ILLINOIS NATURAL HISTORY SURVEY

Mechanisms Affecting Recruitment of Yellow Perch in Lake Michigan

John M. Dettmers[1], A. Scott McNaught[2], Doran M. Mason[3], John Janssen[4], and David J. Jude[5].

[1] Center for Aquatic Ecology, Illinois Natural History Survey
[2] Department of Biology, Central Michigan University
[3] Great Lakes Environmental Research Lab, National Oceanic and Atmospheric Adminstration
[4] Great Lakes WATER Institute, UW-Milwaukee
[5] Center for Great Lakes and Aquatic Science, University of Michigan

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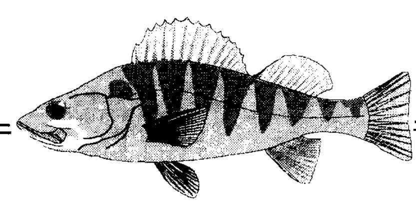

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June 1, 2000 - May 31, 2001

John M. Dettmers[1], A.Scott McNaught[2], Doran M. Mason[3], John Janssen[4], and David J. Jude[5]

[1] Center for Aquatic Ecology, Illinois Natural History Survey
[2] Department of Biology, Central Michigan University
[3] Great Lakes Environmental Research Lab, National Oceanic and Atmospheric Administration
[4] Great Lakes WATER Institute, UW-Milwaukee
[5] Center for Great Lakes and Aquatic Science, University of Michigan

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John M. Dettmers
Principal Investigator
Center for Aquatic Ecology

John M. Epifanio
Director, Center for Aquatic Ecology

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This report summarizes research activities during June 2000 - May 2001, the first year of activity associated with the project *Mechanisms affecting recruitment of yellow perch in Lake Michigan*. We summarize below the major field sampling that occurred during 2000; describe the results obtained to date for larval fish densities, zooplankton densities, acoustic transects, and examination of alewife stomachs; and provide a list of presentations given to national and international meetings using data from this first year of sampling.

Our goals for this project were to examine the relative importance of three possible mechanisms that may affect recruitment success of yellow perch. Those three mechanisms are 1) the importance of zooplankton food availability for larval perch survival, 2) the importance of alewife predation as an explanation for poor larval yellow perch survival, and 3) the importance of offshore transport by wind-driven currents to move larval yellow perch into patches that may be either favorable or unfavorable for survival, depending on zooplankton density and alewife abundance.

At this early stage of the project, we can report on each of these objectives individually but do not have the time series of data needed to compare the relative importance of each. We examine results from each component in more detail below.

Effects of Food Availability

Sampling locations.

All nearshore zooplankton and larval fish sampling was done in waters ≤ 10 m deep. Primary zooplankton sampling locations included Charlevoix, MI (cooperative data from Michigan DNR); Onekama, MI; Muskegon, MI; Evanston, IL; and Waukegan, IL (Figure 1).

Sampling and lab methodologies.

Zooplankton were sampled between late May and mid-August, with some locations sampling for shorter time periods. All zooplankton were collected with vertical tows through the entire water column of a 0.5-m diameter, 63-μm mesh, zooplankton net. Samples were immediately preserved in 5% sucrose-formalin. Zooplankton were sampled at depths of 3, 6, and 9 m at each location, except at Waukegan where zooplankton were collected only in 10 m of water. In the laboratory, zooplankton were counted and identified to the lowest practicable taxon, generally sub-order for copepods and genus for cladocerans.

Larval fish also were sampled between late May and mid-August, with some locations sampling for shorter time periods. All nearshore larval yellow perch sampling was done in waters < 10 m deep, with replicate tows conducted over depths of 3, 6, and 9 m, except over depths of 5 m and 10 m at Waukegan. All larval yellow perch were collected at night by 2-m x 1-m frame neuston nets towed near the surface at speeds of 1.5-2.0 m/s. All nets were equipped with a flowmeter mounted in the mouth of the net to estimate the volume of water filtered by each net. We sequentially increased neuston net mesh size from 500-μm to 1000-μm, and finally to 1800-μm as the larval fish grew. All larvae were preserved immediately in 95% ethanol. In the laboratory, fish larvae were counted and identified to species.

