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EVIDENCE FOR A RELATION BETWEEN A WHITE PERCH YOUNG-OF-THE-YEAR INDEX AND INDICES OF LATER LIFE STAGES

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Abstract

Juvenile indices are employed in fisheries management to predict the future relative abundance of harvestable adults and to monitor the success of management efforts. Frequently, regulations controlling utilization of the resource, and a lack of fishery independent abundance data, make verification of the prediction impossible. In the case of white perch (Morone americana) in Virginia, this is not so. Using the weighting system developed for a Chesapeake Bay-wide index of juvenile striped bass abundance based on summertime beach seine data collected in nursery ground waters, we developed a similar index for white perch in the Virginia portion of the Bay. Regressions against Virginia Institute of Marine Science otter trawl survey indices (taken in deep, mesohaline water during winter months) for young-of-the-year ($r^2 = 0.597$, $p = 0.003$) and age 1+ ($r^2 = 0.703$, $p < 0.001$) white perch were significant and positive. These results lend support for the continued use of juvenile indices for finfish management.

Introduction

Indices of juvenile abundance are increasingly being used as fisheries management tools. The 1981 striped bass management plan adopted by the Atlantic States Marine Fisheries Commission (ASMFC) used an index of juvenile abundance as an indicator for tightening or relaxing of fishing regulations. This juvenile index is constructed from the beach seine survey of the Maryland Department of Natural Resources. The ASMFC plan contained no enforcement provisions. The Federal Atlantic Coast Striped Bass Conservation Act of 1986 codified the use of the Maryland striped bass juvenile index, and is the first instance of a juvenile index becoming part of law. The Atlantic Coast Fisheries Conservation and Management Act of 1994 makes ASMFC management plans binding on the states, with non-compliance triggering a federal moratorium. Many of the ASMFC management plans rely on juvenile indices, e.g. summer flounder, bluefish and weakfish.

The use of a juvenile index assumes there to be a positive relationship between the abundance of young-of-the-year (YOY) fish one year and subsequent adults. It is highly desirable to confirm the existence of this relation. The Maryland striped bass index was validated by comparison to the commercial harvest on following years (Goodyear 1985). When the size of the commercial catch depends on regulation instead of stock abundance (as does striped bass now), this method cannot be employed. What is needed then, is a fishery-independent measure of adult stock size. For white perch (Morone americana) we were able to construct a juvenile index and demonstrate a solid relationship to subsequent one year olds.

Virginia Institute of Marine Science (VIMS) conducts a summer beach seine survey to evaluate the abundance of YOY striped bass (Colvocoresses 1984). This survey takes place in the upper reaches of the rivers, in shallow water, adjacent to shore. Because the congeneric white perch uses the same spawning and nursery grounds (Rinaldo 1971, Setzler-Hamilton 1991, Cowan and Rose 1993), this species is captured as well, and data on all species in the seine are kept.

VIMS also operates a year-round trawl survey of the lower portion of the Chesapeake Bay and the major Virginia tributaries. Each month sites in the James, York, and Rappahannock Rivers, and the Bay proper, are visited and sampled with a 9.7 meter semi-balloon otter trawl (Bonzek et al 1993). The survey is designed "to produce annual indices of juvenile (young-of-year) abundance of commercially, recreationally and ecologically important marine and estuarine finfish and crustaceans" (Bonzek et al. 1993). White perch is among the species for which a juvenile index is produced. This makes possible a second index of abundance produced concurrently with the beach seine survey.

While the VIMS trawl survey program is not designed to sample adult populations, in the case of white perch it does so very well. From these data, an index of age 1+ fish is produced (Bonzek et al. 1993).

