Habitat Use of eelgrass (Zostera marina) in Elkhorn Slough, CA

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Seagrass studies have contributed to understanding how structural complexity in the habitat influences distribution and abundance of organisms
Background: Seagrass ecology

‘Habitat-forming species’

- Physical morphology of plants alters flow in and around beds

(‘eelgrass’)

(Green and Short, 2003)
Background: Seagrass ecology

‘Habitat-forming species’

• Physical morphology of plants alters flow in and around beds

• Upright structure in an otherwise two-dimensional environment

‘eelgrass’

Zostera marina

Blades

Root - Rhizome

(Green and Short, 2003)
Background: Seagrass ecology

Roles of Seagrasses in Estuarine Ecosystems

- Food
- Habitat
- Sediment stabilization
Roles of Seagrasses in Estuarine Ecosystems

- Food
- Habitat
- Sediment stabilization
- Contribute to total primary productivity
- Meadows enhance biodiversity and habitat diversity
- Carbon, nutrient and geochemical cycling
Goal: Address habitat utilization of eelgrass (Zostera marina) in Elkhorn Slough, CA

I. SPECIES-HABITAT ASSOCIATIONS

What taxa occupy eelgrass, algae and bare habitats?
Goal: Address habitat utilization of eelgrass (*Zostera marina*) in Elkhorn Slough, CA

I. SPECIES-HABITAT ASSOCIATIONS

What taxa occupy eelgrass, algae and bare habitats?

Do they vary over time?
Introduction: Objective

Goal: Address habitat utilization of eelgrass (*Zostera marina*) in Elkhorn Slough, CA

I. SPECIES-HABITAT ASSOCIATIONS

What taxa occupy eelgrass, algae and bare habitats?

Do they vary over time?

II. NURSERY HABITAT FOR FISHES

Is eelgrass a potential nursery habitat for fishes within Elkhorn Slough?
Habitat

- Generally, where an organism lives

(Odum, 1971; Minello et al., 2003; Allen et al., 2006)
Habitat

• Generally, where an organism lives

• The place where a population of that species (or life stage) lives at any particular time

(Odum, 1971; Minello et al., 2003; Allen et al., 2006)
Introduction: Terminology

Habitat
• Generally, where an organism lives
• The place where a population of that species (or life stage) lives at any particular time

Nursery
• A concentration of juvenile stages feeding and growing
• One of the four main habitat functions of estuaries

(Odum, 1971; Minello et al., 2003; Allen et al., 2006)
• Higher density (D), growth (G), and survival (S) compared to other habitats

(Beck et al., 2001)
Introduction: Nursery Habitat

- Higher density (D), growth (G), and survival (S) compared to other habitats.
- Greater contribution to the production of recruits to adult populations than other habitats where juveniles occur.

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(Beck et al., 2001)
Introduction: Types of estuarine fishes - 1. Freshwater or brackish (Yoklavich et al. 2002; Allen et al. 2006)
Introduction: Types of estuarine fishes - 2. Residents

(Yoklavich et al. 2002; Allen et al. 2006)
Introduction: Types of estuarine fishes - 3. Partial residents

(Yoklavich et al. 2002; Allen et al. 2006)
Introduction: Types of estuarine fishes - 4. Immigrants/opportunists

(Yoklavich et al. 2002; Allen et al. 2006)
Seasonal patterns of abundance -

• Summer - high diversity and abundances; juveniles and adults enter, locally spawned larvae have grown larger

Seasonal patterns of abundance -

• Summer - high diversity and abundances, juveniles and adults enter, locally spawned larvae have grown larger.

• Fall - abundance and diversity decline, partial resident and immigrant fishes leave.

Introduction: Elkhorn Slough is a nursery for fishes

- shiner surfperch

- Pacific staghorn sculpin

- English sole

- leopard sharks

(Fish photos - Allen et al., 2006)

(Small, 1986; Brown, 2006; Carlisle and Starr, 2009)
Introduction: Possible roles of eelgrass as habitat

Many potential habitat functions for eelgrass in Elkhorn Slough
Introduction: Possible roles of eelgrass as habitat

Many potential habitat functions for eelgrass in Elkhorn Slough

- Seasonal refuge for migratory species
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• Seasonal refuge for migratory species

• Home to residents
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• Seasonal refuge for migratory species
• Home to residents
• Nursery habitat
Introduction: Possible roles of eelgrass as habitat

Many potential habitat functions for eelgrass in Elkhorn Slough

- Seasonal refuge for migratory species
- Home to residents
- Nursery habitat
- Refuge from flow
Methods: Sample sites

• Both beds are located 1-2 km east of HWY 1 bridge, within shallow areas along the north bank

