

ZEITSCHRIFT FÜR FISCHEREI UND DEREN HILFSWISSENSCHAFTEN

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Die anatolischen Seen und ihre fischereiliche Bewirtschaftung

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A. Einleitung

In den Jahren 1953 und 1954 untersuchte ich 11 größere anatolische Seen (Abb. 1) nahezu gleichzeitig jeweils zu den vier verschiedenen Jahreszeiten. Die Ergebnisse der limnologischen Untersuchungen wurden bereits veröffentlicht (NÜMANN 1960). Neben der limnologischen Zielsetzung war auch geplant, den fischereilichen Wert dieser Gewässer zu bestimmen. Daher galt es, zunächst auf Grund der Untersuchungsdaten, qualitativ und quantitativ die Produktion an Nahrung und die Erträge an Fischen zu ermitteln: d. h., es mußten u. a. mehr oder weniger Bonitätsuntersuchungen durchgeführt werden. Ferner war zu prüfen, ob die Seen entsprechend ihrer Konstitution auch artenmäßig richtig mit Fischen besetzt sind und ob schließlich die Befischung ungenügend, hinreichend oder intensiv ist.

Auf die Methodik und die spärliche Literatur wurde in der oben zitierten Arbeit bereits eingegangen. Desgleichen sind dort sämtliche limnologischen Untersuchungsdaten in Tabellen zusammengefaßt. Zur Methodik der fischereilichen Untersuchungen sei noch hinzugefügt, daß neben den Anlandungen der Fischer die mit einer engmaschigen Wade erzielten eigenen Fänge die Unterlagen bildeten.

Es gibt kaum Maßstäbe oder Tabellen, mit denen man auf Grund der *absoluten* Werte für Temperatur, Planktongehalt usw. zum praktisch-fischereilichen Gebrauch die Seen nach Gütewerten genauer einstufen könnte. Da es uns aber möglich war, gleichzeitig eine Reihe von Seen nach den gleichen Methoden zu analysieren, soll der Versuch gemacht werden, durch Vergleichen zu einer

relativen und feineren Bewertung und durch Zusammenfassen der Einzelergebnisse zu einem relativen Gesamturteil zu kommen.

B. Bewertung der Seen auf Grund ihrer wichtigsten limnologischen Daten

1. Die Temperatur

Der Aksehir-, Marmara-, Süleyman-, Apolyont-, Manyas- und Hotamis-See bilden wegen ihrer geringen Tiefe eine Gruppe. Es stellen sich keine nennenswerten Temperaturschichtungen ein und sie passen sich überraschend schnell den Lufttemperaturen an. Da der Wärmehaushalt der Gewässer durch die geographische Lage und Höhe über dem Meeresspiegel maßgeblich bestimmt wird, ist der Marmara-See sowohl wegen seiner südlichen Lage wie geringen Höhe von allen Seen am meisten begünstigt. Die Karpfen können bei Temperaturen von über 12° C in diesem See mindestens 8 Monate lang gut wachsen. Zur Eisbildung kommt es nie. Überraschenderweise sind Manyas- und Apolyont-See, obwohl auf Meereshöhe gelegen, nicht günstiger für das Karpfenwachstum als Süleyman- und Hotamis-See auf rund 1000 m Höhe. Offenbar kompensiert die südliche und geschützte Lage die durch die Höhe bedingten Nachteile. Die Einstrahlung scheint in der reinen und trockenen Luft der Hochebene viel intensiver zu sein; daher hat der Karpfen im Süleyman- und Hotamis-See einen nicht viel kürzeren Sommer als im Marmara-See. Apolyont- und Manyas-See folgen erst an 3. Stelle, denn sie stehen noch unter dem Einfluß der kalten Nordwinde, die vom Schwarzen Meer her im Frühjahr oft Temperaturrückschläge und im Herbst rasche Abkühlung verursachen.

Die Temperaturverhältnisse des Aksehir-Sees sind am ungünstigsten, denn der See liegt sehr hoch, aber noch nicht so weit südlich wie der Süleyman-See. Vor allen Dingen ist er den Winden sehr stark ausgesetzt und erhält im Frühjahr noch lange Zeit kaltes Schneewasser von den Bergen. Etwas wird die langsame Erwärmung allerdings durch eine längere Wärmespeicherung im Herbst ausgeglichen.

Bei Betrachtung der maximalen Temperaturen im Hochsommer nehmen wieder die flachen Seen in der Hochebene die erste Stelle ein; allerdings steht ihnen der Marmara-See nicht nach. Für das Karpfenwachstum bedeutet das wiederum ein Plus gegenüber den anderen Seen. Zur wärmsten Jahreszeit im August hatten Apolyont- und Manyas-See nur gut 21–22° C, die flachen Seen der Hochebene 23–24° C. Ganz allgemein würde man höhere Temperaturen im Sommer erwarten, doch lassen die nächtlichen Ausstrahlungen der flachen Seen offenbar keinen weiteren Anstieg zu. Verglichen mit europäischen Verhältnissen sind alle diese flachen Seen temperaturmäßig sehr gut und entsprechen auch wohl tatsächlich den Anforderungen des Karpfens. Die beiden hochgelegenen Seen von Beysehir und Egridir sind trotz ihrer etwas größeren Tiefe nicht wesentlich verschieden von den meisten flachen Seen. Selbst die Erwärmung im Frühjahr vollzieht sich kaum viel langsamer, während die Abkühlung im Herbst sogar weniger rasch vonstatten geht. Die maximalen Temperaturen sind von Oberfläche bis auf den Boden dieselben wie in den ganz flachen Seen auf Meereshöhe. Der Egridir-See scheint sich etwas langsamer zu erwärmen als der Beysehir-See, dafür kühlt er im Herbst auch etwas langsamer aus. Beides mag mit der etwas größeren Tiefe des Egridir-Sees zusammenhängen. Wenn es nur auf die Temperaturen ankäme, müßten auch diese Seen noch recht gut für Karpfen sein.

Die drei tieferen Seen Iznik-, Sapanca- und Burdur-See haben einen wesentlich anderen Wärmehaushalt als die bisher besprochenen Seen. Sogar direkt an der Oberfläche erwärmen sie sich langsamer im Frühjahr und in 5-10 m Tiefe bleibt die Temperatur zunächst weit hinter denen der rasch erwärmten flachen



Abb. 1 Die untersuchten anatolischen Seen.

Seen zurück. Das Bild wird natürlich wesentlich verschieden, wenn man die unter einem Quadratdezimeter bis zum Boden festgelegten Kalorien vergleicht. Bis zum Untersuchungsdatum wurden im Frühjahr 1953 z. B. im Iznik-See nach einer Überschlagsrechnung 480 Kal., im Manyas aber nur 200 Kal. festgehalten. Von diesem großen Wärmeverrat, der im Laufe des Sommers noch zunimmt, zehren die tiefen Seen im Herbst und kühlen deswegen später aus. Bei häufigeren Untersuchungen würde man wahrscheinlich feststellen, daß in den vergleichbaren oberen Schichten die Summe der Tagesgrade in den tieferen Seen größer ist als in den flachen. Iznik- und Sapanca-See haben an der Oberfläche im Hochsommer auch absolut höhere Temperaturen als die flachen Seen, was an sich zunächst erstaunlich ist. Auch das hängt damit zusammen, daß die tieferen Seen tagsüber mehr Wärme aufnehmen können, als sie des Nachts ausstrahlen. Zwischen 10 und 20 m haben die tiefen Seen im Sommer eine starke Sprungschicht. D. h., unterhalb dieser Schicht, also fast überall am See-

boden, ist das Wasser kälter als 12° C. Karpfen können also wegen der Temperaturen nur in einer schmalen Uferzone gedeihen. Auch während der Teilzirkulationen wird das Wasser nur für kurze Zeit in größeren Tiefen ein wenig erwärmt.

Um irgendwie die Seen nach ihren Temperaturen so bewerten zu können, daß auch das zeitlich verschiedene Erwärmen und Abkühlen, sowie die maximalen Temperaturen berücksichtigt sind, habe ich die mittleren Temperaturen aus der Frühjahrs-, Sommer- und Herbstuntersuchung berechnet. Die Oberflächen- und Tiefentemperaturen sind getrennt aufgezeichnet.

| | | | |
|-----------------------|---------|-------------------|---------|
| 1. Marmara | 18,2° C | 8. Egridir | 15,6° C |
| 2. Burdur Oberfläche | 17,3° C | 9. Aksehir | 15,2° C |
| 3. Hotamis | 16,8° C | 10. Manyas | 14,1° C |
| 4. Süleyman | 16,4° C | 11. Apolyont | 12,5° C |
| 5. Sapanca Oberfläche | 16,2° C | 12. Sapanca Boden | 8,5° C |
| 6. Iznik Oberfläche | 16,1° C | 13. Iznik Boden | 8,3° C |
| 7. Beysehir | 16,1° C | 14. Burdur Boden | 6,4° C |

2. Das SBV bzw. die sekundäre Alkalinität

Es wäre naheliegend, bei der vergleichenden Untersuchung des SBV eine Einteilung der Gewässer nach dem Fehlen oder Vorhandensein eines Abflusses vorzunehmen. Wenngleich die abflußlosen Seen durchweg ein höheres SBV haben, so gibt es auch umgekehrte Fälle: Der Marmara-See mit hohem SBV besitzt einen Abfluß und der Hotamis-See mit niedrigem SBV keinen sichtbaren Abfluß. Da das SBV der Seen in erster Linie vom Kalk- und Kohlen säuregehalt der Zuflüsse, bzw. des Einzugsgebietes, sekundär auch wohl vom Vorhandensein von Abflüssen abhängt, bringt uns eine regionale Zusammenfassung der Seen etwas weiter. Apolyont-, Manyas- und Sapanca-See, die nördlichsten der Marmara vorgelagerten Seen, bilden eine Gruppe mit niedrigen SBV. Beysehir-, Egridir- und Hotamis-See, die Seen im westlichen Taurusgebiet und völlig isoliert von der ersten Gruppe, haben ebenfalls ein niedriges SBV. Zu diesen gehörten ursprünglich auch wohl Süleyman-, Aksehir- und Burdur-See; sie sind dann sekundär durch Verdunstung kalkreich geworden. Der Marmara-See, ohne Beziehung zu den übrigen Seen, ist kalkreich; ebenso hat der Iznik-See trotz des unterirdischen Abflusses ein hohes SBV. Sie zeigen aber wie die meisten europäischen Gewässer, daß die eutrophen Gewässer fast immer kalkreich sind (THIENEMANN). Die türkischen eutrophen Seen Aksehir-, Marmara-, Süleyman- und bis zu einem gewissen Grade auch der Iznik-See sind sehr hart (23–27 D. H.). Alle übrigen türkischen Seen, die in irgendeiner Form oligotroph sind, besitzen eine geringere Härte. Bei allzu großem SBV wird offenbar das Optimum des Trophiegrades schon überschritten. Als Beispiel hierfür kann man den Süleyman-See ansehen; die Karpfenernte ist zwar noch gut, doch wird vielleicht beim übergroßen SBV das Karpfenwachstum schon etwas beeinträchtigt. (Hier spielen allerdings noch andere Faktoren eine Rolle.) Vielleicht kann man aber doch schon von einer gewissen Alkalitrophie sprechen. Der extremste Fall ist der Burdur-See; da jedoch zur hohen Alkalinität noch ein sehr hoher Salzgehalt kommt, können die fischereilich ungünstigen Wirkungen nicht allein auf die Alkalinität zurückgeführt werden.

Wesentliche Veränderungen in der vertikalen Schichtung des SBV lassen nicht einmal die tiefen Seen erkennen, so daß über die Größenordnung einer

möglichen biogenen Entkalkung und damit einer Produktion an organischer Substanz indirekt nichts gezeigt werden kann.

3. Der Sauerstoff

Den Burdur-See möchte ich von der vergleichenden Betrachtung ausschalten, da sein dauerndes Sauerstoffdefizit nicht geklärt ist und sicherlich nicht mit biogenen Vorgängen zusammenhängt.

Die übrigen Seen haben stets in allen Tiefen soviel Sauerstoff, wie zur Erhaltung des tierischen Lebens notwendig ist. Zu einer relativ starken Sauerstoffabnahme kommt es im Hypolimnion der tieferen Seen: Iznik- und Sapanca-See. Sie verhalten sich in dieser Hinsicht nicht mehr wie rein oligotrophe Seen. Besonders der Iznik-See muß als meso- wenn nicht als eutroph bezeichnet werden. Im speziellen Teil wurde schon gezeigt, daß auf Grund der Sauerstoffzehrung sich die Menge der produzierten organischen Substanz für diesen See einigermaßen berechnen läßt. Alle übrigen Seen, einschließlich Beysehir- und Egridir-See, sind zu flach und können fortlaufend bis zum Boden Sauerstoff aus der Luft aufnehmen, so daß der Sauerstoff keine produktionsbiologischen Berechnungen zuläßt. Immerhin gibt es deutlich Unterschiede im Sauerstoffhaushalt, die den verschiedenen Reichtum an organischer Substanz bezeugen.

Ein relatives Bild über die produzierte Menge an organischer Substanz erhält man, wenn man – besonders über Grund – den mittleren Sauerstoffgehalt aus den 4 Untersuchungsdaten berechnet und miteinander vergleicht. Außer den tiefen Seen verbrauchen die flachen Seen Aksehir-, Marmara- und Süleyman-See relativ viel Sauerstoff über Grund. Mit einem größeren Abstand folgen Apolyont- und Manyas-See, und schließlich sind Beysehir- und Egridir-See fast völlig gesättigt. Die Sättigungswerte für die 2. und 3. Gruppe unterscheiden sich zahlenmäßig zwar nicht sehr. Trotzdem ist die Sauerstoffzehrung in den flachen Seen größer, nur wird sie wegen der leichteren Regenerierung mit Luft-sauerstoff stärker verdeckt. Wenn also trotz größerer Tiefe und relativ besserer Schichtung der Sauerstoff im Beysehir- und Egridir-See weniger abnimmt, ist sicherlich auch weniger organische Substanz produziert und vorhanden. – Nur der Hotamis-See ist dauernd mit Sauerstoff übersättigt; es wurde wahrscheinlich gemacht, daß den zahlreichen submersen Pflanzen die Übersättigung zu verdanken ist.

4. Die freien Phosphate

Es läßt sich allgemein schwer sagen, wie stark die Produktion der Gewässer an organischer Substanz von der Menge der vorhandenen Phosphate abhängt. Man weiß, daß die Produktion nach Phosphatdüngung allgemein zunimmt (neben der Phosphatspeicherung) und daß im Süßwasser Phosphat am leichtesten zum Minimumstoff wird. Wenn wir darum die Seen mit den höchsten Konzentrationen an freiem Phosphat für die besten halten, so ist das *cum grano salis* richtig. Wahrscheinlich wird ein flacher See mit einer mäßigen Menge Phosphat, das während einer Saison mehrmals in den Produktionskreis tritt, besser gestellt sein als ein tiefer See, der nach der Frühjahrszirkulation doppelt so hohe Konzentrationen besitzt. Man darf aber wohl annehmen, daß unter sonst gleichen Bedingungen ein höherer Phosphatgehalt auch eine größere Produktionsmöglichkeit anzeigt. Sind somit die freien Phosphate auch keine hinreichende Bedingung für eine gute Produktion, so sind sie doch eine notwendige Voraussetzung.

In diesem Sinne ist der Marmara-See zweifellos der beste; dann folgt der Manyas-See (dieser Wert ist allerdings wegen der Trübungen nicht immer ganz

genau). Aksehir-, Apolyont-, Burdur- und Iznik-See bilden eine weitere Gruppe mit viel freiem Phosphat. Auch der Süleyman-See hat immer freie Phosphate in gut nachweisbaren Mengen. Beim Beysehir-See lassen sich nur zeitweilig geringe Mengen nachweisen, während beim benachbarten Egridir-See die Nachweisbarkeitsgrenze unterschritten wird. Ohne freie Phosphate ist ferner der Sapanca- und Hotamis-See (vgl. die folgende Übersicht).

| | | | |
|-------------|------------------------|----------------|-----|
| 1. Marmara | 64 mg/m ³ P | 7. Süleyman | 13 |
| 2. Manyas | 40 | 8. Beysehir | 2,0 |
| 3. Aksehir | 28 | 9.–11. Egridir | 0 |
| 4. Apolyont | 26,5 | 9.–11. Sapanca | 0 |
| 5. Burdur | 25 | 9.–11. Hotamis | 0 |
| 6. Iznik | 24 | | |

Die Übersicht gibt die mittleren Phosphatkonzentrationen wider, die während der Frühjahrs-, Sommer- und Herbstuntersuchung festgestellt wurden. Für den Iznik- und Burdur-See wurden die Konzentrationen während der Vollzirkulation angegeben.

Nur der Iznik-See gestattet, aus dem Phosphatumsatz die produzierte Mindestmenge an organischer Substanz zu berechnen.

5. Das Makroplankton

Die Untersuchung des Netzplanktons gibt kein Bild über die produzierte, sondern eine gewisse Vorstellung über die jeweils vorhandene Menge. Eine Berechnung der Konzentration, die ja fischereibiologisch „interessiert“, aus einem Vertikalfang ist sicherlich nicht ausreichend, da das Plankton vorwiegend ganz bestimmte Schichten einnimmt. Am besten würde man sich aus der Konzentration aller Schichten und der absolut vorhandenen Gesamtmenge ein Bild über die verwertbare Fischnahrung machen. Das ist aber praktisch sehr schwer durchführbar und in unserem Fall beim Fehlen von Stufenfängen unmöglich. Da die meisten türkischen Seen durchweg flach und mehr oder weniger tief sind, kann man für diese indessen die unter 1 qm befindliche Planktonmenge – besonders wenn man den Mittelwert aus den 4 Untersuchungen berechnet – ohne weiteres miteinander vergleichen. Nur die tiefen Seen rücken bei dieser Betrachtungsweise in ein zu günstiges Licht.

Marmara- und Süleyman-See zeichnen sich auch durch ihren Planktonreichtum aus; sie übertreffen sogar absolut trotz der kleinen Wassersäule, aus der das Plankton filtriert wurde, noch den tiefen Iznik- und Burdur-See. Letztere stehen an 3. und 4. Stelle und trennen den Aksehir-See von den beiden sehr guten Seen, zu denen er auf Grund der anderen Eigenschaften gehört. Sicherlich sind die Konzentrationen im Aksehir-See auch höher und die Umstellung in der Reihenfolge ist nur der hier gemachten Schematisierung zu verdanken. Mit weniger Plankton folgen dann Apolyont-, Manyas-, Beysehir- und Egridir-See. In Wirklichkeit sind diese 4 Seen noch schlechter als die sedimentierten Planktonproben vortäuschen; denn bei den Proben des Apolyont- und Manyas-Sees sind noch Detritus und viel Mikroplankton miterfaßt; beim Beysehir- und Egridir-See ist wegen der etwas größeren Tiefe eine größere Wassersäule filtriert worden. Den Sapanca-See muß man an zweitletzter Stelle führen, da er einmal nach unserem Schema dorthin gehört und zum anderen, weil man die sehr große Wassersäule in Anrechnung bringen muß. Am schlechtesten ist der Hotamis-See.

Die qualitative Untersuchung des Planktons gibt auf Grund einer viermaligen Probeentnahme innerhalb eines Jahres nur eine grobe Vorstellung

über die wirklichen Verhältnisse. Untersuchungen in kleineren Intervallen und über eine längere Zeit zeigen, daß die qualitative Zusammensetzung des Planktons in den einzelnen Jahren variieren kann. Außerdem werden speziell unsere Planktonfänge erst dann mehr erkennen lassen, wenn sie wirklich qualitativ bearbeitet sind. Die Arten charakterisieren häufig ein Gewässer besser als die Gattungen, denn leichter spezialisieren sich bestimmte Species verschiedener Gattungen auf ein bestimmtes Milieu als eine Gattung geschlossen. Trotz der angeführten Mängel zeigt die grobe Übersichtsbestimmung schon einige ganz interessante Beziehungen. Wieder lassen sich die 3 fruchtbaren Seen Akşehir-, Süleyman und Marmara zusammenfassen, in denen *Daphnia* (wahrscheinlich *Daphnia magna*) während des ganzen Jahres die größte Rolle spielt oder zumindest zeitweise vorherrscht. Eine andere *Daphnia* wurde dann noch im weitgehend eutrophen Iznik-See während des Sommers gefunden. Hier kann *Daphnia* zur übrigen Jahreszeit durch *Diaphanosoma* vertreten werden, der in den übrigen Seen weniger Bedeutung zukommt. In den übrigen Seen sind *Daphnien* überhaupt nicht oder nur sporadisch anzutreffen.

In den meisten Seen dominieren die *Diaptomiden*. Vom Burdur-See wissen wir, daß er seine eigene Form hat (*Arctodiaptomus burduricus* [KIEFER]). Beyşehir- und Egridir-See haben wahrscheinlich auch immer ihre eigene Form. (KIEFER bestimmte vor einigen Jahren in beiden *Eudiaptomus vulgaris*.) In den 3 nördlichsten oligotrophen Seen, die der Marmara vorgelagert sind (Manyas, Apolyont und Sapanca), fand ich überhaupt keine *Diaptomiden*. Hingegen kamen sie in dem einzigen mehr oder weniger eutrophen See dieser Gegend, dem Iznik-See, vor und dominieren sogar zeitweilig. Der Iznik-See zeichnet sich auch sonst vor allen anderen Seen durch sein Plankton aus. *Diaphanosoma* überwiegt allein hier zeitweilig, wie bereits erwähnt wurde. Außerdem kommt auch allein hier *Cyclops* während des ganzen Jahres eine große Bedeutung zu; im Frühjahr herrscht er sogar vor. *Cyclops* in mäßigen Mengen kennzeichnet dann noch wieder Beyşehir- und Egridir-See gemeinsam. Der Sapanca-See zeichnet sich dadurch vor allen anderen Seen aus, daß *Heterocope* vorkommt und zwar während des ganzen Jahres vorherrschend. Die 3 mehr oder weniger harmonisch oligotrophen Seen Sapanca, Beyşehir und Egridir besitzen allein von allen Seen *Leptodora!* Manyas- und Apolyont-See zeigen ihre Besonderheit und übereinstimmenden Grundzüge auch im Plankton: *Rotatorien* dominieren immer oder spielen zumindest eine große Rolle in beiden Seen.

6. Die Bodenfauna

Weit mehr als Planktonfänge gibt eine quantitative Probe von Bodentieren ein Bild über die Fruchtbarkeit eines Gewässers. Jegliche Produktion an Bodentieren bleibt immer eine Funktion der im Epilimnion produzierten Menge an organischer Substanz (Tab. 1). Diese Beziehung wird im Prinzip auch dadurch nicht gesört, daß autotrophe Organismen die am Boden freiwerdenden Nährstoffe assimilieren und dadurch selbst wieder Urproduzenten werden. Und genau so, wie man in neuerer Zeit die Bodenfauna zur qualitativen Charakterisierung der Gewässer heranzieht (THIENEMANN und Mitarbeiter, JÄRVI), so kann sie wahrscheinlich auch im quantitativer Hinsicht weitgehend ein Maßstab für die Produktionskraft eines Gewässers sein. Außer den Schwierigkeiten, die prinzipiell die Berechnung des produzierten Planktons macht, ist man bei der Bestimmung der Bodentiere von der Wassersäule unabhängiger und somit der Frage enthoben, ob die Konzentration oder die unter der Flächeneinheit befindlichen Mengen verglichen werden müssen. Ferner ist der

Wechsel der Bodentiere in der Generationsfolge wie in der Menge nicht so großen Schwankungen unterzogen wie der des Planktons. Das schließt nicht aus, daß die Menge im Frühjahr auch durchweg zwei- bis dreimal größer ist als im Herbst (Tab. 1). Im Vergleich zum Plankton sind das geringe Schwankungen.

Trotzdem haftet den eigenen Untersuchungen noch der Mangel an, daß die Zahl der Proben sehr gering ist. Zur vergleichenden Untersuchung der Seen habe ich in jedem Falle aus den Proben vom Herbst und Frühjahr die Durchschnittswerte zu Grunde gelegt (Tab. 1). Wie schon erwähnt, gibt es während des Frühjahrs zwei- oder dreimal so viele Organismen wie im Herbst. (Diese Feststellung ist zweifellos richtig, da in beiden Untersuchungsreihen mit denselben Geräten gearbeitet wurde.) Praktisch finden also Bodenfische im Frühjahr mehr Nahrung als im Herbst und das Wachstum muß dementsprechend in dieser Zeit besser sein.

Es nimmt nach dem bisher Besprochenen nicht mehr Wunder, daß Aksehir-, Marmara- und Süleyman-See auch wegen ihres Reichtums an Bodentieren bei weitem wieder an erster Stelle stehen. Es ist auch selbstverständlich, daß der Iznik-See nur wenig nachsteht. Dann folgen die 3 nördlichen Seen Sapanca, Apolyont und Manyas. Im Frühjahr und Herbst war der Manyas-See besser als die beiden anderen. Weitere Untersuchungen müssen zeigen, ob er sich hierin tatsächlich immer unterscheidet. Beysehir- und Egridir-See können wieder zusammengefaßt werden; sie sind, wie auch sonst in jeglicher Beziehung, schlecht. Wenn man die Mollusken mituntersuchen würde, könnte das Urteil vielleicht etwas milder werden.

Ganz schlecht ist der Hotamis- und Burdur-See. Bei den relativ großen Planktonmengen ist das nach den erwähnten Beziehungen für den Burdur-See zunächst überraschend. Hier verhindert aber wohl sekundär der hohe Salzgehalt die Anpassung einer entsprechenden Bodenfauna. Ich habe noch versucht, den Seen entsprechend der Menge an Bodentieren Prädikate zu erteilen. Die Gruppierung ist natürlich willkürlich und relativ, doch erweist sich die Einteilung in Klassen von 5 zu 5 g/m² in unserem Fall als sehr zweckmäßig.

| schlecht | mittel | gut | sehr gut |
|----------|----------|---------|----------|
| < 5 g | 5–10 g | 10–15 g | > 15 g |
| Beysehir | Apolyont | Iznik | Aksehir |
| Egridir | Manyas | | Marmara |
| Hotamis | Sapanca | | Süleyman |
| Burdur | | | |

7. Gesamtbeurteilung

Die fischereiliche Bedeutung der einzelnen Seen habe ich unter Bewertung aller untersuchten Haushalte zu erfassen versucht. Absolute Werte zu berechnen, ist schon auf Grund des einzelnen Haushalt nicht immer leicht, wenn nicht gar unmöglich. Die einzelnen Haushalte lassen sich auch nicht auf einen gemeinsamen Nenner bringen. Daher habe ich die Seen in ihren einzelnen Haushalten untereinander verglichen und ihrer Güte nach relativ geordnet. Der an 1. Stelle stehende See ist also der beste und der letzte der schlechteste. Gut und schlecht bezieht sich vor allen Dingen auf die direkten und indirekten Ansprüche der Fische und speziell der Karpfen. Temperaturmäßig der beste See ist der, welcher während der ganzen Untersuchungsperiode am längsten die höchsten Temperaturen hat (Mittel aus den Untersuchungen). Da bei den tiefen

Tabelle 1 Beziehung zwischen Netzplankton (ccm/m²) und Bodenfauna (g/m²)

| | Aksehir | Marmara | Süleyman | Apolyont | Manyas | Iznik | Sapanca | Beysehir | Egridir | Hotamis | Burdur |
|--------------------------|---------|---------|----------|----------|--------|-------|---------|----------|---------|---------|--------|
| Plankton | 22,9 | 33,4 | 29,9 | 8,5* | 18,6* | 25,9 | 10,1 | 11,7 | 17,9 | 1,4 | 25,7 |
| Bodentiere | 17,8 | 18,5 | 16,0 | 4,1 | 10,5 | 13,3 | 9,0 | 2,7 | 2,6 | 0,9 | 2,7 |
| Plankton : Bodentiere | 1,3 | 1,8 | 1,8 | 2,0 | 1,8 | 1,9 | 1,1 | 4,0 | 7,0 | 1,5 | 12,0 |

* vorwiegend Einzeller und Detritus.

