Habitat Suitability Modeling for Striped Bass in Chesapeake Bay

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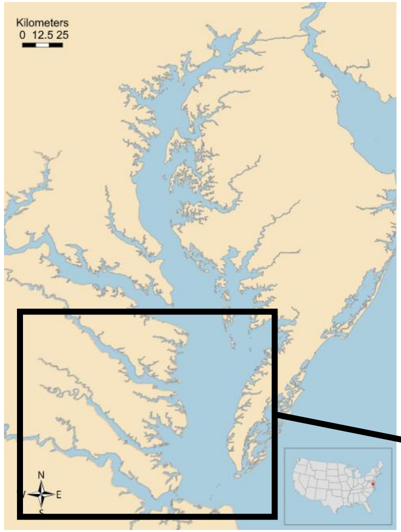
Anchor QEA

Recruitment varies among years and nurseries in Chesapeake Bay



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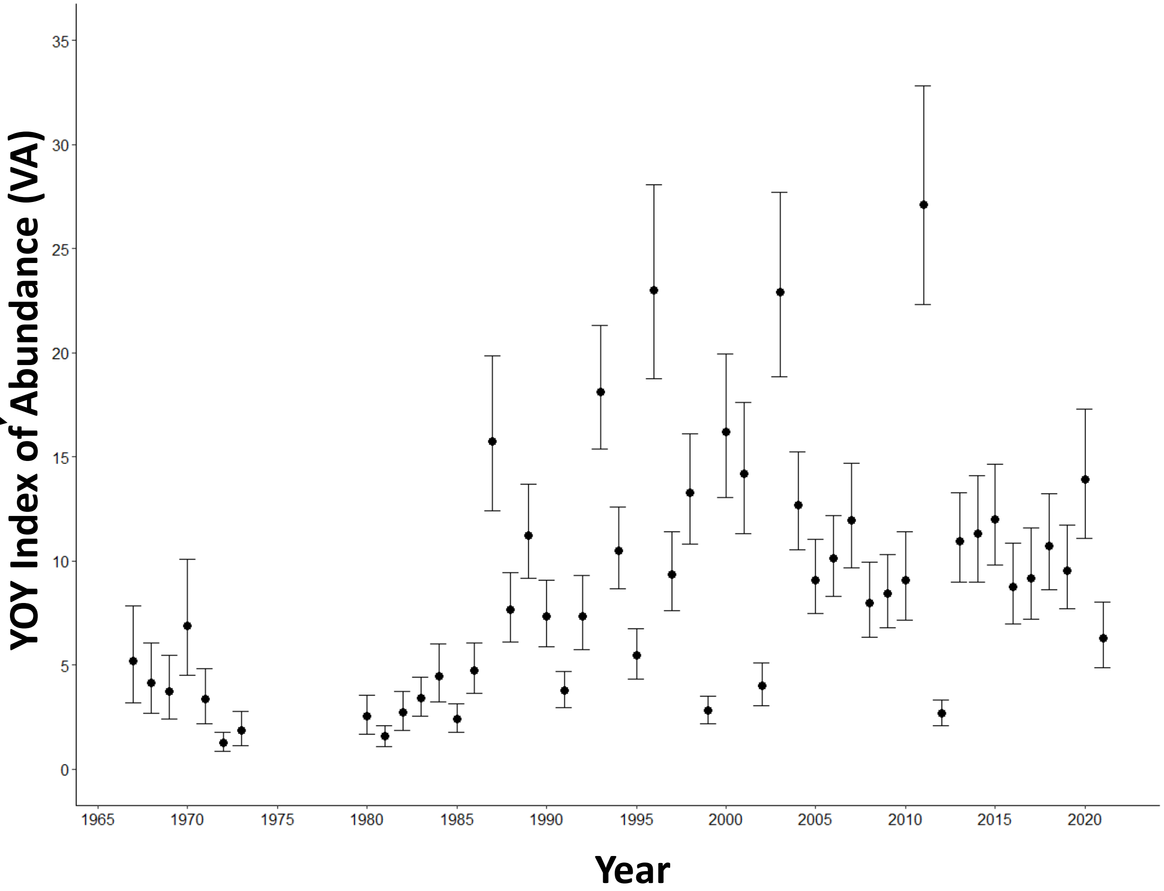
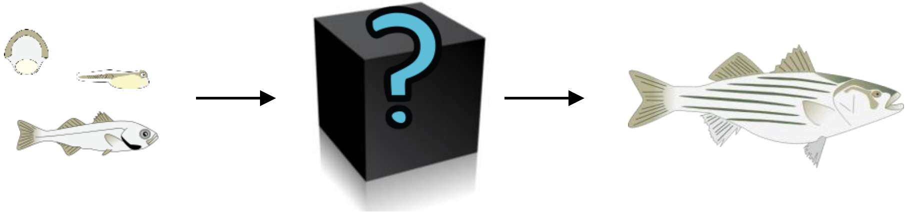
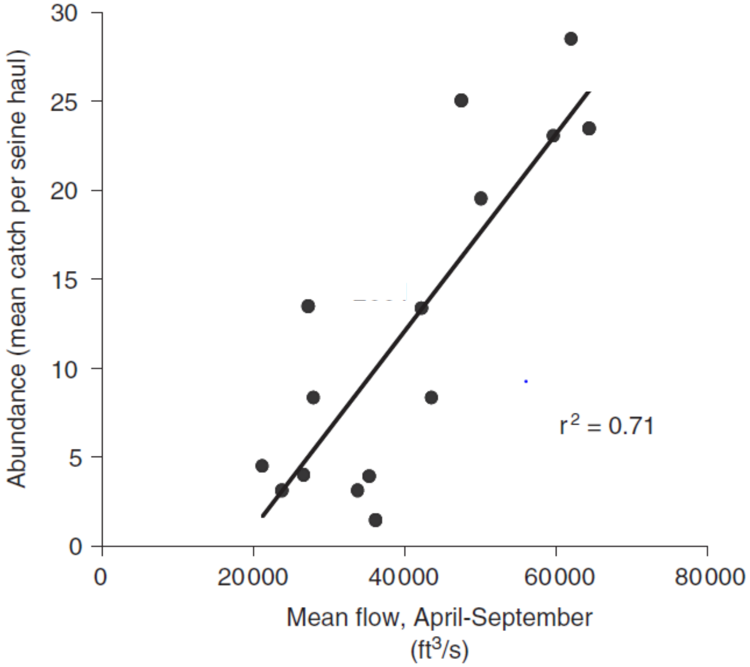