Methods

Using a Chesapeake Bay-wide striped bass juvenile index as a model (Austin et al. 1993), we constructed a similar index for white perch in the major Virginia tributaries to the Bay. These indices are weighted, geometric means. The basis of the white perch juvenile abundance index is catch per unit effort data collected by the VIMS beach seine survey (see Colvocoresses 1984) in the months July - September. The Chesapeake Bay-wide striped bass index used a weighting system based on the surface area of the respective spawning areas within the major tributaries of the Bay, the James, York, and Rappahannock Rivers (in Virginia), the Potomac, Choptank and Nanticoke Rivers and the area known as the Head of the Bay (in Maryland). We used the weights from the Virginia rivers.

On a monthly basis, the VIMS trawl survey visits each of the three major Virginia rivers and the Chesapeake Bay proper. Data for certain months and certain areas are used in the construction of abundance indices for particular species. In the case of white perch, it would not make sense to include Chesapeake Bay data in the index, because the salinity precludes white perch being found there. Also, in warm water months white perch leave the deep water areas sampled by the otter trawl. Thus, the white perch otter trawl indices are constructed from data from the upper reaches of the rivers, taken in the months December - February (YOY) and November - February (age 1+) (Geer et al. 1993). Further, there are two strata per river (up-river and down-river), of which only the up-river strata are used in calculating white perch indices (Geer et al. 1993). The trawl survey white perch indices used here were prepared by VIMS (Christopher F. Bonzek, pers. comm., VIMS, Gloucester Point, Va. 23062).

The indices are constructed by taking the weighted means of the log-transformed catch per haul data, and performing a "back-transformation," as follows:

$$\bar{x}_t = EXP\left[\sum_{k=1}^{3}\left[\left[\frac{\sum_{i=1}^{n_k}\ln(x_{ik}+1)}{n_k}\right]wt_k\right]\right]-1.$$

Here k = 1 = James River, 2 = York River and 3 = Rappahannock River. The weighting factors (wt) for the beach seine index were calculated from the spawning areas of the respective rivers, and the weights for the trawl indices were calculated from the surface areas of strata within the rivers. The n are the numbers of times the k^{th} river system was visited in a particular year.

The construction of the beach seine juvenile index presented here differs slightly from the index of Austin et al. (1993) in the location of the weights and the back-transformation. The index was modified so that it would be directly comparable to the indices constructed by the trawl survey team.

The VIMS beach seine survey was not conducted from 1974-1979, due to a lack of funding. We used the uninterrupted data from 1980 to the present. However, the trawl survey juvenile index begins in 1982, so data for the years 1982 to 1992 were used when comparing the two juvenile indices. The VIMS age 1+ index begins earlier, and we were able to compare the beach seine survey juvenile index from 1980 - 1992 to the trawl survey age 1+ index from 1981 - 1993, respectively lagged one year.

Indices of juvenile abundance were compared using linear regression, with the seine survey index being the independent variable. Because the two indices are spatially and temporally independent, this provided a corroboration of the validity of the beach seine survey to accurately reflect trends in the juvenile population.

The beach seine juvenile index was regressed as the independent variable against the trawl survey age 1+ index, lagged one year. This tested the ability of the juvenile index to predict trends in the population abundance of subsequent one year olds. This analysis assumes that the trawl survey age 1+ population is dominated by one year old fish.

Results

Regression of the beach seine juvenile index against trawl survey juvenile index (Figure 1) produced a highly significant relationship ($r^2 = 0.597$, $p = 0.003$). These indices are entirely independent of each other, and are also spatially and temporally disjoint. If two independent measures of a population disagree, it is impossible to say that one or the other is correct. However, an analysis such as this one gives strong support to the hypothesis that both sampling methods are adequately sampling the populations on which they are employed, and that the populations are one and the same.

The juvenile index created from the beach seine data was used to predict the abundance of age 1+ fish, again by linear regression (Figure 2). The fit of these data ($r^2 = 0.219$, $p = 0.107$) was flawed by a single outlier in Y (1985). This outlier was confirmed by examination of the residuals, and was determined to be elevated by large trawl survey catches in the Rappahannock River. Inspection of the raw data revealed that catches were consistently high in the Rappahannock River that year, and we feel that some environmental effect (e.g. fresh water discharge, temperature) probably caused survival of the 1984 year class to be particularly high, despite it being a fairly small year class.

