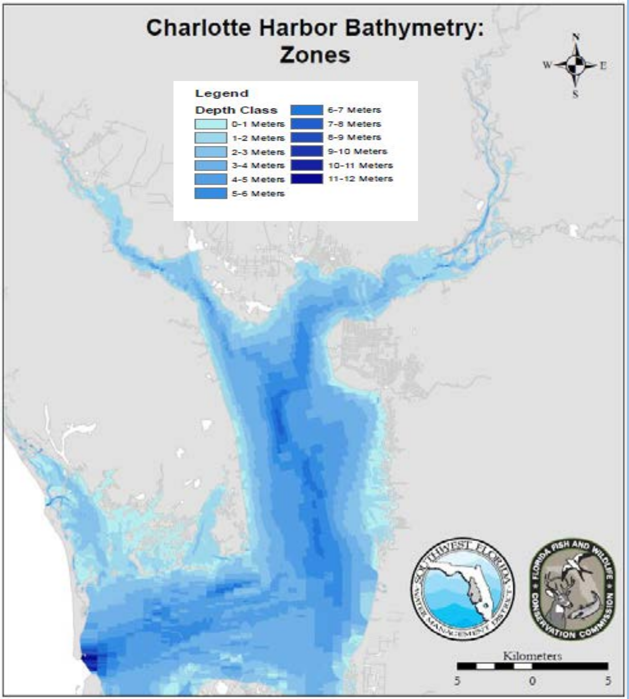


Charlotte Harbor
FIM Sampling Zones
N
Upper P
M
Myakka River
Lower P
Peace River
A
Charlotte
Harbor
B
C
Pine
Island
Fim Sampling Zones
Kilometers
5
0
5

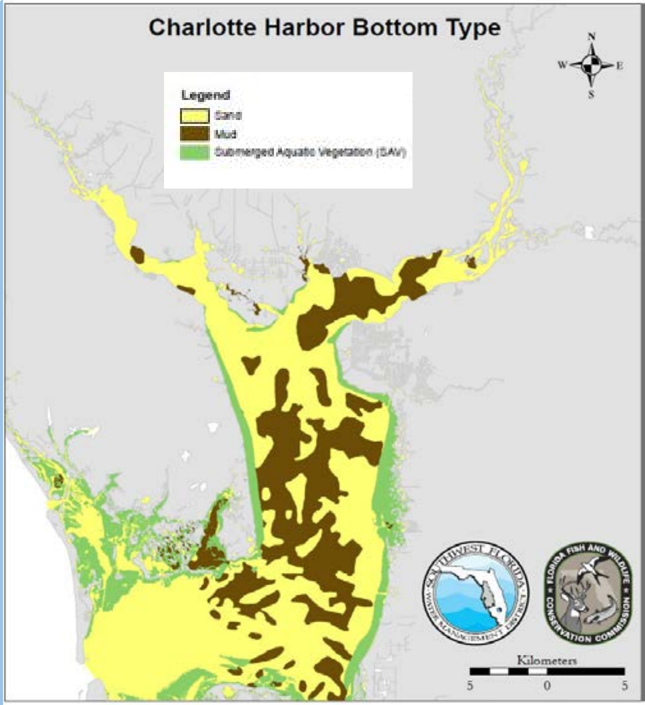








Point data interpolated
to produce seasonal
habitat maps for
dissolved oxygen,
salinity,
temperature and
annual maps for
bathymetry and
bottom type



Species Analyzed to Produce Seasonal HSM Maps In Charlotte Harbor and Lower Peace River

Juvenile Bay Anchovy (*Anchoa mitchilli*) (15-29 mm SL)

Adult Bay Anchovy (*Anchoa mitchilli*) (30-60 mm SL)

Early Juvenile Southern Kingfish (*Menticirrhus americanus*) ((10-119 mm SL)

Early-Juvenile Red Drum (*Sciaenops ocellatus*) (10-299 mm SL)

Early-Juvenile Spot (*Leiostomus xanthurus*) (10-149 mm SL)