Buchanan et al. 2022

Annual production partially reflects environmental conditions during early life stages



- Complex hydrological processes impact survival and growth of larval striped bass
- Multiple spatial and temporal scales
- Conditions that contribute to juvenile production likely vary, and are not fully understood



Martino and Houde 2004

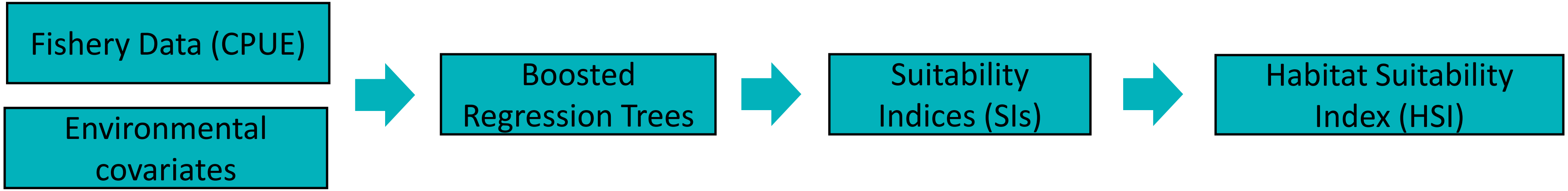
Habitat extent may contribute to production

- High-quality habitats support greater numbers of recruits, but productivity varies within and between tributaries
- Many habitats together support overall nursery function

Photo credit: VIMS Juvenile Trawl Survey

Questions:

- What conditions characterize habitats for juvenile striped bass in Chesapeake Bay?
- Has the extent of suitable and optimal habitat changed over time?
- What is the relationship between habitat and abundance?



Characterize suitable habitats at the time of catch

Project Bay-wide

Tanaka and Chen 2015 (American lobster); Fabrizio et al. 2021 (forage fishes)

Fishery Data (CPUE)

Environmental covariates

→ Boosted Regression Trees → Suitability Indices (SIs) → Habitat Suitability Index (HSI)

Dynamic

Tidal-averaged & Instantaneous

- Salinity & Temperature
  - Surface, near bed, depth-averaged, stratification
- Current Speed
  - Near bed, depth-averaged, horizontal and vertical gradient, max depth-averaged
- Water Depth

Static

- Distance to shore
- Sediment composition (% fine sediment)

Dissolved oxygen (Du and Shen 2014)

- Bottom DO
- Surface DO
- DO stratification

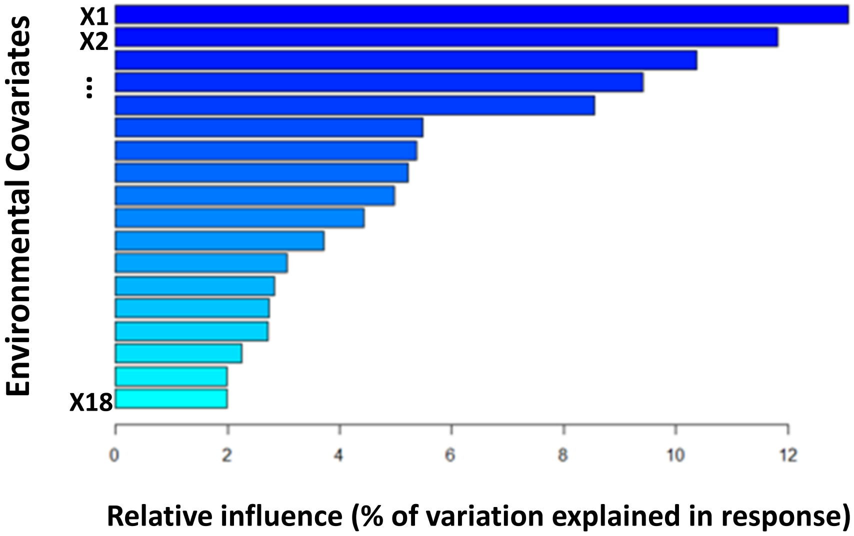
n=33 variables considered

Fishery Data (CPUE)

Environmental covariates

→ **Boosted Regression Trees** → Suitability Indices (SIs) → Habitat Suitability Index (HSI)

- Boosted regression trees (BRTs; Elith et al. 2008)
  - Covariate selection through measures of relative influence
  - Between 3-7 covariates were selected for each habitat model



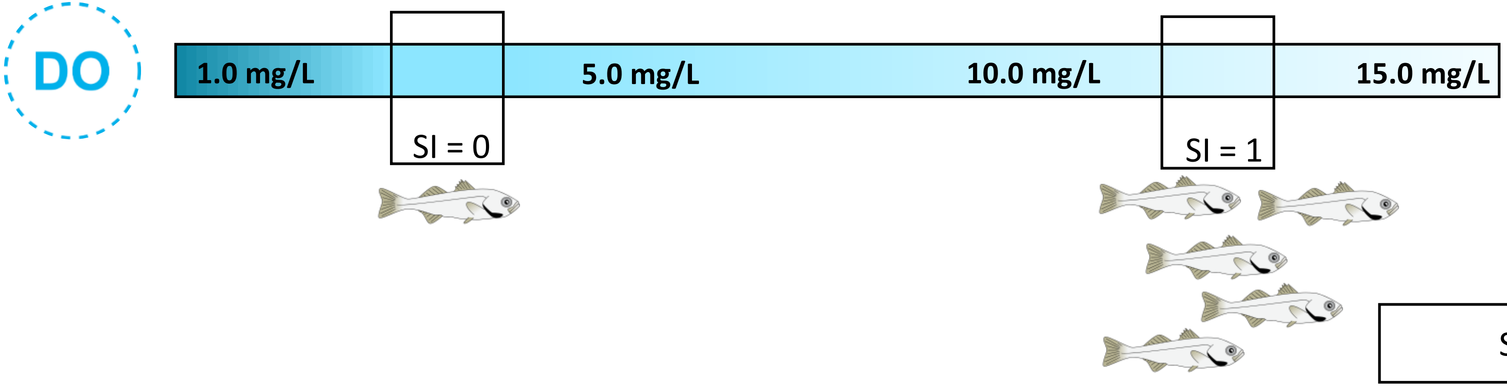
Fishery Data (CPUE)

