P-06-10

Oskarshamn site investigation

Estimation of fish community biomass in Borholmsfjärden, NW Baltic Proper

Anders Adill, Jan Andersson
Swedish Board of Fisheries Institute of Coastal Research

April 2006

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Keywords: NW Baltic Proper, Fish, Species composition, Biomass, Mark and recapture.

Abstract

In this report fish biomass and the composition of species are estimated for Borholmsfjärden, a sheltered bay on the Swedish coast of the Baltic Proper. Biomass was estimated by mark-recapture experiments and by beach seine sampling. Different test fishing methods were applied to collect fish for marking and to describe species composition. The aim of the investigation was to estimate species composition and abundance of all fish species larger than 10 cm total length inhabiting the area. The investigations were carried out in April–June and September of 2005.

The mark-recapture experiments resulted in reliable results for tench and yellow eel. For other species the number of recaptures was too small to produce biomass estimates. Based on beach seine sampling total fish biomass was estimated to 79 kg/ha in spring and to 69 kg/ha in late summer. The eel biomass (1.8 kg/ha) is not included in these estimates. Eurasian perch dominated in both seasons with 34 and 38 kg/ha in the two seasons. The contribution from piscivorous (fish eating) species, mainly perch and pike, was 58% in spring and 74% in September. Adult bream and tench were common and dominated the cyprinid biomass.

The failure to obtain biomass estimates for the majority of species with mark-recapture technique was probably assigned a too small number of marked fish or low catchability of the marked populations. Spawning migrations of adult pike are suggested to hamper the biomass estimates of this species. The spawning season for pike was not fully covered by sampling, but the catch composition suggested a viable population under low fishing pressure.

Sammanfattning

Fisksamhällets biomassa och artsammansättning uppskattades för Borholmsfjärden, en skyddad skärgårdsfjärd vid den svenska Östersjökusten. Biomassa uppskattades med hjälp av märkning-återfångstförsök och med provtagning med strandnot. Olika provfiskemetoder tillämpades för insamling av fisk till märkning och för beskrivning av artsammansättning. Målet var att täcka fisksamhällets alla komponenter ner till en storlek av 10 centimeter. Undersökningarna utfördes under april–juni och september 2005.

Märkningsförsöken gav relativt tillförlitliga uppskattningar av biomassan av sutare och gulål. För andra arter var återfångsterna för få för att kunna användas för biomassaberäkningar. Den totala fiskbiomassan uppskattades med hjälp av provtagning med strandnot till 79 kg/ha på våren och till 69 kg/ha under sensommaren. Dessa värden inkluderar inte ålens biomassa (1,8 kg/ha). Abborre dominerade båda årstiderna med 34 respektive 38 kg/ha under vår och sensommar. Bidraget från fiskätande arter, huvudsakligen abborre och gädda, var 58 % på våren och 74 % i september. Vuxen braxen och sutare var vanligt förekommande och dominerade karpfiskarnas biomassa.

Misslyckandet att erhålla tillförlitliga biomassamått för huvuddelen av arterna med hjälp av märkning och återfångst grundar sig sannolikt på att antalet märkta fiskar var för litet och på att fångstbarheten var låg för märkta fiskar. Lekvandring hos vuxna gäddor diskuteras som en orsak till en osäker uppskattning av biomassan av denna art. Gäddans lekperiod täcktes inte helt av provtagningen, men fångstens sammansättning antyder att beståndet är starkt och fisketrycket lågt.

Contents

1 Introduction

This document reports the results of an estimation of fish community biomass in Borholmsfjärden. The study is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-05-011.

Commissioned by the SKB, the Institute of Coastal Research (ICR), Swedish Board of Fisheries, carried out an investigation of the fish community in a Baltic Sea archipelago during 2005. The study site was Borholmsfjärden (N 57,25,60; E 16,39,50) (Figure 1-1), a sheltered bay 30 km north of Oskarshamn on the Swedish coast of the Baltic Proper. The objectives were to gather information about the species composition and size distribution of the local fish community, and to estimate the total fish abundance (biomass/unit area) in the area. The results of the investigation will be used in modelling the biologic processes in the area as a part of an analysis of potential environmental impact of long term storage of nuclear waste material.

The investigation was mainly carried out with a method based on mark and recapture sampling. Field surveys were carried out in April–June and September of 2005. The field study was performed with different sampling equipments and the ratio of marked and unmarked fish in the catch gave information of species abundance and composition in the area. The tools used in the field study were chosen with respect to catchability of different species. Sampling stations were randomly selected when possible. The objective was to cover all fish species and sizes above a 10 cm minimum length.

The data of this report has been stored in SKB's database SICADA and is traceable by the activity plan number AP PS 400-05-011.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Uppskattning av fisksamhällets totala biomassa i Borholmsfjärden	AP PS 400-05-011	1.0

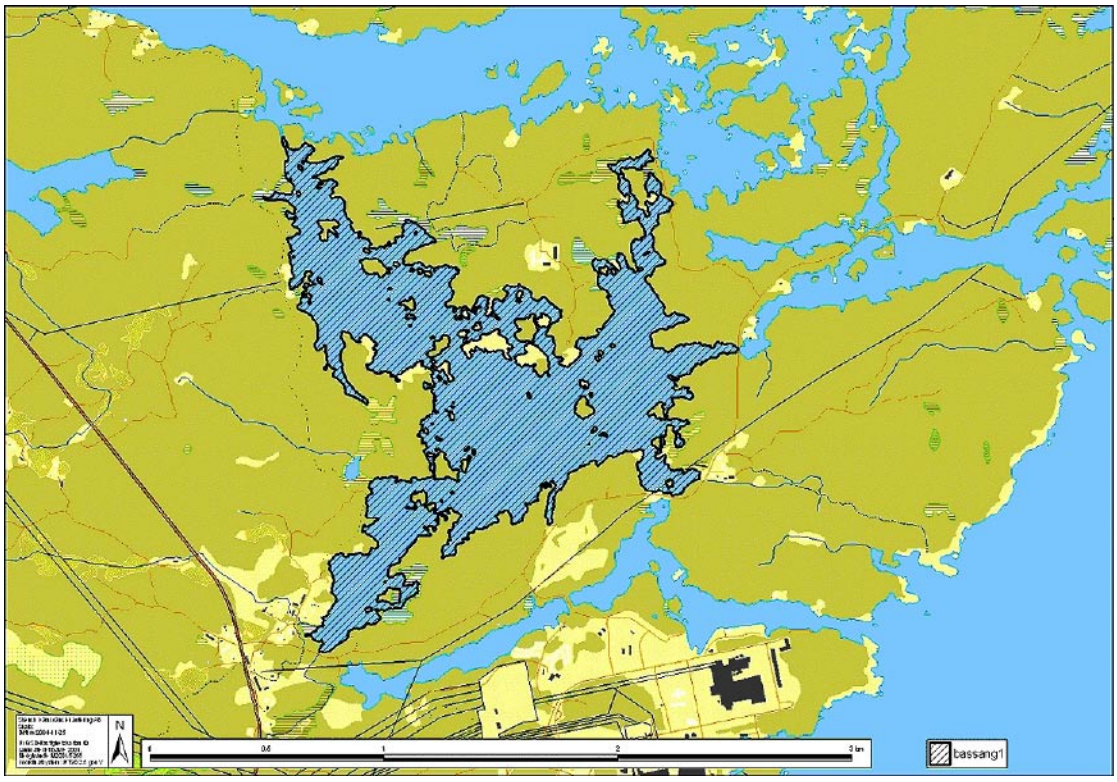

Figure 1-1. *Overview over Borholmsfjärden site investigation area.*

2 Objective and scope

The objectives and aims of this investigation were to gather information about the composition of the local fish species and their size distribution, and to estimate total abundance of fish more than 10 cm in length in Borholmsfjärden. The results of the investigation will be used in modelling the biologic processes in the area as a part of an analysis of potential environmental impact of long term storage of nuclear waste material.

The results on total fish abundance are presented as weight (kg) per hectare. Relative abundance derived from different methods of test fishing is given as numbers per unit effort. Size distribution is given as numbers per cm groups for the most common species.