Results.

Zooplankton density was greater in the northern half of the lake during 2000. Zooplankton were most abundant near Onekama, with peak zooplankton densities above 100/L when larval yellow perch were present (Figure 2). Conversely, zooplankton density peaked at 40/L or less in each of the three southern locations (Figure 2). Interestingly, zooplankton density peaked by mid-June in the northern half of the lake but did not peak until late June or early July in the south. Initial investigations also indicate that zooplankton densities, although broadly consistent, do vary among depths within a given sampling location.

The zooplankton assemblage was generally dominated by copepod nauplii and either calanoid or cyclopoid copepodites (Figure 2). However, *Bosmina* were an important component of the assemblage at the eastern and southeastern sites. Continued sampling of zooplankton will occur during 2001.

Peak densities of larval yellow perch were even more variable than were zooplankton densities. Larval yellow perch were most dense at Onekama, at > 40 larvae /100m^3 (Figure 2). Muskegon and Waukegan saw peak larval perch densities of > 20/100m^3, but Evanston and Charlevoix saw only very low larval fish densities (Figure 2). Continued sampling of larval fish will occur during 2001.

Effects of Predation

Sampling locations.

Hydroacoustic sampling was conducted near Waukegan, from approximately 1.8 km offshore to 13.3 km (from 2 to 7 nautical miles offshore) offshore during mid-June through mid-August of 2000. Gillnets were set to collect alewife stomachs at Waukegan, Muskegon, and Onekama.

Hydroacoustic sampling methodology.

Hydroacoustic data were collected using a Biosonics 129kHz DT6000 digital split-beam transducer from mid-May to mid-July during 1999 and 2000. Surveys were conducted at night along transects established by the Illinois Natural History Survey (INHS). The transducer was deployed in a down-looking configuration for acoustic sampling parallel to shore in 10m water depth. Data along this transect were collected simultaneously with a bottom trawl for ground truthing of acoustic targets. Down-looking data were also collected along a transect perpendicular to shore, starting in 10m water depth, and extending out 6 nautical miles, terminating in approximately 50m water depth. The down-looking configuration of the transducer allowed for determination of alewife distribution along the transect, as well as possible identification of larval perch at depths greater than that sampled by INHS using traditional gear.

Data were collected using the transducer in the side-looking configuration starting at the end of the offshore transect, and ending nearshore in 10m of water. Neuston net samples (see above for specifics) were collected at four points along the transect (1.5, 3.0, 4.5, and 6.0 nautical miles offshore from our starting location, about 1 nautical mile form shore) in conjunction with side-looking hydroacoustics data for ground-truthing of acoustic targets and density estimate comparisons.

Alewife collection methods.

Adult alewife were collected for analysis of stomach contents at Muskegon, Onekama, and Waukegan during the 2000 field season. Alewife were captured using floating gill nets at Muskegon and both floating gill nets and bottom trawling at Waukegan. Gill nets with panels of 25- 38- and 44- mm stretched mesh were set for 30 – 45 min immediately after dark. A semi-balloon otter trawl with a 16-ft headrope was used to collect alewife on nights hydroacoustic sampling was conducted. All adult alewife were immediately measured (nearest mm), sexed, and their stomach removed. Stomachs were placed into a vial of alcohol for later examination in the laboratory.

Results.

Analysis of down-looking acoustic data for 1999 and 2000 showed alewife were likely present in the upper water column (<10m) in offshore areas during periods of thermal stratification in late-June through mid-July. Neuston net data from 2000 indicated that larval yellow perch were also present along the entire offshore transect in the top 1m of water during that same time period. Previous studies (Brandt et al. 1987, Mason and Brandt 1996) have shown alewife predation on larval yellow perch will occur during periods of spatial and temporal overlap. Acoustic and neuston net data suggest that alewife predation may have occurred in 1999 and 2000 due to evidence of such overlap.