Environmental covariates

→ Boosted Regression Trees → Suitability Indices (SIs) → Habitat Suitability Index (HSI)

0 → 1

"Suitable" ≥ 0.5

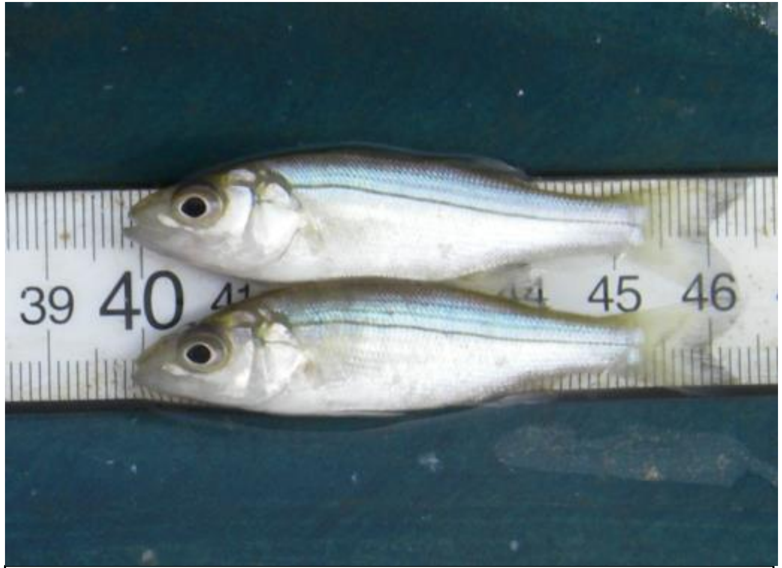


SI – Bottom DO

SI – DO Stratification

SI – Current Speed

Modified from Fig.3 Tanaka and Chen 2015



Age-0 – Young of the year (YOY)

Age-1-4 – Resident sub-adult

Seine (Shoreline habitats ≤2 m)

Trawl (Nearshore habitats)

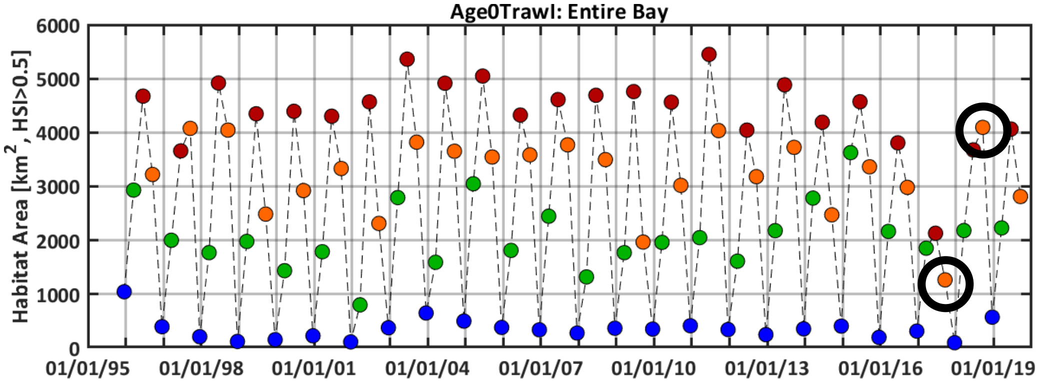
Trawl (Nearshore habitats)

Trawl (Mainstem)

Suitable habitat varies annually

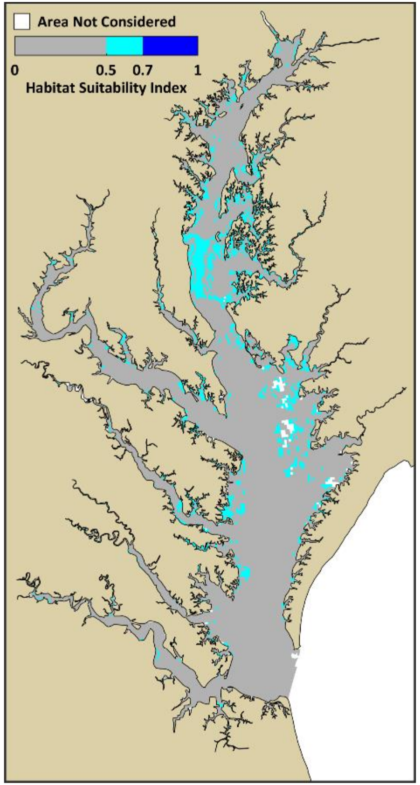
Age-0 Trawl (Nearshore habitats)

Habitat Suitability Index (HSI) 0→1
Suitable ≥ 0.5

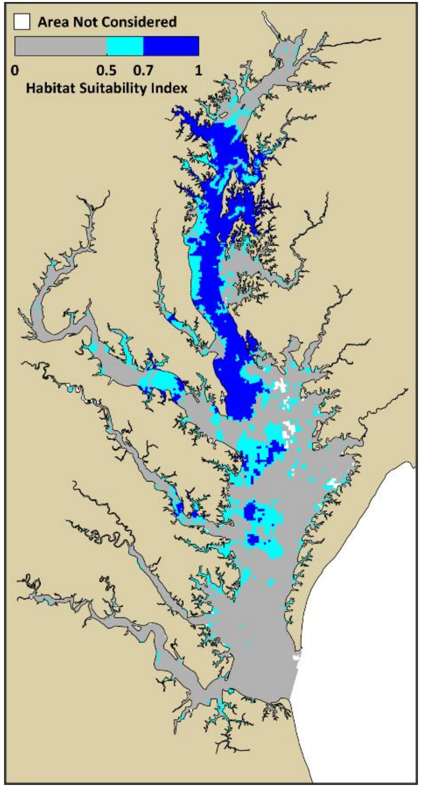


- Early Summer (May-July)
- **Late Summer (Aug-Oct)**
- Winter (Nov-Jan)
- Spring (Feb-Apr)