3 Test-fishing equipment

The various fishing gears used during the investigation were fyke nets, twin-coupled fyke nets, pike fyke nets, Nordic coastal survey nets and beach seine. At every sampling occasion temperature was measured with Oxy-Guard Maxi Temp and the position with Garmin GPS 76 (X,Y and N,E).

Pike fyke nets were used for catching and tagging northern pike (*Esox lucius*), bream (*Abramis brama*) and tench (*Tinca tinca*). The pike fyke net (mesh measure: knot to knot, 19 mm) with a total length of 21 metres comprised one leader net and two wings, leading the fish into the trap (Figure 3-1). The cylinder shaped trap (Ø 100 cm) was divided into two compartments, separated by a funnel shaped inlet, leading into the compartment where the fish was finally trapped, the codend. The leader net (17 metres long and 1.5 metres deep) was tied to a fixed point at the beach and was pulled out with a boat perpendicular to land. The two wings (7 metres long and 1.5 metres deep) were fixed with anchors at the ends approximately four metres from land. The codend was fixed in a straight position by an anchor connected to a surface buoy by a rope.

Fyke nets were primarily used for catching European eel (*Anguilla anguilla*), pike, bream, tench and burbot (*Lota lota*). The fyke net (mesh size between knots: leadernet 17 mm, codend 10 mm) with total length of 7 metres contained one 5 metres long and 50–55 cm high leadernet and a 2 metres cone shaped trap. The trap has a semicircular opening (Ø 50–55 cm) and circular rings to support the net (Figure 3-2). It was divided into three compartments by funnel shaped inlets. The innermost compartment, the codend, had an opening that could be closed with a rope. When fishing, the leadernet was fixed with an anchor tied to the lower part of the net and was set perpendicular to the beach. Two fyke nets were used at each station, connected by a rope from the lower part of the leader net of the outermost fyke net to the codend of the inner fyke net. In the outer end the net was anchored with a stone, connected to a surface buoy. When emptied, the gear was lifted in the outer end.

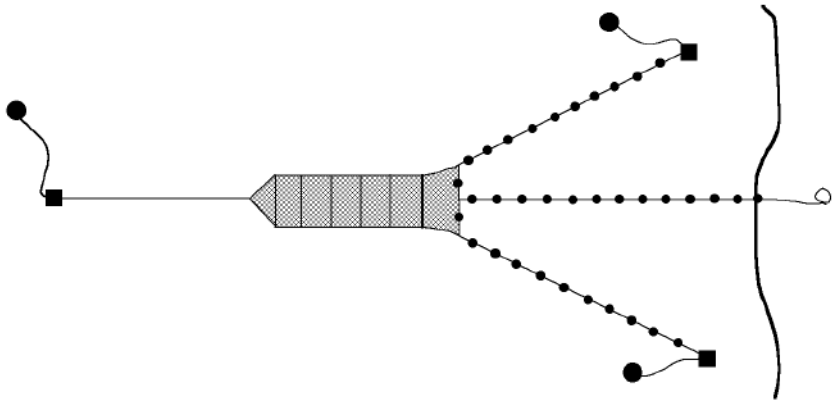

Figure 3-1. *Pike fyke net.*

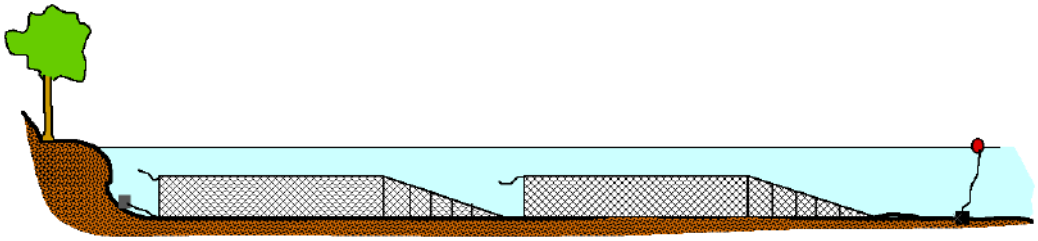

Figure 3-2. *Fyke net.*

Twin-coupled fyke nets were used for catching European eel, pike, bream, tench and burbot. The twin-coupled fyke net (mesh size between knots: leadernet 17 mm, codend 10 mm) with a total length of 8.5 metres comprised two cone shaped traps, coupled to both ends of one leadernet (Figure 3-3). The height of the gear is 40 cm. Each trap contains five circular rings and an opening at the end that could be closed with a rope. Each trap is divided into three departments by three funnel shaped inlets. Six twin-coupled fyke nets (12 cod ends) connected to each other made up one fishing station.

Beach seine were used to collect fish of all species and sizes larger than 10 cm for marking. The beach seine (mesh size between knots: wings, 20 mm, codend plus 2×5 metres of wings, 12 mm) with a total length of 65 metres comprised two wings (6 metres deep and 30 metres long) and a codend (5 metres wide) (Figure 3-4). One of the wings was tied to a fixed point on the beach and the gear was set with boat in a wide circle and back to the starting point. When the fish was caught inside the circular net, the beach seine was pulled towards land slowly by the wings and the fish were contained in the codend.

Nordic coastal survey nets were used for catching fish of all species and length classes. The survey nets, with total length of 45 metres and a height of 6 feet, are divided into nine 5 metres panels, randomly distributed over the net, with different mesh sizes (10, 12, 15, 19, 24, 30, 38, 47 and 60 mm). The nets were set in the direction of the wind at random stations in areas deeper than about 2 metres.

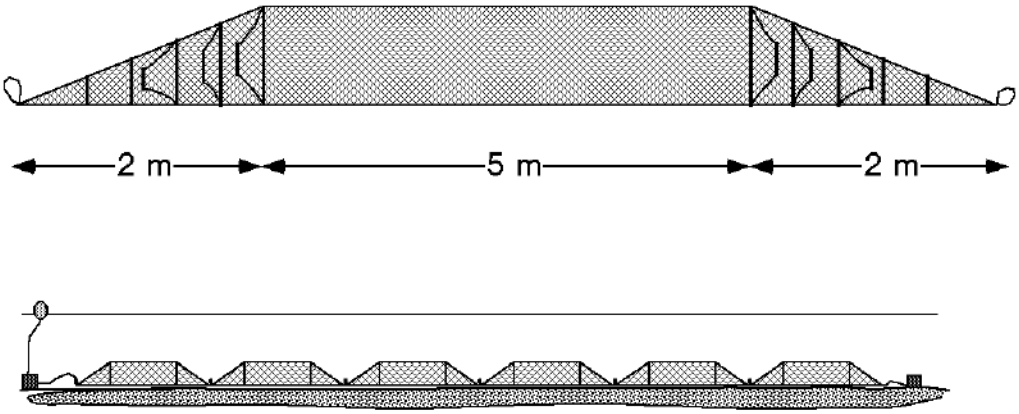

Figure 3-3. *Twin-coupled fyke net.*

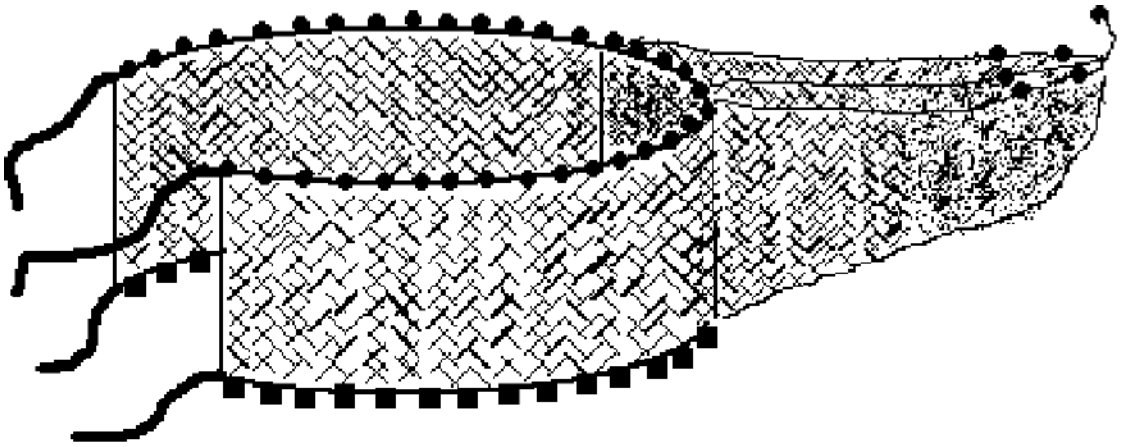

Figure 3-4. *Beach seine.*

3.1 Definition of fishing effort

The results in the survey are presented as catch per unit effort (CPUE). The definition of CPUE for the different fishing gear was based on the number of fish caught on a certain station during a given time.