Juvenile Sand Seatrout (*Cynoscion arenarius*) (10-149 mm SL)

Hogchoker (*Trinectes maculatus*) (10-100 mm SL)

Blue Crab (*Callinectes sapidus*) (10-150 mm SL)

GAMLSS-Generalized Additive Models for Location, Scale, And Shape

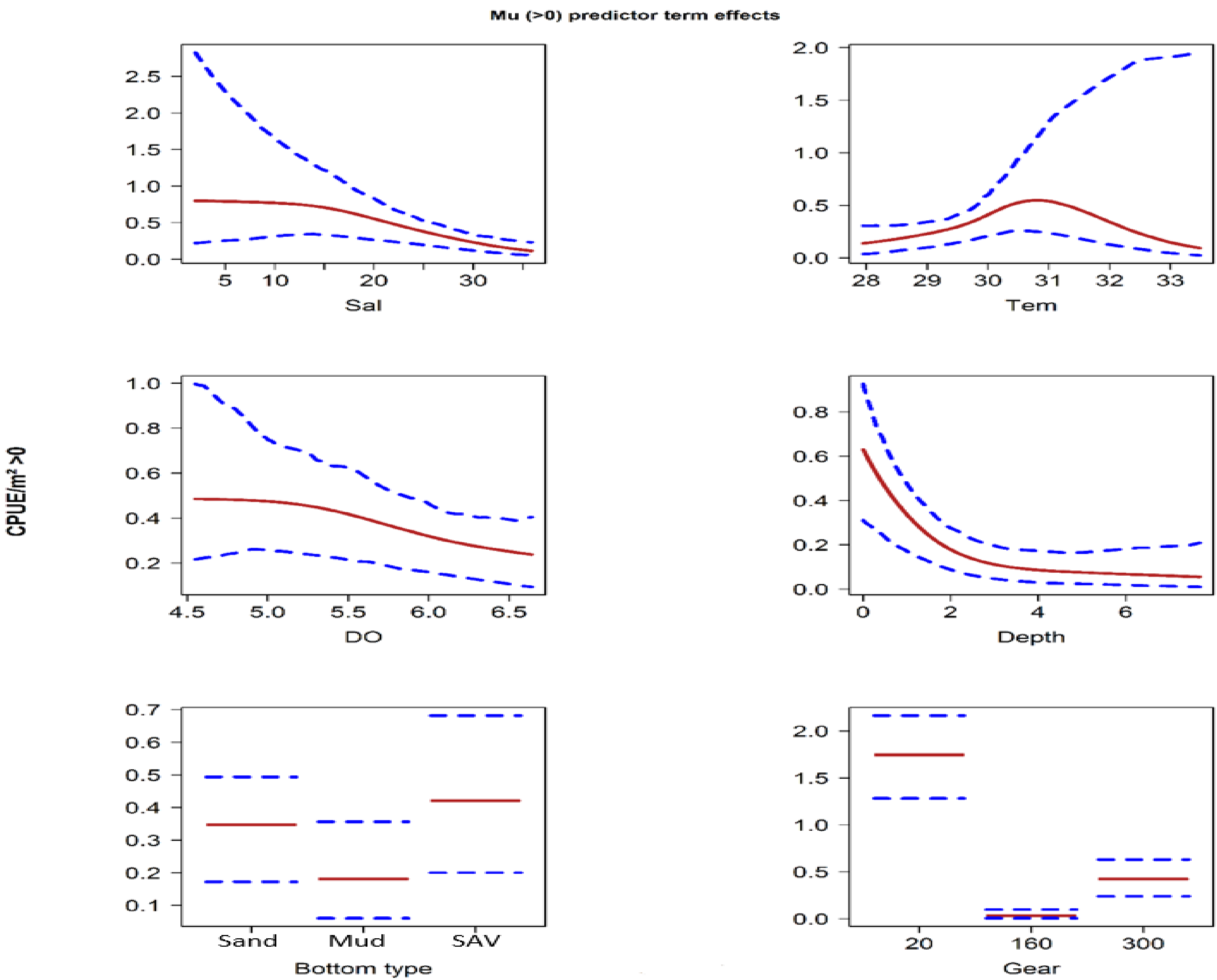
R program:

Simultaneously fits splines across environmental gradients to both positive catch rate (CPUE) data and frequency of occurrence data in one program.