Tabelle 2 Bodentiere g/m² im Frühjahr und Herbst

| | Aksehir | Marmara | Süleyman | Iznik | Sapanca | Apolyont | Manyas | Beysehir | Egridir | Burdur | Hotamis |
|----------|---------|---------|----------|-------|---------|----------|--------|----------|---------|--------|---------|
| Herbst | 10,7 | 9,5 | 5,3 | 8,1 | 4,7 | 2,0 | 5,4 | 1,6 | 1,0 | 0,3 | 0,0 |
| Frühjahr | 25,0 | 27,5 | 26,7 | 18,4 | 13,3 | 6,2 | 15,6 | 3,8 | 4,2 | 1,5 | 5,0 |
| Mittel | 17,8 | 18,5 | 16,0 | 13,3 | 9,0 | 4,1 | 10,5 | 2,7 | 2,6 | 0,9 | 2,7 |

Tabelle 3 Die relative Bewertung der Seen auf Grund der untersuchten Haushalte, Gesamtkonstitution sowie Gewicht, Wachstum der Karpfen, Fangintensität und Fangerträge

| See | T. °C | | SBV | O ₂ Sättigung | P | Plankton | Boden- tiere | Ges. Urteil | | Länge/ Gewicht | Karpfen- wachs- tum | Fang- intensität | Fang- erträge |
|----------|---------------|-------------|------|-----------------------------|------|----------|-----------------|-------------|-------|-------------------|---------------------------|---------------------|------------------|
| | a) Ob. Fl. | b) Boden | | | | | | a) | b) | | | | |
| Aksehir | 9 | 6 | 2 | 2 | 3 | 5 | 2 | 2 | 2 | 1 | 1 | 6 | 4 |
| Marmara | 1 | 1 | 3 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| Süleyman | 4 | 3 | (10) | 4 | 7 | 2 | 3 | 3 | 3 | 7 | 5 | 3 | 2 |
| Apolyont | 11 | 8 | 5 | 8 | 4 | (10) | 7 | 8 | 6 | 4 | 4 | 2 | 5 |
| Manyas | 10 | 7 | 8 | 7 | 2 | (6) | 5 | 6 | 5 | 8 | 8 | 5 | 6 |
| Iznik | 6 | 10 | 1 | 5 | 6 | (3) | 4 | 4 | 4 | 3 | 3 | 4* | 3* |
| Sapanca | 5 | 9 | 9 | 3 | 9—11 | (9) | 6 | 7 | 9 | | | 8* | 7* |
| Beysehir | 7 | 4 | 7 | 10 | 8 | 8 | 8 | 10 | 8 | 5 | 6 | 7 | 8 |
| Egridir | 8 | 5 | 6 | 9 | 9—11 | 7 | 10 | 11 | 10—11 | 6 | 7 | 9 | 9 |
| Burdur | 2 | 11 | 11 | (1) | 5 | 4 | 11 | 5 | 7 | | | 11 | 11 |
| Hotamis | 3 | 2 | 4 | 11 | 9—11 | 11 | 9 | 9 | 10—11 | | | 10 | 10 |

* nach älteren Angaben.

Seen die Temperaturen an der Oberfläche und über dem Boden verschieden sind, habe ich für beide die Bewertung getrennt durchgeführt. Die Härte oder das SBV wurde auch als Indikator mit in die Gesamtberechnung einbezogen, da kalkreiche Gewässer bis zu einem gewissen Grade auch die fruchtbarsten sind. Süleyman- und Burdur-See müssen in diesem Falle als alkalitroph betrachtet und bereits wieder negativ bewertet werden. Den Grad der Sauerstoffzehrung während des ganzen Jahres als Indikator für eine starke Produktion an organischer Substanz habe ich ebenfalls zur Beurteilung herangezogen. Für die tiefen Seen gilt die mittlere Zehrung zwischen Oberfläche und Tiefe. Seen mit stärkster Zehrung sind also bei dieser Beurteilung die besten. Phosphate, Plankton und Bodentiere steigen entsprechend ihren Mengen im Werte. Addiert man die Zahlen, die die Reihenfolge bei der Bewertung der Einzelhaushalte für jeden See angeben, so muß der See mit dem kleinsten Summenwert die beste Gesamtkonstitution besitzen. Die Beurteilung gibt zwar kein absolutes, aber sicher ein gutes relatives Bild, vor allen Dingen werden Ungenauigkeiten, die bei der Untersuchung des einen oder anderen Haushaltes aufgetreten sein können, ausgeglichen und der wirkliche Charakter — da zwischen Phosphat, Plankton und Bodentieren eine Abhängigkeit besteht — mehrfach bestätigt. Man hätte versuchen können, bestimmten Haushalten, z. B. den Bodentieren, eine größere Bedeutung beizulegen oder dem SBV eine geringere usw., aber das würde ohne wesentliche Verbesserung die Beurteilung nur komplizieren. Das Ergebnis der Bewertung ist in Tabelle 3 zusammengestellt.

Schon beim Vergleich der einzelnen Haushalte ergeben sich für jeden See fast völlig übereinstimmende Werte, so daß das Gesamturteil nicht nur einen Mittelwert darstellt, sondern sich auch im einzelnen mit diesen deckt. Größere Unterschiede ergeben sich naturgemäß nur für den Burdur-See, dessen gute Konstitution unter seinem hohen Salzgehalt zu leiden hat. Zusammenfassend ergibt sich, daß die 3 flachen Gewässer, Aksehir-, Marmara- und Süleyman-See, die wir auch früher schon als eutroph angesprochen hatten, fischereilich und speziell für die Karpfenfischerei am geeignetsten sind. Der Iznik-See ist mesoeutroph; allgemein fischereilich nicht schlecht, wegen seiner Tiefe aber nicht gerade für Karpfen das richtige Gewässer. Obwohl der Apolyont- und Manyas-See ebenfalls eutrophe Züge zeigen, sind sie wegen ihrer ständigen Trübungen im Effekt doch überwiegend oligotroph oder besser argyllotroph, also für Karpfen nicht mehr so günstig. Der Sapanca-See muß trotz seiner, wahrscheinlich nur allochthon bedingten Sauerstoffzehrung als oligotroph bezeichnet werden, der für Karpfen außerdem wegen seiner Tiefe ungünstig ist. Ausgesprochen harmonisch-oligotroph sind der Beysehir- und Egridir-See; von ihnen ist fischereilich keine große Ausbeute zu erwarten. Praktisch oligotroph ist auch der stark verkrautete Hotamis-See.

C. Fische und Fischerei

Nach der vergleichenden Beurteilung der untersuchten Seen soll im folgenden auf die Fischerei eingegangen werden, um dann im 3. Teil die Bewirtschaftung beurteilen zu können.

Zur Vermeidung von Wiederholungen sei vorausgeschickt, daß in allen Seen an erster Stelle mit einer Wade, dem Irip gefischt wird; manchmal spielen Spiegelnetze und kleine Flügelreusen aus Garn eine gewisse Rolle.

Eine kurze Beschreibung verdient das Irip, eine Wade mit einem Sack in der Mitte und großen Flügeln. Länge und Höhe variieren je nach den Verhältnissen der einzelnen Seen, doch berührt die Wade stets den Seeboden und die

Schwimmer liegen auf der Oberfläche. Auf den größeren Seen wird ein Zug mit 2 Irips von 4 Hauptbooten (Ruderboote) und mehreren kleineren ausgeführt. Zwischen 2 Booten, die selber je einen Flügel der Wade tragen, hängt der Sack. Am Fangplatz wird der Sack ausgelassen und beide Boote fahren auseinander, während sie die Flügel und Zugleinen auswerfen, bis die Wade hufeisenförmig im Wasser steht und die beiden Zugleinen parallel zueinander verlaufen. Symmetrisch zum 1. Irip wird ein 2. so ausgeworfen, daß beide zusammen eine Elipse bilden. Hierbei fahren auf jeder Seite 2 Boote mit den Zugleinen nahe aneinander vorbei. Jedes Boot verankert sich am Ende des Flügels vom gegenüberstehenden Irip und zieht das eigene Zugseil über eine Welle mit Kreuzstäben ein, bis sich auf beiden Seiten die gegenüberliegenden Flügelenden berühren. Die Flügel werden fest miteinander verbunden. Von der Stelle, an der je 2 Flügel miteinander verbunden sind, führt sodann je ein Boot mit einem Zugseil zur entsprechenden gegenüberliegenden Stelle. Dort befestigen sich die Boote und ziehen, wie oben beschrieben, ihr eigenes Zugseil ein, bis die aus beiden Irips gebildete Elipse hantelförmig eingeschnürt und schließlich in 2 Kreise geteilt wird. Jedes Irip wird einzeln mit Hilfsleinen, die parallel zur Oberähre verlaufen und an den Schwimmern leicht lösbar eingehängt sind, über eine Welle ins Boot gezogen.

Es sei noch erwähnt, daß die Seen (Eigentümer ist der Staat) meistens von Unternehmern gepachtet werden, die selber keine Fischer, sondern Geschäftsleute sind. Die eigentliche Fischerei wird von Kosaken ausgeübt, die schon seit Katharinas Zeiten in der Türkei leben, aber ihre Sprache, Religion und Gewohnheiten beibehalten haben. Sie leben in Dörfern geschlossen während des Winters, vorwiegend am Manyas-See und lassen sich im Sommer von den Pächtern anheuern. Damit ist auch schon gesagt, daß nur im Frühling und Sommer, insbesondere kurz vor und während der Laichzeit auf Karpfen gefischt wird.

Der Aksehir-See wird jeweils auf 5 Jahre verpachtet. Der augenblickliche Pächter bewirtschaftet diesen See und gleichzeitig den benachbarten Ebersee mit ca. 100 Kosaken. Die Fänge bestehen zu 60 % aus Schuppenkarpfen und 40 % aus Hechten. Die Karpfen haben vielfach ein Gewicht von 6 bis 8 kg und eine Durchschnittslänge von 53 cm. Als Jahreserträge wurden angegeben:

| | |
|-------------------------------|-------|
| 1. September 1949—1. Mai 1950 | 378 t |
| 1. September 1950—1. Mai 1951 | 236 t |
| 1. September 1951—1. Mai 1952 | 323 t |
| Total | 937 t |

und Jahresdurchschnitt 312 t.

Das sind aber sicherlich „Mindestfänge“. Schon aus der Tatsache, daß 1953 300 t Karpfen 180 000 Tl einbrachten, denen eine Pacht von 100 000 Tl und für Löhne während 6 Monaten 90 000 gegenüberstanden, außer den Ausgaben für Boote und Fanggeräte, muß man auf höhere Fangergebnisse schließen. Nach eigenen Beobachtungen wurden kurz vor der Laichzeit an einem Tage 25–40 t gefangen; gewiß sah ich auch, daß an anderen Tagen im Herbst nur 200 kg gefangen wurden. Für Mai 1954 erwartete der Fischermeister 500–700 t Karpfen. Zu Beginn der Fangsaison sah ich in großen Zementbecken bereits 10 t gesalzenen Rogen (der als Kaviar verkauft wird). Das setzt einen Fang von 100 t Rogenern oder 200 t Karpfen (♀ und ♂) voraus. Aus allem diesen darf man wohl schließen, daß im Jahre mindestens 600 t Fische gefangen werden. Das entspricht einem Hektarertrag von rund 25 kg, wäre also vergleichbar mit dem mittleren Ertrag eines europäischen Gewässers, dem keine Düngung oder

Fütterung zuteil wird. Bei der guten Konstitution will mir auch dieser Ertrag gering erscheinen.

Der M a m a r a - S e e ist wirtschaftlich von Bedeutung auch nur durch den Fang von Karpfen. Es gibt einige kleinere Fische, auf die im 1. Teil hingewiesen wurde. Raubfische gab es bisher keine. Aale dringen seit der Erstellung einer Verbindung mit dem Gediz ein. Im November 1955 setzten wir 20 000 Zandersetzlinge ein, die sich gut entwickelt haben.

Die Karpfen haben beim Fang eine Durchschnittslänge von 48 cm und erreichen 8 kg. Die Laichzeit der Karpfen variiert stark. In manchen Jahren beginnt sie noch nicht Ende April, in anderen ist sie Ende Mai restlos zu Ende.

Der Marmara-See wird auch auf 5 Jahre verpachtet und je nach der Jahreszeit mit 20–30 Kosaken bewirtschaftet. Die bisherige, an sich sinnlose Schonzeit wurde an diesem See auf Grund unserer Intervention gekürzt. Nach den früheren Fangstatistiken, auf die DEVEDJIEN zurückgreift, soll im See 300 t Fische jährlich gefangen worden sein. Spätere Pächter berichten von geringeren Erträgen. Diese Angaben dürften nicht richtig sein. Im Gegenteil werden die Erträge nach der völligen Aussüßung des Sees größer geworden sein. Nach den Angaben des Pächters, der 1953 den See bewirtschaftete, produziert der See 500 t. Der Wert dürfte stimmen. Ich sah selber, daß an manchen Tagen im Frühling 5 t gefangen wurden. Im Herbst waren es 1–2,5 t täglich. Mit 110 kg/ha gehört der Marmara-See zu den sehr guten natürlichen Fischgewässern.

Der S ü l e y m a n - S e e trocknete im Jahre 1939 aus und wurde dann wieder mit 4 Paar Karpfen aus dem benachbarten Hotamis-See neu besetzt. Es gibt daher keine anderen Fische, insbesondere keine Raubfische. Die Karpfen wachsen sehr langsam und können schon bei einer Länge von 20–25 cm reif werden. Die mittlere Länge liegt für beide Geschlechter bei 35 cm. Sie erreichen maximal ein Gewicht von 3 bis 4 kg. Vor einigen Jahren sollen die Karpfen noch größer geworden sein, und es liegt der Verdacht der Übervölkerung vor.

Der See wird zusammen mit dem Hotamis-See von 2 Pächtern gemeinsam jeweils auf 3 Jahre gepachtet. Für den Süleyman-See werden zeitweilig 4 Kosaken angestellt. Die hier benutzte Wade ist relativ klein, es wird auch nur 1 Wade verwendet. Trotz der Überbesetzung mit Karpfen besteht eine Schonzeit vom 15. April bis 31. August. Da es aber nach Ablauf dieser Zeit noch heiß ist (Kühlanlagen bestehen nicht und die Transportmöglichkeiten sind schlecht), setzt die Fischerei erst im Herbst wieder ein. Die meisten Karpfen werden vor der Schonzeit gefangen.

Im Jahre 1951/52 sollen nur 1 t Karpfen gefangen worden sein; doch wurde für das Frühjahr 1953 ein Fang von 4,5 t zugegeben. Im Frühjahr 1954 beobachtete ich selbst an 3 aufeinander folgenden Tagen Fänge von 250, 1000 und 1500 kg. Allerdings wurden im Herbst an manchen Tagen keine 10 Karpfen gefangen. Man darf wohl annehmen, daß durchschnittlich mindestens 6 t Karpfen jährlich gefangen werden; das entspricht einem Hektarertrag von 60 kg, der als gut bezeichnet werden kann und durchaus der Konstitution des Sees entspricht.

Der A p o l y o n t - S e e liefert ebenfalls vorwiegend Karpfen, es folgen Hecht und in weiterem Abstand Wels und Aal. Die Karpfen wachsen langsamer als im Aksehir- und Marmara-See und erreichen selten eine Länge von 50 cm. Es sollen allerdings auch schon Exemplare von 15 kg gefangen worden sein. Im Durchschnitt sind sie 35 cm lang; die ♀ sind etwas größer als die ♂. Einzelne Rogener werden schon mit 28 cm reif und Milchner noch früher. Die

Welse werden bis zu 30 kg schwer; die Fischer behaupten, daß sie früher bis 90 kg schwere Exemplare gefangen haben.

Als einziges Gewässer wird dieser See nicht von einem Unternehmer gepachtet, sondern von dem Dorf Apolyont, das eine Anerkennungsgebühr zahlt. Alle Bewohner des Dorfes leben von der Fischerei und man kann mit 100 selbständigen Betrieben rechnen. Gefischt wird nur mit Spiegelnetzen und kleinen Flügelreusen. Letztere werden in einer sehr langen, senkrecht zum Ufer verlaufenden Reihe aufgestellt. Die Maschenweite der Reusen beträgt ungefähr 30 mm. Aus sozialen Gründen dürfen an diesem See keine Waden eingesetzt werden. Unverkennbar ist an diesem See die Fischerei auch intensiver als in allen anderen türkischen Gewässern.

DEVEDJIAN bezeichnet den Apolyont-See als sehr fischreich und gibt einen Jahresertrag von 550 t an. Ich stehe dieser Angabe sehr skeptisch gegenüber, da die Konstitution des Sees, das langsame Wachstum der Fische und die beobachteten Fänge allein schon geringere Mengen erwarten lassen. Im Herbst, wenn die Fischerei relativ gut ist, beobachtete ich Tagesfänge (alle Fischer zusammen) von 250, 500 kg und maximal 5 t, allgemein 1 t täglich. Wahrscheinlich wird durch die intensive Fischerei ein sehr großer Fischreichtum nur vortäuscht. Eine seit einigen Jahren sehr gut geführte Fangstatistik zeigt auch, daß DEVEDJIANs Werte zu hoch sind (Tab. 4). Es sei noch bemerkt, daß es die genaueste und glaubwürdigste Statistik in der ganzen türkischen Binnen- und Seefischerei ist. Die Statistik wird vom Bürgermeisteramt geführt und

Tabelle 4
Apolyont-See
Fangstatistik, Gesamtfang an allen Fischen (kg)

| Monat | 1950/51 | 1951/52 |
|-----------|---------|---------|
| September | 40 820 | 35 473 |
| Oktober | 44 809 | 53 202 |
| November | 47 912 | 37 809 |
| Dezember | 35 627 | 43 447 |
| Januar | 18 627 | 26 485 |
| Februar | 14 519 | 17 766 |
| März | 13 873 | 6 531 |
| 15. April | 7 341 | 4 177 |
| Summe | 223 528 | 224 890 |

sämtliche Fische werden zu einem gemeinsamen Sammelplatz gebracht, an welchem sie an die auswärtigen Händler versteigert (!) werden. Da der einzelne Fischer gar keine Absatzmöglichkeiten hat, entgeht auch kaum ein Fisch der Statistik. Das durchschnittliche Fangergebnis von 225 t im Jahr nach der Statistik des Dorfes Apolyont dürfte also recht genau sein. Zusätzlich werden von einigen Unterpächtern noch etwa 15 % gefangen, so daß der gesamte See jährlich ungefähr 280 t liefern könnte. Diese Menge entspricht einem Hektarertrag von rund 20 kg, für mitteleuropäische Verhältnisse also dem Ertrag eines mittleren Sees, in welchem nicht genügend gedüngt oder gefüttert wird.

Der M a n y a s - S e e ist seiner Konstitution und geographischen Lage nach dem Apolyont-See fast gleich; er steht sogar mit ihm in Verbindung. Da er weit

weniger intensiv befischt wird — es gibt nur einen Pächter, der nur bei guten Fangaussichten die Fischerei mit Kosaken betreibt — ist der See überbesetzt, vor allem auch durch die vielen Friedfische, die sich uneingeschränkt vermehren. Daher ist das Wachstum der Fische auch äußerst langsam. Brachsen kommen z. B. nie auf 0,5 kg. Die Karpfen haben durchschnittlich nur eine Länge von 35 cm und ein Alter von mindestens 5 Jahren. Sie werden schon reif, bevor sie 30 cm Länge erreichen. Auch fand ich laichreife Milchner von 15 cm Länge. Bezeichnend ist, daß früher auch Exemplare mit 13–15 kg gefangen worden sein sollen. Ähnliches erzählt man sich auch von Welsen, die früher bis zu 120 kg schwer wurden, aber heute maximal nur noch 70 kg erreichen. Der Hechtfang geht von Jahr zu Jahr zurück.

Das Hauptfanggerät ist im Manyas-See wieder die Wade (Irip). Die ungenügende Befischung zeigte sich uns während unserer Untersuchungen im Frühjahr 1953 und 1954. Obwohl in allen anderen Seen noch gefischt wurde, war sie hier schon beendet, also vor Beginn der Schonzeit. Als Mitte November ein Schneesturm auftrat, wurde die Fischerei für das ganze Jahr eingestellt.

Nach glaubwürdigen Angaben werden jährlich durchschnittlich 300–400 t Fische (fast nur Karpfen) gefangen; d. h. während der Fangsaison 3–4 t täglich. Diese Angaben decken sich mit den eigenen Beobachtungen im Herbst, als täglich ungefähr 4–5 t und maximal 10 t gefangen wurden. Der Hektarertrag ist demnach 15–20 kg, also fast so groß wie im Apolyont-See. Wie weiter unten gezeigt werden soll, müßte sich aber trotz der nicht gerade üppigen Konstitution mehr aus dem Manyas-See herauswirtschaften lassen.

Der Iznik-See ist fischereilich völlig vernachlässigt und unausgenutzt. Der halbe See ist von einem Unternehmer gepachtet, der aber nur kurze Zeit fischen läßt. Daneben gibt es noch einen einzelnen Berufsfischer und einige Bauern, die gelegentlich „Fische fangen“. Wahrscheinlich gibt es am ganzen See nur eine Wade und einige sehr kleine Stell- und Spiegelnetze. Außerdem wird mit kleinen Flügelreusen in der Uferregion auf Karpfen gefischt. Der Wels wird mit Angeln gefangen. *Rutilus rubilio* fängt man mit Reusen aus Holzlatten oder Weidengeflecht an den Mündungen der kleinen Zuflüsse, in gleicher Weise auch die Stichlinge zur Laichzeit. Sodann wird noch zur Laichzeit auf *Pararutilus frisii* gefischt. Die Bedeutungslosigkeit der Fischerei ergibt sich schon daraus, daß der Karpfen in dem relativ tiefen mesotrophen See noch der wirtschaftlich wichtigste Fisch ist, obwohl er sich für diesen See denkbar schlecht eignet.

Da im Pelagial überhaupt keine wirtschaftlich wichtigen Fische leben, haben wir von 1953/54 bis 1955/56 etwa 10 Millionen Coregonenbrütlinge und einige 10 000 Setzlinge eingesetzt, die aus dem Mondsee, Traunsee und den Lacher Seen stammten. Der Versuch ist um so erfolgversprechender, als der See keine Raubfische (außer Wels) hat und die hydrographischen Bedingungen durchaus den Anforderungen der Coregonen entsprechen. Aus äußeren Gründen hat man bisher noch keinen ernsthaften Versuch gemacht, eine Coregonenfischerei aufzuziehen.

In seiner Zusammenstellung kommt DEVEDJIAN zu einem durchschnittlichen Jahresertrag von 450 t. Dieser Wert ist sicher falsch. Auch früher wurde nicht intensiver gefischt, wie ich immer wieder bestätigt bekam. Bezeichnend ist, daß TESSIER vor 75 Jahren schrieb, es sei schwer, überhaupt am See ein Boot zu finden. Es soll nicht bestritten werden, daß der Iznik-See solche Erträge liefern könnte — weiter unten soll hierauf noch eingegangen werden —, doch sind die heute eingesetzten Fanggeräte, Boote und Fischer nicht imstande, Fänge in dieser Größenordnung einzubringen.

Der Sapanca-See dürfte wohl von allen anatolischen Seen am artenreichsten an Fischen sein (28 Arten) (KOSSWIG, NÜMANN). Eine wirtschaftliche Bedeutung kommt wiederum nur dem Karpfen zu, obwohl der See alles andere als ein Karpfengewässer ist. Die Karpfen sollen bis zu 15 kg schwer werden; ich selber sah ein Exemplar von 83 cm Länge und 10 kg Gewicht. Es mag stimmen, daß Hechte bis zu 15 kg schwer werden und Brachsen bis zu 2 kg. Hingegen halte ich es für ausgeschlossen, daß in diesem See Welse auf 500 kg und Barsche auf 5 kg kommen.

Seit einigen Jahren findet sich kein Pächter mehr für den Sapanca-See. Nur einzelne Bauern fischen gelegentlich mit kleinen Spiegelnetzen. DEVEDJIAN berichtet, daß früher mit einer 450 m langen Strandwade gefischt wurde.

Es ist aus den genannten Gründen unmöglich, auch nur Anhaltspunkte über die Höhe der Erträge und Ertragsmöglichkeiten zu bekommen. Nach DEVEDJIAN wurden früher 50 t gefangen. Er findet diese Menge gering und führt das schlechte Ergebnis auf das Fehlen von guten Fischern zurück. In dieser Hinsicht bin ich gleicher Meinung; allerdings vermute ich, daß der arme See auch nicht viel mehr produzieren kann. Schließlich ist 8,3 kg/ha für ein oligotrophes Gewässer ein normaler Ertrag.

Dem Beysehir-See kommt, wie allen übrigen Seen, fischereilich nur durch den Fang von Karpfen eine gewisse Bedeutung zu. Die Karpfen wachsen sehr langsam. Ein Exemplar von 65 cm war gut 10 Jahre alt. Das Gewicht liegt beim Fang allgemein zwischen 3 und 5 kg und die Länge zwischen 30 und 70 cm, durchschnittlich bei 45 cm. Maximal sollen Karpfen auf 12 kg kommen. Neben den Karpfen werden noch einige kleinere Fische gefangen: *leuciscus lepidus* und *Chondrostoma regium*, sowie viele *alburnus*. Die Karpfen werden frisch verkauft, die kleineren Fische gesalzen in Kanistern ins Innere von Anatolien geschickt.

Der Beysehir-See wird von einem Pächter bewirtschaftet, der ein halbes Jahr lang etwa 10-20 Kosaken als Fischer anstellt. Der große See mit 60 000 ha wird also nur von ein paar Leuten befischt und das auch nur zeitweise. Mag die Produktion des Sees auch gering sein und der See nicht mit den geeigneten Fischen besetzt, mögen auch Stürme hier häufig den Fang erschweren, so sind die geringen Erträge doch im wesentlichen einer unzulänglichen Bewirtschaftung zu verdanken. Es wird nur im freien See mit einer großen Wade gefischt. Zur Bedienung sind 2 Hauptboote und 2 kleinere Boote erforderlich. Am Beysehir-See kommt also nur eine einteilige Wade (Irip) zum Einsatz, die 450 m lang und 10 m hoch ist. Im Sack beträgt die Maschenweite von Knoten zu Knoten 20 mm. (Die Fanggeräte sind alle noch von Hand gemacht.)