The CPUE for pike fyke nets, fyke nets and twin-coupled fyke nets was defined as number of caught fish at one station during a 24 hour period. For the Nordic coastal survey nets the definition of CPUE was the number of fish caught in one survey net during one night, approximately 18 hours. The CPUE for the beach seine was the number of caught fish in one station at one occasion or haul. For the beach seine the CPUE could be transformed to catch per unit area, with the assumption of 100% effectiveness and that the gear was set in a perfect circle. With the second assumption the swept area was 0.0336 ha.

The CPUE from the beach seine surveys was transformed from length to weight by specific length-weight relations according to an ICR database. The results were then extrapolated to species specific and total biomass per hectare, and for the entire survey area. The total area of the investigated area is 137.4 hectares.

4 Execution

4.1 General

The main method to estimate the total abundance of the fish population in Borholmsfjärden was a mark and recapture study. During the period of the investigation (2005-04-18–2005-09-16) fish was captured and marked to be released back into the water again. With the knowledge that species may differ in catchability, the survey was carried out with different kinds of fishing gears. The ratio of marked and unmarked fish in the catches could then provide an estimate of the abundance in the survey area.

From experience in earlier studies of similar environments it could be anticipated that Borholmsfjärden inhabit species of different life patterns and traits. In springtime similar locations are serving as important recruitment areas for pike, perch *(Perca fluviatilis)* and several species of cyprinids, like bream, roach *(Rutilus rutilus)* and rudd *(Scardinius erythophthalmus)*. During the year many species can be expected to make seasonal migrations for nourishment and growth into surrounding areas. With this background the field study was carried out in two periods, spring-early summer (week 16–25) and late summer-autumn (week 31–37), with the most fishing effort performed during spring-early summer.

With knowledge about differences in catch efficiency between sampling gears, five different tools were selected to provide samples that could represent the populations in the survey area. To capture species that usually dominates in fish investigations in similar environments, (perch, roach, ruffe *(Gymnocephalus cernuus),* silver bream *(Blicca bjoerkna)* and rudd), Nordic coastal survey nets were used. The net surveys, one in early summer (35 randomly chosen stations) and one in autumn (36 randomly chosen stations), were preceded by a beach seine investigation where every fish above 10 cm of all species except bleak *(Alburnus albula*) was marked by clipping the tip of the left pelvic fin and then released again on the location of capture. Apart from collecting fish for marking the beach seine was used directly for estimation of biomass, since the gear captured fish in a given area.

For species that were known from earlier investigations to be poorly represented in the coastal survey nets, alternative methods were used. Test fishings were carried out with three different types of fyke nets during spring (fyke nets, pike fyke nets and twin-coupled fyke nets). The fishing tools were randomly distributed in the survey area and registered species were pike, bream, tench yellow eel and burbot (in pike fyke nets no yellow eel or burbot were registered). Fish that were caught in the fyke nets were measured and marked by clipping the tip of the left pelvic fin (left pectoral fin in yellow eel) and released into the bay again.

At every sampling occasion, the fish from each station were sorted by species and total individual length was recorded in 1 cm length classes. The data were then registered in ICR's internal fish data base. When examination the capture/recapture samples, data were registered in a separate data base and results were analyzed according to Schnabel /Seber 1982/.

4.2 Preparations

For most fishing methods used in the survey, stations were randomly selected from maps of the investigated area. The maps were arranged with a grid system, where every square was considered as a possible station, as long as depth and vegetation permitted fishing to be performed.

Sampling with pike fyke nets was carried out in two periods (April 20th –May 2nd and May 4th – May 16th) with 13 stations each period. A set of 65 potential stations associated to land were manually selected from the chart, whereafter a final random selection, considering water depth and other factors limiting the use of the gear, were selected. After two weeks a new selection of 13 random stations was made and these stations were fished until the end of the sampling period. The objective for selecting new stations was to avoid hampering the results of the mark-recapture experiment by stationary behaviour of the target species. To shift stations on each fishing occasion was considered too labour intensive.

For fyke nets and twin-coupled fyke nets, stations were randomly selected from maps with 50×50 metres squares. The fyke net stations were always associated to land. Random stations were also used when sampling with Nordic coastal survey nets, although with a coarser grid of squares (100×100 metres).

Due to the practical conditions needed to perform a beach seine haul, the choice of stations for this method was not random. The design though was aiming at a disperse cover of the entire investigation area, although limited to the beaches.

Before and during the field study each fishing gear was carefully checked and repaired immediately when needed.

4.3 Execution of field work

The pike fyke nets were used o sample 24 independent stations. Two stations were sampled during the whole period of fishing. All stations were fished with an interval of 2–3 days except for one occasion, when they were left fishing for five days. All individuals of bream, pike and tench were recorded and length measured in 1 cm classes, before being marked and released. Other species were released alive, without being recorded.

At each sampling occasion with fyke nets, 20 stations were fished. Five of them were randomly selected for registration of all species caught. Ten stations were fished with twin-coupled fyke nets at each sampling occasion. When a set of stations was completed, a new set of stations was chosen for each gear. 126 independent stations were fished with fyke nets, some of them on more than one occasion. The number of independent stations for twin-coupled fyke nets was 48. The time interval between emptying the gears and shift of stations was 2 days to 1 week. Fishing was temporarily stopped when sampling with Nordic coastal survey nets was performed. The fishing with both types of fyke nets targeted the same species as did the pike fyke nets with the addition of eel and burbot. A sub-sample of stations, normally five stations, was chosen randomly for recording all fish species caught.

The investigations with Nordic coastal survey nets were carried out during two periods, one in spring-early summer (35 stations) and one in late summer-autumn (36 stations). Same stations were used during both periods. The nets were set in the afternoon (3–4 PM) and lifted the following morning at 8–10 AM.

Fishing with beach seine was carried out in two periods, one in spring-early summer (15 stations) and one in late summer-autumn (15 stations). When a sampling station was located, sampling started with tying one wing of the gear to a firm object on the shore. The net was then set from a 5.5 metres boat, backing in a wide circle, thus returning to the starting point. The net, now inclosing the potential catch, was towed manually by the wings towards the boat, making sure that the bottom rope stayed close to the bottom. When the codend was retrieved, the catch was lifted batch by batch with a hand net. With careful handling each fish was measured, marked and released as soon as possible. All species and sizes were registered, with the exception of bleak in early summer.

The catch was generally recorded as numbers of individuals per cm-group and species per station. In the Nordic nets, the catch was registered per mesh size. Water temperature was measured close to the gear on each station on all fishing occasions.

Recaptures were recorded and measured for each gear and station, and the fish were released after necessary handling.

4.4 Data handling/post processing

At all sampling occasions data on catch and environmental factors as temperature, Secci depth, wind strength and direction, air pressure and water level, were noted on a water proof form. Later, data were transcribed to a fish survey form. The collected data were then registered in ICR's internal fish data base, using intrinsic steps for quality control. Data on marked and recaptured fish were registered in a separate Excel data base.

4.5 Analyses and interpretations

The main method for estimation of the fish abundance in the survey was the Schnabel-method (/Seber 1982/, http://ifasstat.ufl.edu/AppliedSampling/Lectures/CaptureRecaptureSampling.HT). A set of randomly captured individuals are marked and then released back into their original environment. These marked fish are mixed with unmarked individuals and in followup samples the ratio of marked and unmarked captured fish were used to estimate the abundance, following the steps below.