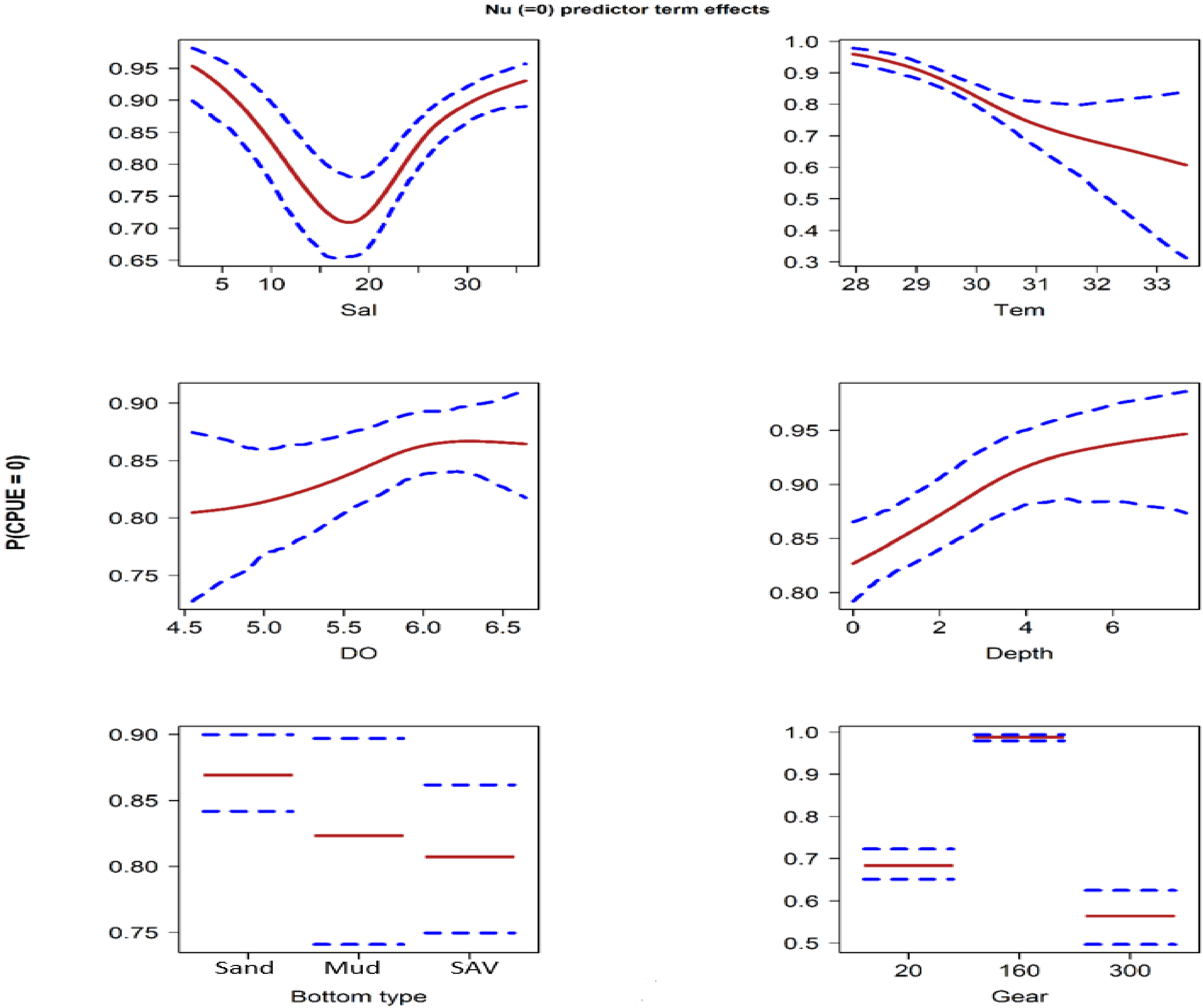
Develops multiplicative models for both +CPUEs and binomial data, then combines outputs to predict CPUEs.