After deleting the 1984/85 data pair, the beach seine juvenile index predicted the trawl survey age 1+ index very well. Regression (Figure 3) yielded a highly significant relationship ($r^2 = 0.703$, $p < 0.001$).

Discussion

Several attempts at validating indices of juvenile white perch abundance have been made, but with little success. One attempt (Barth et al. 1988) met with difficulties in the fishery-dependent data such as inconsistent and unusable estimates of effort, keypunch errors, and a lack of age-structure information. Difficulties were also found in the fishery-independent (beach seine) data, in particular the break in the Virginia time series from 1974-79. Another attempt at validating a white perch juvenile index against commercial landings on the Choptank River, Md. (Bolgiano and Boswell 1987) met with limited success by lagging the index three years.

There exists a question of the age composition of the age 1+ stock. At present researchers at VIMS are pursuing research designed to reveal a length at age relationship in the age 1+ trawl survey catch. When this information becomes available it will be possible to know with better certainty the age composition of the 1+ stock. We feel that the very significant relationship seen in the juvenile index versus age 1+ scatter plot (Figure 3) could not have occurred were the age 1+ stock not dominated by one year old fish.

The recreational and commercial fisheries for white perch in Virginia are important, and considerable fishing pressure exists (pers. obs.). Although no long-term downward trend is apparent in the index of age 1+ white perch abundance (Figure 4), or the Virginia commercial landings data (Figure 5), the potential certainly exists. It is interesting to note that the 1987 commercial harvest in Virginia is unusually large (Figure 5), following two years after an anomalously high age 1+ trawl survey index (Figure 4), suggesting that the commercial catch may have been dominated by three year old fish. However, this seems unlikely. Three year old white perch would be 100-125 mm in length (Piavis 1993), which is too small for the food market. The catch would have been early in the spring, before crab-potting activity, and we do not know of white perch being used by the cat food canners. Also, gill nets are sized to avoid catching fish this size.

Until such time as the age composition of the commercial harvest is established, we are unable to predict trends in the catch. We propose to sample the harvest in the near future to determine the age structure of the market catch. This will enable us to construct a model predicting catch from the beach seine juvenile index. Effort data remain problematic.

Using fisheries-independent data, we have confirmed that the beach seine juvenile index accurately predicts the subsequent size of the one year old population. Because so few indices of juvenile abundance have been validated, the good agreement of the white perch juvenile index with the age 1+ index should be taken as circumstantial evidence for the credibility of using juvenile indices in making management decisions. Ideally, each index should be tested for predicting accurately the trend in adult population size. However, this is not always possible (e.g. Austin et al. 1993). This study lends support to the concept that management agencies should (and undoubtedly will) continue to use indices of juvenile abundance as a key management tool to provide stock assessment.