Assume a series of samples, i = 1.2….n, where all individuals are marked with the same mark after capture. In samples 2 to n, numbers of marked recaptures are recorded. Let:

N_i = number of individuals caught in sample *i* at time t_i
R_i = number of recaptures in sample *i, i= 1, 2, ..., n*
U_i = number of individuals marked for the first time in sample *i*
M_i = number of marked individuals in population just before the *i-th* sample is taken

with $Mi = \sum_{k=1}^{i-1} U_k$

The population estimator is given as $= \frac{\sum_{i=1}^{n} N_i M_i}{\sum_{i=1}^{n-1} R_i}$

To estimate confidence limits, standard error of $^1/_N$ is first estimated as $SE\left(\frac{1}{\hat{N}}\right) = \left[\frac{\sum_{i=1}^{n-1} R_i}{\left(\sum_{i=1}^{n-1} N_i M_i\right)^2}\right]$

We find the confidence interval for $^1/_N$ then take the reciprocals. The 95% confidence interval for $^1/_N$ is given as:

Upper 95% limit ($^1/_N$) = $\frac{1}{\hat{N}} + t_{(975,n-1)} SE\left(\frac{1}{\hat{N}}\right)$

Lower 95% limit ($^1/_N$) = $\frac{1}{\hat{N}} - t_{(975,n-1)} SE\left(\frac{1}{\hat{N}}\right)$

The 95% confidence limits for *N* are given as: $\left(\frac{1}{\text{Upper 95\% limit of } 1/N}, \frac{1}{\text{Lower 95\% limit of } 1/N}\right)$

A second method for estimating abundance was based on beach seining. The beach seine catches was used as a quantitative measure of abundance, assuming that the catchability was 100% and that the gear was set in a perfect circle. A third assumption was that the sampling locations were all representative for the entire area of investigation. As only length was registered in the field, the catches from the beach seine were transformed to weight using length-weight relationships, according to the ICR database.

4.6 Nonconformities

The aim of marking a minimum of 500 individuals of each of the most common species in the beach seine catches was fulfilled only for perch. The activity plan stated that 40 stations should be fished with Nordic coastal survey nets in each period of fishing. In the June period only 35 stations were fished, and in September the number of fished stations was 36. The start of the fishing period with pike fyke nets was delayed 1–2 weeks due to delayed delivery of the fishing gear. The first part of the spawning period for pike was thus not covered.

5 Results

5.1 Catch size and composition

Sixteen different fish species were caught in the five fishing methods that were used. The dominating species were perch, silver bream, bream, pike, roach, tench, eel, rudd, bleak and ruffe. Species that were less common were smelt *(Osmerus eperlanus),* crucian carp *(Carassius carassius),* sprat *(Sprattus sprattus),* burbot, baltic herring *(Clupea harengus)* and ide *(Leuciscus idus).*

Pike fyke nets

During April 18th to May 16th, 24 stations were fished and 1,289 individuals of the three target species were caught in the pike fyke nets. Tench was most abundant (827 ind, 64%), followed by pike (325, 25%) and bream (133, 10%) (Figure 5-1). The total catch per unit effort (CPUE) was 3.7 individuals per fyke net and day and CPUE for tench was 2.3. The estimated total weight over the whole period was 2,048 kg. The weight for tench was 1,224 kg, pike 669 kg and bream 151 kg. The average CPUE expressed as weight per station and day was 5.9 kg.

The length distribution of pike in the pike fyke nets ranged between 29 and 112 cm, with an average length of 65.4 cm (Figure 5-2). Nine of the pikes were 100 cm or bigger. The average length of tench and bream in the pike fyke nets was 45.3 cm and 44.2 cm, respectively.

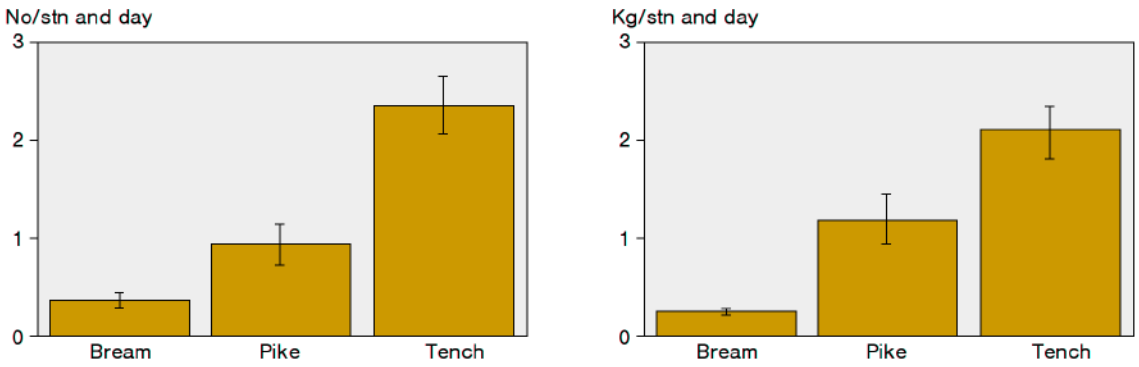

Figure 5-1*. Numbers and weight per unit effort and standard error for target species in pike fyke nets.*

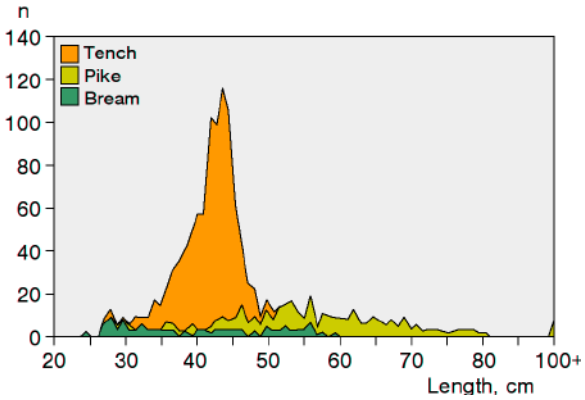

***Figure 5-2**. Length distribution for target species caught in pike fyke nets.*

Fyke nets

During May 9th–June 23rd, 126 stations were fished with fyke nets and the total catch of the four target species was 648 individuals. Tench dominated in the catch (509 individuals), followed by eels (101). The total CPUE during the period for all target species in the fyke nets was 0.90 and CPUE for tench 0.69 (Figure 5-3). The average length of tench in the fyke nets was 43.6 cm and of eels 65.9 cm (Figure 5-4).

At the 39 stations where all species were registered, perch was the dominating species (2,205 out of 2,423 individuals, Figure 5-5). Small sized perch dominated the catch, averaging 15.2 cm. The length frequency distribution of perch showed two peaks, one at 11–12 cm, the other at 17–18 cm (Figure 5-6).