Side-looking data suggests hydroacoustics may provide an efficient means of estimating larval fish densities. Hydroacoustic density estimates in 2000 were similar to those obtained using neuston nets on nights of little surface disturbance (Fig. 3). During times of surface disturbance, hydroacoustic density estimates were greatly inflated. Results of these analyses do not currently differentiate between larval perch and other targets present in the water. To better define the target strength of larval yellow perch, laboratory work will be completed during summer 2001 to allow for the determination of expected hydroacoustic "size" (target strength) of larval perch during from hatch through 16mm. This size range allows for target strength estimation of fish during different stages of air bladder development. Continued field sampling in 2001 will occur based on the success of the 2000 field season.

Little direct evidence of alewife predation was observed based on examination of alewife stomach contents. Near Waukegan, over 200 alewife were collected for diet analysis, of which 86 have been examined to date. Of the 86 alewife stomach examined, 78 had food items present, but no alewife had larval fish present in its stomach. Near Muskegon, none of the 23 alewife examined had consumed larval fish. Data from the sampling at Onekama were not avialble at this time due to problems associated with a graduate student unexpectedly leaving the program at Central Michigan University. Sampling of alewife stomachs will continue in 2001, as will processing of stomachs remaining from 2000.

Laboratory experiments to be conducted by Central Michigan University have been delayed because of problems recruiting and keeping a graduate student.

Effects of Wind-driven Transport

Study sites.

We sampled one transect from nearshore to offshore in conjunction with hydroacoustic sampling at the transect near Waukegan described above. We also sampled in nearshore waters on the same night at Evanston and Muskegon to detect possible differences in larval yellow perch density as a function of wind speed and direction.

Methods.

Larval fish were sampled with neuston nets as described above. To explore the possibility that wind-driven transport affects the observed density of larval yellow perch in nearshore areas, sampling was coordinated between Muskegon (Jude) and Evanston (Janssen) during 2000 and between Muskegon and Milwaukee (Janssen) in 2001. In 2000 the Janssen Group collected "standard" samples on 9 nights and in 2001 the Janssen Group did the standard sampling on 8 nights. Standard sampling included triplicate 5-minute tows with a 1m x 2 m neuston net at a shallow station (3 m in 2000, 5 m in 2001) and a deep station (6 m in 2000 and 10 m in 2001). The difference in depth between the two years was due to differences in bottom topography between the Illinois site and the Wisconsin site. The samples from the Jude Group includes 8 nights in 2000 and 11 nights in 2001 with standard samples at 3 and 6 meters for neuston netting and zooplankton.

Juvenile yellow perch were collected by trawling at Waukegan, beach seining at Evanston, and by seining and trawling at Muskegon during July - September of 2000.

Results.

Evidence of wind-driven current dispersal of larval yellow perch comes from our standard nearshore sampling at Evanston and Milwaukee. Of the 17 sampling dates for 2000-2001 we had upwelling or downwelling events on 8 dates. Our analyses indicate that larval yellow perch at the yolk stage are more abundant offshore with offshore winds but more abundant nearshore with onshore winds ($P < 0.025$; $F = 9.1$; 1,6 df). There was no difference between years/sites (2000 vs 2001 and WI vs IL) indicating that the pattern is general. The pattern of larval yellow perch distribution at Muskegon for 2000 compliments that found by the Janssen Group. Offshore winds for the west side (Janssen) of Lake Michigan would be onshore for the east side (Jude) and vide/versa. In general, when Jude had large numbers of larval yellow perch it was correlated with onshore winds in Michigan. Janssen's samples had few larval yellow perch during those same events. Onshore winds for the west side resulted in high larval yellow perch counts for Janssen and low counts for Jude.

Along the nearshore - offshore transect near Waukegan, larval yellow perch were first detected on June 6, only at the nearshore sampling location over 10 m of water. This location is an historical location where yellow perch spawn and yellow perch larvae have been detected there for over 10 years. By mid-June, larvae were present as far as 13.3 km from shore and were collected at all five sampling locations. By late-June, larvae continued to be present throughout the Waukegan transect. In early July, larval yellow perch densities began to decline and by July 13, a single yellow perch larva was found at the farthest offshore location we sampled. Furthermore, larval yellow perch were larger farther offshore (2-way ANOVA, distance effect, $F_{3,739} = 38.59$, $P < 0.001$), suggesting that older, larger larvae were pushed offshore farther from initial hatching locations relatively near shore. We also analyzed these length data with analysis of covariance (ANCOVA), using date as the covariate to explore whether different sizes of larvae passed through our sampling transect. The result of this analysis indicates that a significant date*distance interaction is present (ANCOVA, $F_{3,752} = 77.12$, $P < 0.001$), suggesting that we are seeing different larval yellow perch cohorts move through our sampling transect.