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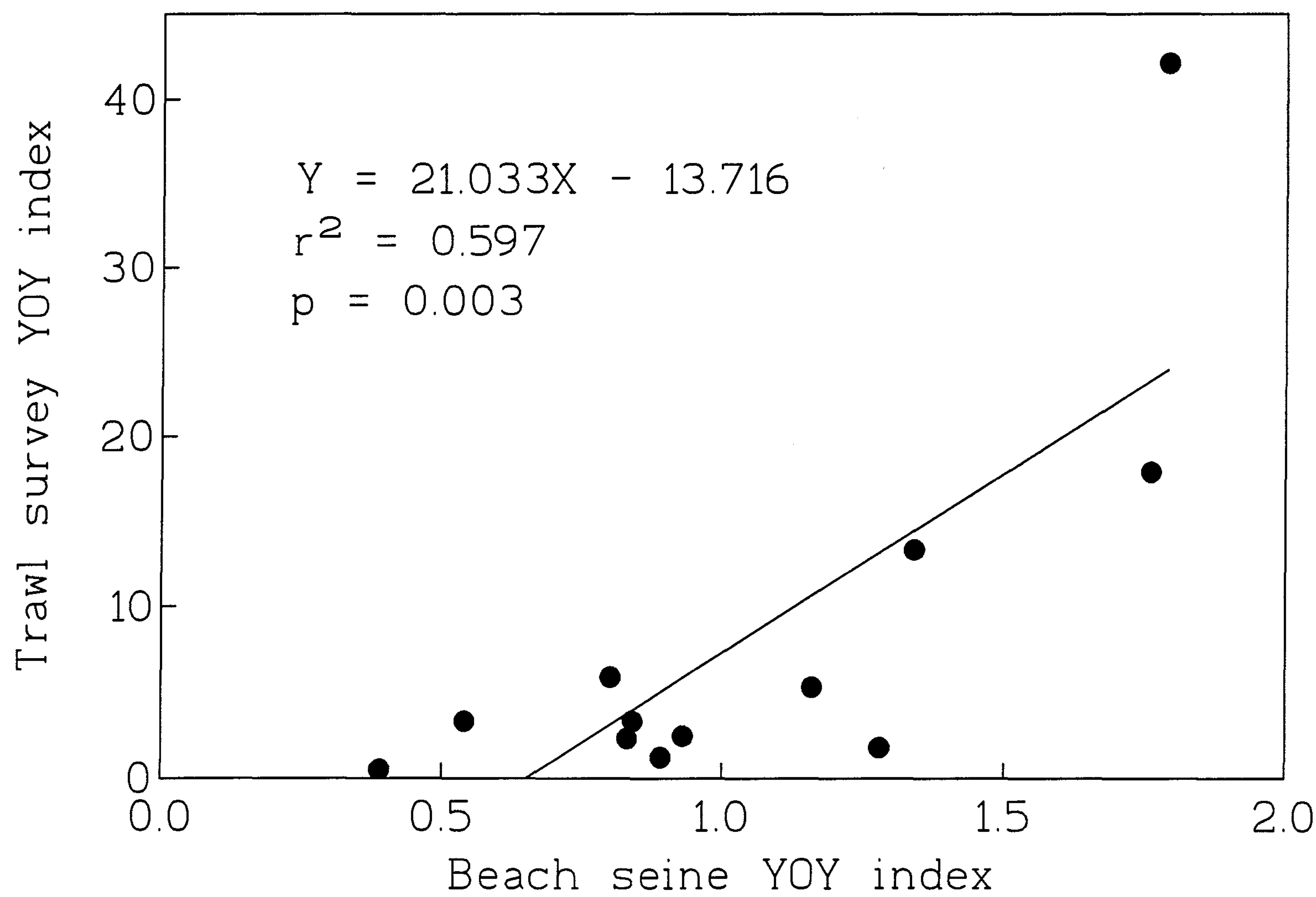
List of Figures

Figure 1



Y = 21.033X - 13.716
r2 = 0.597
p = 0.003
Trawl survey YOY index
Beach seine YOY index
0
10
20
30
40
0.0
0.5
1.0
1.5
2.0