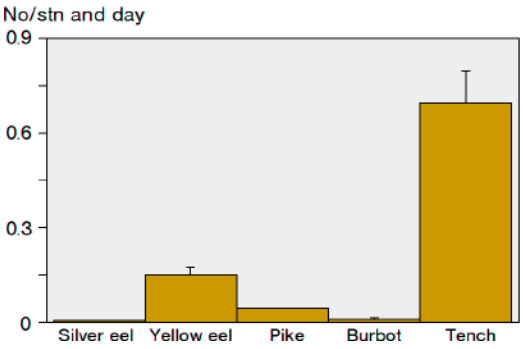

***Figure 5-3**. Catch in numbers per station and day with standard error for target species in fyke nets*

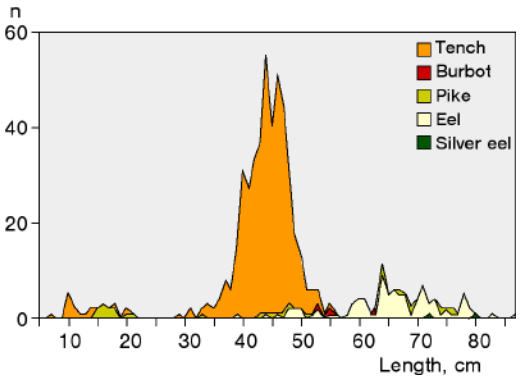

***Figure 5-4**. Length distribution for target species caught in fyke nets.*

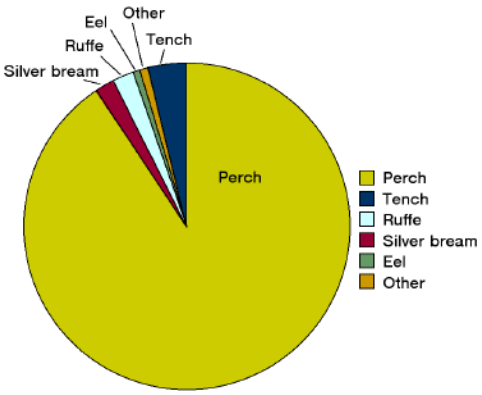

Figure 5-5. *The relative frequency of all species caught in fyke nets.*

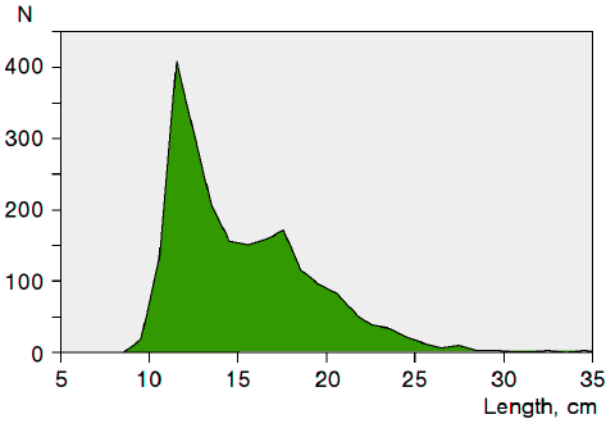

Figure 5-6. *Length frequency distribution of perch in the fyke nets.*

Twin-coupled fyke nets

The total catch with twin-coupled fyke nets during the period May 16th to June 28th was 173 individuals at 48 stations. Eel was the most common species with 96 specimens caught, corresponding to 0.29 eels per station and day (Figure 5-7). Tench was the second most common with a CPUE of 0.20. The average CPUE for all target species during the period was 0.53. The average length of eels was 66.9 cm and of tench 38.5 cm (Figure 5-8).

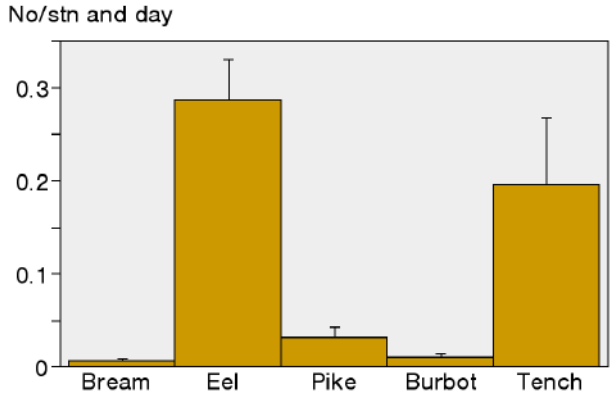

Figure 5-7. *Catch in numbers per station and day with standard error for target species in twin-coupled fyke nets.*

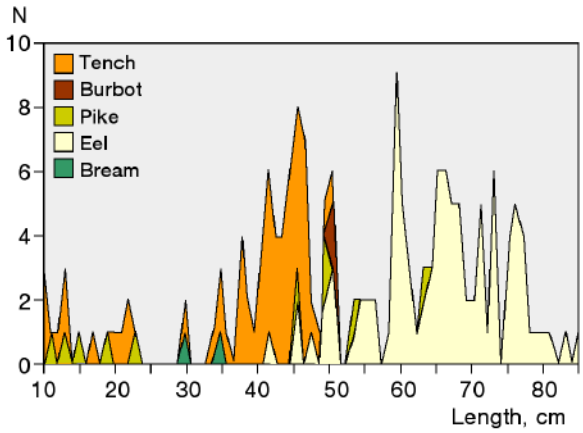

Figure 5-8. *Length frequency distribution for species caught in twin-coupled fyke nets.*

Beach seine

During the two periods of investigations using beach seine, May 23rd–27th and September 5th–7th, 14 and 15 stations were fished, respectively. Perch was the most commonly caught species in both periods, with an average catch of 42.5 specimens per station in May and 45.2 in September (Figure 5-9).

The total catch in May was 1,041 individuals comprising nine different species. The estimated total weight of the catch was 43.8 kg (Table 5-1). Perch dominated strongly, with roach and silver bream as second dominants.

In September the total catch reached 1,284 individuals, and the estimated weight of the catch was 47.9 kg (Table 5-1). The dominance of perch was as strong as in May, and the density of roach was similar to that of the spring period. Rudd had replaced silver bream as third in dominance, and the number of species did not change between periods. Bleak was not noted in May whereas burbot was missing in September.

Small fish sizes were most abundant in the beach seine catches of most species (Figure 5-10). The size of perch in September varied from 5 to 32 cm, but more than 50% belonged to the size groups 10–12 cm. Pike showed the broadest length distribution with sizes ranging from 10 to 61 cm.

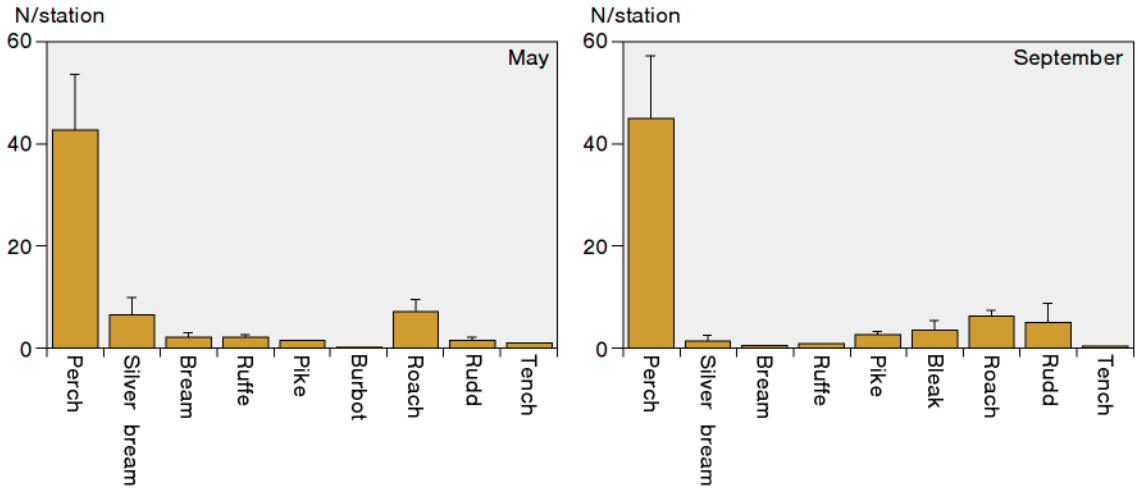

Figure 5-9. *Catch in numbers per station with standard error for species caught in beach seine in May and September of 2005.*

Table 5-1. Total weight, average biomass per station with standard deviation (s), and estimated biomass per hectare based on catches with beach seine hauls in Borholmsfjärden in A, May and B, September of 2005.

