MODELING SALINITY DYNAMICS IN THE CHESAPEAKE BAY

by

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Introduction

Salinity exerts a major influence over the survival and distribution of many fish species in the Chesapeake Bay

- Fish habitats expand or contract in relation to salinity boundary displacements

- White perch estimates are more accurate when salinity used to determine placement and allocation of sampling effort

Introduction -- continued

- High salinity levels favor survival of oyster larval and spat stages, but also provide favorable conditions for the disease MSX

- Success of MDNR's oyster seed transplanting and fossil shell planting programs relies on predicting salinity levels for various areas in the Bay

Goal

Construct multiple regression models that describe the dynamics of salinity in the Maryland portion of the Bay

- Other efforts use time series methods to predict surface and bottom salinity as part of a Bay water quality model

Source of Data

- **Data collected by USEPA from 1984 to 1989**

  -- 18 stations in mainstem Bay
  -- 16 stations in tributaries

- **Water samples collected at different depths**

  -- salinity
  -- ph
  -- survey date
  -- longitude
  dissolved oxygen
  temperature
  latitude
  name of station

- **36,258 water samples**

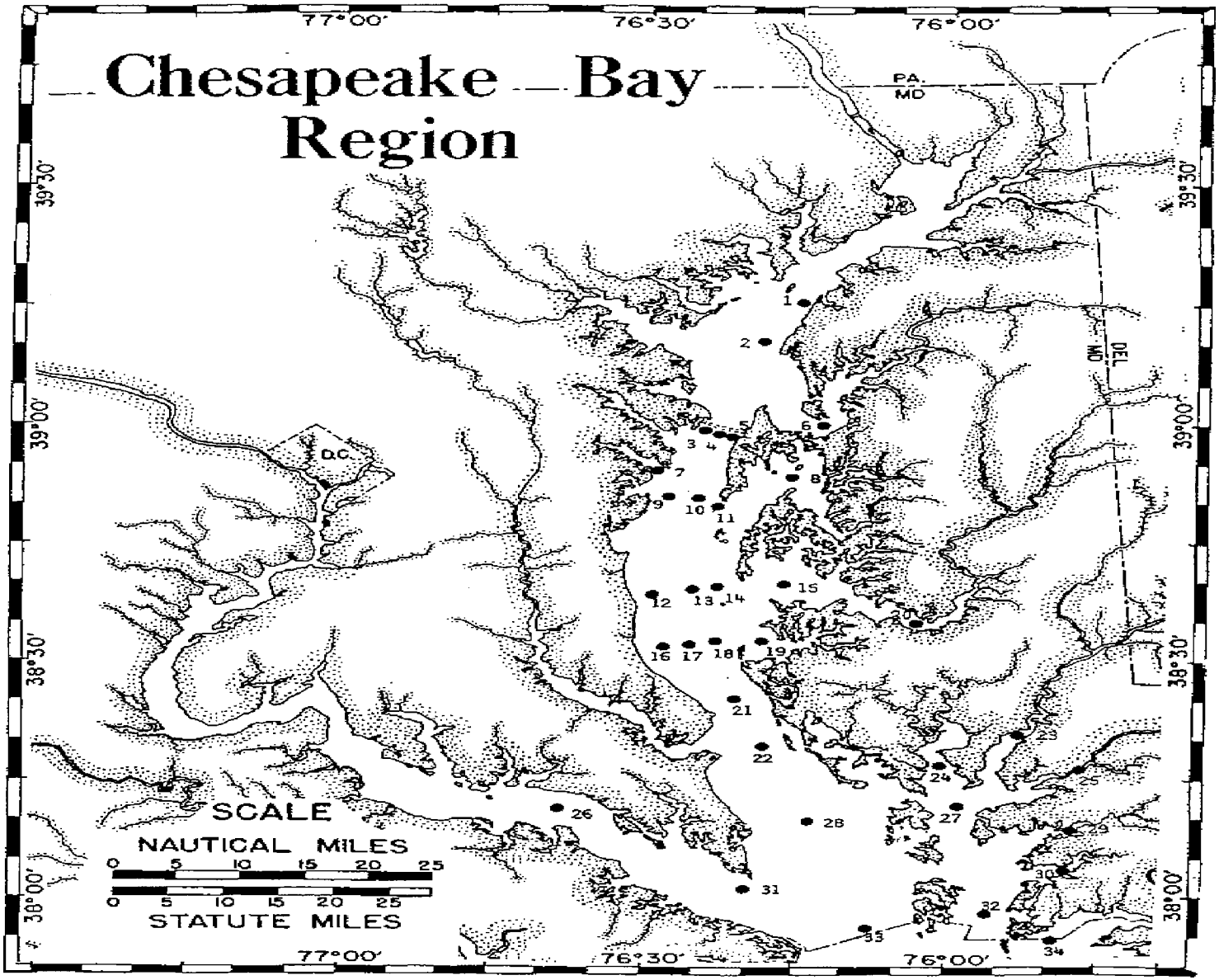

Figure 1. Survey stations in the Chesapeake Bay

Model Building

- **Easy-to-use models that predict salinity levels**
- **Extensive screening phase for independent variables**

Four key independent variables

-- Day	day of the year on which measurements were taken
-- Depth	depth at which measurements were taken
-- Latitude	latitude of sampling station
-- Longitude	longitude of sampling station

Model Building -- continued

- **Transformations of key variables**

-- distance to middle of the Bay is key factor affecting salinity

-- relationship between salinity and depth is nonlinear

salinity = cosine (Depth x π/36)

-- screened quadratic, cubic, interaction terms, indicator variables, about 30 variables in all