2017



2018



1267 km^2

4097 km^2

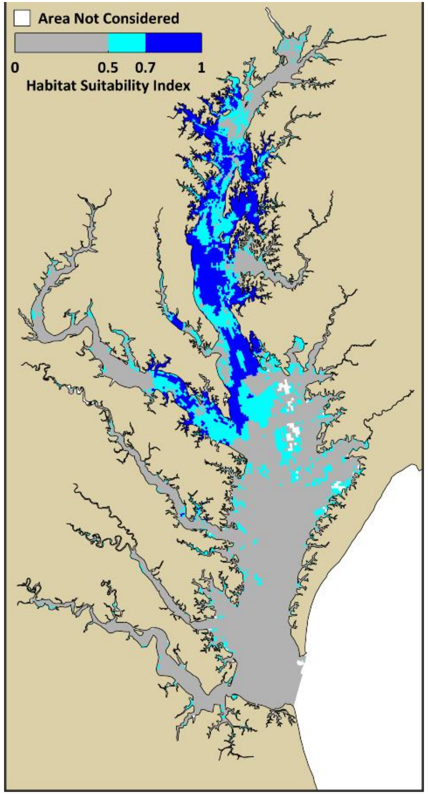
69% increase →

Suitability varies seasonally

2016-2017

Age-0 Trawl (Nearshore habitats)

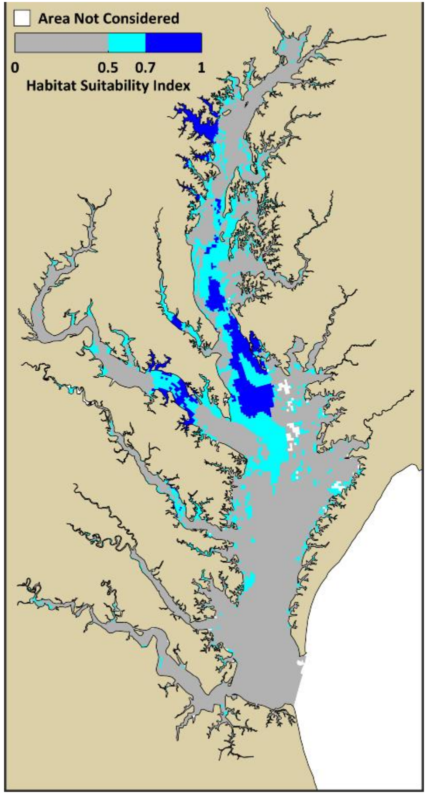
Early Summer (May-July)



3810 km^2

<= 100 mm

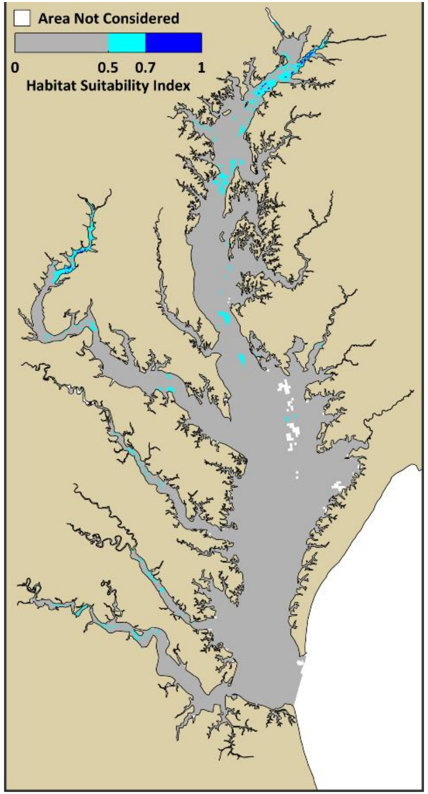
Late Summer (Aug-Oct)



2983 km^2

<= 150 mm

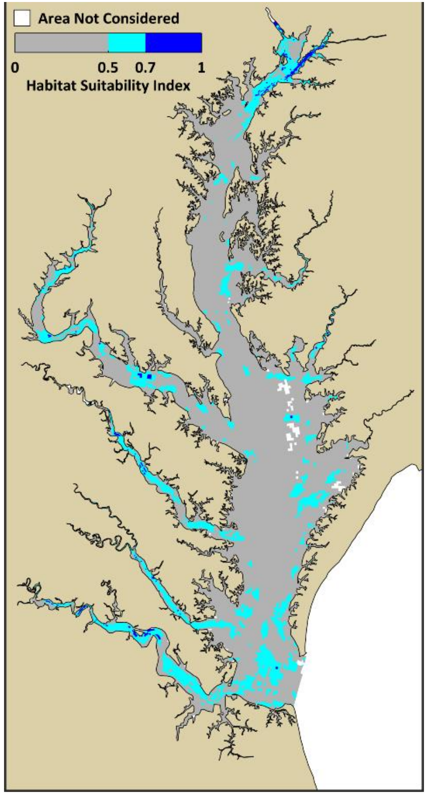
Winter (Nov-Jan)



316 km^2

<= 200 mm

Spring (Feb-Apr)