May	Total weight	CPUE	s	kg/ha
Perch *(Perca fluviatilis)*	19.3	1.14	1.00	33.8
Silver bream *(Blicca bjoerkna)*	2.1	0.14	0.26	4.2
Bream *(Abramis brama)*	4.4	0.31	0.61	9.3
Ruffe *(Gymnocephalus cernuus)*	0.5	0.03	0.04	0.9
Pike *(Esox lucius)*	5.3	0.32	0.40	9.5
Burbot *(Lota lota)*	1.3	0.10	0.36	2.8
Roach *(Rutilus rutilus)*	2.0	0.10	0.10	2.9
Rudd *(Scardinius erythrophthalmus)*	1.4	0.10	0.25	2.9
Tench *(Tinca tinca)*	7.5	0.44	0.90	13.1
All species	43.8	2.67	1.82	79.4
September	**Total weight**	**CPUE**	**s**	**kg/ha**
Perch *(Perca fluviatilis)*	28.5	1.26	1.73	37.5
Silver bream *(Blicca bjoerkna)*	0.3	0.02	0.04	0.5
Bream *(Abramis brama)*	5.4	0.25	0.67	7.5
Ruffe *(Gymnocephalus cernuus)*	0.1	0.01	0.02	0.2
Pike *(Esox lucius)*	8.1	0.45	0.58	13.4
Bleak *(Alburnus alburnus)*	0.8	0.05	0.09	1.4
Roach *(Rutilus rutilus)*	2.0	0.12	0.14	3.5
Rudd *(Scardinius erythrophthalmus)*	1.2	0.08	0.27	2.5
Tench *(Tinca tinca)*	1.4	0.09	0.35	2.7
All species	47.9	2.32	2.22	69.1

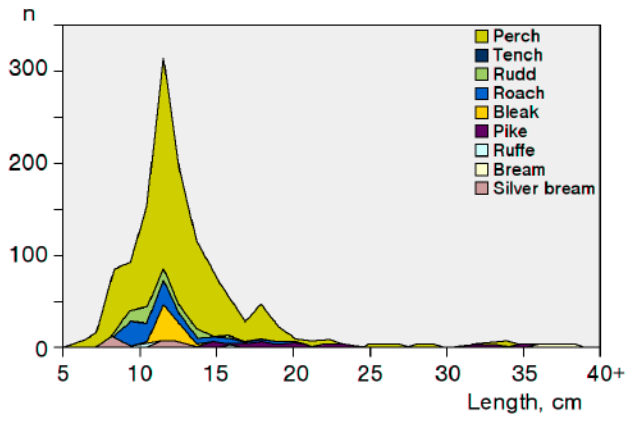

Figure 5-10. *Length frequency distribution of species caught with beach seine in September 2005.*

Nordic coastal survey nets

Sampling with Nordic coastal survey nets, June 3rd–June 9th and September 13th–16th, in total 5,553 individuals of 13 species were caught at 36 stations. Perch, silver bream, bleak and roach were the most common species in both seasons, although in different proportions (Figure 5-11). Bleak dominated in June, whereas perch dominated the catches in September. Bleak, silver bream, tench and bream were more common in June catches and rudd was most abundant in September.

When expresing relative abundance as biomass (weight per unit effort ;WPUE), bream dominated the WPUE in June, followed by tench, pike and perch (Figure 5-12). Of these species, all but perch were represented in the catch by large adult individuals. In September the dominance of perch was even stronger if expressed as WPUE.

Small sized fish dominated the catch by numbers in June (Figure 5-14). Larger individuals, though, were more common in June than in September, mainly due to the presence of adult individuals of bream, pike and tench. A change in length composition of perch between seasons was observed, as bigger individuals were more common in September (Figure 5-13).

In spring catches with the Nordic nets, a strong dominance of male perch was observed in sizes up to more than 20 cm (Figure 5-14). An analysis of fyke net catches also revealed an almost total dominance for males in perch. The male dominance persisted in September in sizes up to 18 cm. Over this length, female representation increased with size and above 30 cm male perch was absent in the catches.

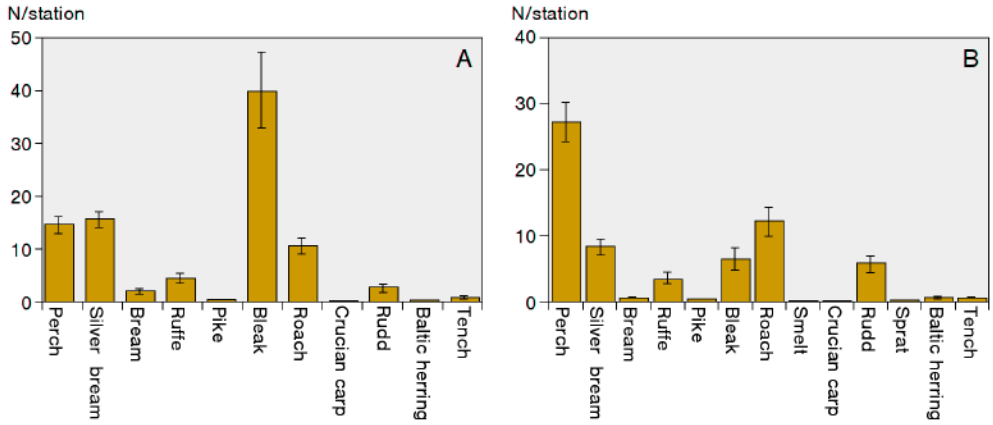

Figure 5-11. *CPUE expressed as numbers per station with standard error for species caught in Nordic coastal survey nets in A, June and B, September of 2005.*

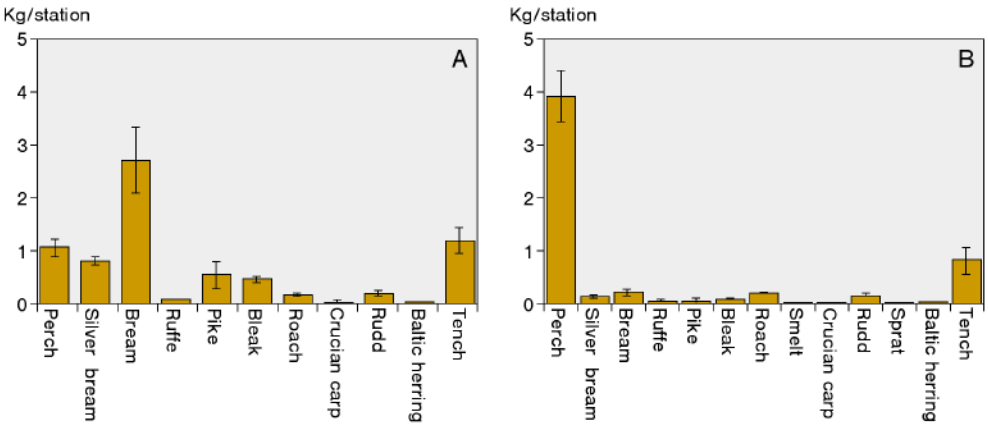

Figure 5-12*. WPUE expressed as kg per station with standard error for species caught in Nordic coastal survey nets in A, June and B, September of 2005.*

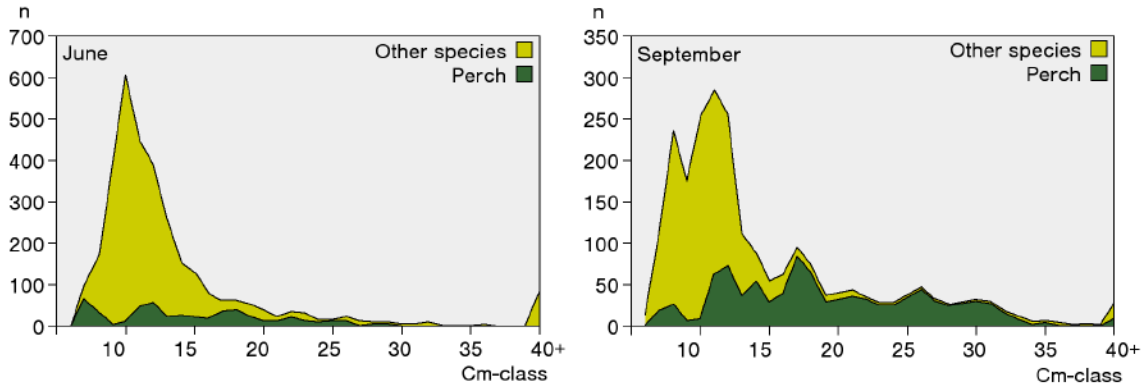

Figure 5-13. *Length frequency distribution of perch and other species in Nordic coastal survey nets in June and September 2005.*