Computes Akaike Information Criterion (AIC) for all possible combinations of environmental factors to choose the best delta-type (beta or gamma) generalized additive model (GAM).

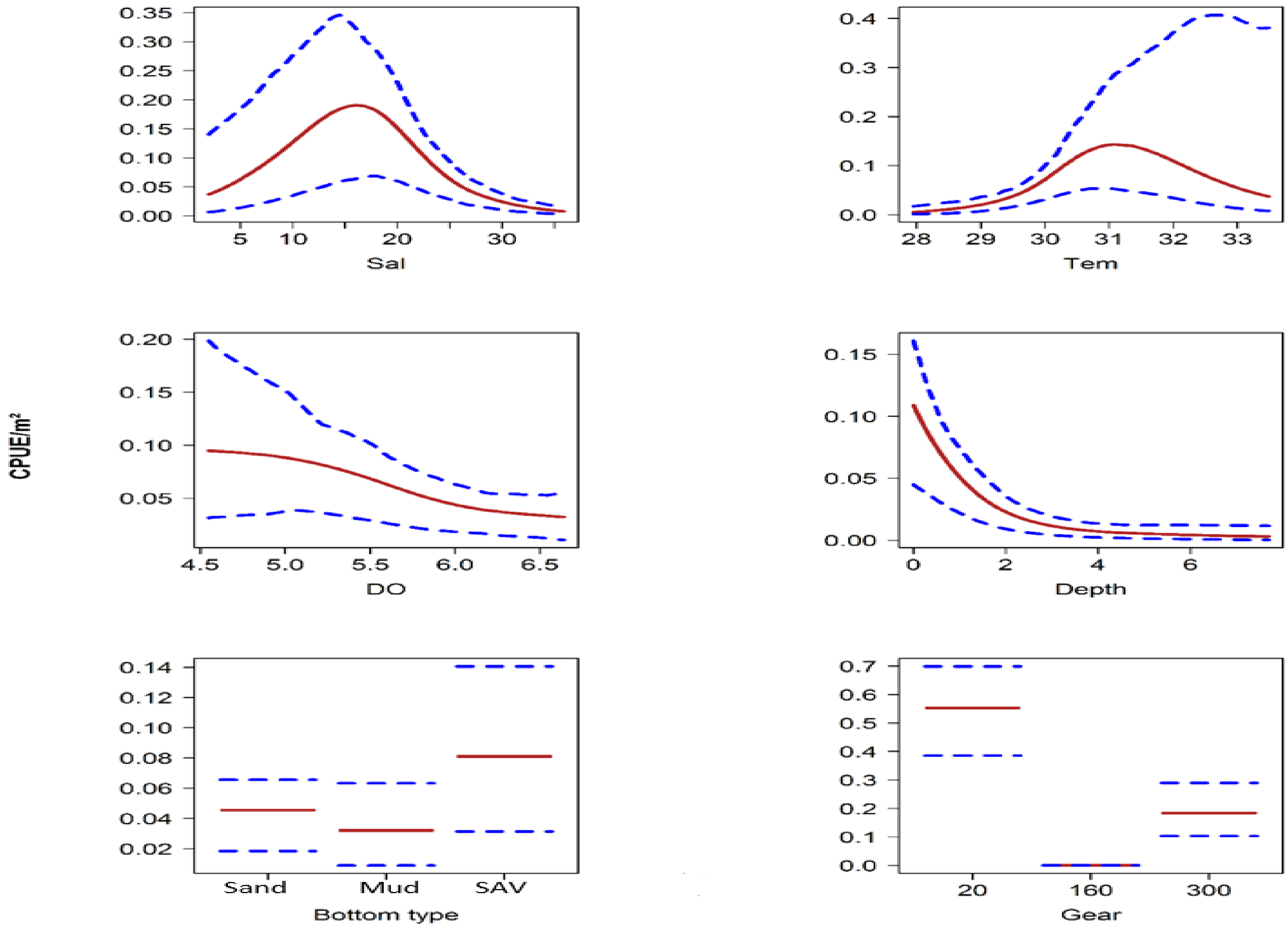
Deals with surplus of zero catches



Mu (>0) predictor term effects
CPUE/m² >0
Sal
Tem
DO
Depth
Bottom type
Sand
Mud
SAV
Gear
20
160
300


Nu (=0) predictor term effects
P(CPUE = 0)
Sal
Tem
DO
Depth
Bottom type
Sand
Mud
SAV
Gear
20
160
300

Combined (0 and >0) predictor term effects (available only for covariates on both sides of reduced model).