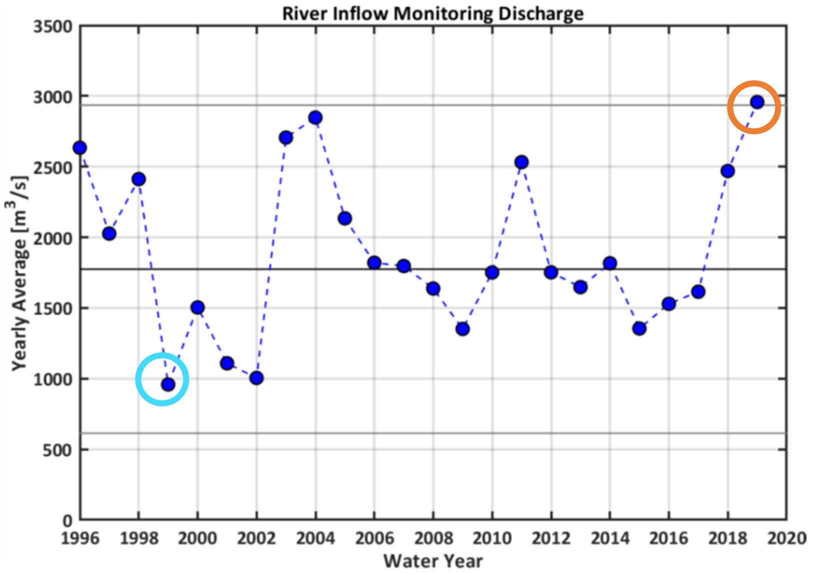


1855 km^2

<= 200 mm

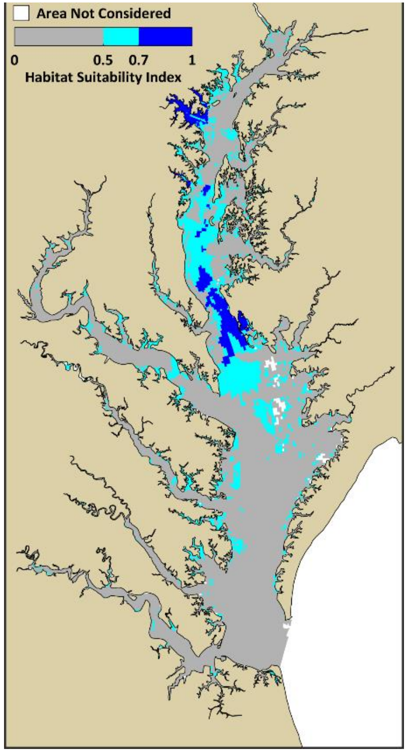
Annual conditions do not account for seasonal variability

Age-0 Trawl (Nearshore habitats)



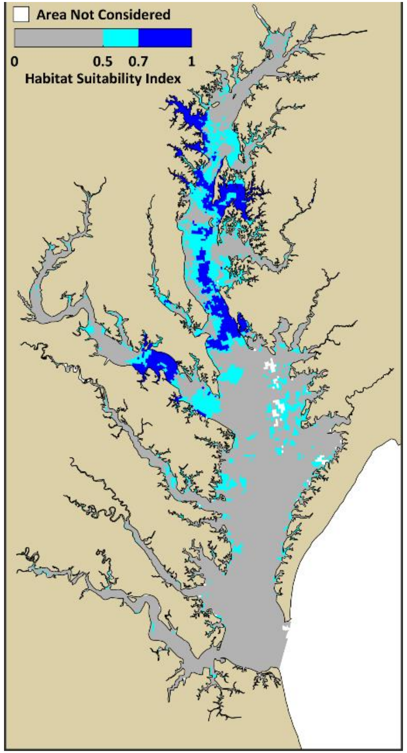
Late Summer (Aug-Oct)

1999 (Dry)



$2488\ km^2$

2019 (Wet)

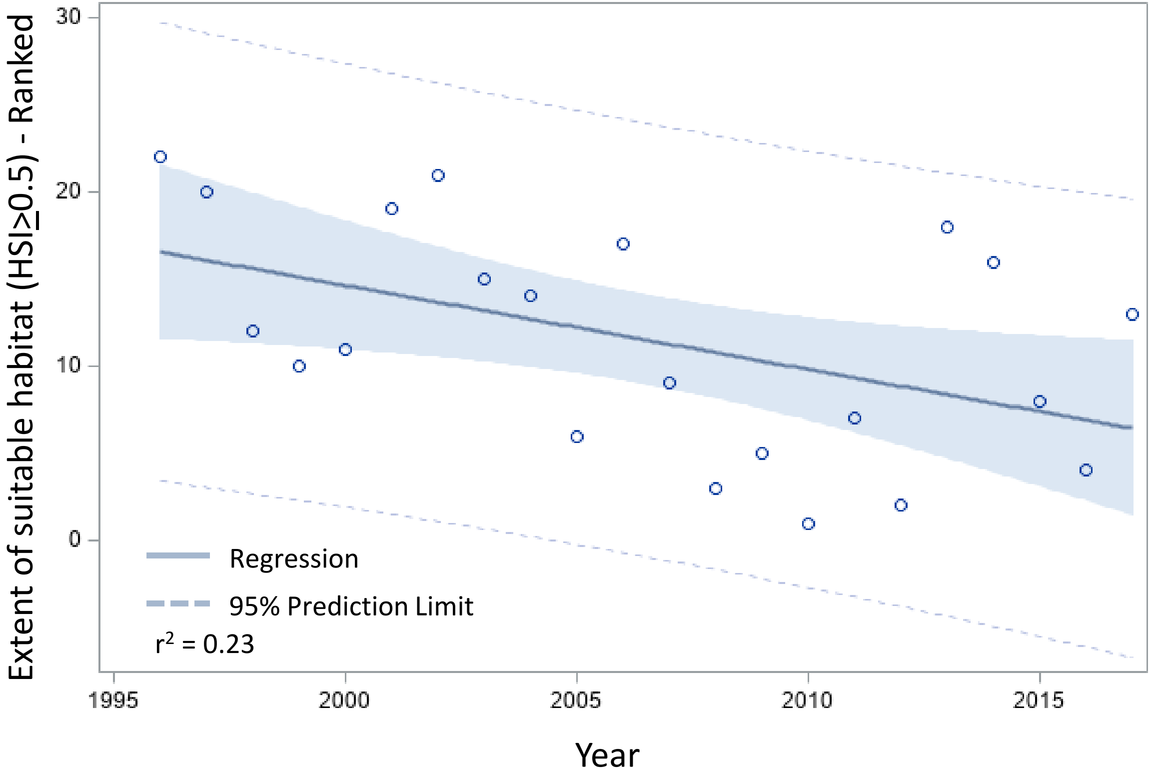


$2814\ km^2$

12% higher

- Precipitation conditions (e.g., wet, dry, average) affected habitat extent; however, patterns were season-dependent.
- Summer-fall flow conditions could structure nearshore habitats for age-0 fish

Does the extent of suitable habitat for age-0 striped bass change over time?