Juvenile yellow perch were very scarce during 2000. One juvenile was collected from near Waukegan, no juveniles were collected from Evanston, and 5 were collected from Muskegon. Otoliths collected from juvenile yellow perch are currently being analyzed for the $^{18}O/^{16}O$ isotope ratio present to determine the thermal history of surviving juveniles that survive to be captured in our trawls and beach seines.

Synthetic Analyses

No synthetic analyses have been conducted to date because we have only 1 year of data to work with.

Deliverables

Meeting Presentations. Several talks directly incorporating data from the 2000 sampling were given at the annual meeting of the International Association of Great Lakes Research, held in Green Bay. A list of talks and authors follows below.

Balge, M. B., and D, M, Mason. 2001. Use of side-looking hydroacoustics to detect and estimate density of larval yellow perch in Lake Michigan. International Association of Great Lakes Research, Green Bay, Wisconsin, June 10 - 14, 2001.

Dettmers, J. M., B. Pientka, and J. Janssen. 2001. Evidence for offshore transport of yellow perch larvae in southern Lake Michigan. International Association of Great Lakes Research, Green Bay, Wisconsin, June 10 - 14, 2001.

Janssen, J., and D. J. Jude. 2001. Lake Michigan yellow perch: washed up or washed out? International Association of Great Lakes Research, Green Bay, Wisconsin, June 10 - 14, 2001.

McNaught, A. S., J. M. Dettmers, D. J. Jude, and D. F. Clapp. 2001. Spatial and temporal availability of food resources for larval yellow perch in Lake Michigan. International Association of Great Lakes Research, Green Bay, Wisconsin, June 10 - 14, 2001.

Peer-reviewed publications. We are currently organizing groups to develop manuscripts. At least one manuscript on the lakewide nearshore zooplankton is in the planning stages, with others deriving from our findings regarding the offshore transport of larval yellow perch also in the planning stages.