• LOBO 400 m long, narrow strip

• Seal Bend is 500 m long S-E and 500 m wide W-E
Sampling shallow vegetated habitats is challenging due to Visibility, Small, cryptic species, and Trawl nets or seines would tear up eelgrass.
Methods: Throw trap sampling

- Throw traps provide relatively accurate estimates of fish
  - density
  - size
  - community structure
across a range of environmental conditions

(Jordan et al., 1997)
Methods: Throw trap sampling

- Fish abundance and standard length (mm)
- Invertebrate abundance
- Algal genera and biomass (wet weight (g)) per algae habitat sample were quantified
Methods: Sampling design

• Three sampling periods for 2008 - ‘season’
  Winter
  Spring/Summer
  Fall
Methods: Sampling design

• Three sampling periods for 2008 - ‘season’
  Winter
  Spring/Summer
  Fall

• Minimum 50 traps per ‘season’

  Zostera : Non-Zostera
Three sampling periods for 2008 - ‘season’
Winter
Spring/Summer
Fall

Minimum 50 traps per ‘season’

Zostera : Non-Zostera

Random, stratified sampling design was used avoiding edges of habitat interface
I. SPECIES-HABITAT ASSOCIATIONS

What taxa occupy eelgrass, algae and bare habitats?

Do they vary over time?

- Total abundance of taxa per habitat per time

- Mean density (#/m³) of common species per time

Methods: Data analysis
II. NURSERY HABITAT FOR FISHES

Is eelgrass a potential nursery habitat for fishes within Elkhorn Slough?

- Abundance of juveniles and adults within eelgrass, algae and bare habitats were compared
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Is eelgrass a potential nursery habitat for fishes within Elkhorn Slough?

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- Case studies
  Pacific staghorn sculpin
  bay pipefish
  three-spine stickleback
  shiner surfperch

Methods: Data analysis
Results: Algal habitat availability

- *Ulva sp.* was dominant algal habitat
- Absent during winter
Results: I. Species-habitat associations - fishes

- Eelgrass
  - Winter (n=39)

- Bare
  - Winter (n=38)

Species: P. staghorn sculpin, 3-spine stickleback, shiner surfperch, bay pipefish, arrow goby, black surfperch, speckled sanddab, English sole, starry flounder, butter sole, KGB rockfish, plainfin midshipman, tomselt, kelpfish, butter sole, starry flounder, English sole, speckled sanddab, dwarf surfperch, black surfperch, arrow goby, bay pipefish, shiner surfperch, 3-spine stickleback, P. staghorn sculpin

Total abundance
Results: I. Species-habitat associations - fishes
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1. Species-habitat associations - fishes

- P. staghorn sculpin
- 3-spine stickleback
- Shiner surfperch
- Bay pipefish
- Arrow goby
- Black surfperch
- Dwarf surfperch
- Speckled sanddab
- English sole
- Starry flounder
- Butter sole
- Kelpfish
- Butterfly sole
- Topsmelt
- Plainfin midshipman
- KGB rockfish
- Rockfish
- Bottomfish
- Eelgrass
- Winter (n=39)
- Eelgrass
- Sp/Sum (n=25)
- Eelgrass
- Fall (n=25)
Results: I. Species-habitat associations - invertebrates

- **Eelgrass**
  - Winter (n=39)
  - Sp/Sum (n=25)
  - Fall (n=25)

- **Bare**
  - Winter (n=38)
  - Sp/Sum (n=10)
  - Fall (n=12)

- **Algae**
  - Sp/Sum (n=15)
  - Fall (n=13)

Species:
- T. sea hare
- Idotea sp.
- Crangon sp.
- brachyuran crabs
- Amphipoda
- nudibranch
- snail
- hermit crab
- brachyuran crabs
- Crangon sp.
Results: I. Species-habitat associations - invertebrates

- Grass shrimp (Crangon sp.)
- Sea hare (Idotea sp.)
- T. sea hare
- Brachyuran crabs
- Hermit crab
- Amphipoda
- Nudibranch
- Snail

### Eelgrass
- Winter (n=39)
- Sp/Sum (n=25)
- Fall (n=25)

### Bare
- Winter (n=38)
- Sp/Sum (n=10)
- Algae

### Algae
- Sp/Sum (n=15)

Total abundance
Results: I. Temporal variation - Mean density of common species

### Invertebrates
- **Eelgrass (n=39)**
- **Bare (n=38)**

### Fishes
- **P. staghorn sculpin**
- **Arrow goby**
- **Bay pipefish**

#### Mean density (#/m³) +/- MSE

- **Grass shrimp**
- **Taylor's sea hare**
- **Idotea sp.**
- **Crangon sp.**
- **Shiner surperch**
- **3-spine stickleback**

**WINTER**
Results: I. Temporal variation - Mean density of common species

Mean density (#/m³) +/- MSE

Invertebrates

WINTER

- Eelgrass (n=39)
- Bare (n=38)