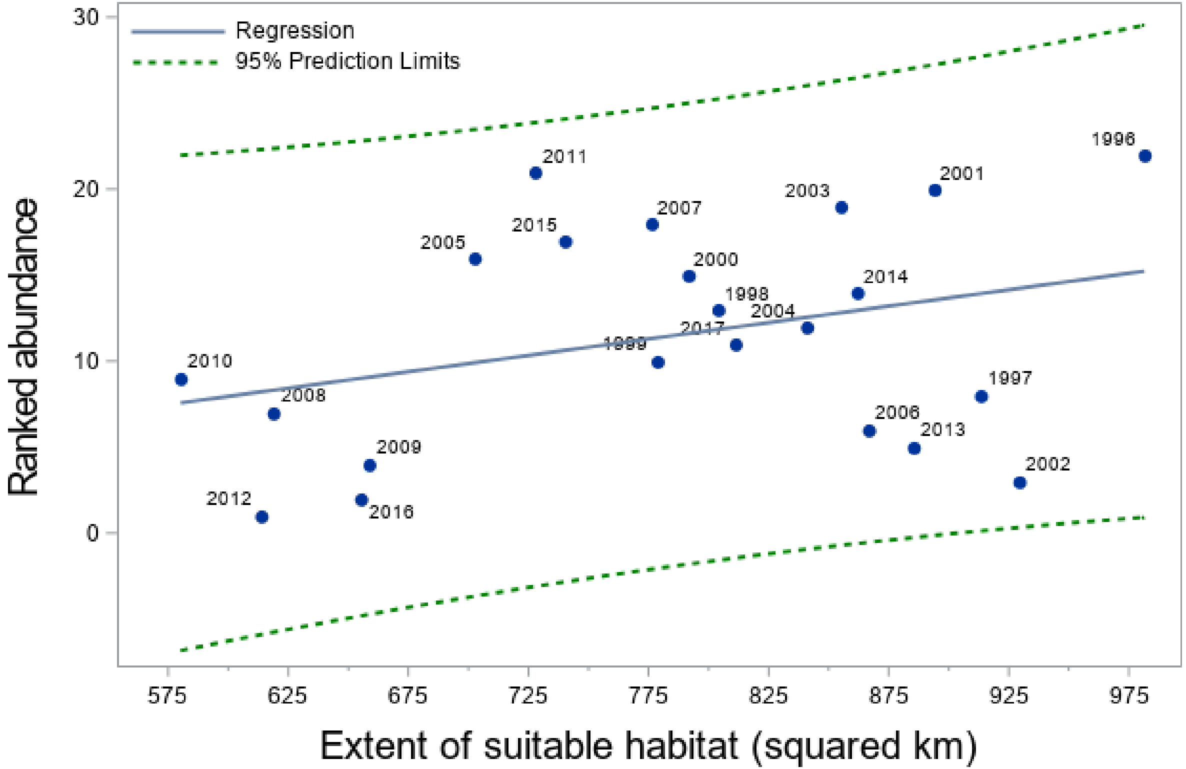


The extent of suitable shoreline habitats (≤2 m) for age-0 striped bass in early summer (June-July) decreased significantly from 1996 to 2017 (F=6.04, *P*=0.02).

Conditions in shoreline habitats have changed since 1996 during this period.

Age-0 Seine (Shoreline habitats)

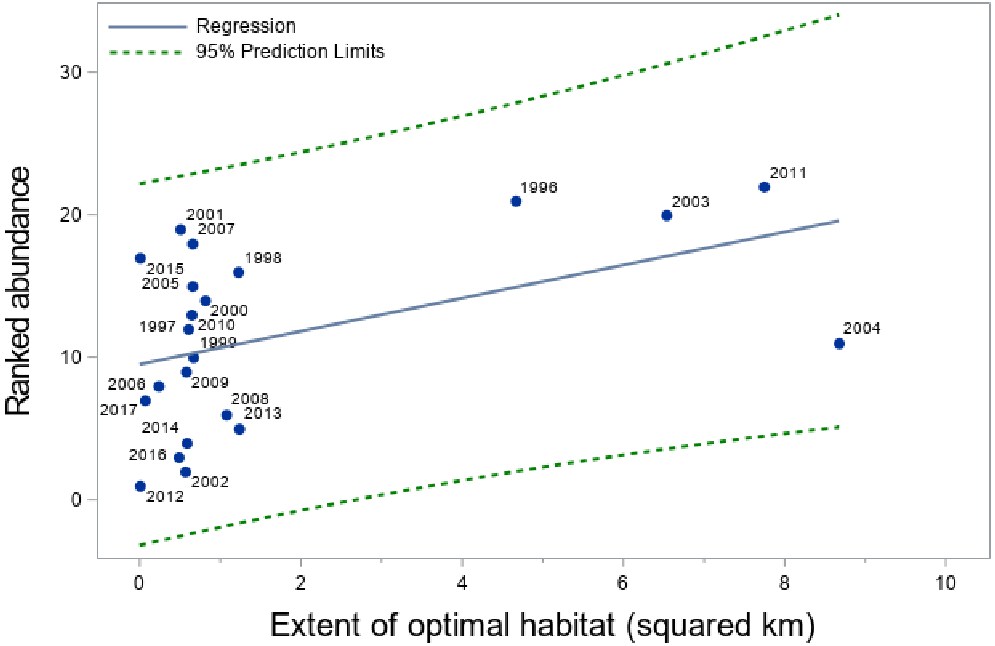
Relative abundance of age-0 striped bass increases with increasing extent of suitable habitat (HSI > 0.5)**