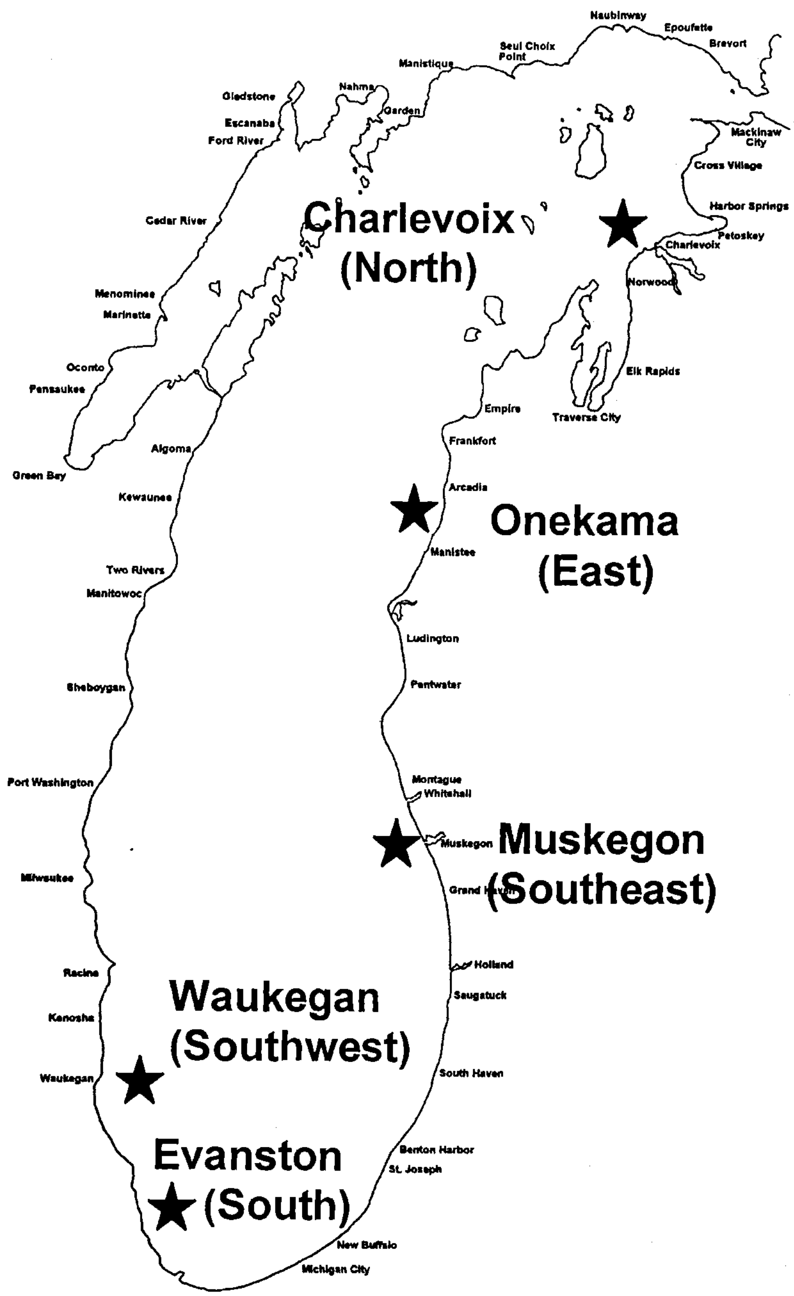
Literature Cited

Brandt, S.B., D.M. Mason, D.B. MacNeill, T. Coates, and J.E. Gannon. 1987. Predation by alewives on larvae of yellow perch in Lake Ontario. Transactions of the American Fisheries Society 116:641-645

Mason, D.M. and S.B. Brandt. 1996. Effect of alewife predation on survival of larval yellow perch in an embayment of Lake Ontario. Canadian Journal of Fisheries and Aquatic Sciences 45:1820-1826