Über die Fangmengen wird keine Statistik geführt. Im Jahre 1952 sollen 20 t Karpfen gefangen worden sein, von Januar bis April 1953 ebenfalls 20 t; jedoch wurde mir Ende des Jahres gesagt, daß das gesamte Jahr nur 7 t Karpfen gebracht habe. Andererseits sollen an kleineren Fischen 1953 150 t gefangen worden sein. Ich sah selbst, wie einzelne Züge mit der Wade 500-1000 kg einbrachten. Im Herbst und Frühling 1953 wurden in meiner Anwesenheit Tagesfänge von 2 t Fischen, darunter einmal 46 kg Karpfen versandt. DEVEDJIAN berichtet von 100 t als Fangergebnis eines Jahres.

Sicherlich sind die Ertragsverhältnisse undurchsichtig. Wenn aber auch 200 t Fische aller Arten im Jahre gefangen würden, so ergibt sich nur ein Hektarertrag von 3 kg. Das ist sicherlich weniger, als der See zu liefern imstande wäre.

Im Egridir-See kommt unter den vorhandenen 10 Fischarten nur dem *Varicorhinus pectai*, *Acanthorutilus handlirschi* und dem Karpfen eine be-

scheidende Bedeutung zu. *Varicorhinus pestai*, der bis zu 3 kg schwer wird, ist wohl am wichtigsten. Über seine Biologie ist sehr wenig bekannt; seine Gonaden sind giftig. *Acanthorutilus* wird vorwiegend im Hoyran-Abschnitt gefangen und erreicht nur ein Gewicht von 200 g. In diesem flacheren Seeteil lebt auch vorwiegend der Karpfen. Obwohl Exemplare von 10 kg vorkommen sollen, beträgt die mittlere Länge nur 42 cm bei einem Gewicht von 1–2 kg im allgemeinen. Auch das Wachstum ist relativ langsam; ein Exemplar von 55 cm war bereits 8 Jahre alt. Im November 1955 wurden von uns 10 000 Zander von 10 bis 15 cm Länge eingesetzt.

Am See gibt es 5 Pächter bzw. Pächtergemeinschaften. Trotzdem ist die Fischerei nicht intensiver als am Beysehir-See. Nur die Pächter im Hoyran-Gebiet, die im Frühjahr einige Kosaken einstellen und auch im Besitze einer Wade sind, fischen relativ gut. Die Hauptpächtergruppe in Egridir beschränkt sich darauf, unterhalb der Schleuse (neuerdings oberhalb) im Abfluß einen Fischzaun mit Reusen zu bauen und zu warten, bis die Fische kommen. Außerdem besitzen sie noch 2–4 Spiegelnetze (für einen Seeabschnitt mit 33 000 ha!). Die übrigen 3 Pächter sind einzelne Bauern, die nur im Frühjahr kurz vor der Laichzeit mit Spiegelnetzen auf Karpfen fischen.

Über die Fangerträge wird keine Statistik geführt. Die täglichen Fänge der 3 einzelnen Fischer kann man stückweise zählen und fallen kaum ins Gewicht. Die Hauptpächter haben angeblich früher ca. 100 t Fische gefangen; jetzt sollen nur noch 20 t eingebracht werden. Nach DEVEDJIAN wurden im eigentlichen Egridir-See 100 t und im Hoyran-Abschnitt 15 t Fische gefangen. Nach allen diesen Daten scheinen pro Hektar nicht mehr als 2 kg geerntet zu werden, also sehr wenig. Dieser Wert ist zwar unsicher, aber bei der schlechten Bewirtschaftung durchaus glaubwürdig.

Der Burdur-See enthält wegen seines hohen Salzgehaltes keine Fische mit Ausnahme eines Zahnkarpfens, der dem *Anatolichthys* sehr nahe steht. Neuerdings hat KOSSWIG euryhaline und eurytherme Cichliden eingesetzt, nachdem sich in Aquarienversuchen gezeigt hatte, daß sie Burdurwasser gut vertragen. Wir selber haben im Mai 1955 120 000 Jungaale eingesetzt, von denen einer im Frühjahr 1957 mit einer Länge von 82 cm zufällig gefangen wurde.

Der Hotamis-See weist außer dem Karpfen keine wirtschaftlich wichtigen Fische auf. Es gibt noch einige unbedeutende Fische, die teilweise durch einen neuen Kanal aus dem Beysehir-See kommen. Bei der geringen Nahrung wachsen die Karpfen sehr langsam: Rogener und Milchner haben nach 5 Jahren durchschnittlich nur 36 cm.

Der See wird für ein geringes Pachtgeld zusammen mit dem Süleyman-See an 2 Pächter gemeinsam verpachtet. Gefischt wird nur mit Spiegelnetzen und kleinen Flügelreusen. Die Wade kann nicht eingesetzt werden, da es zuwenig offene Wasserflächen gibt.

DEVEDJIAN schätzte seinerzeit den Gesamtjahresertrag auf 500 kg. Die Pächter geben heute 3 t zu. Ich war zugegen, als zur besten Fangzeit in 3 Tagen 1,5 t Karpfen gefangen wurden. Allerdings wurden an schlechten Tagen nicht einmal 10 Stück an Land gebracht. Auch wenn von den Pächtern ein zu geringer Wert angegeben würde, so dürfte der Gesamtfang wohl kaum 5 t jährlich überschreiten. Mit einem Hektarertrag von 0,7 kg wäre der Hotamis-See somit der schlechteste aller anatolischen Seen. Die schlechte Konstitution und ungenügende Befischung lassen allerdings auch kein besseres Ergebnis erwarten.

D. Fischproduktion, Fangerträge und F-B-Koeffizient

Im folgenden soll der Versuch gemacht werden, auf Grund unserer limnologischen Untersuchungsergebnisse die Richtigkeit der Angaben über die Fangerträge festzustellen und die Ertragsmöglichkeiten oder Überfischungsgefahren quantitativ einzuschätzen.

Für den Iznik-See war es möglich, auf Grund des P- und O₂-Haushaltes eine übereinstimmende Mindestproduktion von 1 kg/m² organische Substanz jährlich zu errechnen. Diese sogenannte effektive Produktion in den Gewässern, zunächst einmal nicht erntbar, erleidet auf dem Wege zum Fischfleisch mehrere mit Verlusten verbundene Umsätze. GRIM setzt den Verlust auf $\frac{14}{15}$ für den ersten Umsatz von Phytoplankton zu Zooplankton an, d. h., im Iznik-See würden unter 1 m² aus dem Kilo Phytoplankton rund 70 g kleiner Krebschen entstehen. Unter der Annahme, daß wir es in dem See nur mit planktonfressenden Fischen zu tun haben, d. h. ohne einen weiteren Umsatz über räuberische Krebschen, könnten bei 90 % Verlust durchschnittlich unter 1 m² noch 7 g Fischfleisch entstehen. Praktisch errechnet GRIM im Mittel wegen weiterer Umsätze aber nur einen Nutzeffekt von $\frac{1}{1000}$ der Urproduktion. Legen wir den letzten Wert zugrunde, so müßte der Iznik-See an pelagischen Planktonfressern mindestens (wir sind stets von Minimalwerten ausgegangen) bei einer Fläche von 30 000 ha 300 t Fischfleisch im Pelagial jährlich liefern können.

Die Produktion an Bodenfischen aus den Mengen an Bodentieren zu berechnen, ist noch schwieriger. Wir stellen uns allerdings immer vor, daß ein großer Teil der organischen Substanz, die nicht im Pelagial in Fischfleisch umgesetzt wird oder im Energiehaushalt aufgeht, irgendwie einmal auf den Boden sinkt, sofern sie nicht schon unterwegs zersetzt wird. Wegen der hohen P-Konzentration und der starken Sauerstoffabnahme über dem Boden darf man wohl annehmen, daß es sich um beachtliche Mengen handelt. Kämen auch nur 50 % der Urproduktion auf den Boden und würden von diesen $\frac{1}{15}$ wiederum nur in Bodentiere mehr oder weniger direkt umgesetzt, so ständen im Iznik-See den Bodenfischen 30 g/m² im Laufe eines Jahres zur Verfügung, die den Aufbau von 3 g/m² Fischfleisch ermöglichen würden. Daß diese Spekulation nicht so abwegig ist, beweist eine andere Berechnung, bei der man von der wirklich festgestellten Menge an Bodentieren ausgeht. Das sind im Iznik-See maximal 18 g/m². Allein diese — ohne Rücksicht darauf, daß im Laufe des ganzen Jahres weit mehr produziert wird — würden bei einem 90 %igen Verlust durch den Umsatz eine Produktion von 1,8 g/m² Fischfleisch gestatten. Dieser Wert muß natürlich etwas niedriger sein, weil wir im zweiten Fall von der stehenden Ernte ausgingen und nicht von der Jahresproduktion an Bodentieren. Nach einer groben Überschlagsrechnung müßte der Iznik-See außer den 300 t pelagischer Fische also mindestens noch 600 t Bodenfische erzeugen können, also 30 kg/ha, ein Wert, der bei der Konstitution des Sees nicht unwahrscheinlich ist.

Die übrigen anatolischen Seen lassen, abgesehen von den generellen Fehlern einer solchen Berechnung, überhaupt aus dem P- und O₂-Haushalt keine Berechnung der Produktionsmöglichkeiten zu (NÜMANN 1960). Es soll jedoch, wie bereits angedeutet, der Versuch gemacht werden, über die Bodenfauna zu Annäherungswerten zu kommen. Aus den einzelnen Bodentierproben (Ernten) läßt sich jeweils nur berechnen, welche Fischmengen aus diesen aufgebaut werden könnten. Da nicht bekannt ist, wie alt die einzelnen Formen sind, wie lange sie leben, wie oft die Generationen wechseln, d. h. wieviel Individuen

zwischen zwei Untersuchungsdaten gebildet wurden, wieviel gestorben und wieviel erhaltengeblieben sind, geben die einzelnen Proben oder auch Mittelwerte aus verschiedenen Zeitabständen nur Minimalwerte für die Produktion an Bodentieren und damit auch an Bodenfischen wieder.

In manchen Fällen würde man aus der einmalig erntbaren Menge an Bodentieren, besonders wenn es sich um die Jahreshöchstmenge handelt, bereits erkennen, ob sie als Nahrung im Mindestverhältnis zur Fischproduktion steht. Zum Beispiel wurden im Egridir-See im Herbst $4,2 \text{ g/m}^2$ an Bodentieren gefunden; das sind 42 kg/ha . Nehmen wir an, bei einem Direktumsatz könnten 10% in Fischfleisch umgewandelt werden, so müßten $4,2 \text{ kg/ha}$ Fisch produziert und möglichst geerntet werden. Sicherlich werden aber im Laufe des ganzen Jahres mehr Bodentiere produziert. Daher müßte der Fischertrag viel größer sein. Da aber in Wirklichkeit nicht einmal diese Mindestmenge eingebracht wird, ist die Bewirtschaftung dieses Sees zweifellos schlecht.

Indessen kann man auch, zurückgehend auf ALMs Untersuchungen in schwedischen Gewässern, rein empirisch feststellen, daß eine gewisse Beziehung besteht zwischen den Jahreserträgen an Fischen und der jeweils erntbaren Menge an Bodentieren – der Wert muß nur repräsentativ sein. Es sei nochmals betont, daß dieses Verfahren keine Berechnung des Umsatzes, sondern nur eine empirische Feststellung ist. Die Beziehung läßt sich zahlenmäßig festlegen und gibt jedem See einen charakteristischen Wert (FB-Koeffizient). Die Standardwerte wurden an gut bewirtschafteten Seen aller Trophiegrade, an denen auch eine gute Statistik geführt wurde, gewonnen. Abweichungen von diesen Werten besagen, daß zuviel oder zuwenig gefischt wird.

Der Koeffizient wird zunächst nur für die Bodenfische angewendet. Mehr als man vielleicht vermutet, würde er auch zu einem gewissen Grade auf die übrigen Fische angewendet werden können, denn, wie mehrfach gezeigt wurde, stehen Plankton und Bodenfauna ihrerseits auch in einem bestimmten Verhältnis zueinander. In den untersuchten türkischen Seen ist der Quotient von cm^3/m^2 Plankton : g/m^2 Bodentiere in fast allen Fällen $1,3\text{--}1,8$ (Tab. 1). Egridir- und Beysehir-See weichen deswegen wahrscheinlich etwas stärker von den übrigen Seen ab, weil die Mollusken, die dort eine größere Rolle spielen, bei unseren Untersuchungen nicht miterfaßt wurden. Damit sei nur angedeutet, daß es evtl. auch möglich ist, rein erfahrungsgemäß aus der vorhandenen Menge an Plankton und Bodentieren auf die Gesamtproduktion an Fischen Schlüsse zu ziehen. Im folgenden beschränken wir uns indessen nur auf die Bodenfische.

Gegen die bisherigen Versuche, aus der Bodenfauna und den Fangerträgen die Befischungsintensität abzuleiten, wurde geltend gemacht (SELIGO), daß vielfach die sich direkt am Ufer entwickelnde Fischnahrung, die nicht mit dem Bodengreifer erfaßt wird, an Bedeutung viel wichtiger ist. Auch soll die Bedeutung an Flugnahrung nicht genügend gewürdigt werden. Bei den großen anatolischen Seen, in denen das Ufergebiet im Verhältnis zur ganzen Fläche nur sehr klein ist, dürften Erwägungen dieser Art vernachlässigt werden. Da alle Seen vorwiegend Karpfen, also Bodenfische, produzieren, ermutigen diese günstigen Umstände auch, die Produktion an Fischen in den einzelnen Gewässern aus der Menge an Bodentieren zu bestimmen.

Es ist jedoch notwendig, zum besseren Verständnis wie zur Kritik, auf ALMs Ausführungen einzugehen. ALM suchte aus dem Verhältnis vom statistisch ermittelten Fangertrag zu der gefundenen Menge an „Schlammtieren“ (Bodentieren) den sogenannten FB-Koeffizienten zu ermitteln (nicht BF = Befischungskoeffizient!). Dieser Wert schwankte in den einzelnen Seen von $1/0,8$

bis 1/19,8. ALM schloß daraus (nach SELIGO): Wenn der Koeffizient niedrig ist, sollte der See stärker befischt werden. Ist er jedoch hoch, befinden sich im See mehr Fische, als der Nahrungsmenge entspricht. Diese Schlußfolgerungen bedürfen unseres Erachtens aber einer Erweiterung. Zunächst sei festgestellt,

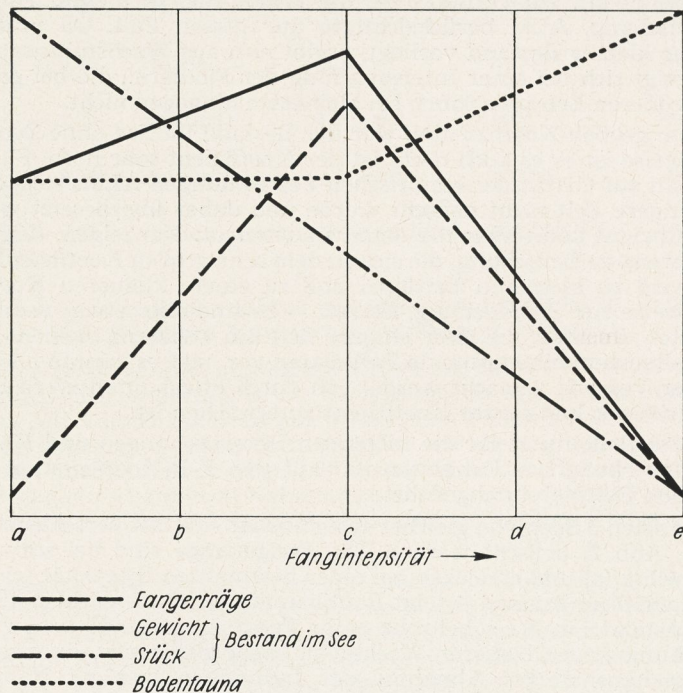


Abb. 2 Die Abhängigkeit des Fangertrags, des Fischbestandes und der Bodenfauna von der Fangintensität (Schema).

daß es sich um keine gegenpoligen Schlußfolgerungen handelt. Auf Grund des kleinen Koeffizienten wird eine Aussage über die Fangmenge bzw. Fangintensität gemacht. Der große Koeffizient dient zur Beurteilung der Bestandsgröße im See. Bringt man die beiden verschiedenartigen Feststellungen aber durch weitere Umrechnungen auf denselben Nenner, so müßte man in beiden Fällen folgern, wenn bei kleinem Koeffizienten intensiver gefischt werden soll, müssen zuviele Fische vorhanden sein. Wir haben also dieselbe Schlußfolgerung wie bei einem großen Koeffizienten. Oder anders ausgedrückt: Wenn bei großem Koeffizienten zuviele Fische vorhanden sind, muß intensiver gefischt werden. Die Situation ist also dieselbe wie beim kleinen Koeffizienten.

Tatsächlich gibt der Koeffizient zunächst aber nur an, ob die Fangerrträge im Verhältnis zur vorhandenen Nahrung gering oder hoch sind. Bleibt der Koeffizient bei einer längeren gleichmäßigen Befischung konstant klein, so kann der Bestand im See so-

wohl sehr gering wie hoch sein. Im ersten Fall ist der Bestand gering, weil der See schon überfischt wird; daher geringe Fangmengen und kleiner Koeffizient. Als Schlußfolgerung ergibt sich: Der See muß weniger intensiv befischt oder geschont werden. Im zweiten Fall ist der Bestand groß, aber infolge unzureichender Fanggeräte oder Fangintensität wird nicht genügend aus dem See herausgeholt; daher ebenfalls geringe Fangmengen und kleiner Koeffizient. Als Schlußfolgerung ergibt sich in diesem Falle: Intensivere Befischung. ALM berücksichtigte nur diesen Fall. Ob praktisch ein großer oder kleiner Bestand vorliegt, ergibt sich aus Wachstumsuntersuchungen oder zeigt sich bei einer Intensivierung der Fischerei, die bei großem Bestand zu größeren Erträgen führt, bei kleinerem hingegen nicht.

Bei einem großen Koeffizienten war der Bestand im See ohne Zweifel groß, möglicherweise ist er es auch noch. Ist der Koeffizient sehr hoch. $F : B = > 1$, so kann man auf Grund der empirischen Feststellungen ALMs sicher sein, daß der See längere Zeit nicht befischt wurde und daher überbesetzt war. Dieser große Koeffizient kann aber nie einen Dauerzustand anzeigen, denn die einsetzende intensive Befischung, die sich in dem sehr großen Koeffizienten widerspiegelt, wird zu kleineren Erträgen und zu einem kleineren Koeffizienten, möglicherweise zur Überfischung, führen. — Es sind aber etwas weniger große Koeffizienten denkbar, die über längere Zeit hin konstant bleiben. In diesem Fall liegt allgemein eine optimale Befischung vor, und es könnte höchstens ein vorsichtiger Versuch gemacht werden, ob durch etwas intensivere Befischung noch ein größerer konstanter Koeffizient zu erreichen ist.

Wegen der Bedeutung für die folgenden Untersuchungen und Rückschlüsse sei die Auswirkung der Fangintensität auf den F-B-Koeffizienten an einem theoretischen Beispiel durchgeführt:

Gegeben seien 5 Seen von gleicher Konstitution, die mit verschiedener Intensität (a—e, Abb. 2) befischt werden. Die Fangerträge sind bei schwacher Befischung gering (a) und erreichen bei einer bestimmten Intensität (c) ihr Maximum. Bei weiterer Intensität setzt Raubbau ein (d, e). Gewichtsmäßig könnte der Fischbestand im See bei sehr guten Fangerträgen evtl. trotz zunehmender Befischung wegen besseren Wachstums sogar zunehmen, da insgesamt für den Energiehaushalt bei Abnahme der Individuen weniger Nahrung verbraucht wird. Später macht sich der Raubbau auch im Bestand bemerkbar. Zahlenmäßig nehmen die Fische im See mit stärkerer Befischung immer ab. Die absolute Menge an Bodentieren wird durch die Fische reduziert. Sie dürfte bei geringer bis optimaler Befischung (a—c) entsprechend einem großen oder mittleren Fischbestand bis auf einen wenig angreifbaren Teil konstant sein. Die Bodentiere werden aber erst bei Überfischung, also bei geringem Fischbestand, zunehmen (selbstverständlich sind die jahreszeitlichen Schwankungen bei diesen Berechnungen in jedem Falle ausgeschaltet). Dementsprechend läßt sich aus dem Quotienten folgendes ablesen (Tab. 5): Ein kleiner Koeffizient ist sowohl für eine zu geringe als auch für eine zu starke Befischung (a und e) charakteristisch. Allerdings liegt bei „a“ gewichtsmäßig ein guter Bestand im See vor, bei „e“ ein sehr schlechter. Bei „a“ ist er zahlenmäßig zu dicht und bei „e“ zu licht. Ein hoher F-B-Koeffizient (c) zeugt von einer optimalen Befischung, sehr guten Fangerträgen und gewichts- wie zahlenmäßig von einem guten Bestand im See. Keineswegs zeigt also, wie ALM annimmt, ein hoher F-B-Koeffizient unbedingt einen zu dichten Bestand im Verhältnis zur Nahrung an. Je größer der Koeffizient, sofern er nur konstant bleibt, um so besser die Bewirtschaftung! Man darf nicht irrtümlich aus einem hohen Koeffizienten ableiten, es wären mehr Fische als Nahrung vorhanden. Bei der Nahrung handelt es sich nur um einen einmaligen Befund oder um einen Mittelwert, wäh-

Tabelle 5
Rückschlüsse aus dem F-B-Koeffizienten (Schema)

| Fangertrag/ Bodentiere | Fangintensität | Bestand im See Gewicht | See Stück | Fangertrag |
|---|----------------|---------------------------|--------------|-------------|
| a) $\frac{0,5}{10} = \frac{1}{20} = 0,05$ | sehr gering | gut | viel zu viel | sehr gering |
| b) $\frac{6,6}{10} = \frac{1}{1,5} = 0,66$ | mittel | gut | zu viel | mittel |
| c) $\frac{12,5}{10} = \frac{1}{0,8} = 1,25$ | optimal | sehr gut | viel | sehr gut |
| d) $\frac{6,6}{12,5} = \frac{1}{1,89} = 0,53$ | zu stark | schlecht | wenig | mittel |
| e) $\frac{0,5}{15} = \frac{1}{30} = 0,03$ | viel zu stark | sehr schlecht | sehr wenig | sehr gering |

rend sicherlich innerhalb des Jahres viel mehr produziert wird. Der Vergleich wird aber mit dem gesamten Jahresertrag an Fischen angestellt.

In den hier besprochenen anatolischen Seen ist, soweit ich unterrichtet bin, keine revolutionäre Änderung in der Fangintensität und in den Fangerträgen eingetreten. Mit Vorsicht müssen nur in manchen Fällen die Angaben über die Fangerträge gewertet werden, doch möchten wir diese gerade mit dem F-B-Koeffizienten überprüfen. In allen Fällen, in denen der Hektarertrag (Tab. 6) entsprechend der vorhandenen Nahrung zu niedrig ist, liegt der Verdacht nahe, daß die Angaben nicht richtig sind, daß also zu geringe Fänge angegeben wurden.

Der Marmara- und Apolyont-See mit höchsten Koeffizienten werden am intensivsten befischt. Das entspricht auch wohl den gemachten Beobachtungen. Am Süleyman- und wahrscheinlich auch am Manyas-See wird nicht intensiv genug gefischt. Dafür sprechen auch andere Gründe. Der kleine Koeffizient zeigt, daß der Bestand des Sees (also nicht der Ertrag) zu groß ist. Hotamis-, Beysehir- und Egridir-See sind Gewässer mit extrem niedrigem F-B-Koeffizienten. Es kann kein Zweifel bestehen, daß der Fischbestand wegen ungenügender Befischung für diese Seen zu groß ist. Eine Überfischung, die ein kleiner F-B-Koeffizient ja auch anzeigt, kann in diesem Falle nicht vorliegen, denn das Wachstum der Fische ist sehr schlecht. Die Wachstumsuntersuchungen, die noch gesondert behandelt werden sollen, können darüber entscheiden, ob zuviel oder zuwenig gefischt wird.

Die relativen Mindestertragsmöglichkeiten der einzelnen Seen lassen sich auf anderem Wege überschlagsweise berechnen. Ausgangs- und Bezugspunkt sind Marmara- und Apolyont-See, die bei intensiver Befischung die besten Erträge bringen. Für beide Seen liegen auch die zuverlässigsten Angaben über die Fänge vor. Der Jahresertrag an Fischen ist trotz der verschiedenen Konstitution ungefähr halb so groß wie die durchschnittliche stehende Ernte an Bodentieren. Verglichen mit diesen beiden Gewässern ist der F-B-Koeffizient aller andern Seen viel kleiner und zeugt daher von einer schlechten Bewirtschaftung oder von nicht vollständigen Fangangaben. Die Tabelle 6 zeigt in der vierten Spalte, wie groß die Fangerträge bei gleicher Fangintensität bzw. bei einem F-B-Koeffizienten von $\frac{1}{2}$ in den andern Seen sein müßten. Bezogen auf den Marmara- und Apolyont-See, für die wir bei einem F-B-Koeffizienten von

Tabelle 6
Gefundene Mengen an Bodentieren,
deklarierte Fangmengen an Fischen und ausgenutzte Ertragsmöglichkeiten,
bezogen auf den gut bewirtschafteten Marmara- und Apolyont-See

| See | Dekla- rierter Jahres- ertrag an Fischen kg/ha | Bodentiere vorhandene Menge kg/ha | Fangertrag : Bodentiere | Theoreti- scher Jahres- ertrag F/B = $\frac{1}{2}$ | Aus- genutzte Ertrags- möglich- keit % |
|----------|---|--|-------------------------------|--|---|
| Marmara | 110 | 185 | 1 : 1,7 | 93 | 100 % |
| Apolyont | 20 | 41 | 1 : 2,1 | 20 | 100 % |
| Süleyman | 60 | 160 | 1 : 2,7 | 80 | 75 % |
| Iznik | 40 | 133 | 1 : 3,3 | 67 | 60 % |
| Manyas | 15—20 | 105 | 1 : 5,5 | 52 | 34 % |
| Aksehir | 25 | 178 | 1 : 7,1 | 79 | 32 % |
| Beyşehir | 3 | 27 | 1 : 9,0 | 14 | 21 % |
| Sapanca | 8,3 | 90 | 1 : 10,4 | 45 | 18 % |
| Egridir | 2 | 26 | 1 : 13 | 13 | 15 % |
| Hotamis | 0,7 | 27 | 1 : 38 | 13 | 5 % |

$\frac{1}{2}$ eine mehr oder weniger hundertprozentige Ausnutzung der Ertragsmöglichkeiten festsetzen, ergeben sich bei gleicher Betrachtung für die anderen Seen die in Spalte 5 aufgeführten Ausnutzungsgrade. Ob die Fischerei darüber hinaus evtl. noch weiter intensiviert werden kann, läßt sich zunächst noch nicht sagen. Eine weitere Intensivierung hängt davon ab, ob unser Bezugspunkt zu niedrig angesetzt ist, d. h., ob im Marmara- oder Apolyont-See auch noch eine Intensivierung möglich ist.

Im ersten Teil unserer Untersuchungen wurden die Seen entsprechend ihrem relativen Gütewert auf Grund der limnologischen Daten geordnet. Eine weitere Aufstellung läßt sich entsprechend den absoluten Fangerträgen und der Fangintensität durchführen. Ergänzt werden diese durch eine Aufstellung auf Grund des Karpfenwachstums und ihres Ernährungszustandes (Länge/Höhe). Da die Karpfen und speziell das Karpfenwachstum in den anatolischen Seen gesondert behandelt werden sollen, sei hier nur das Ergebnis aufgeführt.