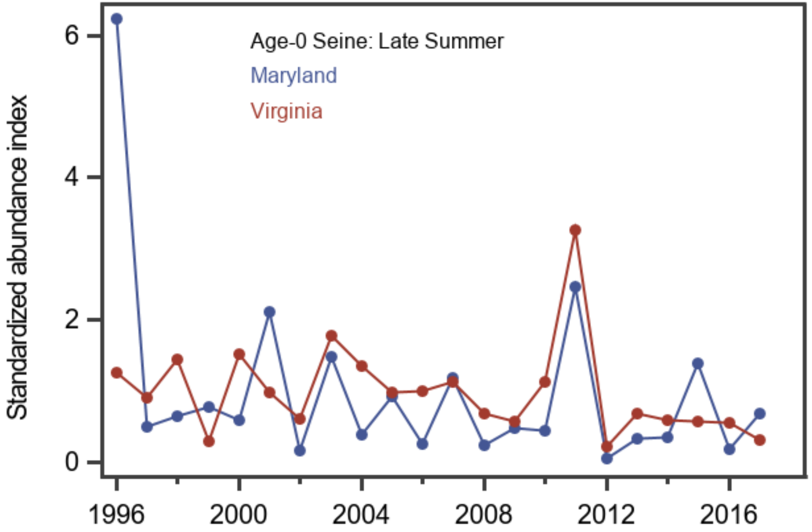


**However, this trend was not significant, despite the loss in habitat during this time (F=2.43, *P*=0.13)

Relative abundance of age-0 striped bass increases (significantly) with increasing extent of optimal habitat (HSI > 0.7)

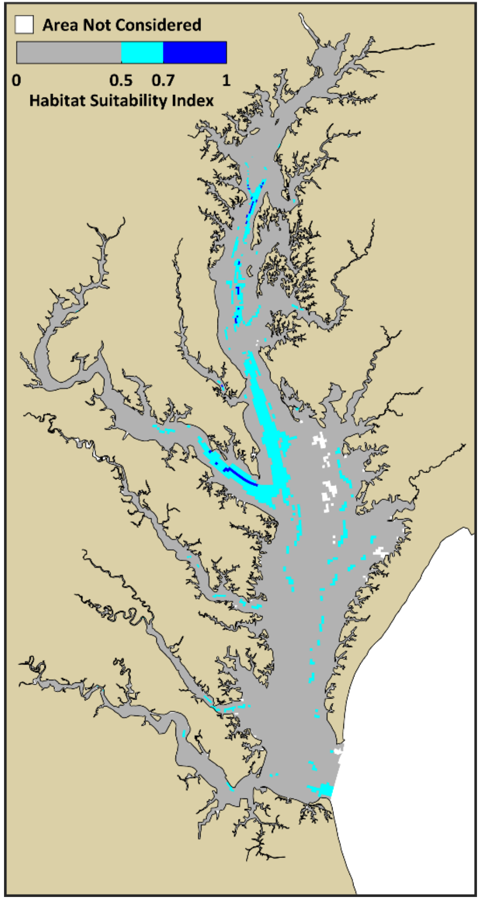
As the extent of optimal-quality shoreline habitats (HSI > 0.7) increased, higher abundances of age-0 striped bass were supported, particularly in late summer (F=5.51, *P*=0.03).