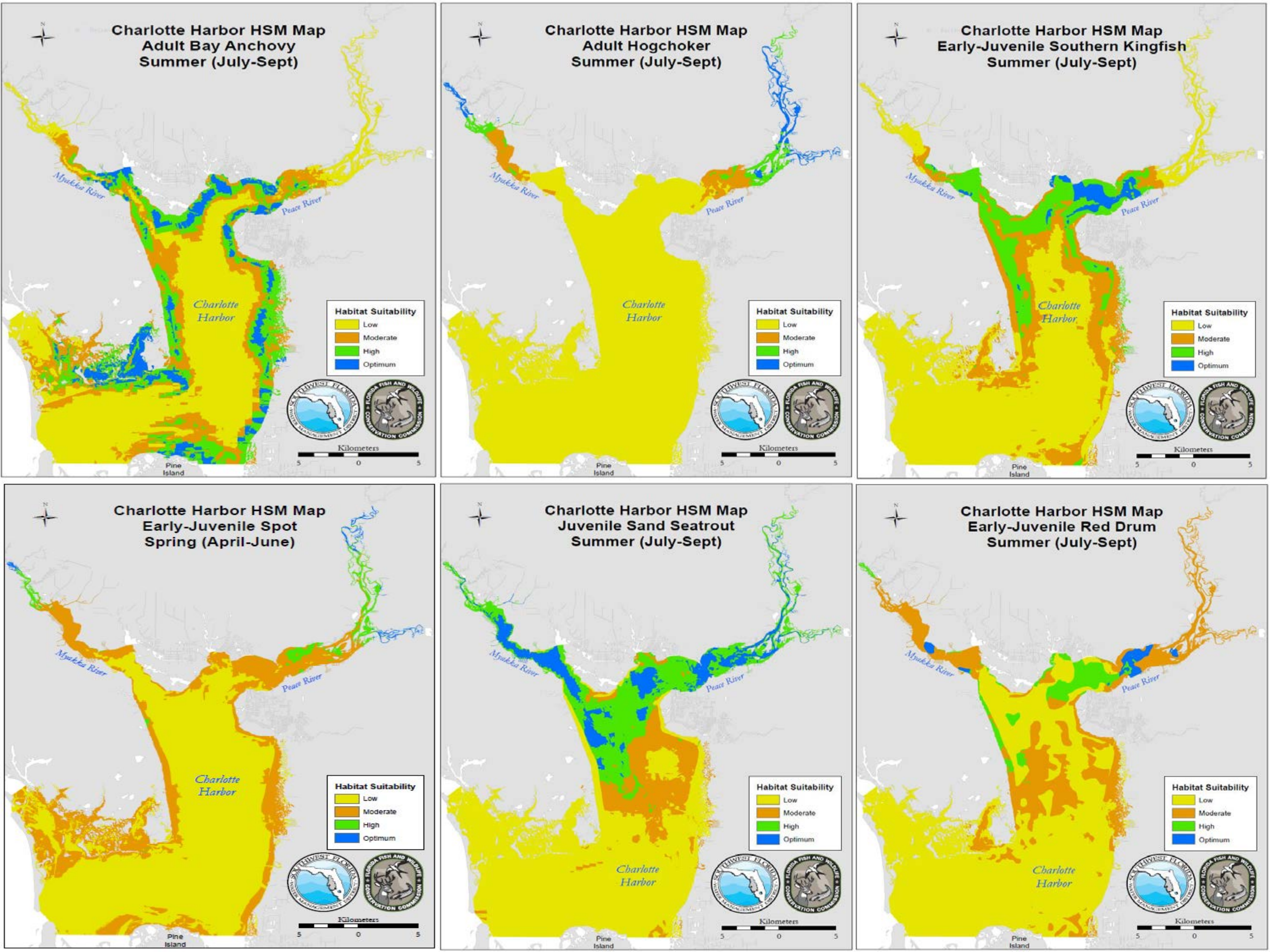
Procedure to Create HSM Maps

The models use fisheries independent monitoring (FIM) data consisting of CPUEs and associated environmental data (temperature, salinity, dissolved oxygen, depth, bottom type).

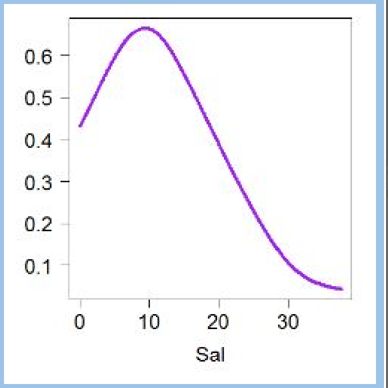
By linking the models to environmental data derived from interpolated habitat grids, we created predicted CPUEs (no/m^2).