Ein Vergleich der verschiedenartigen Aufstellungen (Tab. 3) zeigt zunächst, daß man aus der gesamten limnologischen Konstitution, wie sie sich bei der Art unserer Untersuchung ergab, allgemein auf die absoluten Fangerträge schließen kann. In den Fällen, in denen keine gute Übereinstimmung vorliegt, ist entweder die Fangintensität nicht ausreichend, oder die Fangangaben werden nicht vollständig durchgeführt. Zum Beispiel hat der Aksehir-See die besten Voraussetzungen für sehr gute Fangerträge; praktisch zeigt sich das aber nicht in den Fangangaben. Dasselbe beweist auch der F-B-Koeffizient. Der Ernährungszustand und das Wachstum der Karpfen sind aber so ausgezeichnet, daß der See nicht überbesetzt sein kann. Der See wird also ausreichend befischt, nur werden die Fangerträge nicht richtig angegeben.

Die angegebenen absoluten Fangerträge entsprechen mehr oder weniger auch der berechneten Fangintensität. Allerdings gibt es zwei Ausnahmen: Bei der einen, dem Aksehir-See, konnte schon gezeigt werden, daß die Fangerträge in Wirklichkeit höher liegen müssen und daß die Fangintensität zu niedrig eingestuft wurde. Umgekehrt wird aber im Apolyont-See bei nur mittelmäßiger

Konstitution noch relativ viel gefangen, weil die Fischerei sehr intensiv betrieben wird. Ganz unabhängig von diesen Berechnungen zeigt sich die intensive Befischung am Apolyont-See auch im Ernährungszustand und Wachstum der Karpfen. Beide Merkmale sind im gleichgearteten Manyas-See, mit dem der Apolyont-See sogar in Verbindung steht, wesentlich schlechter, weil dieser bei ungenügender Befischung überbevölkert ist.

Die Tabelle zeigt, daß sich die Karpfen allgemein gemäß der festgestellten Konstitution des jeweiligen Sees entwickeln. Man sieht aber auch, daß im oligotrophen Manyas-See die Karpfen wesentlich schlechter wachsen, als der Konstitution des Sees entspricht. Den Grund für dieses Mißverhältnis kann man eindeutig auf die ungenügende Befischung zurückführen, wie das Verhältnis von Bodenfauna zu Fangerttrag zeigt. Der Manyas-See ist wegen der ungenügenden Befischung, wie bereits früher gesagt, überbevölkert. Die vorhandene Nahrung wird für den Energiehaushalt allzu vieler Individuen verwendet und nicht zum Wachstum. Daher kann das Wachstum der Karpfen nicht der Konstitution des Sees entsprechen.

Im Süleyman-See ergeben sich bei recht intensiver Befischung entsprechend der Konstitution auch gute Fangerträge. Unerwartet ist aber trotzdem das langsame Wachstum und der schlechte Ernährungszustand, die auf eine Überbevölkerung schließen lassen. Eine Überbevölkerung betrifft aber nicht die erwachsenen Karpfen, sondern die jungen im Alter von 1 bis 3 Jahren, auf die noch nicht gefischt wird. Da Raubfische und überhaupt andere Fische fehlen, unterbleibt die natürliche Ausmerzung des Überschusses an kleinen Fischen. Der Mangel an Futter infolge Überbevölkerung wirkt sich also vornehmlich auf die jungen Karpfen aus, die trotz starker Befischung der ältern Jahrgänge nicht erfaßt werden.

Umgekehrt erkennt man, wie die Hektarerträge des Apolyont-Sees bei relativ schlechter Konstitution durch intensive Fischerei doch noch erhöht werden können. Daher ist das Wachstum der Karpfen auch viel besser als im völlig gleich beschaffenen Manyas-See.

Insgesamt zeigt die Zusammenstellung in Tabelle 6, daß die limnologischen Untersuchungen ein Bild über die Konstitution der Seen entwerfen, welches durchaus das Verhalten und die Entwicklung der Karpfen, unabhängig von den direkten Untersuchungen, im voraus erkennen läßt. Aus der Fangintensität, die, wohlgemerkt, keine vage Schätzung, sondern ein errechneter Wert ist, lassen sich zusammen mit der Konstitution des Sees oder mit der Entwicklung der Karpfen, also auf zwei verschiedenen Wegen, Schlüsse auf die Fangerträge ziehen, die auch tatsächlich mit den direkt festgestellten Werten übereinstimmen. Ja, man kann im Rahmen dieser relativen Betrachtung sagen: Wenn von den 4 Daten (Konstitution des Sees, Karpfenentwicklung, Fangintensität und Ertrag) 3, evtl. auch nur 2, bekannt sind, lassen sich die fehlenden Werte berechnen.

E. Praktische Schlußfolgerungen

Als Hauptforderung ergibt sich für alle Seen, für die fruchtbaren und insbesondere für die unfruchtbaren, eine Intensivierung der Fischerei. Die ungenügende Bewirtschaftung bedeutet nicht nur quantitativ einen Ausfall in der landwirtschaftlichen Produktion, sondern auch durch die Überbevölkerung der Seen qualitativ eine Verkümmernng des Bestandes.

Die zur Auflage gemachten Schonzeiten sind bei der jetzigen Fangintensität zu lang und überhaupt überflüssig. Man könnte zumindest vorläufig völlig auf

Schonzeiten verzichten, denn der Hauptfisch, der Karpfen, kommt allgemein mehrere Male zum Laichen.

Die schlecht bewirtschafteten Seen müßten von mehr Fischern befischt werden. Allerdings sind weitere Momente, die außerhalb der eigentlichen Fischerei liegen, zu berücksichtigen, z. B. die sozialen und wirtschaftlichen Verhältnisse oder die Mentalität des Landes. Ferner müßte durch den Bau von Kühlanlagen, geeigneten Transportmitteln und Entwicklung des Marktes auch für einen besseren und leichteren Absatz der Fische gesorgt werden. Allgemein haben Fischer und Pächter die Vorstellung, daß eine Verbesserung der Fanggeräte zu reichlicheren Erträgen führen würden. Meines Erachtens kann man sich aber für die großen, freien Flächen der anatolischen Seen keine besseren Fanggeräte denken als die bisher benutzten Waden. Nur müßte eine größere Anzahl von Fanggeräten eingesetzt werden. Noch schlimmer ist es, daß am Apolyont- und Egridir-See Waden überhaupt nicht zum Einsatz kommen. In Apolyont müßten bei Einführung der Waden-Fischerei allerdings wohl wegen der relativ vielen „kleinen“ Fischer soziale Rücksichten genommen werden.

Besonders schwierig gestaltet sich eine intensive Bewirtschaftung der stark verkrauteten Seen. Es ist hoffnungslos, diese mit Unterwasser-Schilfschneidemaschinen freilegen zu wollen. Abgesehen von dem enormen Aufwand, würden die am Boden verbleibenden Stoppeln das Arbeiten mit der Wade erschweren oder unmöglich machen. Die Unterstücke der Fanggeräte liegen dem Boden nicht dicht genug an, so daß der schlaue Karpfen immer entweichen wird. Eventuell ließen sich nach dem Schneiden von Schneisen Ankerreusen und Trappnetze mit langen Zuleitern einbauen. Gewiß geht der Karpfen nicht gerne in Reusen! Immerhin würden die großen Ankerreusen gegenüber den kleinen Flügelreusen eine Verbesserung bedeuten. Unter Benutzung von Elektrofängergeräten, bei denen allerdings wohl die Scheuchwirkung wesentlich wäre, ließen sich in flachen Seen mit nicht zu weichem Untergrund die Karpfen aus den dichten Pflanzenbeständen in die Reusen und Spiegelnetze treiben.

Neben dem Versuch, mit technischen Verbesserungen die Fangerträge zu steigern, dürfte es wichtig sein, mit biologischen Methoden einzugreifen. Es handelt sich in erster Linie darum, wertlose Fische durch wertvollere zu ersetzen. Der Marmara-See ist zwar für Karpfen bestens geeignet, wenn auch das Wachstum nicht ganz so gut ist wie im Aksehir See. Da aber gerade hier viele wertlose Friedfische beachtliche Nahrungskonkurrenten des Karpfens sind, die sich immer üppiger entwickeln, weil es keine Raubfische gibt und sie selbst nicht durch die Fischerei kurz gehalten werden, entschlossen wir uns für den Einsatz von Raubfischen (ausführlicher in NÜMANN 1959). Am 12. November 1955 wurden 10 000 Zander mit einer Länge von 10–15 cm eingesetzt, von denen heute schon schöne Exemplare gefangen werden. Gegenüber dem Hecht haben wir den Zander wegen seines besseren Fleisches vorgezogen.

Dem Süleyman-See, der nur mit Karpfen besetzt ist, fehlt unbedingt eine Auflichtung des Bestandes. Da er nicht wie ein ablaßbares Gewässer bewirtschaftet werden kann, müßten auch hier Raubfische eingesetzt werden. Da Hecht und Zander in dem relativ kleinen See leicht zu fangen sind, besteht auch keine Gefahr, daß der Hecht den Karpfenbestand zurückdrängt.

Am Manyas-See muß zunächst der Karpfenbestand durch intensivere Befischung ausgedünnt werden. Mit allen Mitteln (evtl. mit Elektrogeräten oder anderen engmaschigen Netzen) müssen die kleinen, wertlosen Fische gefangen werden, selbst wenn man sie nur als Dünger verwertet. Da die vorhandenen Hechte offenbar abnehmen, sollten die Gräben zu den Laichwiesen besser offengehalten werden. Sogar an die künstliche Erbrütung von Hechteiern am

Manyas-See ist zu denken, und die Brut sollte möglichst vor dem Aussetzen noch angefüttert werden. Die Verhältnisse am Apolyont-See sind mit Karpfen und Hechten direkt ideal. Es könnte allenfalls noch der Versuch gemacht werden, mit Schleien die kärgliche Nahrung des Sees noch besser auszuwerten. Vielleicht würde man den Hecht auch wohl besser wegen seines Fleisches durch den Zander ersetzen. Das trübe Wasser und die vielen Rotatorien rechtfertigen besonders den Einsatz von Zandern. Der Aksehir-See hat am wenigsten einen Einsatz von neuen Fischen nötig. Kein Fisch ist geeigneter als der Karpfen. Hechte sorgen auch dafür, daß sich das Fischunkraut nicht in zu großen Mengen entwickelt. Da 40 % des Fanges aus Hechten besteht, ist es für diesen See vielleicht angebracht, eine weitere Zunahme des Hechtbestandes zu verhindern.

Der Iznik-See ist kein Gewässer für Karpfen, wie ich verschiedentlich gezeigt habe. Er ist aber ausgezeichnet für Coregonen aller Art, Boden-, Ufer- und vor allem Pelagial-Formen. Deswegen haben wir in den Jahren 1954-1956 insgesamt 11 Millionen Coregoneneier, die aus Deutschland und Österreich kamen, eingesetzt. Zum Teil wurde die Brut bis 2-3 cm angefüttert. Ein kleiner Coregone wurde mit dem Planktonnetz wieder gefangen. Weiter beschrieb uns später ein Fischer einen 12-15 cm langen, ihm unbekanntem Fisch, den er gefangen hatte. Nach seinen Darlegungen kann es sich nur um einen Coregone handeln. Leider wurden bisher nicht die Mittel aufgebracht, um Fanggeräte für Coregonen einzusetzen.

Der Sapanca-See ist im Grunde aus biologischen und fangtechnischen Gründen noch weniger ein Karpfengewässer als der Iznik-See. Auch hier sollten Coregonen eingesetzt werden, um das Pelagial zweckmäßiger auszunutzen. Da es aber im Sapanca-See verschiedene Raubfische, vor allen Dingen die sehr unangenehmen Barsche gibt, ist der Einsatz von Coregonen mit einem gewissen Risiko verbunden. Darum sollte man mit dem Einsatz warten, bis aus eigener Produktion des Iznik-Sees billig Eier eingesetzt werden können.

Beysehir- und Egridir-See sind ebenfalls aus biologischen und fangtechnischen Gründen keine Karpfengewässer, obwohl der Karpfen heute noch der wirtschaftlich wichtigste Fisch ist. Wahrscheinlich wäre eine Bewirtschaftung mit Brachsen schon zweckmäßiger. Sicherlich müßten aber beide Seen mit Hecht und Zander so stark wie möglich besetzt werden, damit wenigstens ein Teil der wertlosen Fische in wertvolles Fischfleisch umgesetzt wird. Im Jahre 1955 machten wir am Egridir-See auch den Versuch mit dem Einsatz von 10 000 Zander-setzlingen, die eine Größe von 10-15 cm hatten. Auch hier wurden schon in den letzten Jahren größere Zander gefangen. Für Coregonen sind die Temperaturen dieser Seen im Sommer wahrscheinlich zu hoch, zumal es kein kühleres Tiefenwasser gibt, das zum Ausweichen aufgesucht werden könnte.

Der Hotamis-See ist in jeglicher Hinsicht schlecht, vor allem aber deswegen, weil er nicht richtig befischt werden kann. Dem Karpfen böte er schon den richtigen Lebensraum, doch müßte man für den Fang wenigstens versuchen, durch Freilegen von Schneisen, wie wir es für den Aksehir-See vorschlugen, an die Karpfen heranzukommen. Auch der Einsatz von Raubfischen zur Vernichtung der minderwertigen Fische würde wichtig sein.

Besonders schwierig liegen die Verhältnisse am Burdur-See wegen des hohen Salzgehaltes. KOSSWIG setzte *Tilapien* ein, die sowohl euryhalin wie eurytherm sind. Wir selber besetzten 1955 den See mit 120 000 Stück Aalbrut, von denen 1957 ein Exemplar mit einer Länge von 82 cm wieder gefangen wurde. Leider wurden bisher auch hier keine Mittel aufgebracht, um die Einsatzversuche zu kontrollieren.

F. Zusammenfassung

In allen vier Jahreszeiten wurden 11 größere anatolische Seen jeweils fast gleichzeitig limnologisch und speziell fischereibiologisch untersucht. Entsprechend den gefundenen Daten wurde den einzelnen Seen ein relativer Gütwert beigemessen, der ein Maßstab für die potentielle Fisch-, insbesondere Karpfenproduktion darstellen soll. Nach einer Aufzählung der vorkommenden, wirtschaftlich bedeutungsvollen Fische und einer Beschreibung der Art sowie des Umfangs der Fischerei wurde der Versuch gemacht, durch Vergleich der limnologischen Daten mit den Fangmeldungen und dem Karpfenwachstum die Fangintensität zu bestimmen. Besonders der F-B-Koeffizient, das Verhältnis von Jahresfangergebnis zur einmaligen oder mittleren Ernte an Bodentieren, erlaubt festzustellen, ob ein Gewässer gut oder schlecht befischt wird, bisweilen auch, ob die Fangmeldungen richtig sind. Auf Grund der Ergebnisse werden für die einzelnen Seen Vorschläge zur besseren Bewirtschaftung gemacht.

Summary

Limnological and particularly fishery-biological examinations were made almost simultaneously in eleven larger Anatolic lakes in all four seasons. According to the data found the individual lakes were given a relative quality mark which is to be a standard for the potential fish and carp production especially. After a statement of the occurring economically important fish and a description of the kind as well as extent of fishery it was attempted to determine the catch intensity by comparing the limnological data with catch reports and carp increment. Particularly the F-B-coefficient, i. e. the ratio of the annual catch result to the single or average yield of soil-inhabiting animals, permits the determination whether a water is fished well or badly, or sometimes also, whether the catch reports are correct. On the basis of the results proposals for a better farming are made for the individual lakes.

Резюме

Во все четыре времена года на одиннадцати больших анатолийских озерах почти одновременно проводились лимнологические и специальные рыболовно-биологические исследования. В соответствии с полученными данными отдельным озерам приписывали относительную качественную ценность, применяемую в качестве масштаба для потенциального производства рыбы, особенно карпа. После перечисления встречающихся экономически важных видов рыбы и описания способа и объема рыбной ловли, была совершена попытка определить интенсивность улова путем сравнения лимнологических данных со сведениями об уловах и росте карпов. Особенно коэффициент у-д, т. е. соотношение между результатом годового улова и однократным или средним сбором донной фауны, позволяет определить, хорошо ли или плохо производится рыбная ловля на водоемах и правильны ли сведения об уловах. На основе этих результатов разработаны предложения для лучшего хозяйственного использования отдельных озер.

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ZEITSCHRIFT FÜR FISCHEREI UND DEREN HILFSWISSENSCHAFTEN

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Am 10. Oktober 1961 fand in Berlin die Gründungsversammlung der

Parasitologischen Gesellschaft der DDR

statt. An der Versammlung beteiligten sich zahlreiche parasitologisch arbeitende Wissenschaftler und Praktiker; sie nahmen ein Statut an und wählten für die Dauer von 2 Jahren einen aus 7 Personen gebildeten Vorstand.

Die Gründung der Gesellschaft entspricht einem dringenden Bedürfnis nach Zusammenschluß der auf den verschiedenen Gebieten der Parasitologie in der DDR arbeitenden Persönlichkeiten und Institutionen; die Gesellschaft verfolgt das Ziel, den Mitgliedern durch regelmäßige wissenschaftliche Veranstaltungen einen Erfahrungs- und Meinungsaustausch auf breiter Grundlage zu ermöglichen.

In diesem Sinne wird die Parasitologische Gesellschaft auch bestrebt sein, auf nationaler und internationaler Grundlage mit den Parasitologen anderer Länder, d. h. mit Einzelpersonen und Gesellschaften, durch gegenseitigen Besuch von Kongressen, Symposien, Gründung von Arbeitsgemeinschaften und dgl. sowie durch Vorträge und Veröffentlichungen zusammenzuarbeiten.

Als eine ihrer dringendsten Aufgaben betrachtet es die Gesellschaft, die staatlichen Institutionen für die Planung und Durchführung groß angelegter parasitologischer Forschungsaufgaben zu gewinnen, insbesondere solcher, die unter Zusammenfassung der besten Arbeitsmöglichkeiten und -kräfte nur kollektiv gelöst werden können.

Ein weiteres wesentliches Ziel sieht die Gesellschaft darin, zur Schaffung eines wissenschaftlichen Nachwuchses sich für die Unterweisung von Studenten, Doktoranden, Diplomanden, Aspiranten u. a. in Universitäts- und Akademieinstituten auf parasitologischem Gebiet in gleicher Weise einzusetzen wie für die Weiterausbildung bereits tätiger Parasitologen auf Spezialgebieten.

Zur Erfüllung ihrer Aufgaben bedarf die Gesellschaft der Mitarbeit zahlreicher Persönlichkeiten, die wissenschaftlich oder praktisch parasitologisch tätig und gewillt sind, die Entwicklung der Parasitologie in ihren verschiedenen Fachrichtungen zu fördern. In diesem Sinne wendet sich die Gesellschaft an die Biologen, Human- und Veterinärmediziner, die Angehörigen der Land-, Forst-, Fisch- und Wasserwirtschaft, Phytopathologie, Pharmazie und Schädlingsbekämpfung sowie die Bearbeiter von Spezialgebieten, wie Protozoologie, Helminthologie, Entomologie, Akarologie und Netzinsektenkunde (Ameisen-, Bienen- und Seidenraupenzucht).

Prof. em. Dr. med. vet. habil. Dr. agr. h. c. A. Borchert
1. Vorsitzender

Anschrift der Gesellschaft:

Berlin-Friedrichsfelde, Tierpark. Fernruf: 55 00 12. Sekretär: Dr. K. Odening.

17.8) 2 juv. (3.6—4.0); (41): Gilboa Mt. nr. Heftziba 1 juv. ♀ (5.2); (45): Sdath Yam, Cesarea: 2 ♂ (11.7, 12.5) 1 ♀ (15.0) 1 juv. (4.6); (58): Kiryat Anavim, Judean Mts. 1 ♀ (8.6); (64): on Alumot-Kineret Rd. 1 ♀ (10.0) 1 juv. ♂ (6.3) 1 juv. ♀ (7.0); (68): Mt. Tabor, Margalit 3 ♂ (8.2—8.8); (30): on Beith Govrir Hgw. nr. Mechus Ict. 3 ♂ (15.2—19.7) 2 ♀ (18.4—19.0); Sdath Yam; 2 km W. Nazareth, Shfaram Hghw. Neve Shaanan; Gilboa, Khirbet Ner; Carmel, Damun; Daliat el Carmel; Carmel, 40 Oaks; Talfit, Nablus, Cave; Galil, Zuvit.

Coll. WAHRMAN: (PO 71): Aqua Bella 1 ♂ (17.8) 1 ♀ (15). Außer dem gelbweißen Fleck beiderseits der Mitte auf den Tergiten noch mit ebensolchen größerem Querfleck auf den Epimeren. (PO 74): Aqua Bella 4 ♂ (12—17) 2 ♀ (12.5, 17)

Armadillo albomarginatus DOLLÉ.

Coll. WARBURG: (165): Negev, Kfar Yeruham, T. TOVIA & FISHELSON leg. 4 ♂ (5.6—6.5) 2 ♀ (5.6—7.0) 3 juv. (3.2—3.5); (53): Negev, S. of Dimona, 3 ♂ (6.6—8.6) 2 ♀ (8.7, 10.8); (63): Negev, E. of Beer Sheva 21 km on Dimona Hgw. 1 juv. ♀ (3.0); (151): Negev, Shuval, 1 ♂ (8.0) 2 ♀ (6.7, 8.8); (151): 2 ♀ (8.0, 9.0);

Coll. WAHRMAN: (PO 12): Sahl el-Hawa (Negev) 1 ♂ (9.8/4.8) 1 ♀ (9.5/4.5) 1 ♀ (12/5.3) m. Mars. (Typuserie von *A. wahrmanni*); (PO 15): Wadi north of Ras Um Jurfan (Negev) 1 ♂ (10/4.6) 1 ♀ (9.8/4.5); (PO 33): Hamakhtesh Hagadol (3 Wadi Hathira) 2 juv. (4.6, 5.7); (PO 35): Shivta (3 Subeita) 1 ♂ (7) 4 ♀ (8.5—9); (PO 36): Nahal Lavan (3 Wadi Abyad) 9 ♂ (4.7/2.4—7.6/3.5) 15 ♀ (4/2.1—9.8/4.5); Thoracalepimere breit, Hinterrand des Cephalothorax und der thoracalen Tergite ± breit aufgehellt, Abdomen oft zur Gänze hell, so daß meistens der Cephalothorax und die Thoracalergite in der Mitte angedunkelt sind; (PO 44): Horsha (= Khurashe) 2 ♂ (8.0, 9.5) 3 ♀ (8.5—11.3/5.3); (PO 45): detto, 5 juv. (4.1—4.5); (PO 47): Negev 2 juv. (4.1, 4.6); (PO 67): Nahal Lavan (3 Wadi Abyad) 4 ♂ (7—9.2) 3 ♀ (7.4—9) 3 juv. (3—3.4) (PO 82) WERNER leg., Givat Yeruham (3 Tell Rekhme) 2 ♂ (7.2, 8.5) 3 ♀ (10—10.5) (PO 91): Sinai, Arayif en Naya 1 ♂ (7) 2 ♀ (7.0, 7.3); (PO 96): Horsha 2 ♀ (10, 11.5); (PO 101): Sinai Arayif en Naya 2 ♂ (6—7) 1 ♀ (7.4) Yarkoni; (PO 107): Sinai 1 ♂ (8.4) J. Yellequ; (PO 14): Negev, Wadi Lussan, 1 ♂ (9.8/4.4) 2 ♀ (8.7/4.4, 9.0/4.6); 2 ♀ m. Marsupium (9.0/4.6).

Armadillo officinalis DUMERIL

Coll. WARBURG: Mikve Yisrael; S. of Lavah; Carmel, Wadi Faliah; Carmel, 40 Oaks; Herzlia; Aco Jasur Jct.; Lavie; Yodefet-Segev Rd.; Galil, Dir. Hana; Lahav; Nahal Bezet; Gadot; Kiryat Anavim, Jerusal Mts.; Sasa, Galil.

Armadillo tuberculatus VOGL

Coll. WARBURG: S. Devirah; Yavniel-Kineret Rd.; S. Lahav; Carmel, Ein Hod; Carmel, Wadi Fallah, Carmelia; Lavich; Atzmon Mt..

Bericht über eine Sammelreise nach Iran im Frühjahr 1972

VON GERHARD PRETZMANN¹⁾

Manuskript eingelangt am 11. Dezember 1973

Im Frühjahr 1972 unternahmen Dr. Friedrich KASY und Dr. Gerhard PRETZMANN eine Sammelreise nach Persien in einem privaten VW-Bus; bei dieser Fahrt wurden sie von Frau Anna KONETSCHNIG, Herrn Karl BILEK und Herrn Franz RESSL begleitet. Die Abreise von Wien erfolgte am 9. März 1972. Dank des guten Wetters konnte die Persische Grenze am 16. März ohne Schwierigkeiten erreicht werden. An diesem Tag jedoch erfolgte ein Wetterumschwung, der ausgiebige Schneefälle in der Osttürkei und in Nordpersien mit sich brachte. Die Weiterfahrt war wegen Schneeglätte und Glatteis, insbesondere zwischen Makoo und Zandjan sehr erschwert. Nach einem Wagenservice in Teheran wurde am 22. März Bandarabass am Persischen Golf erreicht. Der starke Touristenzustrom anlässlich der iranischen Staatsfeiertage hatte alle Unterkünfte überfüllt. Dank der Vermittlung des österreichischen Botschafters in Teheran gelang es dennoch, ein Quartier zu finden, das gute Arbeitsmöglichkeiten bot. Vom 23. März bis 17. April wurde in Bandarabass und Umgebung intensiv gearbeitet, teilweise in 2 Gruppen. Am Sandstrand östlich der Stadt wurden zahlreiche Decapoden aufgesammelt (*Ocypode rotundata*, *Uca annulipes*, *Metaplex indicus*, *Macrophthalmus pectinipes*, *M. grandidieri*, *M. depressus*, *M. resli*, *Scopimera scabricauda*, *Ebakopsis* sp., *Chasmagnathus* sp. u. a.). Ein dicht besiedeltes Gebiet am Ostrand der Stadt wurde eingehend hinsichtlich Verteilung der Arten, Gelände, Populationsdichte, Mikroklima, Geländestruktur und Bodensubstrat untersucht. Weiters wurde das Verhalten mehrerer Arten beobachtet und gefilmt. Am Strand, sowie in der weiteren Umgebung von Bandarabass in Flüssen konnten auch Serien von Fischen gesammelt werden, sowie Amphibien. *Liotelphusa blanfordi* ssp. konnte in einer Therme 38 km N Bandarabass sowie an zwei Stellen im Minab-River gefangen werden. In der näheren und weiteren Umgebung der Stadt wurden auch 15 Lichtfänge durchgeführt. Die Abfahrt nach Teheran erfolgte am 17. 4. Bei Sirjan wurde einen Tag gesammelt, sowie ein Lichtfang durchgeführt. Die Überholung des Wagens in Teheran erforderte 4 Tage Auf-

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enthalt, sodaß erst am 25. 4. die Weiterfahrt nach Gorgan angetreten werden konnte. 39 km östlich Teheran konnte *Potamon magnum persicum* in einer größeren Serie aufgesammelt werden. Bei Amol und Gorgan konnte *Potamon ibericum* gefangen werden, sowie 12 km SO Schahpasand (der bisher östlichste Nachweis dieser Art). Die Rückreise erfolgte über Chalus, Bandar-Pahlevi-Gazvin.