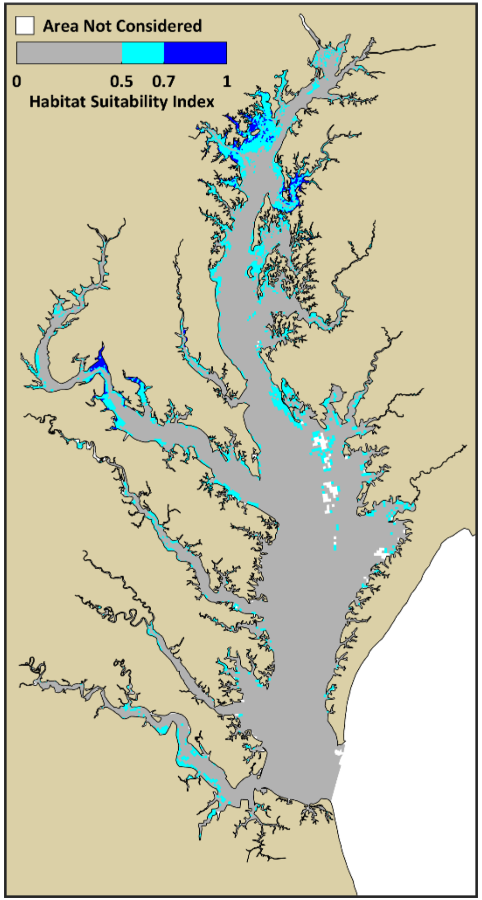


Suitability also reflects detection and selectivity

Spring (March – June)
2015

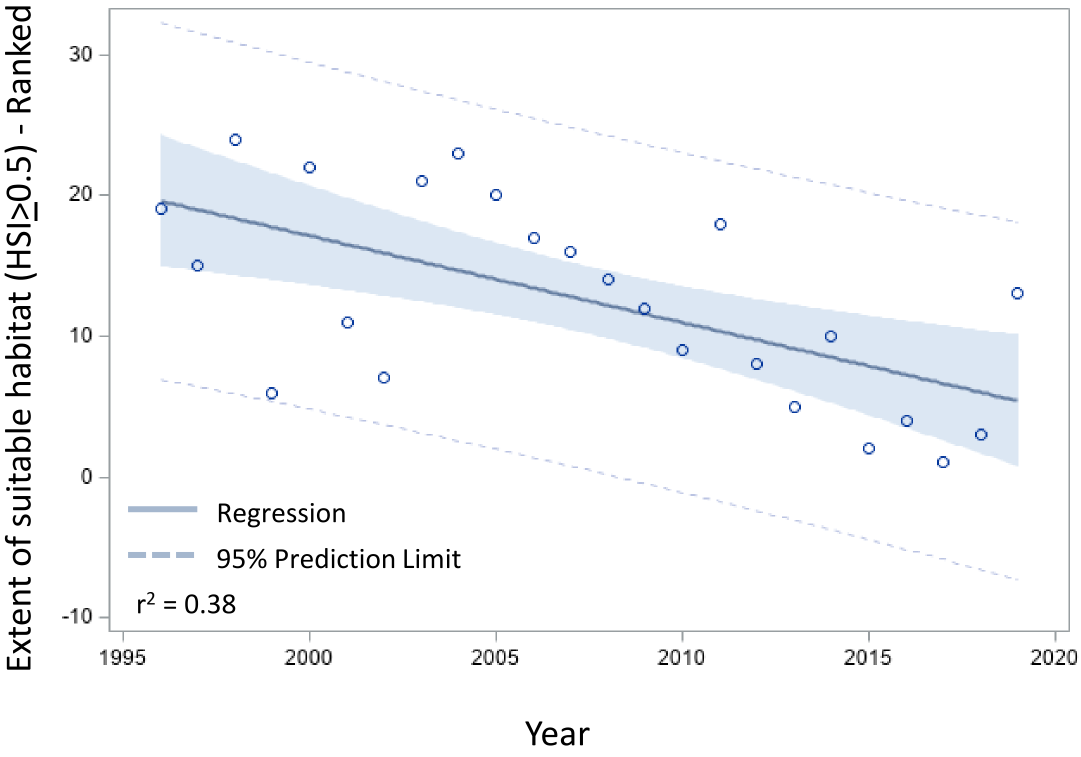


ChesMMAP



VIMS & MDDNR Trawl Surveys

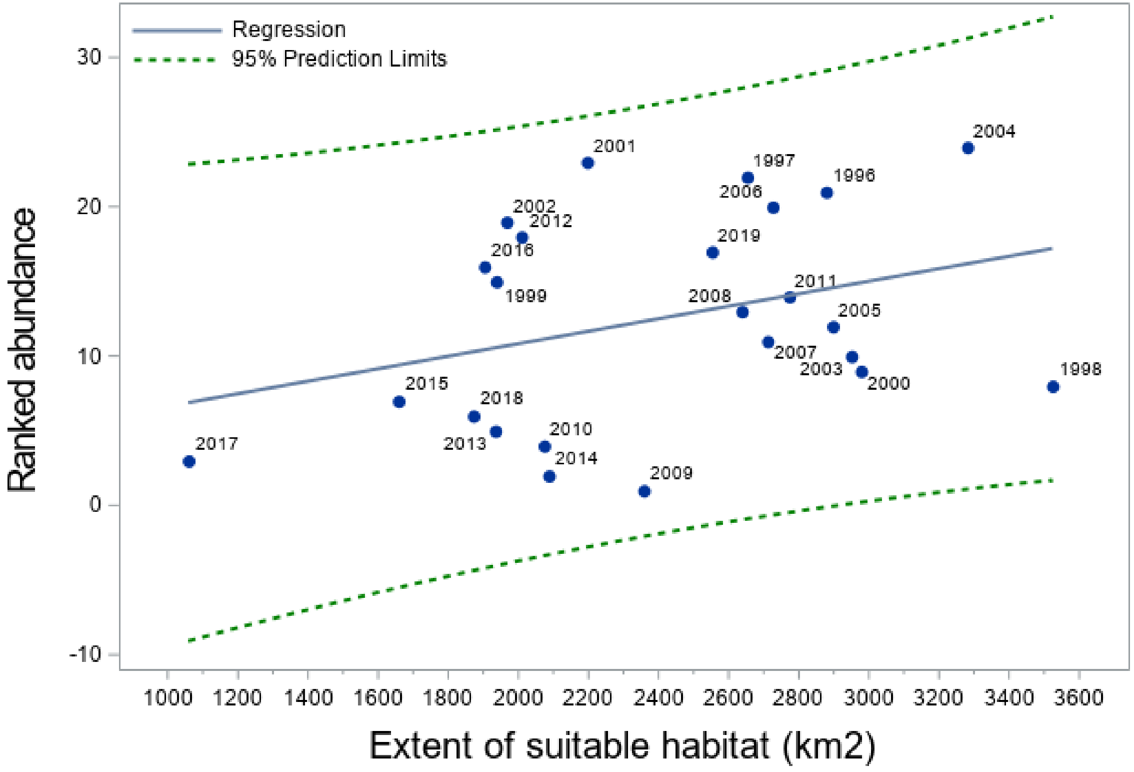
Bay-wide extent of suitable habitats for age 1-4 striped bass also decreased in Spring from 1996 to 2019



The extent of suitable habitats for age 1-4 striped bass in spring (March-June) also decreased significantly from 1996 to 2019 (F=13.55, *P*=<0.01).

This appears to be driven by a significant decrease in habitat in Maryland, specifically, in the Patuxent River.

Relative abundance of age 1-4 striped bass increases with increasing extent of suitable habitat (HSI ≥ 0.5)



Again, we were unable to detect a significant relationship between habitat area and abundance in spring from 1996 to 2019 (F=2.85, *P*=0.11).

This pattern is evident across age groups and seasons.

Summary of Major Findings

1. **Conditions that defined suitable and optimal habitats varied across seasons and among years**
   - "Suitability" is a function of covariates selected, and factors impacting estimation of abundance

2. **Water quality conditions were key predictors of habitat suitability**
   - Dissolved oxygen, current speed
   - Changing conditions in response to climate change and management efforts

3. **Juvenile striped bass use less-than-ideal habitats**
   - Tolerate broad variations in some environmental conditions; habitat use reflects a combination of conditions
   - Other biotic factors also likely influence fish-habitat relationships

Summary of Major Findings (cont.)

4. Local conditions may be important to consider

- Tributary-specific trends
- Driving some seasonal declines in suitable habitat

5. Early evidence that habitat conditions are changing over time

- Significant decline in the extent of suitable habitats for age-0 fish captured by seines in early summer (June-July), and age 1-4 fish captured by small trawls in spring (March-June)

6. Suitable habitat <u>may</u> be limiting for juvenile striped bass

- Consistent pattern in the relationship between abundance and extent of suitable habitat
- Decline in suitability may contribute to observed declines in abundance

Management Recommendations

- Continued support of the Chesapeake Bay Total Maximum Daily Load (TMDL) and associated water-quality standards to protect vital habitats
  - Local scale in addition to Bay-wide efforts
- Continued support for abiotic data collection during existing survey efforts
  - Fine-scale data needs for understanding localized conditions (e.g., shoreline habitats)
- Expand or develop survey efforts in particular areas (e.g., Potomac, eastern shore)
- Future analyses may wish to consider additional ecological complexity and/or years of data

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DO Model

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