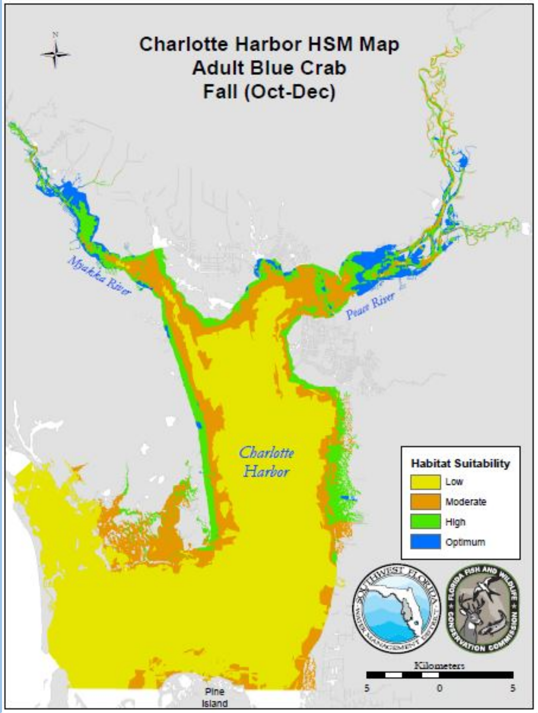
Then the predicted CPUE data were imported into the GIS to create a CPUE grid for 1.9 million 15-m X 15-m cells across Charlotte Harbor.

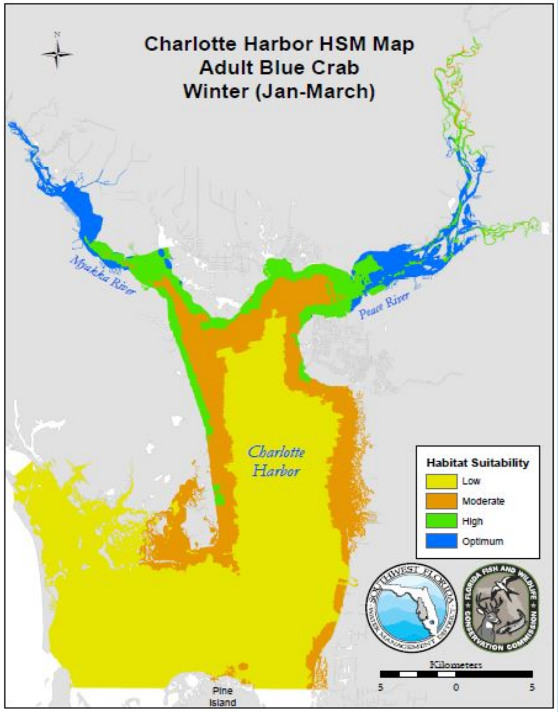
The grid was then partitioned into 4 zones based on natural breaks to create seasonal HSM maps for each species life-stage.