Model Building -- continued

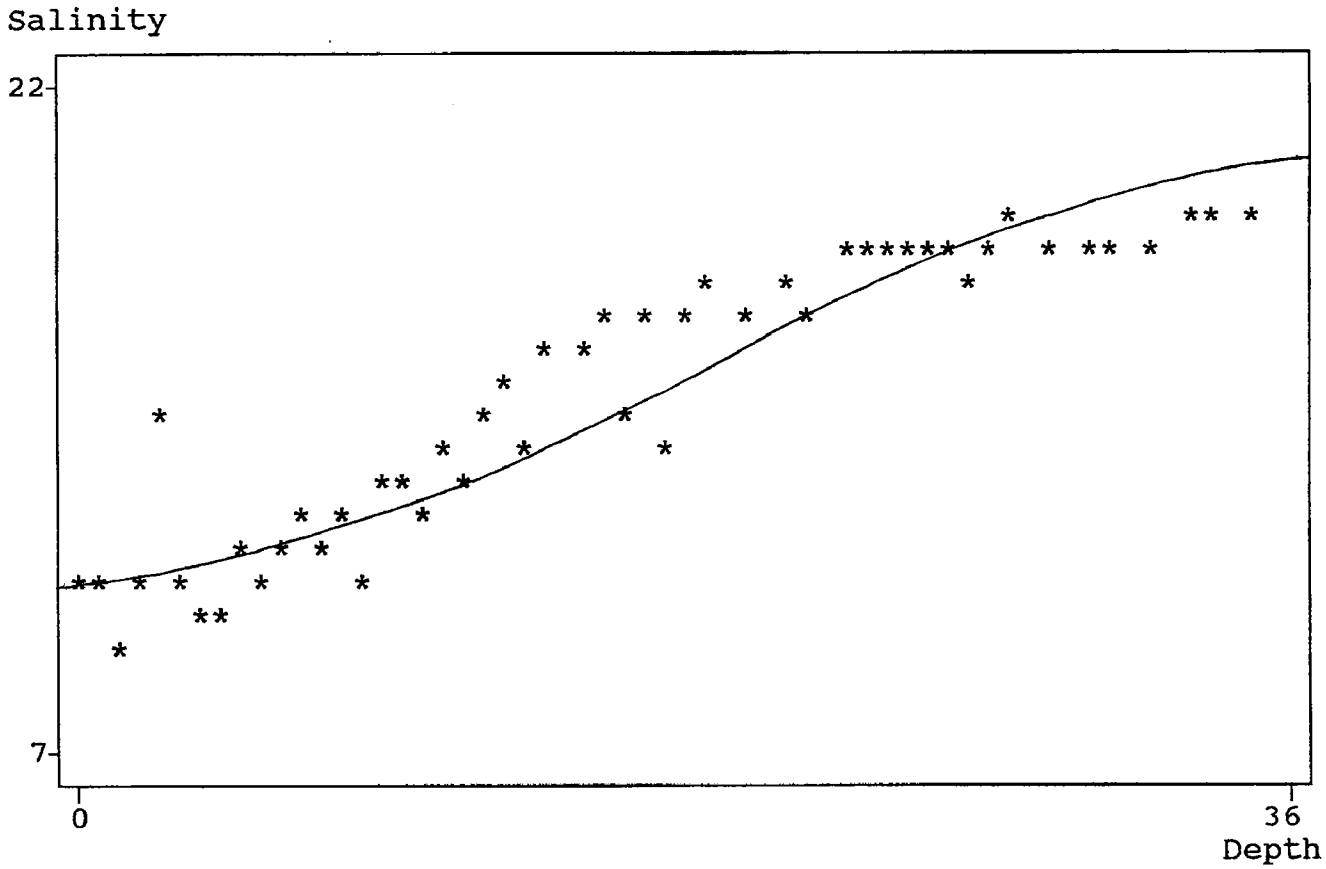

Figure 2. Mean salinity versus depth

Model Building -- continued

- **Four key transformations**

  -- Day1 sine transformation of Day
  -- Day2 sine transformation of Day
  -- Depth1 cosine transformation of Depth
  -- Longitude1 square of Longitude

- **Two key interactive terms**

  -- Depth x Longitude
  -- Latitude x Longitude

Model Building -- continued

- **Divided Bay into three regions**

  -- Salinity varies widely

  -- Construct more accurate models

  -- About equal number of stations in each region

  - Upper Bay through 9, 10, 11
  - Middle Bay through 21
  - Lower Bay

Model Building -- continued

- **Used stepwise regression in SPSS/PC**

  -- Avoid highly correlated independent variables

  -- Keep models simple: don't include variables that add little in predictive power

Model Results

- **Constructed 10 models in all**

  -- 5 bottom data models, 5 total data models

  - Upper, Middle, Lower, Entire Bay, Lower Tributaries

- **Entire Bay Model**

  -- $R^2 = 0.649$

  - Depth increases, salinity increases
  - Salinity = 199.839 – 1.151 Day1 + 1.161 Day2
    + 0.283 Depth - 4.863 Latitude
    – 1.543 Longitude – 13.402 Longitude1

Model Results -- continued

- **Six independent variables in each model**

  -- All coefficients significant

  -- Each model easily passed an F test

  -- No problems with multicollinearity

- **Aptness of the models**

  -- R^2 values range from 0.56 to 0.81

  -- Examination of standardized residuals

  - very few outliers
  - histograms confirmed normality
  - residual plots did not reveal nonconstant error variance

Model Validation

- **Tested our ten models on new data**

  -- Mainstem Bay January 1990

  -- Tributaries January 1989

- **Computed mean absolute error (MAE)**

		MAE			MAE
bottom data	upper	1.383	total data	upper	1.575
	middle	1.955		middle	1.766
	lower	2.416		lower	2.155
	tributaries	3.744		tributaries	3.701
	entire bay	1.966		entire bay	2.120

Conclusions

- **Ten models are simple, easily explained, and have been validated**
- **These models can now be used to predict salinity for a location on the Bay at a specified depth and date**
- **More survey data are needed to improve the accuracy of the lower tributary models**
- **It would be desirable to include precipitation as an independent variable in our models**