Interessant war der Nachweis von *Potamon magnum armenicum* 20 km SO Makoo. Am 1. Mai wurde die Türkei erreicht. Serien von *Potamon magnum* konnten 23 km O Agri, 72 km O Erzerum, 38 km W Elazig gesammelt werden. 15 km W Pinarbasi wurde *Potamon potamios karamani* gefunden. Besonders interessant war eine Serie von *Potamon ibericum* 36 km NO Kaiseri, insbesondere weil an der Stelle südlich Ürgüp, an der 1967 diese Art nachgewiesen wurde, diesmal keine Krabben gefunden werden konnten. Hingegen gelang es wieder, 1 km o. Sereflikochisar *Potamon hüceste* zu erbeuten. Die weitere Rückreise verlief ohne besondere Ereignisse. Am 10. 5. kam die Gruppe in Wien an.

| | | |
|---------------------|--------------------|-----------|
| Gesammelte Objekte: | Fische | 248 |
| | sstg. Vertebraten | 333 |
| | Käfer | ca. 2.500 |
| | Schmetterlinge | ca. 2.300 |
| | div. Insekten | 200 |
| | Arachnoideen | 413 |
| | Myriopoden | 179 |
| | Isopoden | 348 |
| | Decapoden | 1.375 |
| | Mollusken | 1.105 |
| | sstg. Evertebraten | 58 |
| | Pflanzenarten | 120 |

weitere einige Mineralstufen, Fossilien und Feuersteinwerkzeuge. Die Ausbeute umfaßt etwa 9.400 Einzelobjekte, Wasser- und Bodenproben, ca. 200 m (8 mm) wissenschaftlichen Film sowie etwa 300 Tier- und Biotopphotos.

Die Reisetilnehmer danken dem Bundesministerium für Wissenschaft und Forschung, der Hammer-Purgstall Gesellschaft, dem Wissenschaftsreferat der Gemeinde Wien, dem Notring der Wissenschaftlichen Verbände Österreichs und dem Verein der Freunde des Naturhistorischen Museums in Wien für die gewährten Subventionen. Frau Anna KONETSCHNIG danke ich für die materielle Unterstützung sowie für die technische Assistenz bei den Freilandarbeiten und die Buchführung der Reise.

Verzeichnis der Fundplätze:

- | | |
|--------------------|------------------------|
| 1. 5 km O Sorgun | 4. 15 km O Nain |
| 2. 56 km O Erzerum | 5. Sirjan, Hotelgarten |
| 3. 44 km W Nain | 6. 102 km SW Sirjan |

7. 135 km S Sirjan
8. Hadjabad
9. Strand O Bandarabass
10. Lichtfang 15 km O Bandarabass
11. 15 km O Bandarabass
12. 25 km N Bandarabass
13. 62 km N Bandarabass
14. Lichtfang 30 km O Bandarabass
15. Strand O Bandarabass
16. 115 km O Bandarabass
18. 15 km N Bandarabass
19. 38 km N Bandarabass, Seitental ca. 2 km östl. der Hauptstraße bei Therme.
20. Sandsteinklippen W Bandarabass
21. W Bandarabass
22. 38 km N Bandarabass
23. 65 km N Bandarabass
24. 100 km N Bandarabass
25. Bei Minab
26. Therme 38 km N Bandarabass
27. Lichtfang Therme 38 km N Bandarabass
28. Kol-River W Bandarabass
29. 80 km N Bandarabass
30. Lichtfang 22 km N Bandarabass
31. Abad Geno 40 km N Bandarabass
32. Lichtfang 13 km N Bandarabass
33. Lichtfang 41 km N Bandarabass
34. 40 km N Bandarabass
35. Lichtfang 8 km O Bandarabass
36. Lichtfang 22 km N Bandarabass
37. Lichtfang 17 km O Bandarabass
38. 16 km O Bandarabass
39. Lichtfang 16 km O Bandarabass
40. Lichtfang 22 km N Bandarabass
41. Lichtfang N Bandarabass
- 41 b) 10 km S Hadjabad
42. Lichtfang SO Sirjan
43. 62 km NW Sirjan
44. 41 km NW Sirjan
45. Isphahan, Kanal in der Stadt
46. Yazd, Garten des Hotels
47. Bei Robat Tork, NW Isphahan
48. N Delijan
49. 30 km W Abali (39 km O Teheran)
50. 21 km N Amol
51. 10 km N Amol
52. 12 km SO Schahpasand
53. Gonabad, Gorgan River
54. 10 km O Gorgan
55. 10 km O Behshar
56. 30 km O Sari
57. 5 km W Baholsar
58. Chalus, Bach und Strand.
59. 2 km S Chalus
60. Ramsar
61. Strand bei Bandar Pahlevi
62. 36 km S Rasht
63. 62 km S Rasht
64. 27 km N Gazvin
65. 60 km O Täbriz
66. ca. 40 km O Täbriz
67. 28 km O Täbriz, Stausee
68. 95 km SO Makoo
69. 46 km SO Makoo
70. 20 km S Makoo
70. 20 km S. Makoo
71. 23 km O Agri
72. 16 km O Horasan
73. 72 km O Erzerum
74. 9 km N Dagyalu (N Tunceli)
75. 38 km W Elazig
76. 15 km W Pinarbasi
77. 36 km NO Kayseri
78. 1 km NO Sereflikochisar
79. 20 km O Gerede
80. 2 km O Adapazari
81. O Istanbul
82. 60 km O Sofia

Population, survival, growth and production of trout *Salmo trutta* in a small Danish stream

E. Mortensen

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Mortensen, E. 1977. Population, survival, growth and production of trout *Salmo trutta* in a small Danish stream. - *Oikos* 28: 9-15.

The population dynamics of a trout *Salmo trutta* L. population were studied in a small Danish stream. Fry mortality was density-dependant in the first three months of life, but after that mortality was density-independant. Significantly different length-weight relationships were found for trout below and above 45 mm length. A regular annual growth cycle was found in all year classes. The total annual production of trout was 18.8 g per m². The production of the 0 and I group together was 81% of the total annual production. The turnover ratio (P/B) of the year classes varied between 2.8 and 0.5 according to age, the highest value being found in the 0 group. The yield of smolts by number was about 4 per 100 m². The interactions of the different population parameters are discussed.

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Исследовали динамику популяции форели *Salmo trutta* L. в небольшой реке Дании. Смертность зависела от плотности в первые 3 месяца жизни, но после этого возраста смертность не определяется плотностью. Для форелей длиной больше и меньше 45 см установлены существенные различия соотношения длины и веса. У всех возрастных классов обнаружен регулярный годичный ритм роста. Общая годовая продукция форелей составляет 18,8 г м⁻². Продукция нулевой и первой групп составляет вместе 81 % от общей годовой продукции. Скорость круговорота (П/Б) различных возрастных классов колеблется между 2,8 и 0,5 в соответствии с возрастом, причем наибольшая величина характерна для нулевой группы. Урожай рыб по количеству особей составляет около 4 на 100 м². Обсуждаются отношения параметров различных популяций.

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Introduction

The brown trout *Salmo trutta* L. occurs abundantly in many small European streams and is of considerable importance in their ecology. Since the work of Allen (1951) trout populations have received some attention (e.g. McFadden and Cooper 1962, 1964, Le Cren 1965, 1969, 1973, Libosvářský 1968, Egglisshaw 1970, Mann 1971) but studies on population dynamics including production during their first years of life in small streams, are few. The present work is part of a comprehensive study of the ecological factors affecting the population dynamics and production of trout and the relationship of the fish to their food supply in small Danish streams.

2. Study area

The investigation took place in Bisballe bæk in the middle of Jutland, Denmark (9°20'E., 56°22'N.). The stream is a 450 m long springbrook, originating from helocrenous areas and small rheocrens at an altitude of 35 m. It joins another stream 200 m from its point of entrance into Lake Hald. In the middle part of the springbrook a section of 170 m length (area 146 m²) was selected for study. The springbrook is 0.5–1.5 m wide, has a slope of 50 ‰ and a maximum depth of 20 cm. The stream bed consists of sand, gravel and stones with patches of phanerogamic vegetation, mainly *Sium erectum* Huds. Several trees mainly alders *Alnus glutinosa* L. and willow scrubs *Salix* spp. grow on the stream banks. The discharge at the downstream end of the springbrook was about 45 l s⁻¹ and was fairly constant throughout the year. The maximum-minimum temperature varied between 1.0°C and 12.0°C. Bisballe bæk is a spawning stream for lake trout *Salmo trutta* and juvenile trout are present throughout the year. Only occasionally are other fish (brook trout *Salvelinus fontinalis* (Mitchell) and rainbow trout *Salmo gairdneri* (Richardson)) present. The most abundant benthic invertebrates are Plecoptera larvae (*Leuctra*, *Nemoura* and *Amphinemura*), Chironomidae, Simuliidae and *Gammarus pulex*.

3. Methods

3.1. Population estimates

Sampling was carried out every fifth week from April 1974 to May 1975 in two periods of electro-fishing using a 200 V DC generator. As electro-fishing may be size selective (Junge and Libosvářský 1965) the size of the trout population was estimated using the catch data for each year class separately and applying the formula from Seber and Le Cren (1967). Minimum and maximum estimates were calculated for each year class as 95% confidence limits for the population size. On occasions when this produced a minimum value less than the number of trout caught in the two catches the number of trout actually caught was taken as the minimum population estimate.

Samples were also taken in November 1973, January and March 1974. These samples were meant primarily for observations on the spawning stock, but they were also used for growth analyses and biomass calculations.

3.2. Age and growth estimates

Fish caught were anaesthetized with tricaine methane-sulphonate (MS-222 SANDOZ) and their lengths from the tip of the jaws to the tip of the tail were measured to the nearest lower half cm. In April when the 0 group trout were very numerous only a proportion of them were measured. Throughout the study subsamples of anaesthetized fish were measured to the nearest mm and then weighed. After determination of length and weight and sampling of scales, the fish were placed in holding boxes for recovery and then returned alive to the stream.

From the modes of length-frequency histograms and aged samples of scales from fish of intermediate length the catches were separated into age groups (Fig. 1).

The length-weight relationship was established and regression lines calculated by using the method of least squares.

As the weight equivalent to the modal mean weight of the length-frequency histograms of each year class was smaller than the true mean weight (see also Tesch 1968: 119), the length-frequency histograms were converted into weight-frequency histograms before the mean weight of each year class was calculated.

3.3. Production estimates

Production is here defined as the total quantity of tissue elaborated by a population in a definite period of time regardless of the ultimate fate of this tissue (Ivlev 1945) and the unit used g fresh wt m⁻² yr⁻¹. Production was calculated using Allen's graphical method (Allen 1951). The point estimates for weight-survivorship were connected by straight lines and production was measured by counting squares on graph paper.

The main inaccuracy of production estimates lies in the estimations of the size of the fish population. Because of this a range of values for annual production of each year class was obtained by plotting the minimum, mean and maximum estimates of numbers of survivors against the same mean weight.

4. Results

4.1. Population and mortality

Spawning occurred during late November and December in both 1973 and 1974. Immigration of large fish from the 1972 year class took place in October and November 1974 (Fig. 1). Before and during the spawning season all brown trout above 13 cm were found to be mature males, except one mature female caught in late November 1973. However, during the spawning season immi-

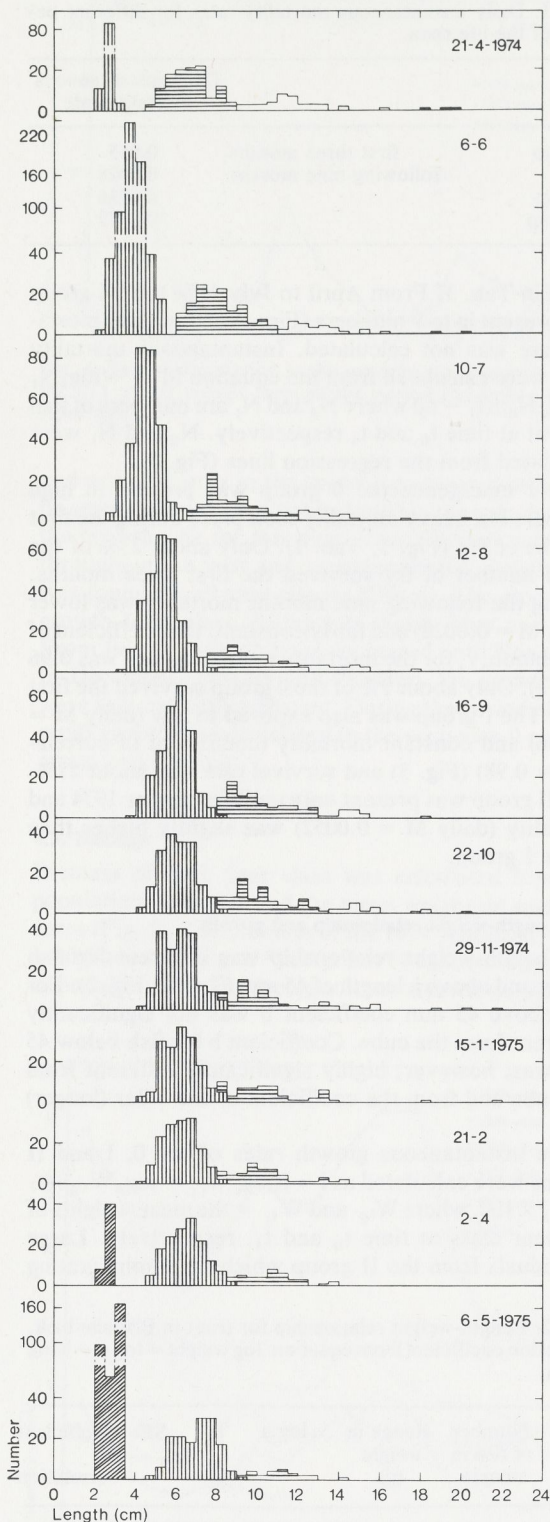


Fig. 1. Length-frequency histograms of the trout population on the sampling dates. ▨ = 1975 year class, ▤ = 1974 year class, ▥ = 1973 year class, □ = 1972 year class and ■ = 1971 year class. On 21 April 1974 only a proportion of the 0 group was measured.

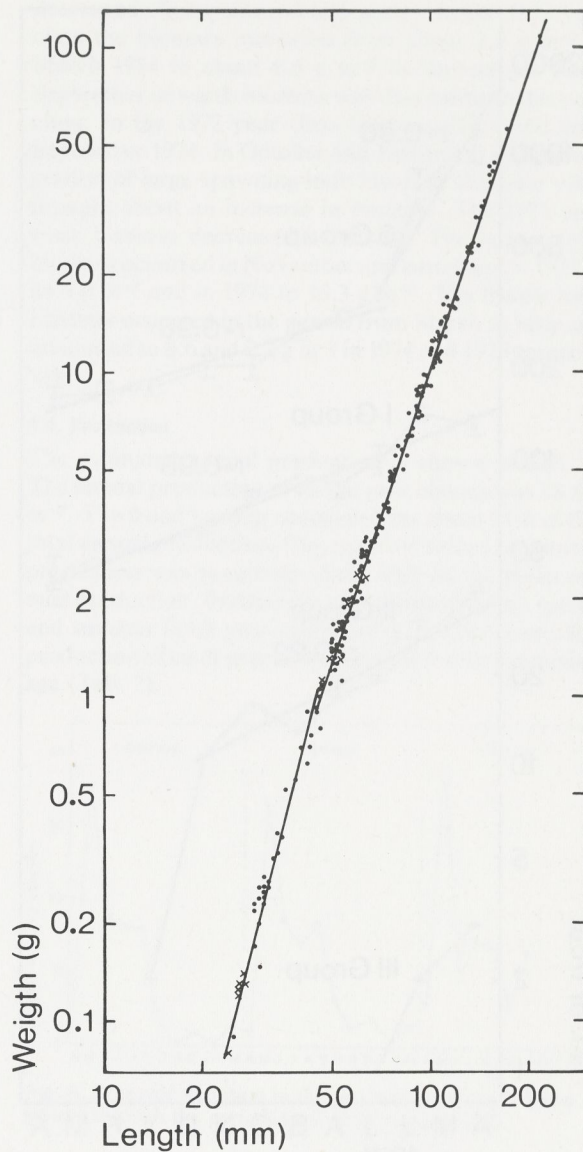


Fig. 2. Weight plotted against length. Calculated regression lines for trout below and above a length of 45 mm are drawn. × indicates two or more points.

gration of adult female lake trout (*Salmo trutta f. lacustris*) from Lake Hald took place in both 1973 and 1974. No adult male lake trout were caught.

In 1973 spawning took place in a 15 m long reach situated about 60 m below the upstream end of the study area. Several redds were found in this area in December 1973. The first fry was observed in early April and 1 April was designated as the mean birth date of the new year class. In both April and June 1974 most fry (about 90%) were caught just downstream the spawning area and only 10% were caught above the redds. In July fry were more or less evenly distributed downstream, but

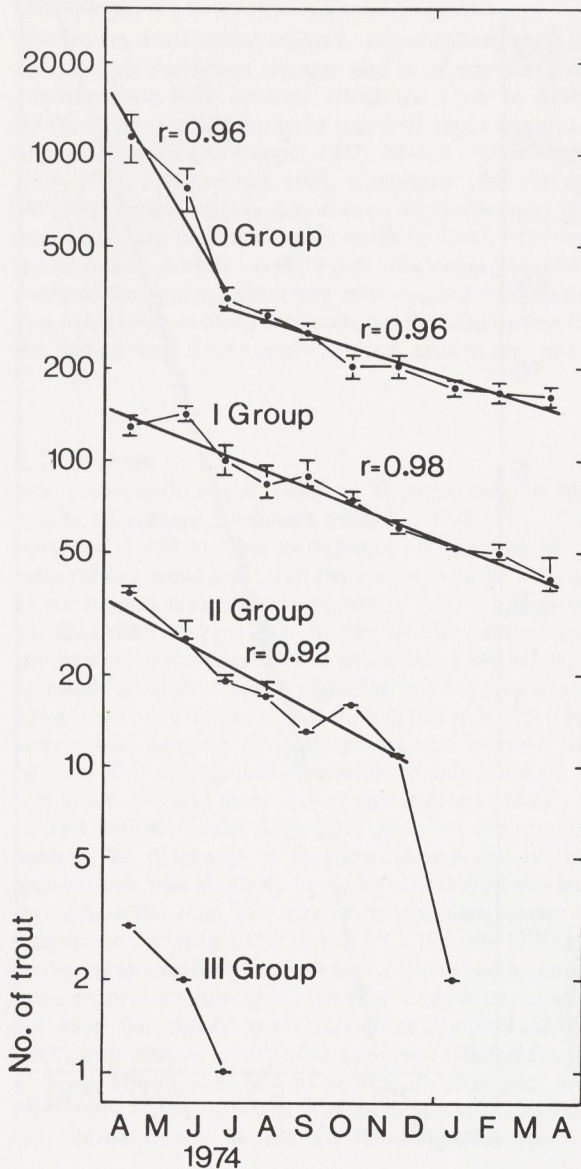


Fig. 3. Curves showing population size of the 0, I, II and III groups (thin lines) through the period April 1974 to April 1975. Vertical lines indicate 95% confidence limits. Calculated regression lines (heavy lines) for different periods are drawn. r = coefficient of correlation.

not upstream of the redds. From August onwards fry were fairly evenly dispersed throughout the whole study area.

Seasonal changes in the size of the trout population are shown in Fig. 3 as survivorship curves where the mean population estimates calculated for each year class together with their 95% confidence limits are plotted on a logarithmic scale. Mortality rates are shown by regression lines on the curves. Actual values of the daily instantaneous mortality rates for different periods are

Tab. 1. Daily instantaneous mortality rates for different periods of the life span.

| | Daily instantaneous mortality rate | |
|----------|------------------------------------|--------|
| 0 group | first three months | 0.015 |
| | following nine months | 0.0028 |
| I group | | 0.0036 |
| II group | | 0.0052 |

given in Tab. 1. From April to July 1974 the III group was present in low numbers (Fig. 1) and so their mortality rate was not calculated. Instantaneous mortality rates were calculated from the equation $M = -(\log_e N_1 - \log_e N_0)/(t_1 - t_0)$ where N_0 and N_1 are numbers of fish present at time t_0 and t_1 respectively. N_0 and N_1 were calculated from the regression lines (Fig. 3).

After emergence the 0 group was present in high numbers but heavy mortality took place during the first months of life (Fig. 3, Tab. 1). Only about 23% of the initial number of fry survived the first three months. During the following nine months mortality was lower (daily $M = 0.0028$) and fairly constant, the coefficient of correlation, r , for the mortality regression line was 0.96 (Fig. 3). Only about 9% of the 0 group survived the first year. The I group was also exposed to low (daily $M = 0.0036$) and constant mortality (coefficient of correlation = 0.98) (Fig. 3) and survival rate was about 27%. The II group was present only until December 1974 and mortality (daily $M = 0.0052$) was slightly higher than in the I group.

4.2. Length-weight relationship and growth

The length-weight relationship was different for fish below and above a length of 45 mm (Tab. 2, Fig. 2). For fish above 45 mm coefficient b was not significantly different from the cube. Coefficient b for fish below 45 mm was, however, highly significantly different from the cube and from the coefficient of the older (longer) fish.

The instantaneous growth rates of the 0, I and II groups were calculated as $i = [(\log_e W_{t_1} - \log_e W_{t_0})/(t_1 - t_0)] \times 100$, where W_{t_0} and W_{t_1} = the mean weights of the year class at time t_0 and t_1 , respectively. Large individuals from the II group which were immigrating

Tab. 2. Length-weight relationship for trout in Bisballe bæk, regression coefficient from equation: $\log \text{ weight} = \log a + b \log \text{ length}$.

| | Number of fish in sample | Range in weight (g) | $\log a$ | b | SE b | Coefficient of correlation |
|-------------|--------------------------|---------------------|----------|-------|--------|----------------------------|
| Fish <45 mm | 44 | 0.08–0.93 | -2.498 | 3.823 | 0.089 | 0.988 |
| Fish >45 mm | 179 | 0.80–108.5 | -2.011 | 3.023 | 0.020 | 0.996 |

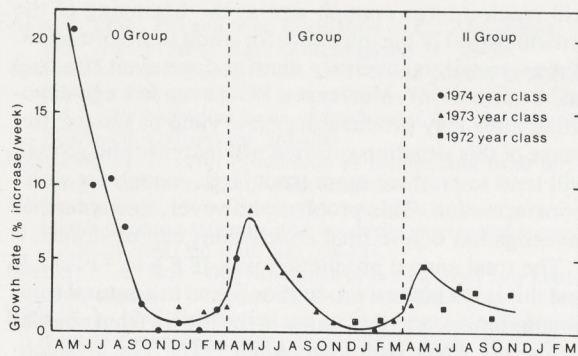


Fig. 4. Seasonal variation in the instantaneous growth rate of the 0, I and II groups through the period December 1973 to April 1975.

and occurring only in the spawning season could easily be separated and were not included in the calculation of the growth rate for this year class. Growth continued throughout the year and a regular annual growth cycle was found for all year classes (Fig. 4). The most rapid growth took place during late April, May and June. From July the growth rates decreased until November. In December, January and February the growth rates were low and fairly constant. During the period of most rapid growth rate decreased in the sequence 0 group, I group and II group.

4.3. Biomass

Biomass of each year class was calculated from the population estimates and the mean weight on sampling dates (Fig. 5). The biomass of the 1974 year class increased from about 1 g m^{-2} in April 1974 to about 4 g m^{-2} in September 1974, but during autumn and winter biomass

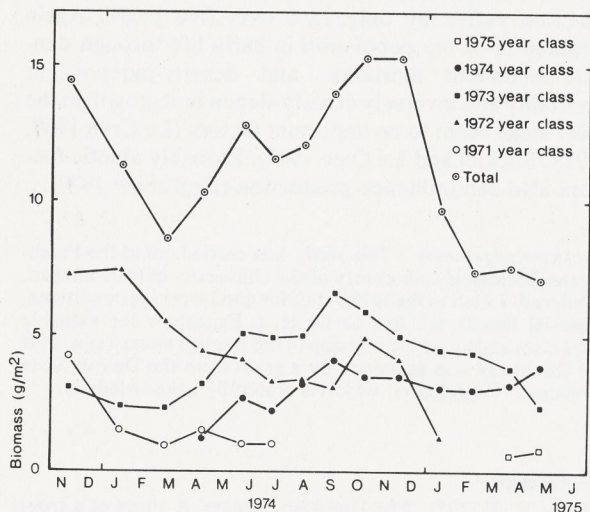


Fig. 5. Variation in biomass of each year class and total biomass through the period November 1973 to May 1975.

decreased slightly from 4 to 3 g m^{-2} . In the 1973 year class the biomass increased from about 2.5 g m^{-2} in March 1974 to about 6.5 g m^{-2} in September. From September onwards biomass was decreasing in this year class. In the 1972 year class biomass decreased until September 1974. In October and November 1974 immigration of large spawning individuals of this year class brought about an increase in biomass. The 1971 year class biomass decreased with time. The largest total biomass occurred in November and amounted in 1973 to 14.5 g m^{-2} and in 1974 to 15.3 g m^{-2} . The lowest total biomass occurred in the period from March to May and amounted to 8.6 and 7.2 g m^{-2} in 1974 and 1975 respectively.

4.4. Production

The estimated annual production is shown in Tab. 3. The annual production of all the year classes was 18.8 g m^{-2} . The 0 and I group accounted for about 81% of the total annual production. The range of values for annual production was maximum about 10% of the mean annual production. Production was greatest during spring and summer in all year classes (Fig. 6). However, the production of each year class decreased with increasing age (Tab. 3).

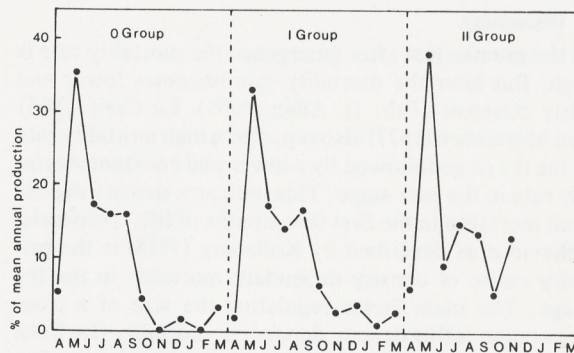


Fig. 6. Seasonal variation in the production of the 0, I and II groups through the period April 1974 to April 1975.

Tab. 3. The annual minimum, mean and maximum production (P), mean biomass (B) and turnover ratio (P/B) in the 0, I, II and III group and the whole population. For the mean annual production the percentage contribution made by each year class is given in brackets.

| | Minimum P (g m^{-2}) | Mean P (g m^{-2}) | Maximum P (g m^{-2}) | Mean biomass B (g m^{-2}) | Turnover ratio P/B |
|------------------|------------------------------------|---------------------------------|------------------------------------|---|--------------------|
| 0 group | 7.5 | 8.3 (44.1) | 9.2 | 3.0 | 2.8 |
| I group | 6.4 | 6.9 (36.7) | 7.6 | 4.3 | 1.6 |
| II group | 3.4 | 3.4 (18.1) | 3.6 | 2.9 | 1.2 |
| III group | 0.2 | 0.2 (1.1) | 0.2 | 0.4 | 0.5 |
| Whole population | 17.5 | 18.8 (100.0) | 20.6 | 10.6 | 1.8 |

From estimates of the mean annual production and mean biomass, turnover ratios for the 0, I, II and III group and the whole population were calculated (Tab. 3). The turnover ratio was 2.8 for the 0 group and 0.5 for the III group and decreased with increasing age. For the whole population the turnover ratio was 1.8.