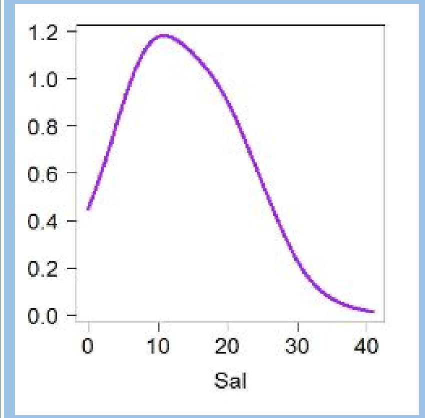

Charlotte Harbor HSM Map
Adult Bay Anchovy
Summer (July-Sept)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island
Charlotte Harbor HSM Map
Adult Hogchoker
Summer (July-Sept)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island
Charlotte Harbor HSM Map
Early-Juvenile Southern Kingfish
Summer (July-Sept)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island
Charlotte Harbor HSM Map
Early-Juvenile Spot
Spring (April-June)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island
Charlotte Harbor HSM Map
Juvenile Sand Seatrout
Summer (July-Sept)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island
Charlotte Harbor HSM Map
Early-Juvenile Red Drum
Summer (July-Sept)
Myakka River
Peace River
Charlotte Harbor
Habitat Suitability
Low
Moderate
High
Optimum
Kilometers
5
0
5
Pine Island