SPRING/SUMMER

- Eelgrass (n=25)
- Bare (n=10)
- Algae (n=15)

FALL

- Eelgrass (n=25)
- Bare (n=12)
- Algae (n=13)
Results: II. Nursery habitat - Total abundance of fishes per age class

- Juveniles
  - topsmelt
  - starry flounder
  - speckled sanddab
  - English sole
  - butter sole
  - KGB rockfish
  - plainfin midshipman
  - kelpfish
  - 3-spine stickleback
  - dwarf surfperch
  - black surfperch
  - shiner surfperch
  - bay pipefish
  - Pacific staghorn sculpin
  - arrow goby

- Adults
  - English sole
  - butter sole
  - KGB rockfish
  - plainfin midshipman
  - kelpfish
  - 3-spine stickleback
  - dwarf surfperch
  - black surfperch
  - shiner surfperch
  - bay pipefish
  - Pacific staghorn sculpin
  - arrow goby

Graph showing the total abundance of fishes per age class in the nursery habitat for 2008.
Results: II. Nursery habitat - Pacific staghorn sculpin

Pacific staghorn sculpin
(Leptocottus armatus)

Size at maturity
120 mm

SL (mm) per individual

WINTER
SPRING/
SUMMER
FALL

(29)(102) (8)(1)(24) (3) (total abundance)
Results: II. Nursery habitat - bay pipefish

bay pipefish (*Syngnathus leptorhynchus*)

Size at maturity: 100-120 mm

Reproductive Adults (Feb. - Oct.)

- WINTER: 9
- SPRING/Summer: 3
- FALL: 14

(total abundance)
Results: II. Nursery habitat - bay pipefish

bay pipefish (*Syngnathus leptorhynchus*)

- Size at maturity: 100-120 mm
- Reproductive Adults (Feb. - Oct.): 6-12 months old (9) (3) (14) (total abundance)

Size at maturity: 100-120 mm

- 6-12 months old: (9) (3) (14) (total abundance)

Reproductive Adults (Feb. - Oct.)
bay pipefish (*Syngnathus leptorhynchus*)

### Size at maturity

- **100-120 mm**

### Reproductive Adults (Feb. - Oct.)

- 6-12 months old: 9
- Adults, juveniles and recently hatched young: 14
- Total abundance: 32

**Graph Notes:**

- **SL (mm) per individual**
- **Size at maturity:** 100-120 mm
- **WINTER**: 6-12 months old
- **SPRING/SUMMER**: Adults, juveniles and recently hatched young
- **FALL**: 6-12 months old
- **(total abundance)**: 32
Results: II. Nursery habitat - three-spine stickleback

three-spine stickleback (*Gasterosteus aculeatus*)

Size at maturity 30-35 mm

SL (mm) per individual

<table>
<thead>
<tr>
<th></th>
<th>SPRING/SUMMER</th>
<th>FALL</th>
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<td>(41) (92)</td>
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(total abundance)
Results: II. Nursery habitat - shiner surfperch

shiner surfperch (*Cymatogaster aggregata*)

Size at maturity: 80 mm

<table>
<thead>
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<th>SL (mm) per individual</th>
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<tr>
<td>100</td>
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- **Zostera** (SPRING/SUMMER)
  - (60) individuals

- **Zostera** (FALL)
  - (1) individual
  - (4) individuals

- **Algae** (FALL)

(total abundance)
Discussion: eelgrass as nursery habitat

• Higher proportion of juveniles in eelgrass

Pacific staghorn sculpin

three-spine stickleback

shiner surfperch
Discussion: eelgrass as nursery habitat

• Higher proportion of juveniles in eelgrass

Pacific staghorn sculpin

three-spine stickleback

shiner surfperch

• Tagging, caging, or tracking studies could be used to test a nursery hypothesis for eelgrass within Elkhorn Slough
• The species assemblages change over time in all habitats
Project Summary

• The species assemblages change over time in all habitats.

• Eelgrass is an important habitat for permanent and migratory species.
Project Summary

• The species assemblages change over time in all habitats.

• Eelgrass is an important habitat for permanent and migratory species.

• Some species might rely on eelgrass as nursery habitat.
• The species assemblages change over time in all habitats

• Eelgrass is an important habitat for permanent and migratory species

• Some species might rely on eelgrass as nursery habitat

• Eelgrass can provide important physical and biological ecosystem services to these species
• The species assemblages change over time in all habitats

• Eelgrass is an important habitat for permanent and migratory species

• Some species might rely on eelgrass as nursery habitat

• Eelgrass can provide important physical and biological ecosystem services to these species

• Eelgrass in Elkhorn Slough should be monitored in the future
Acknowledgments

Thesis Committee

Lara
Mike
Greg

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