Figure 2

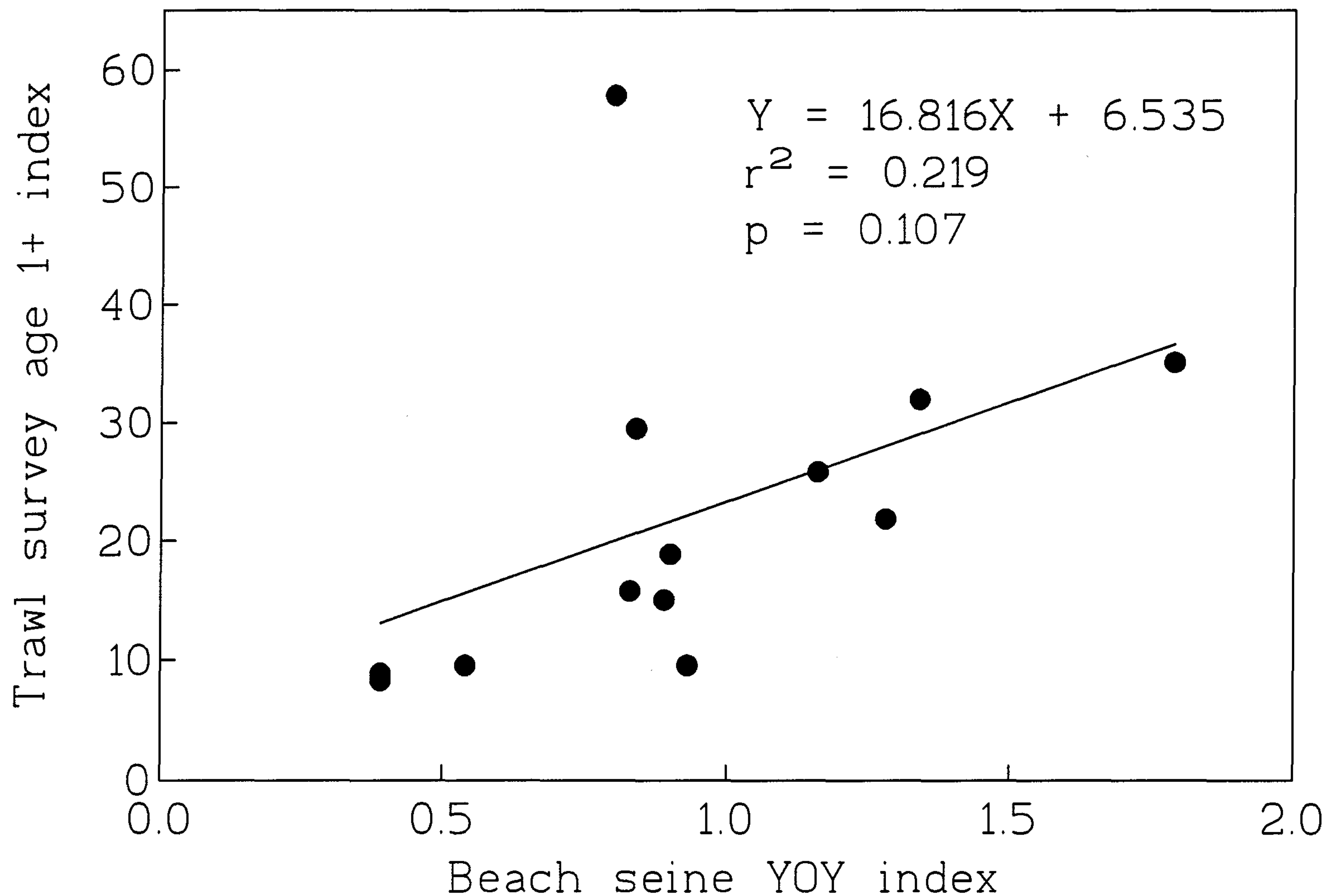

Y = 16.816X + 6.535
r2 = 0.219
p = 0.107
Trawl survey age 1+ index
Beach seine YOY index
0
10
20
30
40
50
60
0.0
0.5
1.0
1.5
2.0