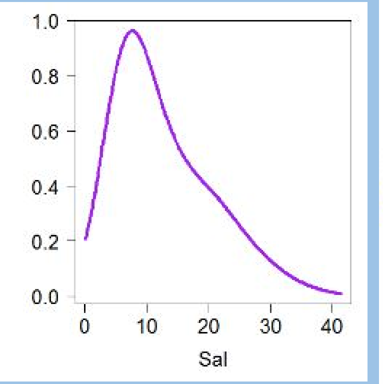
Seasonal changes in optimal zone

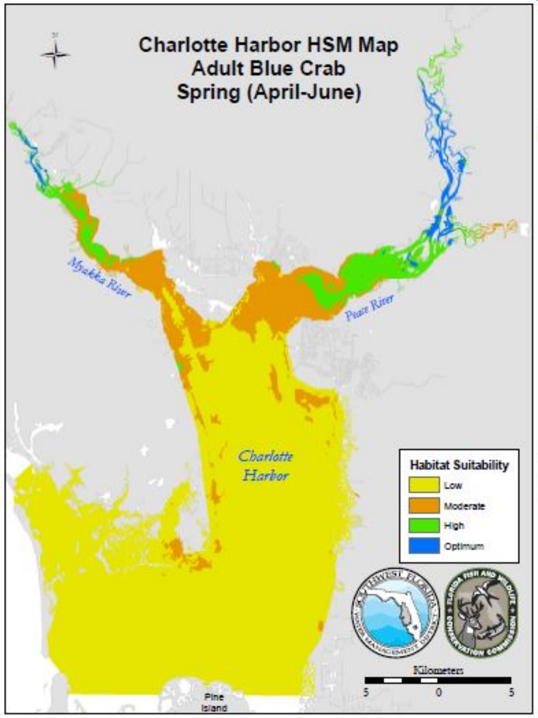


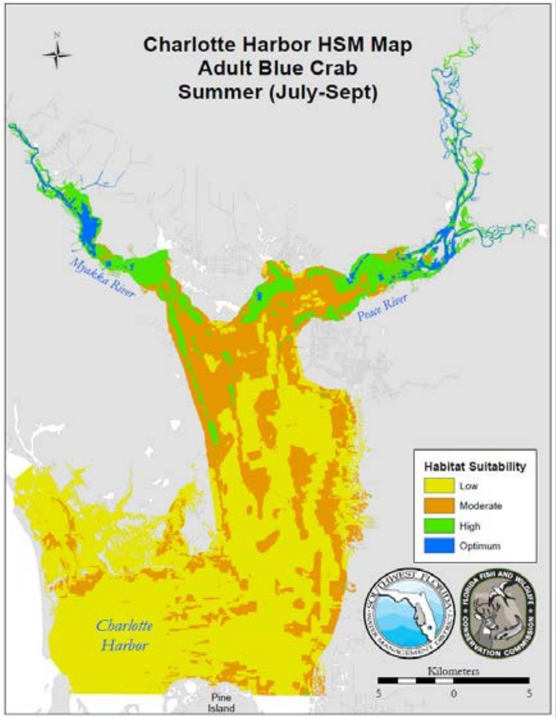


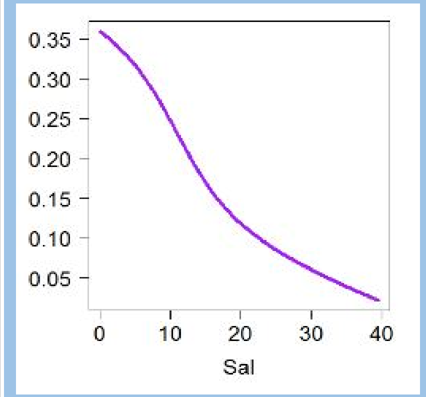












POPULATION ESTIMATE ADULT BAY ANCHOVY SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	1.1694	974043	219160000	256290087
Moderate	6.0381	405457	91227800	550846228
High	11.7183	353465	79529600	931951712
Optimum	18.7693	173718	39086600	733628121
		1906683	**429004000**	**2472716149**

POPULATION ESTIMATE JUVENILE SAND SEATROUT SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	0.0024	1147708	258234000	628748
Moderate	0.0128	257425	57920600	739281
High	0.0288	336635	75742900	2179828
Optimum	0.0419	164915	37105900	1554726
		1906683	**429003400**	**5102583**

POPULATION ESTIMATE ADULT BLUE CRAB SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	0.0013	1147798	258255000	329585
Moderate	0.0025	521615	117363000	294806
High	0.0048	182826	41135800	197724
Optimum	0.0082	54444	12249900	100867
		1906683	**429003700**	**922982**

POPULATION ESTIMATE EARLY-JUVENILE RED DRUM SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	0.0001	1333595	300059000	18010
Moderate	0.0002	456197	102644000	25507
High	0.0005	90820	20434500	10359
Optimum	0.0010	26071	5865980	5974
		1906683	**429003480**	**59850**

POPULATION ESTIMATE ADULT HOGCHOKER SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	0.0013	1754173	394689000	531488
Moderate	0.0240	69095	15546400	372750
High	0.0454	45586	10256900	465358
Optimum	0.0644	37829	8511530	548435
		1906683	**429003830**	**1918031**

POPULATION ESTIMATE EARLY-JUVENILE SOUTHERN KINGFISH SUMMER				
HSM	MEAN GC-CPUE	CELL	ZONAL	POPULATION
ZONE	no/sq m	COUNT	AREA sq m	NUMBER
Low	0.0019	1209165	272062000	508748
Moderate	0.0086	388102	87323000	748994
High	0.0194	259476	58382100	1133261
Optimum	0.0320	49940	11236500	359186
		1906683	**429003600**	**2750188**

Conclusions

Rainfall is generally low during the winter (January-March) and spring (April-June) and higher in the summer (July-September) and fall (October-November). Using the HSM analyses, the influence of water withdrawals during each season will be determined.

The HSM analyses can help SWFWMD managers make decisions concerning minimum flows and levels that conserve the estuarine ecosystem.