4.5. Yield of smolts

Transformation to the smolt stage took place in April and the emigration of smolts to Lake Hald occurred in April and early May. Only the two year old trout which were at least 11.5 cm long smoltified. The yield of smolts was calculated as the difference between the number of trout above 11.5 cm present at the end of the growth period of their second year and those left over the beginning of the growth period of their third year. The yield of smolts was similar in the two years being 3 and 5 smolts per 100 m². In Bisballe bæk the smolt producing area is about 200 m². The stream therefore probably produces about 8 smolts per year.

In calculating the yield of smolts no attention was paid to growth in the period in question and mortality was assumed to take place only in the trout below 11.5 cm.

5. Discussion

In the months just after emergence the mortality rate is high. But later the mortality rate becomes lower and fairly constant (Tab. 1). Allen (1951), Le Cren (1965) and Mortensen (1977) also reported a high mortality rate in the fry stage followed by a lower and constant mortality rate in the parr stage. This indicates density dependant mortality in the first few months of life. Territorial behaviour as described by Kalleberg (1958) is the primary cause of density dependant mortality in the fry stage. The main factor regulating the size of a trout population is this density dependant mortality (Le Cren 1973). The stimulus for territorial behaviour is visual so configuration of the streambed, current velocity and turbulence are important factors for the final population density (Stuart 1953, Kalleberg 1958, Hartmann 1963). This is of great significance for fishery management as the numbers of trout in the population to a great extent will depend more on the area of suitable fry rearing ground available for the fry in their early stages.

One of the most important parameters in a trout fishery (sea and lake trout) is the yield of the smolts. When egg depositing rates are high, this parameter will depend more on the density-dependant mortality in the fry stage than on the size of the spawning population (Alm 1950, Le Cren 1973). In Bisballe bæk the yield of smolts is probably about 8 per year. But even this quite small run of smolts gives rise to egg-depositing rates which are much greater than the number of fry found in midsummer when mortality became density-independent. Thus in April 1974 about 22 fry m⁻² were found downstream of the redds. At high egg-depositing rates not all trout

will reach a large enough size at the beginning of the growth period of the third year for smolt transformation. But as growth is inversely density-dependant (Backiel and Le Cren 1967, Mortensen 1977) even low egg-depositing rates may produce the same yield of smolts. Because of this situation survival will increase and growth will tend to produce more trout large enough for smolt transformation. This problem, however, needs further investigation before final conclusions can be drawn.

The total annual production was 18.8 g m⁻² (Tab. 3) and this is the highest production found in a natural trout population, except that found in the brown trout population in the River Horokiwi (Allen 1951). The productivity of the 0 and I groups were about equal and accounted for 81% of the total annual production (Tab. 3). Mortality and growth, however, operate differently in these year classes (Tab. 1). In the 0 group mortality is higher and growth more rapid than in the I group.

The rapid growth in spring and summer (Fig. 4) caused a high production rate (Fig. 6) resulting in increasing biomass during summer and autumn (Fig. 5). Similar changes in growth rates, biomass and production rates were found by Horton (1961), Egglisshaw (1970) and Mann (1971).

The interactions between production rate and changes in biomass in the different year classes are also seen in the turnover ratio (Tab. 3). Egglisshaw (1970) did not calculate turnover ratios although his data are sufficient. From Allen (1951), Horton (1961) and Mann (1971) only calculations for all year classes combined are available. But as the turnover ratio changes with increasing age (Tab. 3) these data are not sufficient. Thus there is need for more data before valid comparisons can be made.

Year to year variations in production of trout are probably small. Hunt (1966) working with brook trout *Salvelinus fontinalis*, whose general biology is similar to that of the brown trout, found that annual production varied by only 15% over five years. Again regulation of the population in early life through density-dependant mortality, and density-independent mortality and inversely density-dependant growth in the parr stage seem to be important factors (Le Cren 1965, 1973, Backiel and Le Cren 1967). Probably abiotic factors also can influence production (Egglisshaw 1970).

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**THE POPULATION DYNAMICS AND PRODUCTION
OF TROUT (*SALMO TRUTTA* L.)
IN A SMALL DANISH STREAM**

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ERRATUM

ERIK MORTENSEN, NATIONAL AGENCY OF ENVIRONMENTAL PROTECTION, THE FRESHWATER LABORATORY, LYSBROGADE 52 - DK-8600, SILKEBORG, DENMARK: "The population dynamics and production of trout (*Salmo trutta* L.) in a small Danish stream"

Abstract

For the years 1974-1976 the population size, survival, growth and production of a trout population (*Salmo trutta* L.) were studied within three sections of a small Danish stream. In all sections the 0 group dominated. However, the age composition changed along the length of the stream and older trout became more common in downstream sections. Fry mortality was density-dependent in the first few months of life; after that mortality was fairly constant and density-independent. Only minor differences were found in the annual growth cycles of the year classes in the three sections. Annual production was estimated from Allen curves. The trout production of the three sections was affected by the abundance of each year class present. In the uppermost and middle sections the total fresh weight productions were $14.1 \text{ g m}^{-2}\text{a}^{-1}$ and $22.1 \text{ g m}^{-2}\text{a}^{-1}$, respectively, with the 0 and I group combined contributing 83-85% of the total. In the lower section, the production was $27.4 \text{ g m}^{-2}\text{a}^{-1}$ and $33.1 \text{ g m}^{-2}\text{a}^{-1}$, respectively, for the two years studied. The 0 and I group contributed 56-71% whilst the II group contributed 26-33% of the total. The P/\bar{B} ratios ranged from 2.4 - 3.0 in the 0 group, 1.2 - 1.7 in the I group, 0.8 - 1.5 in the II-group and 0.2 - 0.9 in the III group and older.

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ABSTRACT

For the years 1974-1976 the population size, survival, growth, and production of a trout population (*Salmo trutta* L.) were studied within three sections of a small Danish stream. In all sections the 0 group dominated. However, the age composition changed along the length of the stream, and older trout became more common in downstream sections. Fry mortality was density-independent. Only minor differences were found in the annual growth cycles of the year classes in the three sections. Annual production was estimated from Allen curves. The trout production of the three sections was affected by the abundance of each year class present. In the uppermost and middle sections the total fresh weight production was $14.1 \text{ g m}^{-2} \text{ a}^{-1}$ and $22.1 \text{ g m}^{-2} \text{ a}^{-1}$, respectively. In both sections, the 0 group contributed 83-85% of the total. In the lower section, the production was $27.4 \text{ g m}^{-2} \text{ a}^{-1}$ and $33.1 \text{ g m}^{-2} \text{ a}^{-1}$, respectively for the two years studied. The 0 group and I group contributed 56-71% while the II group contributed 26-33% of the total. The P/B ratios ranged from 2.4 - 3.0 in the 0 group, 1.2 - 1.7 in the I group, 0.8 - 1.5 in the II group, and 0.2 - 0.9 in the III and older groups.

INTRODUCTION

Recently, increasing attention has been paid to the production ecology of salmonid fishes in small streams. This has greatly contributed to the knowledge of the ecological factors controlling wild salmonid populations in streams. Adequate assessments of these factors are of great importance in promoting efficient management and improvement of small salmonid streams. Many Danish streams maintain dense populations of trout (*Salmo trutta* L.), which produce catchable brown trout and sea trout. These streams are therefore of considerable importance in their ecology. The aim of this study was to investigate the population dynamics and production of a trout population in a typical small Danish trout stream.

THE STUDY AREA

The Brandstrup bæek is a 4.5 km long stream situated in the middle of Jutland, Denmark ($9^{\circ} 46' \text{E}$, $56^{\circ} 23' \text{N}$). The stream

is a tributary of the River Gudenå, rising from several very small springs within a small deciduous wood at an altitude of 45 m. The stream is 0.5-1.5 m wide, has a slope of 9.5 o/oo throughout its whole length and a maximum depth of 0.5 m. The stream-bed consists of sand, gravel and stones with patches of phanerogamic vegetation, mainly *Berula erecta*. About 2.7 km from the source, the Brandstrup bæek is joined by the small springbook Boskilde. The surroundings of the stream are a mixture of small woods, alder shrub (*Alnus glutinosa*) growing along the stream and cattle pasture. The Brandstrup bæek is a spawning stream for sea trout and brown trout (*Salmo trutta*). The juvenile trout are mainly the offspring of sea trout and are present throughout the year. These usually become smolts and emigrate after the end of their second year, and only a few older individuals remain in the stream.

Three rather different reaches were selected for study. The physical and chemical characteristics of these reaches have been described by Mortensen (1977b, 1977c) and only the main features are summarized here and in Table 1. Brandstrup bæek reach 1, the uppermost reach, was situated 1.1 km from the source. Here the stream is broad and shallow; the surface of the water is about 1.5 m under the surrounding land and abundant growth of *Berula erecta* occurs. Brandstrup bæek reach 2, the middle reach, was situated a further 1.4 km downstream, and is somewhat deeper and shadowed by dense alder shrub growing along the banks. These overhanging banks and tree roots provide cover for fish. Brandstrup bæek reach 3, the lowermost reach, situated a further 0.9 km downstream is deeper still and the aquatic and riparian vegetation, combined with larger stones, offer good hiding places for fish.

In February - March 1976, a part of the stream including Brandstrup bæek reach 3 was dredged and straightened. The investigation was stopped in April 1976 and the effect of the dredging was not studied, as it proved impossible to obtain money for continuation of the investigation.

METHODS

The methods used in this investigation

Table 1. Physical data of the three study reaches in Brandstrup bæk

| | Mean width (m) | Mean depth (m) | Length (m) | Duration of study |
|---------|----------------|----------------|---------------|--|
| Reach 1 | 1.05 | 0.08 | 215 215 x) | March 1974 - May 1975 May 1975 - September 1975 |
| Reach 2 | 0.80 | 0.15 | 85 | March 1974 - May 1975 |
| Reach 3 | 0.95 | 0.20 | 125 80 | January 1974 - June 1975 June 1975 - April 1976 |

x) Divided into four subsections: la, lb, lc and ld. For further details see Mortensen (1977c).

are similar to those described in detail by Mortensen (1977a, c) and only a summary will be given here.

Population estimates

Sampling was conducted entirely by electrofishing. Each section were sampled regularly throughout the year with about one sample every fifth week. The size of each year class was estimated using capture data based on the removal method. (Brandstrup bæk reaches 1 and 3) and on the single-catch method (Brandstrup bæk reach 2) (Seber & Le Cren 1967). Minimum and maximum estimates were calculated for each year class as 95% confidence limits for the population size in Brandstrup bæk reaches 1 and 3. No confidence limits were calculated for the population size in Brandstrup bæk reach 2.

Age and Growth Estimates

Captured individuals were anaesthetized with MS-222, and their total length measured. Subsamples of these fish were also weighed. After determination of length and weight and removal of a sample of samples, the fish were placed in holding boxes for recovery and then returned alive to the section in which they were captured. Each catch was separated into age groups corresponding to the modes of length-frequency histograms. Age estimates obtained from scales of fish of intermediate length aided this procedure. Length-weight relationships were established and used for converting length-frequency histograms into weight-frequency histograms and for subsequent calculation of the mean weight of each year class.

Production Estimates

Production was calculated using Allen's graphical method (Allen 1951). The results of production estimates are expressed as grams wet weight/m² of stream-bed per year. For Brandstrup bæk reaches 1 and 3, a range of values for annual production of each year class was obtained by plotting the minimum, mean and maximum estimates of survivors against the same mean weight.

RESULTS

Populations and Mortality

Adult sea trout begin to arrive at the spawning sites of Brandstrup bæk in late October, and spawning takes place during late November, December and early January. Both sea trout and brown trout spawned in the stream, and data for juvenile trout is treated under the general heading "trout" because it did not prove possible to distinguish between the two forms at the parr stage. During the spawning season several redds were found in the study reaches. The first fry was observed in early April, and, therefore, 1 April was designated as mean birth date for a new year class.

Examples of seasonal changes in the size of the trout populations are shown in Fig. 1 as survivorship curves where the mean population estimates calculated for each year class are plotted together with their 95% confidence limits. Actual values of the daily instantaneous mortality rates (Z) and survival rates (S) for different periods of the life span for all year classes at each reach are given in Table 2. These two rates were calculated from the equations: $Z = -(\log_e N_1 - \log_e N_0) / (t_1 - t_0)$ and $S = N_1 / N_0$, where N_0 and N_1 are numbers of fish present at time t_0 and t_1 , respectively.

There were large differences in the recruitment of the 0 group in all the reaches studied (Fig. 1). Mortality also varied largely during the first three months of life (Table 2). However, when the daily instantaneous mortality rates of fry during the first three months of life for all the reaches studied are plotted against the initial density of fry, it can be seen that mortality was strongly correlated with the initial density of fry; indicating density-dependent mortality during this initial period of life (Fig. 2).

The daily instantaneous mortality rates varied between 0.0023 and 0.0099 during the rest of the life (Table 2). However,

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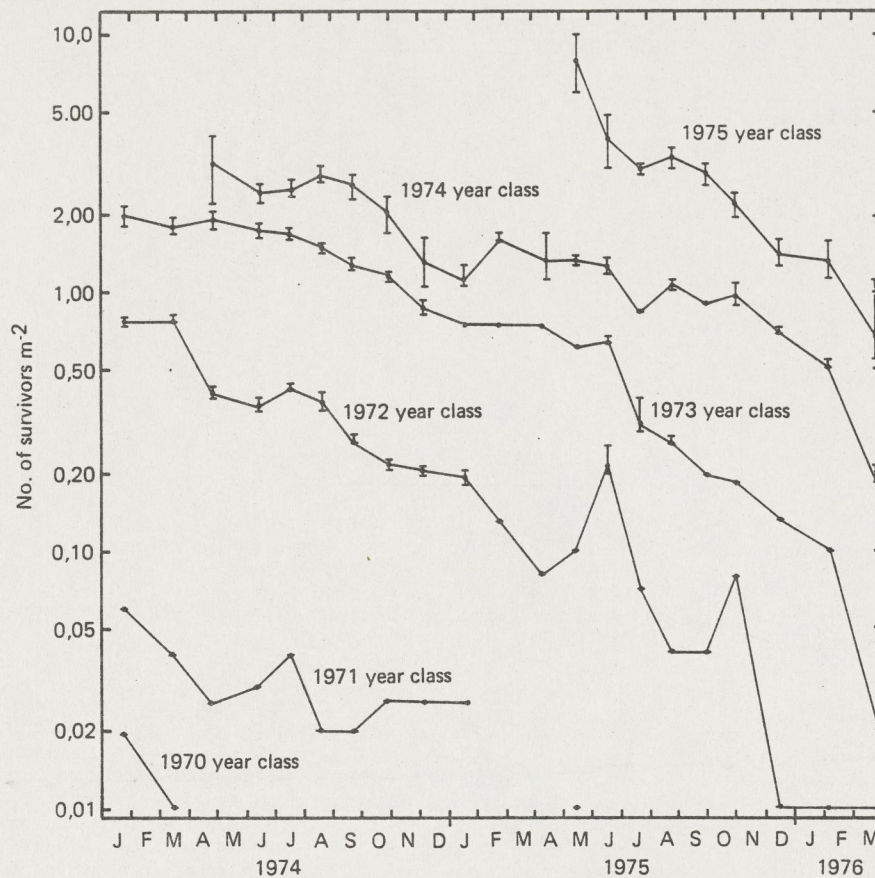


Figure 1. Survivorship curves for the trout population divided into different year classes at Brandstrup bækk reach 3. Vertical lines indicate 95% confidence limits.

Table 2. Daily instantaneous mortality rates (Z) and survival rates (S) in brackets of trout for different periods of the life span

| Age group | Reach 1 | Reach 1a | Reach 1b | Reach 1d | Reach 2 | Reach 3 | | |
|-----------|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | 1974-1975 | 1975 | 1975 | 1975 | 1974-1975 | 1974-1975 | 1975-1976 | |
| 0 group | first three months | 0.0034 (0.74) | 0.0052 (0.63) | 0.0169 (0.22) | 0.0103 (0.39) | 0.0073 (0.52) | 0.0030 (0.76) | 0.013 (0.31) |
| | following nine months | 0.0046 (0.28) | | | | 0.0037 (0.36) | 0.0023 (0.54) | 0.0054 (0.23) |
| | first year | 0.0042 (0.21) | | | | 0.0044 (0.20) | 0.0024 (0.41) | 0.0073 (0.07) |
| I group | 0.0040 (0.24) | | | | 0.0031 (0.32) | 0.0024 (0.42) | 0.0060 (0.11) | |
| II group | 0.0053 (0.14) | | | | 0.0082 (0.05) | 0.0049 (0.17) | 0.0099 (0.03) | |
| III group | | | | | | 0.0038 (0.25) | 0.0063 (0.10) | |

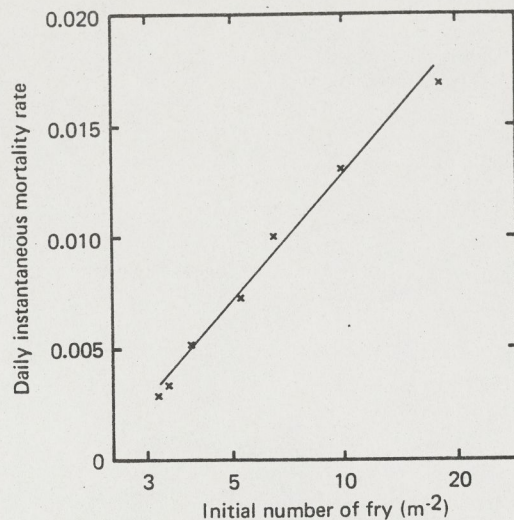


Figure 2. The initial number of fry m^{-2} and the daily instantaneous mortality rate of fry during the first three months of life.

in most of the year classes the mortality rates was fairly constant throughout the study period (Fig. 1) and were therefore considered to be density-independent.

Length-Weight Relationship and Growth

The regression coefficient of log weight plotted against log length was calculated for trout at Brandstrup bæk reach 1 and for reaches 2 and 3 combined (Table 3). The length-weight coefficients (b) were different for trout below and above a length of 50 mm. The coefficient (b) for trout above 50 mm was not significantly different from the cube. For trout below 50 mm the coefficient (b) was, however, highly significantly different from the cube and from the coefficient of older trout.

For each of the reaches the data on growth in length have been combined to give growth curves for composite year classes (Fig. 3). The growth curves showed only marginal differences in the growth rates of the trout at the three reaches studied, and these can be accounted for by sampling variation. The instantaneous growth rates for the year classes present were calculated as $i = (\log_e \bar{w}_{t_1} - \log_e \bar{w}_{t_0}) / (t_1 - t_0) \times 100$, where \bar{w}_{t_0} and \bar{w}_{t_1} are the mean weights of the year class at time t_0 and t_1 , respectively. A regular annual growth cycle was found in all year classes (Fig. 4). Normally, growth continued throughout the year, although occasionally growth rates close to zero or slightly negative were found for a few year classes at Brandstrup bæk reaches

Table 3. Length-weight relationship for trout. Regression coefficient from equation: $\log \text{weight} = \log a + b \log \text{length}$

| | Number of fish in sample | Range in weight (g) | log a | b | SE _b | Coefficient of correlation |
|-----------------|--------------------------|---------------------|--------|-------|-----------------|----------------------------|
| Reach 1 | | | | | | |
| fish < 50 mm | 43 | 0.10-1.30 | -2.362 | 3.636 | 0.0609 | 0.994 |
| fish > 50 mm | 111 | 1.25-95.5 | -1.929 | 2.943 | 0.0291 | 0.995 |
| Reaches 2 and 3 | | | | | | |
| fish < 50 mm | 52 | 0.11-1.29 | -2.421 | 3.716 | 0.0704 | 0.991 |
| fish > 50 mm | 348 | 1.30-370 | -1.955 | 2.953 | 0.0239 | 0.996 |

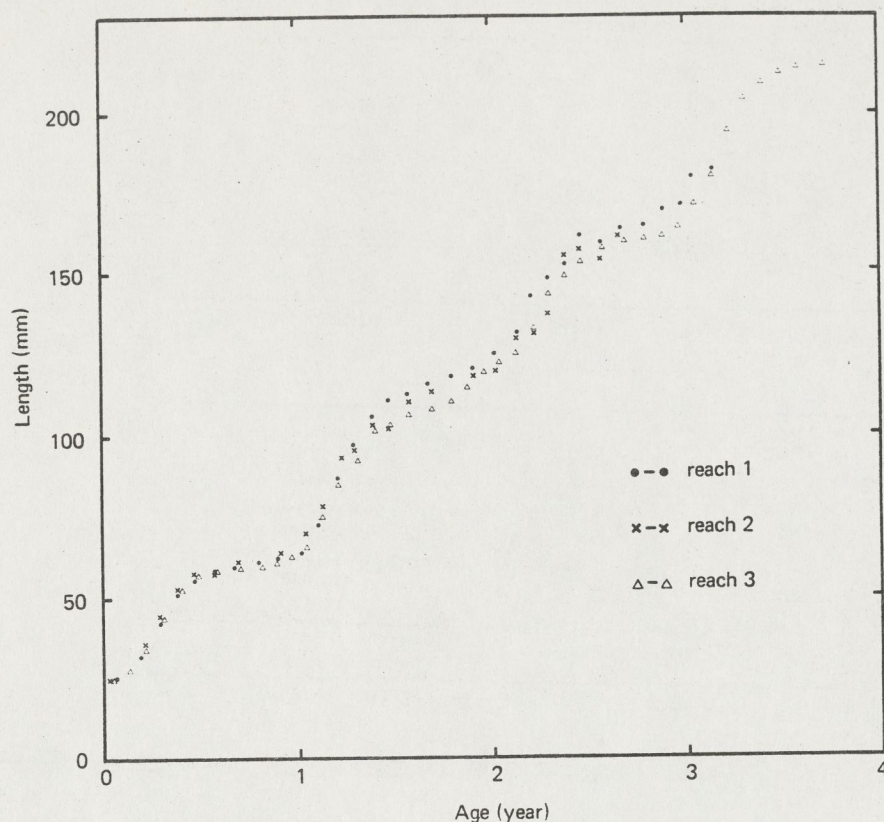


Figure 3. Growth in length of a composite year class of trout at reaches 1, 2 and 3.

2 and 3 during winter. The period of most rapid growth at all reaches was during late April, May, and June. From July onwards growth rates decreased to a minimum in December, January and February. During the period of most rapid growth the growth rates decreased in the sequence: 0 group, I group and II group.

Biomass

The biomass is the amount of living tissue existing in the species at a particular time. Here the biomass of each year class was calculated as the product of the mean population estimate and the mean weight on sampling dates. The biomass of trout in the three reaches divided into the separate year classes is shown in Fig. 5. The largest total biomass occurred between July and October and was about 11.5 g m^{-2} and 20 g m^{-2} in reaches 1 and 2, respectively, and about 32 g m^{-2} at reach 3 in both 1974 and 1975. The lowest total biomass occurred in April or May, and was about 6.5 g m^{-2} at reach 1 in both 1974 and 1975. At reach 2 this amount was about 14.5 g m^{-2} and 12 g m^{-2} in 1974 and 1975, respectively. At reach 3, the lowest biomass was about 17.5 g m^{-2} in both 1974 and 1975, while in 1976 the lowest biomass was only about

6 g m^{-2} . This rather low value may be attributed to the dredging of the stream in February - March 1976. Seasonal changes in the biomass of a year class were essentially similar at reach 3 in 1974 and 1975.

All data on biomass at reaches 1 and 3, respectively, have been combined to give changes in biomass of composite year classes (Fig. 6). At reach 1, a year class reached its largest biomass already during the first year of life, while at reach 3 the largest biomass of a year class first was reached during the second year of life.

Production

The annual production for all year classes at each reach was estimated from production curves (Table 4). The total annual production was different at the three reaches. In 1974-1975, the annual production was 14.1 g m^{-2} at reach 1 and 22.2 g m^{-2} at reach 2. The 0 and I group accounted for 83 - 85% of the total annual production at these two reaches (Table 5). At reach 3, the annual production was 27.4 g m^{-2} and 33.1 g m^{-2} in 1974-1975 and 1975-1976, respectively. Here the 0 and I group contributed 56 - 71%, while the II group contributed 26-33% of the total annual pro-

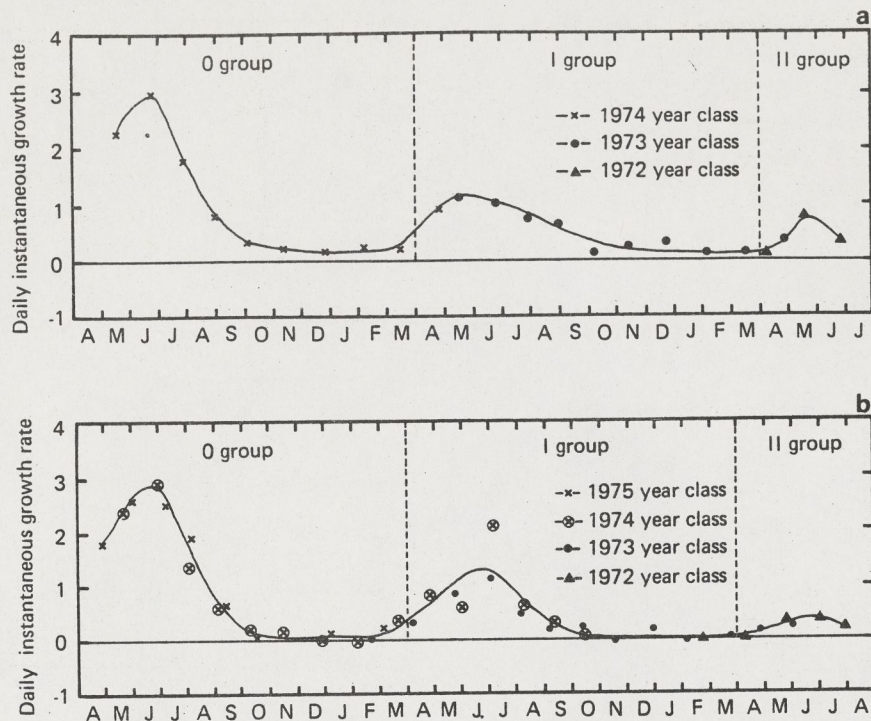


Figure 4. Seasonal variation in the instantaneous growth rate of the 0, I and II group at reach 1 (a) and reach 3 (b).

duction. The range of values for annual production was at maximum only 8% of the mean annual production.

From the mean annual production (P) and mean biomass (B) the P/\bar{B} ratios for the 0, I, II and III group and the whole population at the three reaches were calculated

(Table 5). The P/\bar{B} ratios decreased with increasing age and ranged from 2.4 - 3.0 in the 0 group, 1.2 - 1.7 in the I group, 0.8 - 1.6 in the II group, and 0.2 - 0.9 in the III group.