Figure 3

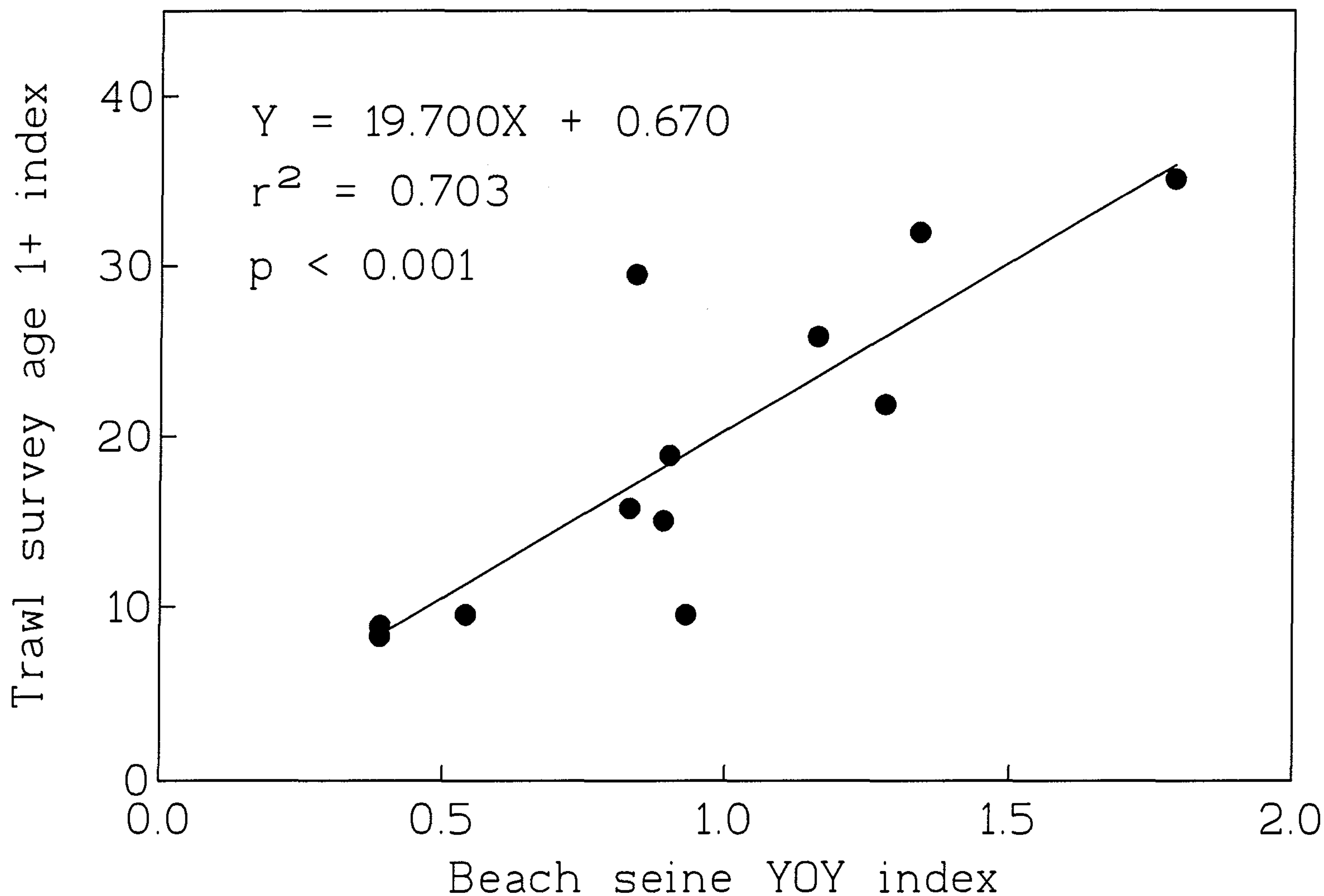

Y = 19.700X + 0.670
r² = 0.703
p < 0.001
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
Trawl survey age 1+ index
Beach seine YOY index