List of Figures

Figure 1.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Brevort
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Harbor Springs
Petoskey
Charlevoix
Charlevoix
(North)
Cedar River
Norwood
Menominee
Marinette
Oconto
Pensaukee
Elk Rapids
Empire
Traverse City
Frankfort
Algoma
Green Bay
Kewaunee
Arcadia
Onekama
(East)
Manistee
Two Rivers
Manitowoc
Ludington
Pentwater
Sheboygan
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Muskegon
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Milwaukee
Holland
Racine
Saugatuck
Waukegan
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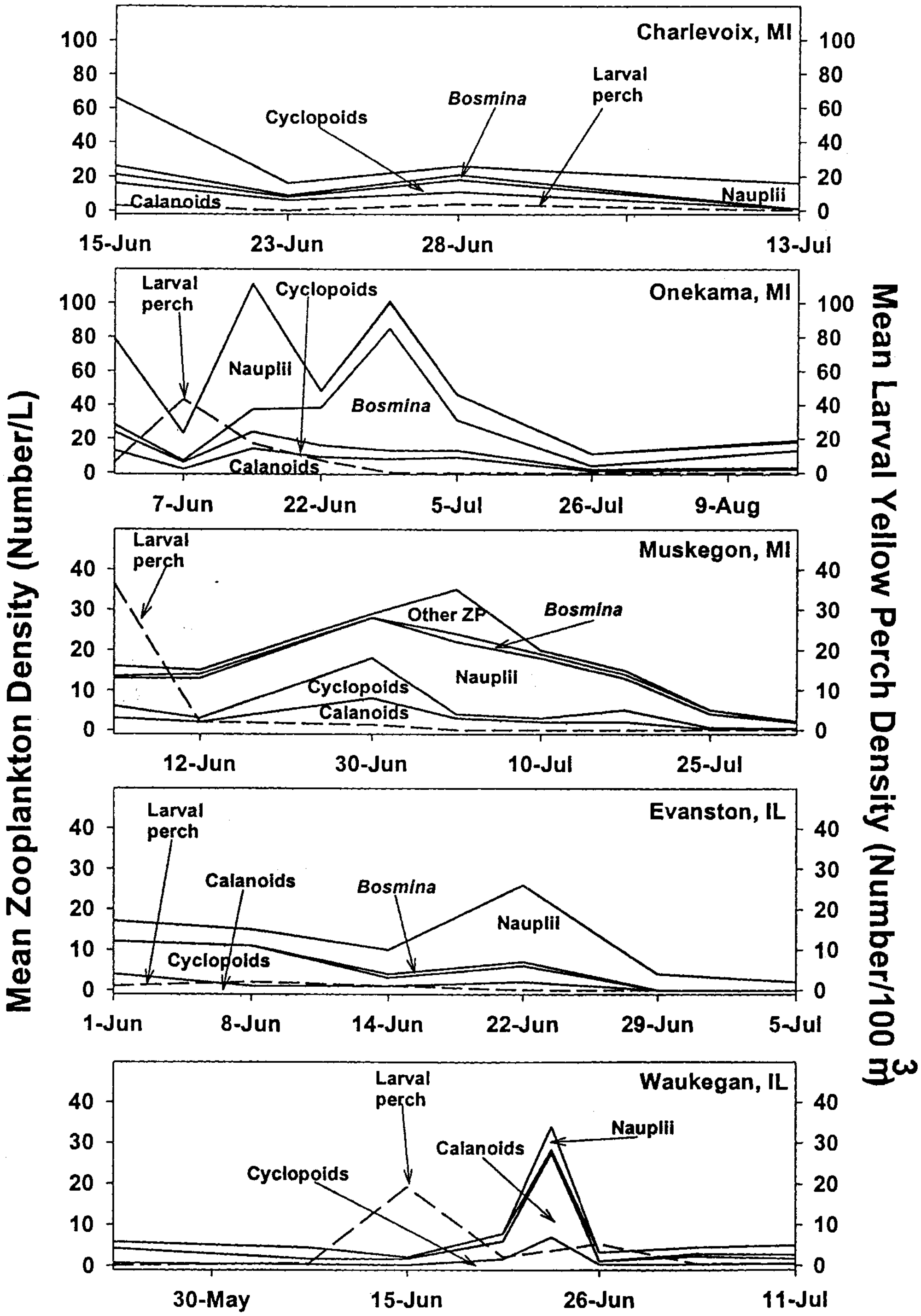
Kenosha
Waukegan
South Haven
Evanston
(South)
Benton Harbor
St. Joseph
New Buffalo
Michigan City

Figure2.


Charlevoix, MI
Larval perch
Bosmina
Cyclopoids
Nauplii
Calanoids
15-Jun
23-Jun
28-Jun
13-Jul
Onekama, MI
Larval perch
Cyclopoids
Nauplii
Bosmina
Calanoids
7-Jun
22-Jun
5-Jul
26-Jul
9-Aug
Muskegon, MI
Larval perch
Other ZP
Bosmina
Nauplii
Cyclopoids
Calanoids
12-Jun
30-Jun
10-Jul
25-Jul
Evanston, IL
Larval perch
Calanoids
Bosmina
Nauplii
Cyclopoids
1-Jun
8-Jun
14-Jun
22-Jun
29-Jun
5-Jul
Waukegan, IL
Larval perch
Nauplii
Calanoids
Cyclopoids
30-May
15-Jun
26-Jun
11-Jul
Mean Zooplankton Density (Number/L)
Mean Larval Yellow Perch Density (Number/100 m3)