Changes in biomass and accumulated production of composite year classes at reaches

Table 4. The mean annual production (gm^{-2}) of the 0, I, II and III group and the whole population with minimum and maximum values where these were determined

| Age group | Reach 1 | Reach 2 | Reach 3 | Reach 3 |
|------------------|---------------------|-----------|---------------------|---------------------|
| | 1974-1975 | 1974-1975 | 1974-1975 | 1975-1976 |
| 0 group | 7.0 (6.6-7.3) | 7.3 | 5.7 (5.0-6.4) | 8.1 (7.4-8.9) |
| I group | 4.9 (4.8-5.1) | 11.2 | 13.6 (13.0-14.7) | 10.5 (10.2-11.0) |
| II group | 2.0 (2.0-2.2) | 3.7 | 7.1 (7.0-7.5) | 10.9 (10.8-11.9) |
| III group | 0.2 (0.2-0.2) | 0.0 | 1.0 (1.0-1.0) | 3.6 (3.6-3.6) |
| Whole population | 14.1 (13.6-14.8) | 22.2 | 27.4 (26.0-29.6) | 33.1 (32.0-35.4) |

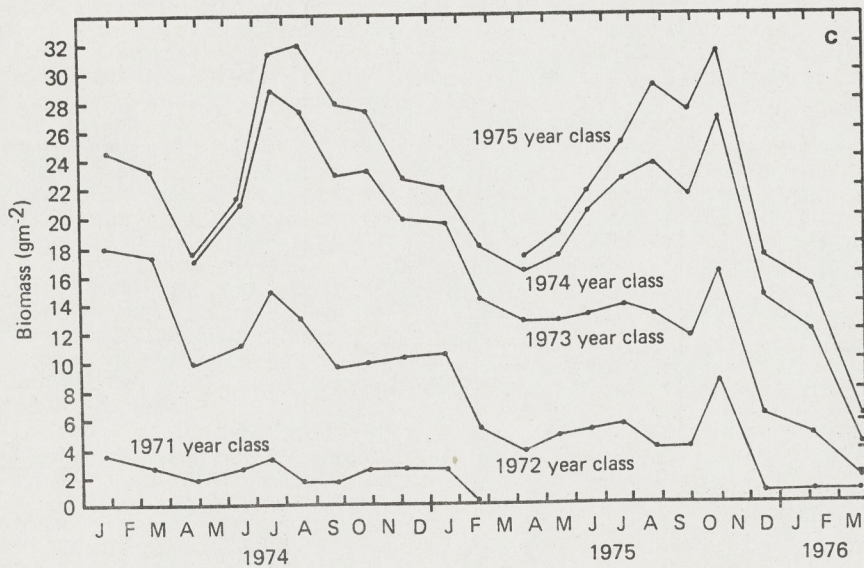
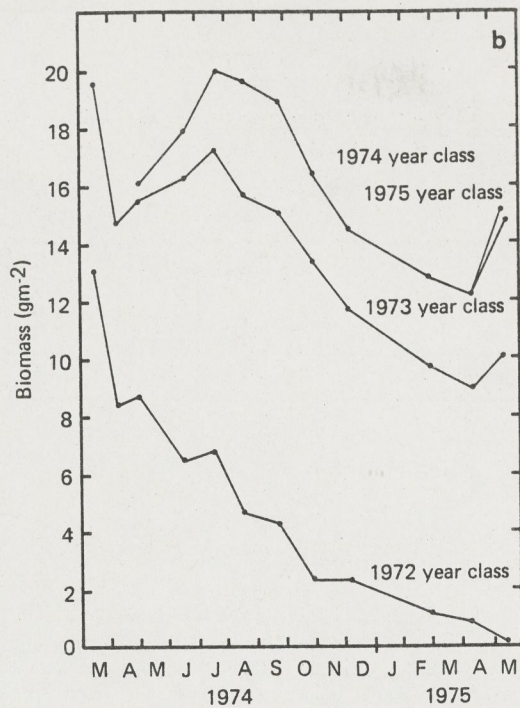
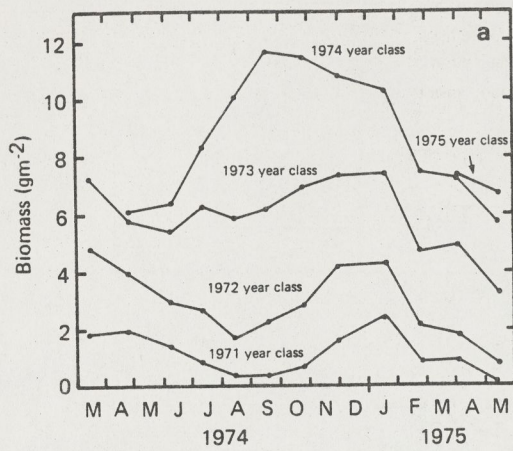


Figure 5. Variation in biomass of trout divided into the contributions made by different year classes. (a) reach 1, (b) reach 2 and (c) reach 3.

Table 5. The mean annual production (P) in $g\ m^{-2}$, mean biomass (\bar{B}) in $g\ m^{-2}$ and turnover ratio (P/\bar{B}) in the O, I, II and III group and the whole population. For the mean annual production the percentage contribution made by each year class is given in brackets.

| Age group | Reach 1 1974-1975 | | | Reach 2 1974-1975 | | | Reach 3 | | | | | |
|------------------|----------------------|-----------|-------------|----------------------|-----------|-------------|-----------|-----------|-------------|-----------|-----------|-------------|
| | | | | | | | 1974-1975 | | | 1975-1976 | | |
| | P | \bar{B} | P/\bar{B} | P | \bar{B} | P/\bar{B} | P | \bar{B} | P/\bar{B} | P | \bar{B} | P/\bar{B} |
| O group | 7.0 (50) | 2.9 | 2.4 | 7.3 (33) | 2.8 | 3.0 | 5.7 (21) | 2.9 | 1.9 | 8.1 (24) | 3.0 | 2.7 |
| I group | 4.9 (35) | 3.1 | 1.6 | 11.2 (50) | 9.4 | 1.2 | 13.6 (50) | 10.9 | 1.3 | 10.5 (32) | 6.1 | 1.7 |
| II group | 2.0 (14) | 1.7 | 1.2 | 3.7 (17) | 4.4 | 0.8 | 7.1 (26) | 8.0 | 0.9 | 10.9 (33) | 7.2 | 1.5 |
| III group | 0.2 (1) | 1.2 | 0.2 | | | | 1.0 (4) | 1.8 | 0.6 | 3.6 (11) | 3.8 | 0.9 |
| Whole population | 14.1 | 8.9 | 1.6 | 22.2 | 16.6 | 1.3 | 27.4 | 23.6 | 1.2 | 33.1 | 20.1 | 1.6 |

1 and 3 are plotted in Fig. 6. Production rates were greatest during spring and summer in all age groups.

DISCUSSION

Just after emergence, fry of several salmonid species which are resident in streams show inter- and intraspecific aggressive territorial behavior (Lindroth 1955, Kalleberg 1958, Keenleyside 1962). The regulation of population densities during the early months of life by density-dependent mortality probably arising from territorial behaviour has been demonstrated for salmonid populations (Fig. 2 and McFadden et al. 1967, LeCren 1973, Mortensen 1977c). The stimulus for territorial behavior may be visual (Stuart 1953, Kalleberg 1958). Thus, a physically more complex stream-bed with greater obstruction to mutual vision may permit a larger population to be maintained. The results from Lawrence Creek (Hunt 1969, 1976), Bere Stream (LeCren 1969, Fig. 1; Mann 1971) and Mausing Møllebæk and Brandstrup bæk (Mortensen 1977b, Figs. 1 and 2) clearly support this suggestion. However, weed cutting and dredging tends to decrease physical complexity and thus increases territorial behaviour resulting in additional mortality (Mortensen 1977c, Fig. 3). That the type of habitat is an important factor in determining the amount of trout production is exemplified by the marked differences observed between the three rather different study reaches. As only insignificant differences in growth rates (Fig. 3) could be observed between the three populations, the variation in the trout production has largely resulted from differences in abundance of the year classes present at each reach. The highest population densities and production estimates were found at reaches 2 and 3, where the varied appearance of the stream-bed (Mortensen 1977b, Fig. 2) seems to have favoured particularly the I group.

The main factors regulating and limiting juvenile trout populations in streams are probably density-dependent mortality caused by territorial behaviour in early life and the area of suitable fry rearing grounds available for the fry in their early stages (LeCren 1973, Mortensen 1977c). Such important parameters in trout fisheries as the recruitment of smolts and catchable adult trout therefore depend to a great extent on the physical complexity of the stream-bed. The conclusion is that stream management which makes the streams more uniform will be in conflict with sound fishery management.

LeCren (1972) has summarized the production estimates for salmonids in small streams. Most of the values ranged from 2 to about $18\ g\ m^{-2}\ a^{-1}$, only two values exceeded this range. These were $55\ g\ m^{-2}\ a^{-1}$ for trout in the Horokiwi (Allen 1951) and $17\ to\ 23\ g\ m^{-2}\ a^{-1}$ for trout and salmon in the Shelligan Burn (Egglislaw 1970). The very high estimate for Horokiwi may be an overestimate because early mortality could not be adequately studied. However, it would seem unlikely that the annual production was less than $38\ g\ m^{-2}\ a^{-1}$ (LeCren 1969). The estimate of $30\ g\ m^{-2}\ a^{-1}$ for brook trout in Big Spring (Cooper and Scherer 1964) also exceeded this range. The annual production rates obtained in the present study and by Mortensen (1977b) appear to be typical for trout in small Danish streams and it may be concluded that small Danish trout streams are among the most productive.

Production is the basic parameter in population dynamics linking population numbers, mortality rate and growth rate. LeCren (1972) fully discussed the main factors (general productivity, species composition and intra-specific factors) influencing production in his comprehensive review on fish production in freshwaters. Some, but not all, of these factors can be influenced by man. Recently this has been discussed in

some detail from a management point of view by Hunt (1974). There is therefore no need to add to this subject here. Firm conclusions about adequate management of fish

populations in trout streams must await further data. In particular, the results of long term studies may be helpful.

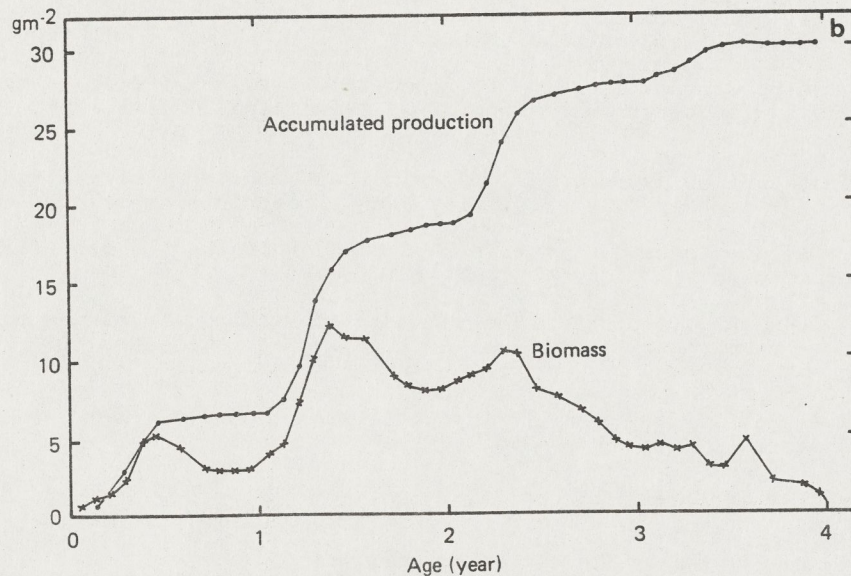
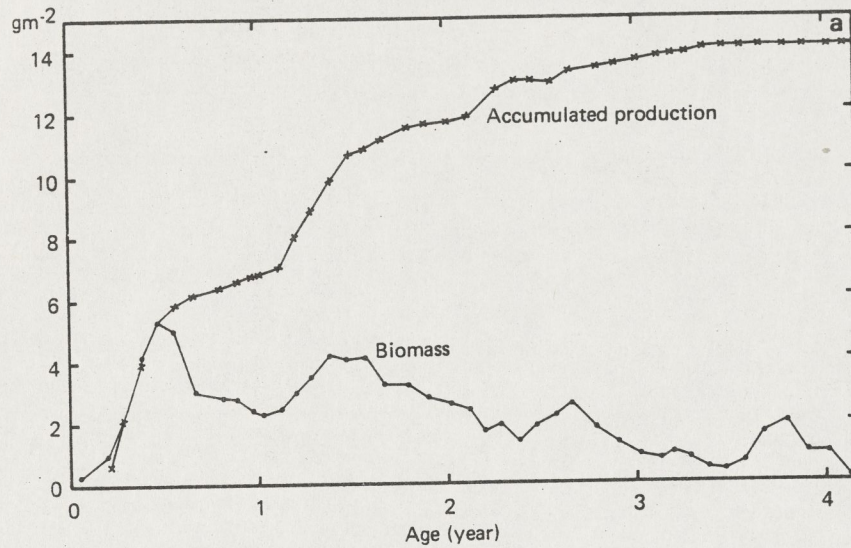


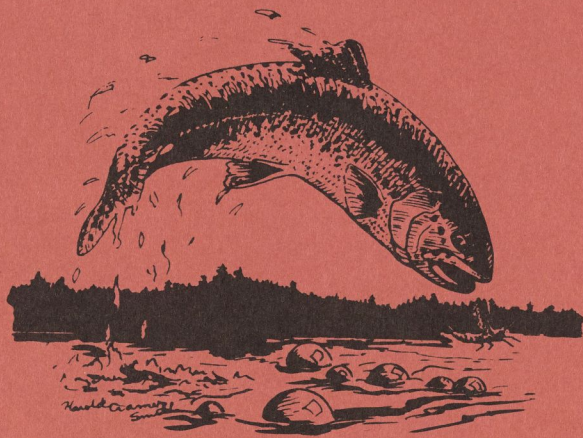
Figure 6. Changes in biomass and accumulated production of a composite year class at reach 1 (a) and reach 3 (b).

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POPULATION DYNAMICS, REGULATION AND PRODUCTION OF STREAM SALMONIDS

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Abstract

The main factors affecting population dynamics and production of stream salmonids are reviewed. Data on both population dynamics and production emphasize the importance of the young stages and small species. Commercial and sports fisheries are increasing their exploitation while other activities by Man are changing the environment and much more will need to be known about fish production and population dynamics before adequate management of stream salmonids can be soundly based. Long-term studies on selected types of streams in different environments may be useful to provide guidelines for future management.

INTRODUCTION

Several salmonids species occur abundantly in many streams. They constitute a limited resource of considerable economic importance. Commercial and sports fisheries are increasing their demand on these species while other activities such as agriculture, forestry, hydroelectric or urban development are changing the environment in a way which can have major affect on the salmonid populations (Fig. 1). Therefore, information on the ecology of salmonid populations in different environments is needed to provide a basis for developing and improving the present fisheries. This information is necessary to establish water quality standards and criteria for monitoring a stream ecosystem which can maintain salmonid population for fisheries.

A number of investigations have dealt with particular or general aspects of population dynamics of salmonids and recently increasing attention has been paid to the production ecology, but no single species has been so intensively studied over a wide range of environmental conditions that its population dynamics and production ecology are fully understood. However, it is generally agreed that resident salmonid species (brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*)) and anadromous species (Atlantic salmon (*Salmo salar*), lake-trout and sea-trout (*Salmo trutta*)) share many ecological significant characteristics. Therefore, in this paper I will review a number of papers dealing with population dynamics and production of these species to

provide information on the ecological factors regulating and limiting wild salmonid populations in stream environments.

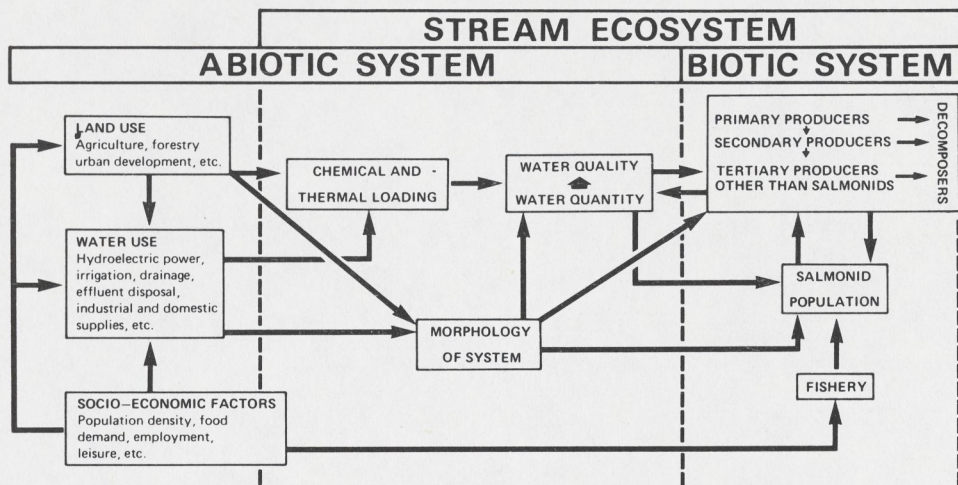


Fig. 1. Interrelationships between major environmental systems which can affect a salmonid population.

DYNAMICS AND REGULATION OF POPULATIONS

The egg depositing rates and the survival of eggs and alevins in brown trout and brook trout populations are, under natural conditions, usually high (Hobbs 1940, McFadden 1961, Allen 1962, Warner 1963) and just after emergence densities of fry as high as 12 to 31 m⁻² in brook trout (McFadden 1961, McFadden et al. 1967), 22 m⁻² in brown trout (Mortensen 1977b) and 12 m⁻² in Atlantic salmon (Egglshaw & Shackley 1977) are reported. However, during the first few months of life heavy mortality takes place (Allen 1951, Latta 1962, Le Cren 1965, Egglshaw 1970, Egglshaw & Shackley 1977, Mortensen 1977a, b, d, 1979). Just after emergence fry of salmonid species which are resident in streams show inter- and intraspecific aggressive territorial behaviour (Lindroth 1955, Kalleberg 1958, Keenleyside 1962). The stimulus for territorial behaviour may be visual (Stuart 1953, Kalleberg 1958) and the number of territories a given stretch of stream contains are determined partly by physical features, such as larger stones and undercut banks which isolate fish visually, water turbulence and stream velocity (Kalleberg 1958, Hartman 1963, Chapman 1966). The heavy mortality is density-dependent (Fig. 2 and McFadden et al. 1967, Le Cren 1973, Mortensen 1977c, d) and may be related to the territorial behaviour (Miller 1958, Le Cren 1973). Thus a physically more complex stream-bed with greater obstruction to mutual vision may permit a larger population density to be maintained. The results reported by Hunt (1969, 1971, 1976), Le Cren (1969 Fig. 1), Mann (1971) and Mortensen (1977c Figs. 1 and 2) clearly support this suggestion. However, weed cutting, dredging and cleaning out of the stream-bed tends to decrease physical complexity and thus increases territorial behaviour resulting in additional mortality, and only very low population densities will be maintained (Mortensen 1977d).

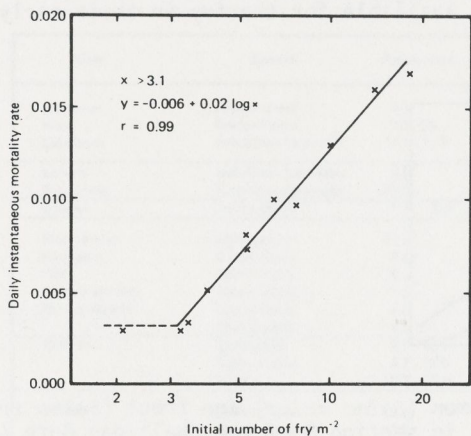


Fig. 2. The initial number of fry m^{-2} and the daily instantaneous mortality rate of fry during the first three months of life.

After the period of density-dependent mortality in early life, mortality becomes fairly constant and density-independent (Figs. 3, 4 and McFadden 1961, Le Cren 1973, Egglisaw & Shackley 1977, Mortensen 1977a, b, 1979).

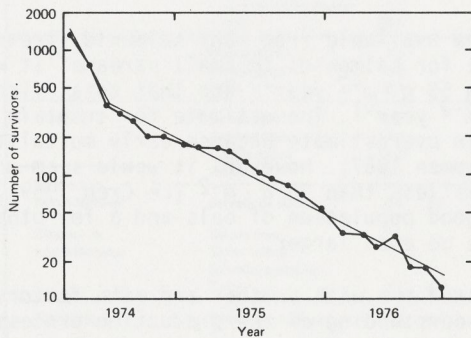


Fig. 3. Survival curve for the 1974 year class of trout (*Salmo trutta*) in Bisballe bæk.

Le Cren (1973) and later Mortensen (1977b) suggested the main factors regulating and limiting juvenile salmonid populations in streams are density-dependent mortality caused by the territorial behaviour in early life and the area of suitable fry rearing grounds available for the fry in their early stages.

The implications of these relationships are that good smolt runs and large number of catchable adults can be obtained from quite small spawning populations and in most situations the size of a salmonid population will depend more than anything upon the physical complexity of the stream-bed and the

Dr. Fausch,
I would appreciate receiving a reprint
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Thank you

Sincerely,
Bob Martin

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**Competition among Juveniles of Coho Salmon,
Brook Trout, and Brown Trout in a Laboratory Stream, and
Implications for Great Lakes Tributaries¹**

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area of suitable fry rearing grounds available for the fry in their early stages.

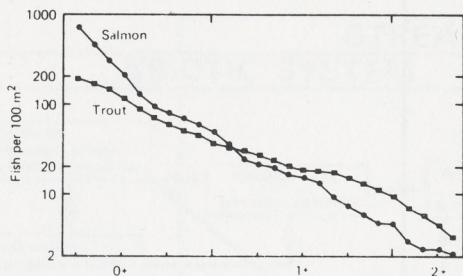


Fig. 4. Mean survival curves for salmon (*Salmo salar*) and trout (*Salmo trutta*) during the years 1966 - 1972 in section D of the Shelligan Burn (after Eglisshaw & Shackley 1977).

PRODUCTION ESTIMATES

Production is here defined as the total quantity of fish flesh elaborated by a population in a definite period of time regardless of its ultimate fate and whether it survives to the end of the period (Ivlev 1945). Production is the basic parameter in population dynamics linking population numbers, mortality rates and growth rates.

Production estimates for fish are now available from many salmonid streams (Table 1). Many of the estimates are for salmonids in small streams. It will be seen that these range from 0.1 to 55 $\text{g} \cdot \text{m}^{-2} \text{year}^{-1}$ and that total fish production range from 0.1 to 50 $\text{g} \cdot \text{m}^{-2} \text{year}^{-1}$. The estimate for trout in the River Horokiwi (Allen 1951) may be an overestimate because early mortality could not be adequately studied (Chapman 1967). However, it would seem unlikely that the annual production was less than 38 $\text{g} \cdot \text{m}^{-2}$ (Le Cren 1969), but the River Horokiwi also maintain a good population of eels and a few other species so the total production must be even larger.

Estimates of production can be compared one with another and with factors in the environment to yield a better understanding of the production processes in the ecosystem.

A significant characteristic of the production studies is the large contributions made by small and/or young fish to the total production (Table 1). The early stages of a year class not only are crucial in determining its survival but they may also make major demands on the production capacity of the stream ecosystem to provide food for the species.

The stream in the Matamek Watershed and in north Norway (studied by O'Connor & Power (1976) and Power (1973) respectively) situated in areas with low environmental productivity have low total fish production, whereas the English chalk streams and many of the Danish streams (studied by Mann (1971) and Mortensen (1977c, 1979) respectively) situated in areas with high environmental productivity have high total fish production. This is an illustration of the general concept of increase in total production with an increase in general productivity.

Table 1. Estimates of production (g fresh weight $m^{-2} a^{-1}$) for freshwater fish in natural rivers. The range and the percentage contributions made by 0 group and I group to the production of each species are given where available.

| River | Species | Production | Percentage contributions made by 0 group and I group | Author |
|-------------------------|-------------------------------|-------------|--|-----------------------------|
| Horokiwi | <i>Salmo trutta</i> | 55 | | Allen, 1951 |
| Walla | <i>Salmo trutta</i> | 10 - 18 | | Horton, 1961 |
| Lawrence | <i>Salvelinus fontinalis</i> | 9.4 - 10.8 | 81 - 95 | Hunt, 1966 |
| Larry's | <i>Salvelinus fontinalis</i> | 5.8 | 70 | Cooper & Sherer, 1968 |
| Big Spring | <i>Salvelinus fontinalis</i> | 30.9 | 61 | |
| Loucka | <i>Salmo trutta</i> | 1.7 - 8.6 | | Libosvasky, 1968 |
| Black Brows | <i>Salmo trutta</i> | 10.0 | 97 | Le Cren, 1969 |
| Kingswell | <i>Salmo trutta</i> | 7.4 | 62 | |
| Hall | <i>Salmo trutta</i> | 5.2 | | |
| Appletreeworth | <i>Salmo trutta</i> | 3.0 | | |
| Nether Hearth | <i>Salmo trutta</i> | 5.0 | | |
| | <i>Cottus gobio</i> | 1.0 | | |
| Shelligan | <i>Salmo salar</i> | 5.7 - 12.6 | 76 - 98 | Egglisshaw, 1970 |
| | <i>Salmo trutta</i> | 6.7 - 12.6 | 70 - 93 | Egglisshaw & Shackley, 1977 |
| | Total | 16.3 - 25.0 | | |
| Tarrant | <i>Salmo trutta</i> | 12.0 | 100 | Mann, 1971 |
| | <i>Cottus gobio</i> | 43.1 | 99 | |
| | <i>Phoxinus phoxinus</i> | 3.9 | | |
| | <i>Nemacheilus barbatula</i> | 0.6 | | |
| | Total | 59.6 | | |
| Devil's | <i>Salmo trutta</i> | 4.8 | | Mann, 1971 |
| | <i>Cottus gobio</i> | 14.4 | | |
| | <i>Gasterosteus aculeatus</i> | 0.6 | | |
| | Total | 19.8 | | |
| Docken's | <i>Salmo trutta</i> | 12.1 | 79 | Mann, 1971 |
| | <i>Phoxinus phoxinus</i> | 1.9 | | |
| | Total | 14.0 | | |
| Bere, I | <i>Salmo trutta</i> | 2.6 | 100 | Mann, 1971 |
| | <i>Cottus gobio</i> | 30.4 | 98 | |
| | <i>Phoxinus phoxinus</i> | 2.0 | | |
| | <i>Gasterosteus aculeatus</i> | 1.8 | | |
| | Total | 36.8 | | |
| Bere, II | <i>Salmo trutta</i> | 2.9 | 100 | Mann, 1971 |
| | <i>Cottus gobio</i> | 6.2 | 97 | |
| | Total | 9.1 | | |
| Bere, III | <i>Salmo salar</i> | 12.9 | 60 | Mann, 1971 |
| | <i>Salmo trutta</i> | 7.9 | | |
| | <i>Cottus gobio</i> | 15.0 | 93 | |
| | Total | 35.1 | | |
| Streams in north Norway | <i>Salvelinus alpinus</i> | 0.7 - 3.7 | | Power, 1973 |
| Streams in north Norway | <i>Salmo salar</i> | | | |
| | <i>Salmo trutta</i> | | | |
| | <i>Salvelinus alpinus</i> | | | |
| | Total | 0.1 - 6.1 | | |
| Kaikhosru | <i>Salvelinus fontinalis</i> | 6.1 - 6.6 | 78 - 82 | O'Connor & Power, 1976 |
| Gallienne | <i>Salvelinus fontinalis</i> | 3.7 - 3.9 | 62 - 64 | |
| Sherry | <i>Salvelinus fontinalis</i> | 1.5 - 1.6 | 64 - 73 | |
| Tchinicaman | <i>Salvelinus fontinalis</i> | 1.5 - 4.1 | 73 - 76 | |
| | | | | |
| Lillebækken | <i>Salmo trutta</i> | 4.6 | 49 | Mortensen, 1977c |
| Mausing Møllebæk I | <i>Salmo trutta</i> | 22.3 | 73 | |
| | <i>Salmo gairdneri</i> | 4.8 | | |
| Mausing Møllebæk II | <i>Salmo trutta</i> | 13.2 | 80 | |
| | <i>Gasterosteus aculeatus</i> | 0.5 | | |
| | | | | |
| Bisballe | <i>Salmo trutta</i> | 18.8 | 81 | |
| Brandstrup I | <i>Salmo trutta</i> | 14.1 | 84 | Mortensen, 1977c, 1978 |
| Brandstrup II | <i>Salmo trutta</i> | 22.2 | 83 | |
| Brandstrup III | <i>Salmo trutta</i> | 27.4 - 33.1 | 56 - 70 | |
| Mattrup | <i>Salmo trutta</i> | 9.5 | 67 | Mortensen, 1977c |
| | <i>Phoxinus phoxinus</i> | 0.4 | | |
| | <i>Gasterosteus aculeatus</i> | 1.0 | | |
| | Total | 10.9 | | |

Obviously also other factors such as temperature, the variance of the discharge and the type of habitat influence the production. That the type of habitat is an important factor in determining the amount of trout production is exemplified by the marked differences observed between the rather different study reaches in Bere Stream (Le Cren 1969 Fig. 1, Mann 1971) and Brandstrup bæk (Mortensen 1977c Fig. 2).