Figure 4

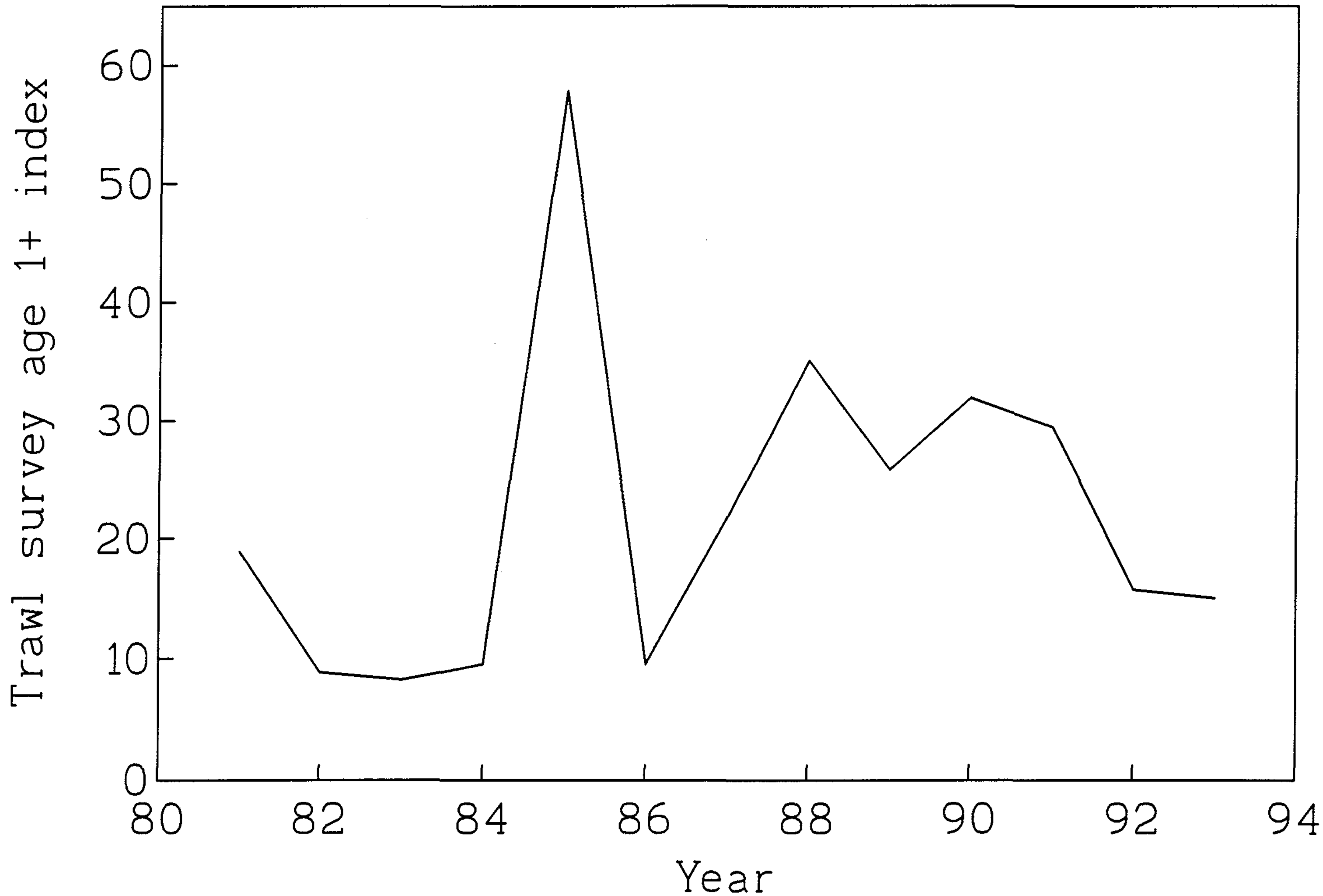
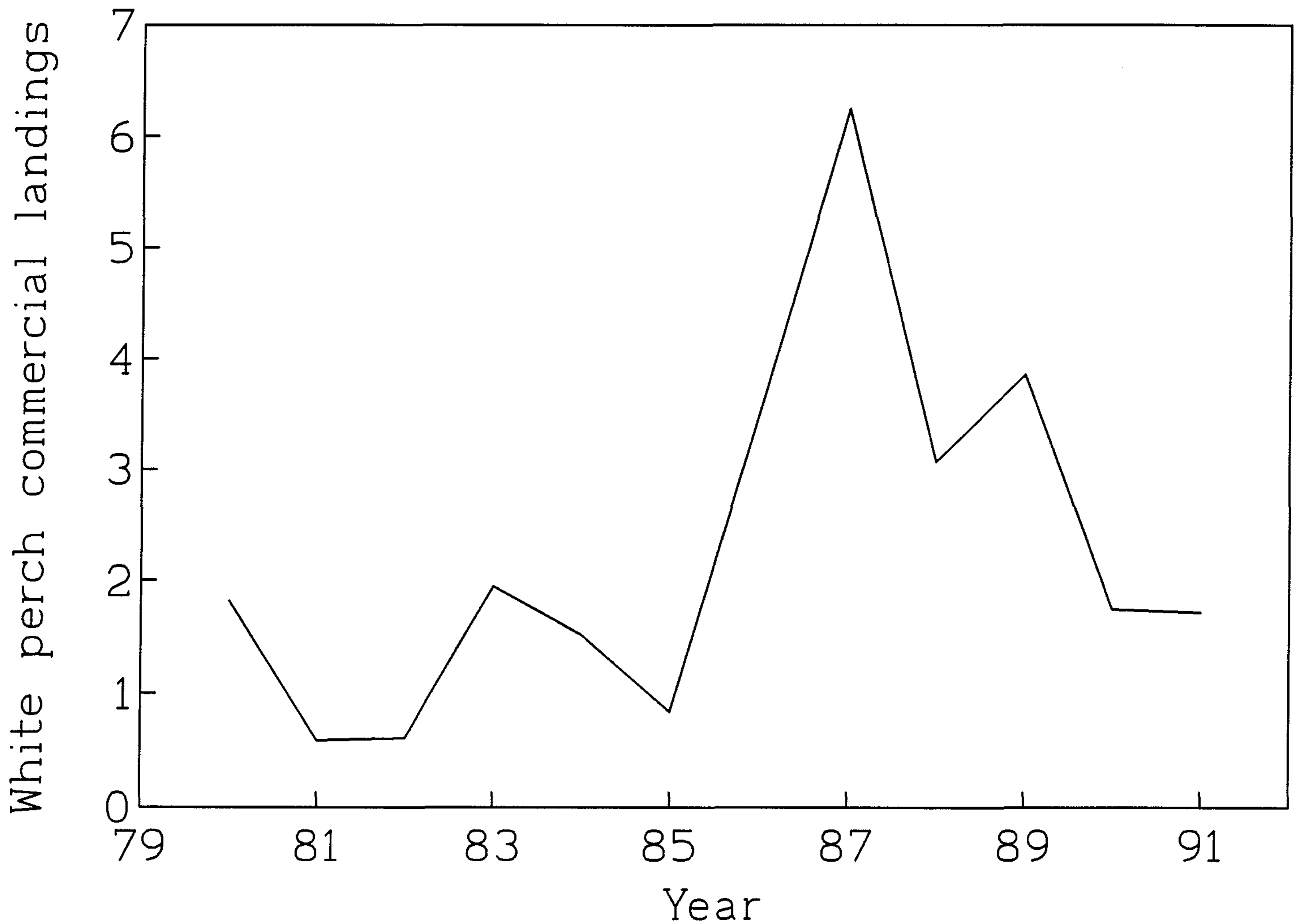

Trawl survey age 1+ index
0
10
20
30
40
50
60
80
82
84
86
88
90
92
94
Year

Figure 5


White perch commercial landings
0
1
2
3
4
5
6
7
79
81
83
85
87
89
91
Year