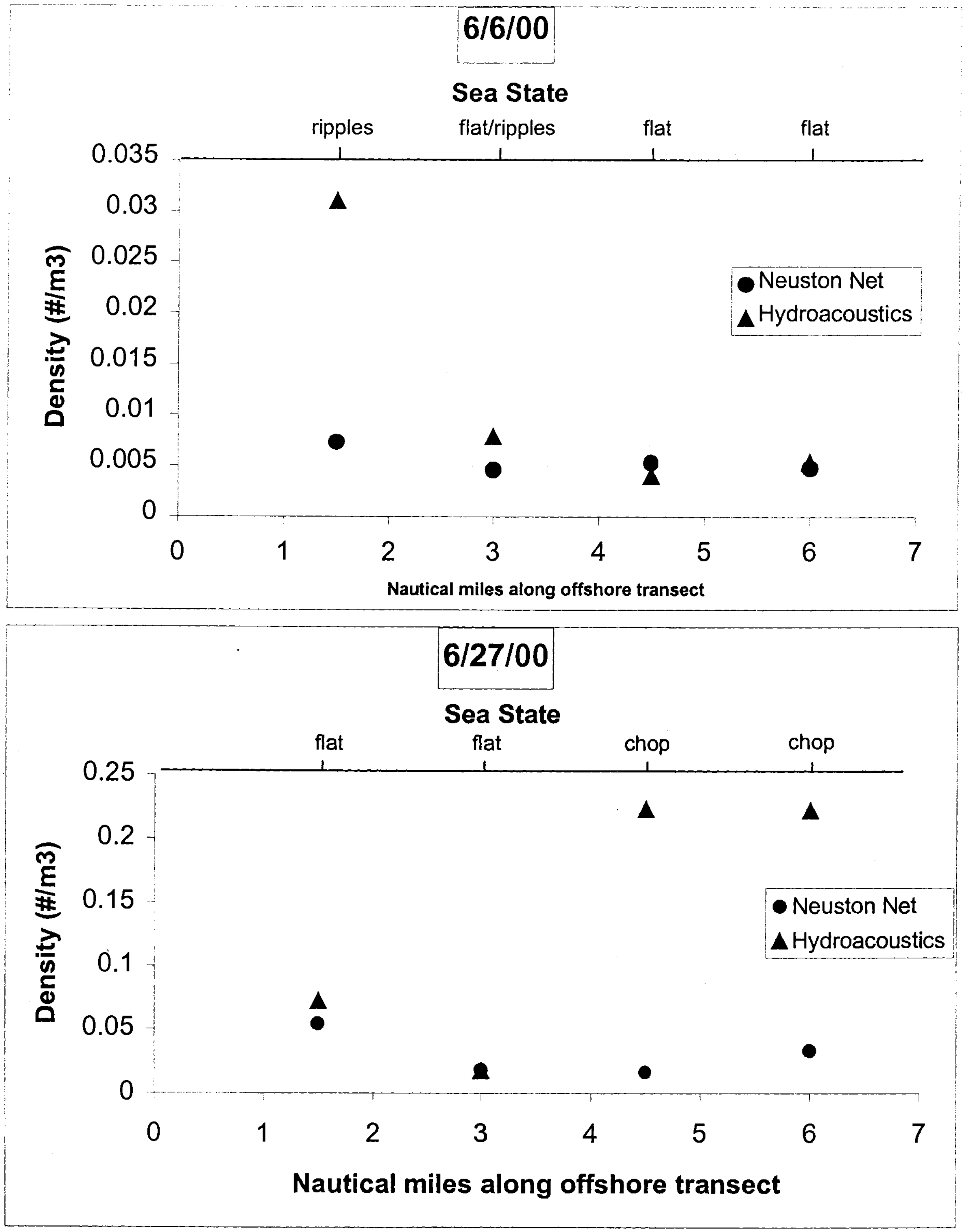

6/6/00
Sea State
ripples
flat/ripples
flat
flat
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Density (#/m3)
Neuston Net
Hydroacoustics
0
1
2
3
4
5
6
7
Nautical miles along offshore transect
6/27/00
Sea State
flat
flat
chop
chop
0.25
0.2
0.15
0.1
0.05
0
Density (#/m3)
Neuston Net
Hydroacoustics
0
1
2
3
4
5
6
7
Nautical miles along offshore transect

Figure 3.