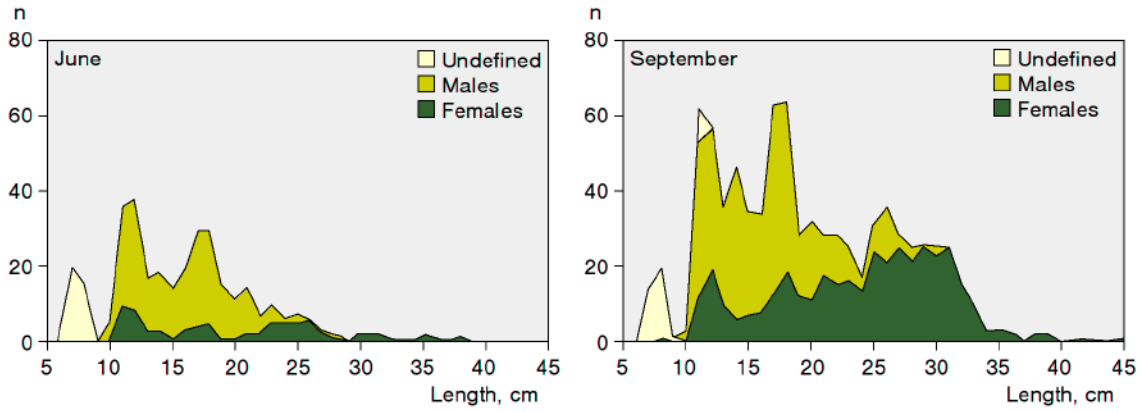

Figure 5-14. *Distribution of sex and length among perch caught in Nordic coastal survey nets in June and September 2005.*

5.2 Biomass estimates

5.2.1 Mark and recapture experiments

In April-June 2,554 individuals were marked and released (Table 5-2). The number of marked individuals in this period was largest for perch, originating primarily from beach seine catches. Tench, pike and eel followed in numbers, ranging from 718 to 171. In the late summer-autumn period the only gear used to collect fish for marking was the beach seine. One thousand individuals were marked out of which 80% were perch.

The numbers of recaptured fish during the spring period was 543, with tench as the most abundant species (Table 5-3). The tench recaptures were mainly obtained from pike fyke nets and the smaller fyke nets. The common feature for these gears was that they were all located along the shoreline. Eel was the second most frequently recaptured species. Out of the 341 marked pikes, only 17 were recaptured, most of them in the pike fyke nets. In late summer-autumn only two species were recaptured, tench (13) and perch (22). Tench recaptures were mainly obtained from the Nordic coastal survey nets, whereas recaptures of perch originated from the beach seine, i.e. the gear used to collect material for marking.

Table 5-2. Marked fish in numbers from different gear in April-June and September of 2005.

	April–June Pike fyke nets	Twin-coupled fyke nets	Fyke nets	Beach seine	Total	September Beach seine
Perch	0	284	0	683	967	790
Silver bream	0	1	0	62	63	12
Bream	132	0	0	29	161	10
Ruffe	0	0	0	21	21	4
Eel	0	77	94	0	171	0
Pike	310	0	9	19	338	42
Roach	0	0	0	97	97	86
Rudd	0	1	0	17	18	57
Tench	636	18	64	0	718	0
All species	1,078	381	167	928	2,554	1,001

Table 5-3. Recaptures of marked fish by gear and season.

	April–June						September		
	Pike fyke nets	Twin-coupled fyke nets	Fyke nets	Nordic coastal survay nets	Beach seine	Total	Nordic coastal survay nets	Beach seine	Total recapture
Perch	0	0	1	1	4	6	2	20	22
Silver bream	0	0	0	0	0	0	0	0	0
Bream	1	0	0	0	0	1	0	0	0
Ruffe	0	0	0	0	0	0	0	0	0
Eel	0	19	9	0	0	28	0	0	0
Pike	13	2	2	0	0	17	0	0	0
Roach	0	0	0	0	0	0	0	0	0
Rudd	0	0	0	0	0	0	0	0	0
Tench	191	26	261	13	0	491	12	1	13
All species	205	47	273	14	4	543	14	21	35

Due to the limited number of recaptures of other species, estimation of abundance according to Schnabel was restricted to tench, eel and pike. For tench the estimation was based on recaptures in pike fyke nets, fyke nets and twin-coupled fyke nets. The estimated total abundance of tench was 1,359 individuals (95% confidence level 1,230–1,517) (Figure 5-15). From an estimated average weight of the tench of 1.48 kg in fyke net catches, the total biomass was estimated to 2,011 kg, corresponding to 14.6 kg per hectare.

The estimated abundance yellow eel was 520 individuals (95% confidence level 369–879) (Figure 5-16). The estimated average individual weight of eel in fyke net catches of was 0.48 kg and the estimated total weight in the area was 250 kg, corresponding to 1.8 kg/ha.

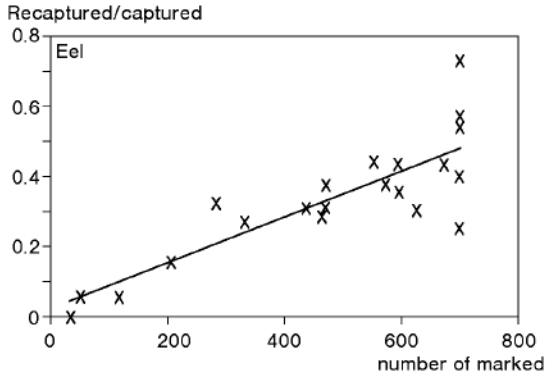

Figure 5-15. *Relationship between recaptures and total catch of tench in pike fyke nets, fyke nets and twin-coupled fyke nets, plotted against the size of the marked population at time of recapture.*

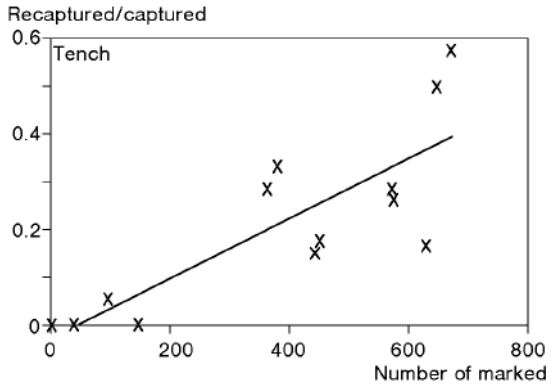

Figure 5-16*. Relationship between recaptures and total catch of yellow eel in fyke nets and twin-coupled fyke nets, plotted against the size of the marked population at time of recapture.*

The abundance of pike was estimated to 2,415 individuals, corresponding to 4,971 kg or 36.2 kg/ha. Due to a low number of recaptures, the 95% confidence interval was wide 1,662–4,418).

5.2.2 Biomass estimates from beach seine sampling

The estimated total biomass of fish based on beach seine catches, was 79.4+/–31.3 kg (95% confidence level) per hectare in May and 69.2+/–36.6 kg (95% confidence level) per hectare in September (Table 5-4, Figure 5-17). For the dominating species in both periods, perch, the biomass was estimated to 33.8+/–17.3 kg/ha in spring and 37.5+/–28.5 kg/ha in autumn. Pike biomass was estimated to 9.5 and 13.4 kg/ha (95% confidence level 6.9 and 9.6) respectively in spring and late summer. The proportion of the piscivorous species perch, pike and burbot was almost 60% in spring and more than 70% in September. The cyprinids bream and tench were among the dominants in spring. A relatively high biomass of bream remained in late summer, but the estimate of tench biomass was lower. The standard deviation was higher than the mean for most species, indicating uncertain estimates. The only exceptions were the estimates of the perch biomass in spring and those of the total biomass in both periods.

Table 5-4. Fish biomass estimates (kg/ha) with standard deviation (s), derived from beach seine sampling in Borholmsfjärden in May and September of 2005.