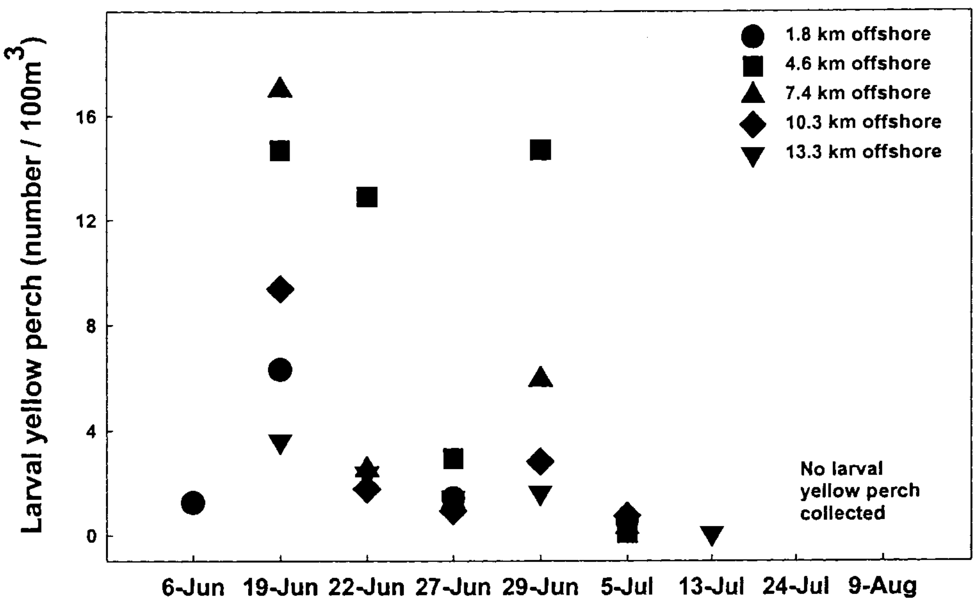

Larval yellow perch (number / 100m3)
16
12
8
4
0
1.8 km offshore
4.6 km offshore
7.4 km offshore
10.3 km offshore
13.3 km offshore
No larval
yellow perch
collected
6-Jun
19-Jun
22-Jun
27-Jun
29-Jun
5-Jul
13-Jul
24-Jul
9-Aug

Figure 4.

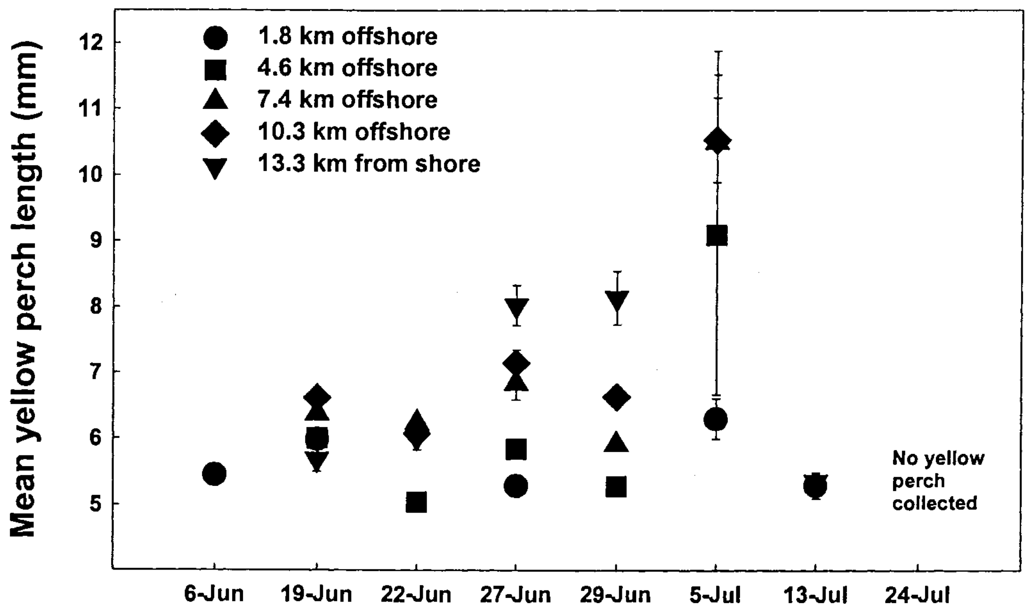

Mean yellow perch length (mm)
12
11
10
9
8
7
6
5
1.8 km offshore
4.6 km offshore
7.4 km offshore
10.3 km offshore
13.3 km from shore
No yellow perch collected
6-Jun
19-Jun
22-Jun
27-Jun
29-Jun
5-Jul
13-Jul
24-Jul

Figure 5.