	May mean	s	September mean	s
Perch	33.8	29.88	37.5	51.39
Silver bream	4.2	7.85	0.5	1.14
Bream	9.3	18.18	7.5	19.95
Ruffe	0.9	1.28	0.2	0.45
Pike	9.5	11.92	13.4	17.41
Bleak			1.4	2.77
Burbot	2.8	10.58		
Roach	2.9	2.91	3.5	4.09
Rudd	2.9	7.37	2.5	7.91
Tench	13.1	26.85	2.7	10.45
Total biomass	79.4	54.28	69.1	66.05

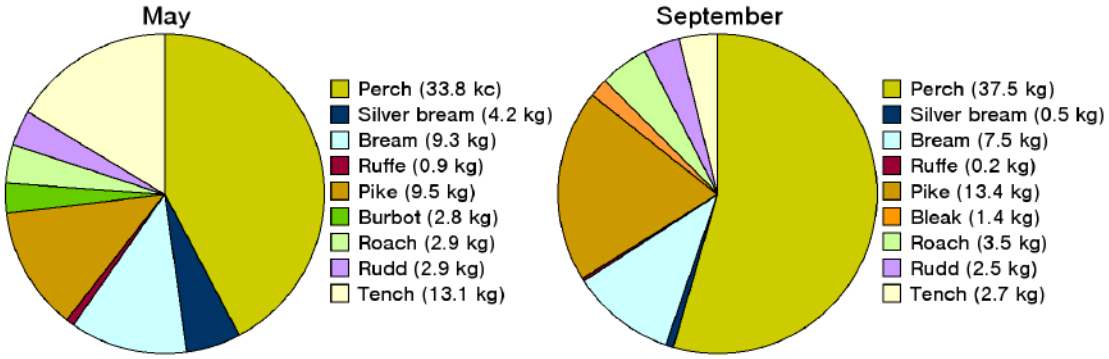

Figure 5-17. *Fish biomass estimates (kg/ha), derived from beach seine sampling in Borholmsfjärden in Maj and September of 2005.*

6 Summary and discussions

The main aim of this investigation was to estimate the fish community biomass in Borholmsfjärden using the Schnabel mark-recapture method. Due to low number of recaptures of some of the marked species, the method was applied only for eel, pike and tench. Beach seine sampling provided an opportunity to estimate fish biomass directly from catch per unit effort in a given area, assuming that all fish inhabiting this area was caught with 100% efficiency and that the gear was set in a perfect circle. These assumptions are possibly not completely met, and a catchability below 100%, and a smaller area results in an underestimation of the biomass.

The estimates of total biomass were 79 kg/hectare in spring and 69 kg/hectare in late summer. Perch dominated in both seasons with 34 and 38 kg/ha respectively. These results are similar to those presented from SW Bothnian Sea by /Heibo and Karås 2005/. In this area total biomass ranged 50–80 kg/ha and facultative piscivores, dominated by perch, ranged in the interval 25–37 kg/ha. The results from the Bothnian Sea were derived from CPUE in gill net surveys, and were, due to net selectivity, considered highly uncertain. Selectivity as a cause of uncertainty should be a minor problem for an estimate based on beach seine sampling. In this case uncertainty is related to catchability, fishing technique and spatial coverage. In Borholmsfjärden sampling was restricted to beaches, but it covered almost completely the depth interval present in the area. Due to a high variance among sampling stations, the specific contribution to total biomass by less abundant species is uncertain.

For tench, an estimate of biomass from the mark-recapture experiment, with relatively high precision, could be compared to a less precise estimate from the beach seine in the same season. In this case the results were similar (14.6 and 13 kg/ha respectively). Imprecise estimates of pike biomass differed more between methods in spring, with 10 and 38 kg/ha respectively for beach seine and mark-recapture estimates. In the beach seine estimate the value was based on sizes from small to medium for the species (19–49 cm), while in the estimation from mark-recaptures fish below 30 cm were not included due to low catchability. In the pike fyke net catches used in the mark-recapture experiment, almost 90% of the marked population was larger than 50 cm in length. Thus, the overlap in size between the estimated "sub-populations" of pike was small. This indicates that the beach seine experiment might underestimate the pike population because of low catchability of large individuals. Large individuals were abundant in the pike fyke nets, although the spawning season was not fully covered. The estimate derived from this material should be considered uncertain, due to few recaptures made in the same gear used for collecting fish for marking. CPUE and size structure of the catches with pike fyke nets indicate that Borholmsfjärden is an important recruitment area for pike, subjected to low fishing pressure. Immigration into the bay for spawning can not be ruled out. Thus, the condition of demographic closure may not be fulfilled for the spawning population of pike.

The eel population in Borholmsfjärden was estimated to 1.8 kg/ha and this figure should be added to the total biomass, estimated from the beach seine. Compared to another area in the same region (own data), the size distribution demonstrated a sub-population of eel dominated by larger individuals (Figure 6-1). Although the reason behind the absence of small individuals is unknown, differences in mobility between size groups may have influenced the outcome. The relative contribution of smaller individuals was higher in summer in the reference area (Figure 6-1). If this difference between seasons is due to a general size-dependent behaviour, the eel biomass in Borholmsfjärden may have been underestimated.

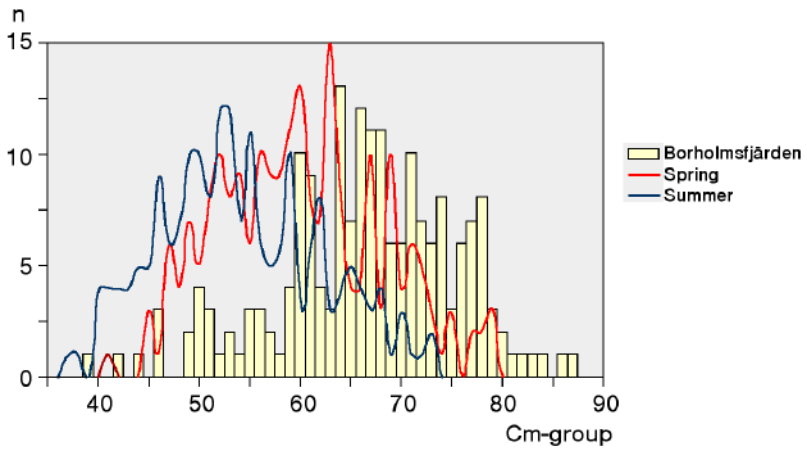

Figure 6-1. *Size frequency distribution in yellow eel catches in Borholmsfjärden and in unsorted commercial catches in a nearby fishery in May and August of 2005.*

The estimate of the total biomass in Borholmsfjärden differed 10 kg between seasons. This difference would have been even larger if bleak had been registered and included in the spring estimate. The observed change is due to a lower biomass of cyprinids and a slightly higher biomass of piscivores in late summer. The reasons behind these changes are not known, however, the decrease of cyprinid biomass may be caused by migrations. The change in size and sex composition of perch in the catches may be due to immigration of females from surrounding areas in late summer, probably to remain in the area until spawning in the following spring season. Borholmsfjärden is recognized for good conditions for angling, both by rod and bait in the autumn and from the ice in winter.

The sampling of the fish community using beach seine and Nordic coastal survey nets resulted in a similar species composition. The same species dominated by numbers in both methods, but in the beach seine, perch outnumbered the most abundant cyprinids, silver bream and roach. The main reasons behind the differences between gears are probably gillnet selectivity in the multimesh gillnets and the fact that catchability in a passive gear is influenced both by fish density and the activity of the fish. This may explain why large sized perch were more abundant in the net catches. Relatively low catchability of small individuals in gillnets also may explain the low level of recaptures of perch in the marking experiment. As small sized fish dominated in the marked population, the share of bigger individuals with higher catchability was probably too small to provide significant results in the mark-recapture experiment. The fact that the beach seine was not operated randomly in the explored area might also have contributed to the observed difference.

There are few studies that have estimated total biomass of fish in the coastal zone of the Baltic Sea. When calculating the fish biomass in the Forsmark area using Nordic coastal survey nets in the summer of 2004, /Heibo and Karås 2005/ estimated that CPUE of facultative piscivores, strongly dominated by perch, 25 individuals per net corresponded to a total biomass of 30 kg/ha. The corresponding figures for CPUE of perch in Borholmsfjärden in September of 2005 was 27 and estimated total biomass 38 kg/ha. Using a similar approach as in Forsmark for Borholmsfjärden, the estimated perch biomass would have been in the same order (32 kg/ha) as the biomass derived from the beach seine. Thus two independent methods would have reached a similar result. Non-published data based on sampling with Nordic multimesh gillnets and total fish count after rotenone treatment of a lake also support this relation /Appelberg 2006/.

7 References

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