Some effects of density-dependent factors on salmonid production have been discussed (Backiel & Le Cren 1967, Le Cren 1972). However, firm conclusions must await further data.

Statistical analyses of the production estimates from the different environments may lead to some general conclusions. However, before salmonid populations can be managed on sound basis there will have to be much greater understandings of the population dynamics and production ecology. Valuable progress is most likely to result from long-term studies on selected types of stream in different environments.

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Production of trout, *Salmo trutta*, in a Danish stream

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Population dynamics, Density, Age, Growth, Biomass, Migration, Survival, Temperature, Stream salmonids

Synopsis

The numbers of trout, *Salmo trutta*, in Granslev å, Denmark, were estimated by the removal method on 18 dates from March 1974 to March 1976. Populations density varied from 0.39 to 0.74 trout m^{-2} in 1974–75 and from 0.36 to 0.59 m^{-2} in 1975–76 and at all times four or five year classes were present. The age structure of the population was unstable and the variable natural survival, immigration into and emigration from the study site could not be separated. An annual growth cycle with the most rapid growth for all year classes taking place from May to early August was found. Statistically significant differences between different years occurred in the growth of the 0, I and II age groups, but no evidence of density-dependent growth was found. The biomass ranged from 35.4 to 9.5 $g m^{-2}$. The total mean annual biomass was 22.8 and 14.7 $g m^{-2}$ in the two years and the II group made the greatest contribution, 44 and 48%, respectively. During 1975–76 the mean annual biomass of each year class only was about two-thirds of that in 1974–75. Annual production in the two years was 25.7 (range 24.7–28.5) and 12.6 $g m^{-2}$ (range 11.7–15.0) and the II group accounted for about 46 and 38% of the production. In addition eel, *Anguilla anguilla*, produced about 0.5 $g m^{-2} yr^{-2}$. The unstable age structure of the trout population was compared with trout populations from other streams. The importance of immigration as a recruitment process in middle and lower reaches of streams and of migrations as a mechanism to optimise utilization of the total stream habitat, as well as temperature as a factor controlling the growth rate are discussed.

Introduction

Previous studies on stocks and production of trout, *Salmo trutta* L., in Danish streams have concerned trout populations dominated by abundant age 0 fish (Mortensen 1977a, b, 1978). However, many Danish streams maintain stocks of both juveniles and older brown trout, which are progeny of both anadromous sea trout, *Salmo trutta trutta*, and

resident brown trout, *S. trutta fario*. These stocks are important in producing catchable brown trout for recreational fisheries in the streams and sea trout for the commercial fishery in the inlets and along the seaboard of Denmark. Stream stocks may be deleteriously affected by reclamation projects (Dahl 1963) or stream management, e.g. dredging and weed cutting (Mortensen 1977c). Knowledge of factors controlling densities and production of wild trout stocks in streams, therefore, are necessary in promoting efficient fishery management and improvement of trout streams.

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Study area

This study was conducted in Granslev å, which is situated within the catchment area of the River Gudenå in Central Jutland, Denmark (9° 55' E., 56° 21' N.). Granslev å rises in Hammel Skov at an altitude of 44 m, flows north-eastwards for 4 km and then northwards another 9 km to join the River Lilleå at an altitude of 7 m, which empties into the River Gudenå. The catchment area of Granslev å is rather evenly divided into forest and agricultural land. The surroundings of the headwaters of the stream are coniferous forest, but from about 2 km to about 11.5 km from its source the stream flows through pastured meadow with scattered riparian vegetation of alder, *Alnus glutinosa*. On the uppermost 8 km of this meadow stretch several reaches are straightened. The study area was located in the lowermost 1.5 km of this meadow stretch, which is naturally meandering. The specific study site was 180 m long with an area of 490 m² and consisted mainly of shallow fast-flowing water and some pools with deep slow-flowing water. The study site was 2.1–3.3 m wide, had a mean depth of 0.5 m and the discharge varied from about 200 to 1000 l s⁻¹. The streambed consisted chiefly of sand and clay with patches of the vascular macrophytes *Potamogeton crispus* and *Elodea canadensis*. Further details on physical and chemical variables are summarized in Table 1. Granslev å is a spawning stream for brown trout and sea trout, but the study area contained little suitable spawning habitat. The fish community is dominated by trout, but a small population of eels, *Anguilla anguilla*, and an oc-

Table 1. Physical and chemical data from Granslev å. Minimum, mean and maximum values of 9 samples during the period April 1974 to February 1975.

| | | Minimum | Mean | Maximum |
|---|----------------------|---------|-------|---------|
| Temperature | °C | 0.5 | — | 14.0 |
| Conductivity | µS cm ⁻¹ | 329 | 362 | 385 |
| pH | | 7.2 | — | 8.4 |
| NO ₂ ⁻ + NO ₃ ⁻ | mg N l ⁻¹ | 0.72 | 1.75 | 4.60 |
| NH ₄ ⁺ | mg N l ⁻¹ | 0.060 | 0.175 | 0.350 |
| PO ₄ ⁻³ | mg P l ⁻¹ | 0.025 | 0.060 | 0.100 |
| Alkalinity | meq l ⁻¹ | 1.71 | 1.89 | 2.49 |

casional rainbow trout, *Salmo gairdneri*, and three-spined stickleback, *Gasterosteus aculeatus*, are present.

Materials and methods

Stock estimates

Sampling was conducted entirely by repeated electrofishing using a 220 V DC generator. Samples were taken regularly all the year round from March 1974 to March 1976. The size of the trout stock was estimated for each year class separately using capture data based on the removal method and applying the formula from Seber & Le Cren (1967). Minimum and maximum estimates were calculated for each year class as the 95% confidence limits for the stock size. On occasions when this produced a minimum value less than the number of trout caught in the two catches the number of trout actually caught was taken as the minimum estimate.

Age and growth estimates

Captured individuals were anaesthetized with tricaine methanesulphonate (MS-222 SANDOZ) and their total length measured to the nearest lower half cm. Throughout the study, subsamples of anaesthetized fish were measured to the nearest mm, weighed, and samples of scales were taken for age analysis. After processing the fish were placed in holding boxes for recovery and then returned alive to the stream.

From the capture data a series of length-frequency distributions were constructed and divided into age groups corresponding to the modes of the distributions. The subsamples of aged scales aided this procedure.

The weight-length relationship was calculated by regressing the logarithm of weight on the logarithm of length and expressed in the form,

$$\log_{10} W = \log_{10} a + b \log_{10} L, \quad (1)$$

where W = body wet weight in grams, L = length in cm and a, b are constants. As mean weight estimated directly from observed mean length may

be erroneous (Tesch 1971, Nielsen & Schoch 1980) the length-frequency distributions were converted into weight-frequency distributions and the mean weight of each year class was calculated.

Production estimates

Production is here defined as the total amount of fish flesh elaborated by a population in a definite period of time regardless of the ultimate fate of this flesh (Ivlev 1945). Production was calculated using

Allen's graphic method (Allen 1951) in which, for each sampling date, the density of each year class is plotted against their weight and the area under the resulting curve represents the production. In the present study the point estimates for density-weight were connected by straight lines and the production estimates expressed as grams wet weight per square metre of streambed per year. A range of values for annual production of each year class was obtained by plotting minimum, mean and maximum estimates of densities against the same mean weight.

Table 2. Numbers of trout in study section (490 m²), with their 95% confidence limits in parentheses, and total density m⁻².

| Sampling dates | Year class | | | | | | Stock density |
|-------------------|----------------|------------------|------------------|------------------|---------------|------------|---------------|
| | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | |
| 13 March 1974 | — | — | 110 (101.121) | 105 (103.121) | 55 (52.63) | 1 (1.1) | 0.55 |
| 20 April 1974 | — | 0 (0.0) | 128 (122.137) | 96 (92.104) | 51 (50.56) | 1 (1.1) | 0.56 |
| 7 June 1974 | — | 3 (3.3) | 93 (86.103) | 105 (97.117) | 43 (42.47) | 3 (3.3) | 0.50 |
| 12 July 1974 | — | 47 (42.62) | 124 (100.157) | 117 (114.124) | 45 (43.52) | 6 (6.6) | 0.69 |
| 13 August 1974 | — | 64 (63.66) | 102 (99.108) | 110 (106.116) | 14 (14.15) | 3 (3.3) | 0.60 |
| 17 September 1974 | — | 51 (47.59) | 88 (82.98) | 71 (67.79) | 10 (10.10) | 1 (1.1) | 0.45 |
| 24 October 1974 | — | 135 (125.148) | 140 (130.152) | 77 (73.84) | 10 (10.10) | 1 (1.1) | 0.74 |
| 1 December 1974 | — | 133 (125.144) | 134 (127.143) | 41 (40.46) | 9 (9.9) | 2 (2.2) | 0.65 |
| 17 January 1975 | — | 68 (64.81) | 82 (82.99) | 33 (33.35) | 4 (4.4) | 3 (3.3) | 0.39 |
| 23 February 1975 | — | 104 (94.117) | 96 (84.114) | 31 (31.83) | 1 (1.1) | 1 (1.1) | 0.48 |
| 4 April 1975 | 0 (0.0) | 109 (96.128) | 82 (75.94) | 26 (25.30) | 1 (1.1) | 0 (0.0) | 0.44 |
| 11 May 1975 | 14 (14.18) | 81 (70.99) | 87 (71.258) | 21 (20.33) | 0 (0.0) | 0 (0.0) | 0.41 |
| 19 June 1975 | 18 (18.19) | 105 (90.127) | 69 (65.78) | 26 (25.55) | 0 (0.0) | 0 (0.0) | 0.44 |
| 22 July 1975 | 31 (31.34) | 104 (93.120) | 84 (74.100) | 12 (12.12) | 1 (1.1) | 0 (0.0) | 0.47 |
| 25 August 1975 | 86 (80.96) | 132 (128.138) | 67 (67.69) | 6 (6.6) | 0 (0.0) | 0 (0.0) | 0.59 |
| 3 November 1975 | 85 (83.90) | 134 (109.176) | 57 (52.65) | 2 (2.2) | 0 (0.0) | 0 (0.0) | |
| 13 December 1975 | 79 (67.100) | 124 (113.137) | 39 (36.45) | 4 (4.4) | 0 (0.0) | 0 (0.0) | 0.50 |
| 26 March 1976 | 71 (61.91) | 83 (73.100) | 22 (22.22) | 2 (2.2) | 0 (0.0) | 0 (0.0) | 0.36 |

Results

Stock size

Data for the brown trout and sea trout have been treated together as it was not possible to distinguish between the juveniles (parr) of these two forms. On all sampling occasions there were trout from four or five year classes present and the mean densities range from 0.36–0.74 trout m^{-2} (Table 2).

Brown trout and sea trout spawned in the Granslev å from early December to mid January. The alevins emerged from the streambed in the April following spawning and 1 April has been taken as the birth-date of the new year class. Because there was little spawning habitat in the study area few age 0 fish were found the first few months after emergence. In fact, the 1974 and 1975 year classes reached their highest density at an age of about 1.5 years. Nearly all age groups were more abundant during the 1974–75 growing season than during the following year. In April 1975 several 13 to 18 cm smolts, all belonging to the 1973 year class, were caught indicating that the age structure of the trout stock was affected by immigration and emigration in addition to mortality. The effects of these three variables could not be separated in this study.

Weight-length relationship and growth

From length-weight data of 148 trout sampled throughout the year and ranging in body wet weight from 0.32 to 360 g the regression with 95% confidence limits of the weight-length relationship was $\log_{10}W = -1.920 (\pm 0.041) + 2.923 (\pm 0.038) \log_{10}L$. The correlation coefficient (r) was 0.998.

Growth in length of all year classes was most pronounced between April and October and almost ceased from November to March (Fig. 1). Growth in weight followed a similar pattern, as did daily instantaneous growth rates (Fig. 2). The growth rates showed a regular annual cycle and the most rapid growth for all year classes took place during May, June, July and early August. During the period of most rapid growth the growth rates decreased sequentially for age groups 0 through III.

The mean length of each age group at the end of

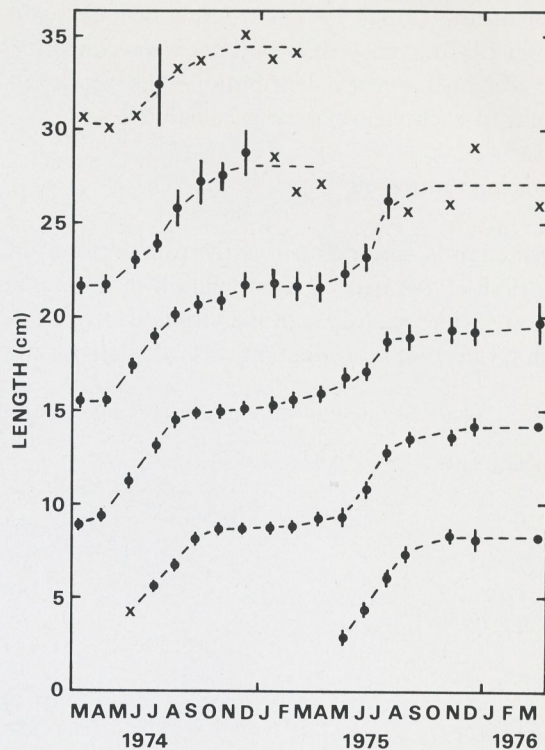


Fig. 1. Growth in length of each year class of Granslev å trout. ● = Mean length for samples of five or more fish, 95% confidence limits are indicated by vertical lines, × = means only for smaller samples.

the growing seasons in different years were compared by an analysis of variance (Table 3). Significant differences ($p < 0.001$ and $0.025 > p > 0.01$) were found between the mean lengths of age groups 0, I and II, respectively, indicating that for all age groups growth was slower in the 1975–76 growing season than in 1974–75.

Biomass

The biomass divided into the contributions made by each year class present is shown in Figure 3. The largest total biomass in both 1974–75 and 1975–76 occurred in July and was 35.4 and 16.9 $g m^{-2}$, respectively. The lowest total biomass occurred between March and early May and ranged from 9.5 to 19.2 $g m^{-2}$. Changes in the percentage contributions made by year classes of the same age during 1974–75 and 1975–76, were similar. However, total

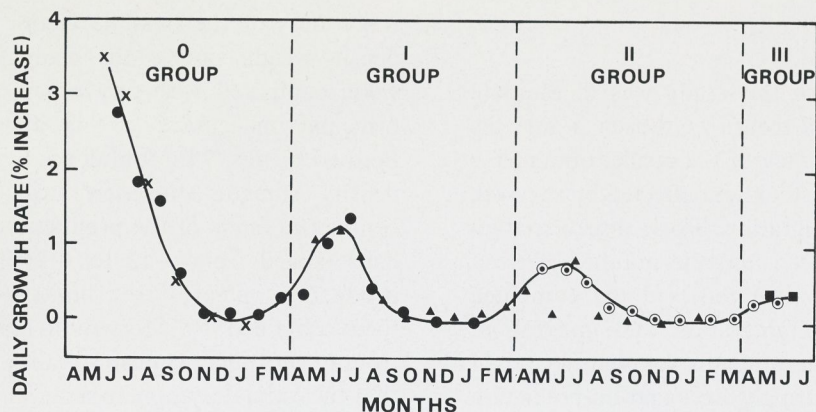


Fig. 2. Seasonal variation in the instantaneous growth rate of 0, I, II and III groups of Granslev å trout. \times = 1975 year class, \bullet = 1974 year class, \blacktriangle = 1973 year class, \odot = 1972 year class and \blacksquare = 1971 year class.

Table 3. Comparison between the late March – early April mean length of trout in different years.

| Age group | Year | Number of trout in sample | Mean length (cm) | 95% confidence limits | Significant difference between means? |
|-----------|---------|---------------------------|------------------|-----------------------|---------------------------------------|
| 0 | 1973–74 | 100 | 8.62 | 0.22 | |
| | 1974–75 | 96 | 8.95 | 0.18 | Yes |
| | 1975–76 | 30 | 8.02 | 0.46 | $p < 0.001$ |
| I | 1973–74 | 103 | 15.14 | 0.30 | |
| | 1974–75 | 75 | 15.63 | 0.39 | Yes |
| | 1975–76 | 36 | 13.92 | 0.53 | $p < 0.001$ |
| II | 1973–74 | 52 | 21.22 | 0.55 | |
| | 1974–75 | 25 | 21.19 | 0.78 | Yes |
| | 1975–76 | 11 | 19.43 | 1.13 | $0.01 < p < 0.025$ |

biomass changed substantially during the study period, because of lower density and slower growth of trout during 1975–76. This change was reflected in the mean annual biomass (\bar{B}) (Table 4). During 1975–76 the mean annual biomass of each year class and that of the whole stock were about two-thirds of those in 1974–75. In both growing seasons the biomass of a year class increased with age and peaked in the third year of life. Afterwards the biomass of year classes decreased until they disappeared during their fifth year of life.

Production

The annual production of all year classes was 25.7 g m^{-2} in 1974–75 and only 12.6 g m^{-2} in 1975–76.

76 (Table 4). The age II group accounted for about 46 and 38% of the total annual production in 1974–75 and 1975–76, respectively. In both seasons this was the greatest contribution made by a single year class. Age groups I and III, respectively, were next in rank and these three age groups combined accounted for approximately 95% of the total annual production. The highest production rate for all age groups occurred during spring and summer, at the time when growth rate was highest. The range of values for annual production varied between -11.5 and $+20.5\%$ of the mean annual production. The turnover ratio (P/\bar{B}) for the whole population was 1.1 in 1974–75 and 0.8 in 1975–76 and was for all age groups, except the 0 group, higher in 1974–75 than in 1975–76.

Discussion

The main purpose of this study was to estimate annual production of trout in Granslev å, and the question of the accuracy of the results obtained is pertinent. The trout stock was affected by survival, immigration and emigration. These three variables could not be separated and the number of trout present at any one time reflected the combined effect of survival, immigration and emigration. Therefore, the point estimates for density-weight were connected by straight lines and no prediction of the true density-weight curve was made for estimates of production. Sampling error associated with growth estimates was quite small, but size selective emigration and immigration may have occurred and lead to errors in determining mean weights. This source of error apparently only caused minor shifts in growth, as all year classes showed the regular annual growth cycle commonly found among trout in streams in temperate regions (Allen 1951, Horton 1961, Mortensen 1977a, 1978).

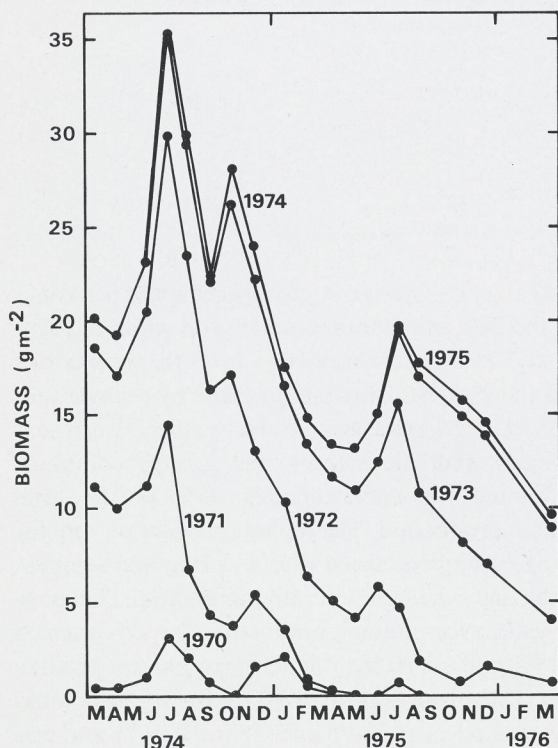


Fig. 3. Seasonal variation in biomass of Granslev å trout divided into the contributions made by each year class.

Regardless of the possible errors in growth and density-weight curves the estimates for density were, compared with any other component, the principal inaccuracy of production estimates. Because of this, 95% confidence limits of the stock density estimates were used in calculating the 95% confidence limits of the production estimates. The later ranged from -12 to +21% of the annual production values. These limits were wider than those obtained by Mortensen (1977a, 1978) for trout in very small Danish streams, but considering that the estimates apply to a larger stream it seems unlikely that they could be reasonably further refined. The average density and biomass of eel in the Granslev å was about 0.05 m^{-2} and 1 g m^{-2} , respectively during the whole study period. Judging from these figures the production of eel most likely has been about $0.5 \text{ g m}^{-2} \text{ yr}^{-1}$. Adding this figure to the estimated production of trout gives the total annual fish production in the Granslev å.

The trout stock in the specific study site showed unstable age structure. Similar instability was reported for brown trout in tributary streams of the upper River Wye, Wales (Milner et al. 1978, 1979). Unstable trout stocks may largely be maintained by immigration. This immigration may be related to the downstream migration from nursery areas to areas where adult growth takes place between 6 months of age and age of maturation observed by Solomon & Templeton (1976). The extent of immigration may vary considerably between stocks and streams. Allen (1951) found almost no migration of brown trout between specific sampling sites in the Horokivi Stream, whereas in this study and in other streams considerable immigrations have been observed (Horton 1961, Mills 1969, Milner et al. 1978, 1979). However, immigration evidently is an important recruitment process in downstream reaches of streams and migration may provide a mechanism to optimise utilization of the total stream habitat, with trout taking up positions appropriate to their size and territorial requirement.

Production is the basic variable in population dynamics linking density, growth rate and survival rate. The environmental factors regulating production act by changing density of fish present and their weight, which is regulated by recruitment,

Table 4. The mean annual production (P) of trout with minimum and maximum values in parentheses, mean annual biomass (\bar{B}) and turnover ratios (P/ \bar{B}) during 1974–75 and 1975–76. +, less than 0.1 g m⁻².

| Age group | 1974–75 | | | 1975–76 | | |
|-------------|------------------------|--------------------------------|--------------|------------------------|--------------------------------|--------------|
| | P (g m ⁻²) | \bar{B} (g m ⁻²) | P/ \bar{B} | P (g m ⁻²) | \bar{B} (g m ⁻²) | P/ \bar{B} |
| 0 | 0.9 (0.0–1.1) | 0.8 | 1.1 | 0.6 (0.6–0.7) | 0.4 | 1.3 |
| I | 6.9 (6.2–7.9) | 6.0 | 1.1 | 4.4 (3.9–5.3) | 4.3 | 1.0 |
| II | 11.7 (11.4–12.7) | 10.0 | 1.2 | 4.9 (4.4–5.9) | 7.0 | 0.7 |
| III | 5.6 (5.6–6.2) | 4.9 | 1.1 | 2.7 (2.7–3.1) | 2.9 | 0.9 |
| IV | 0.6 (0.6–0.6) | 1.1 | 0.5 | + | 0.1 | |
| Whole stock | 25.7 (24.7–28.5) | 22.8 | 1.1 | 12.6 (11.7–15.0) | 14.7 | 0.8 |

survival and migration and by growth, respectively. Therefore, it may be helpful to compare trout production in different years in the same stream and in different streams and relate differences between them to factors in the environment. Total annual production was estimated at 25.7 g m⁻² in 1974–75 and 12.6 g m⁻² in 1975–76 and these values are high compared with most other published figures on salmonid production. Chapman (1978) after reviewing several fish production studies, summarized that salmonids in most cold water streams produced up to 18 g m⁻² yr⁻¹, with notable exceptions being 30 g m⁻² yr⁻¹ from Big Spring, Pennsylvania (Cooper & Scherer 1967) and 54.7 g m⁻² yr⁻¹ from the Horokiwi stream (Allen 1951). The latter value may be an overestimate because early mortality could not be adequately handled (Chapman 1967), but a value less than 38 g m⁻² yr⁻¹ would seem unlikely (Le Cren 1969). Le Cren (1969) postulated a maximum stream salmonid production of 12 g m⁻² yr⁻¹. Later Le Cren (1972) discussed the significance of a maximum production of between 12 and 18 g m⁻² yr⁻¹ and considered the possibility that the maximum was more apparent than real. The annual production of 25.7 g m⁻² estimated in this study and the total annual salmonid production from 22.2 to 33.1 g m⁻² in Brandstrup bæk (site 1 and 2) and 27.1

g m⁻² in Mausing Møllebæk (Mortensen 1977 b, 1978) are higher than the postulated maximum. Egglshaw & Shackley (1977) in Shelligan Burn and Milner et al. (1978) in the tributary Duhonw of the River Wye, also found higher annual values, 16.3–25.0 g m⁻² and 21.5–25.4 g m⁻², respectively. Therefore there seems to be no reason why salmonid production in streams should be limited to a maximum of about 18 g m⁻² yr⁻¹ and it may be concluded that many Danish streams exceed this rate of production.

The estimated annual production differed widely, from 25.7 to 12.6 g m⁻², in the two years of study. This difference was caused by lower density and slower growth during the 1975–76 growing season. However, it is probably relevant that temperature and streamflow also differed greatly in the two years, with the summer of 1976 being particularly hot and dry, and that growth showed no evidence of density-dependence. Whether the observed differences in growth rates of the trout in the Granslev å can be explained by greater deviations from an optimal growth temperature in 1975–76 than in 1974–75 is uncertain; but Elliott (1975) showed a pronounced decrease in growth with deviation from the optimal growth temperature of about 13°C for brown trout on maximum rations. Further, Edwards et al. (1979) used the growth model of

Elliott (1975) and compared actual and calculated maximum growth rates for brown trout in streams of contrasting character and location in the United Kingdom and largely explained the observed growth rates in the streams by their ambient temperature regime. In general they suggested that growth rates for wild brown trout are between 60 and 90% of the maximum for the simultaneous temperature regime. The production of trout in the Granslev å can vary somewhat from year to year, because of the unstable age structure, but investigations similar to that of Edwards et al. (1979), together with observations on other environmental factors, may be useful for understanding the complex of factors influencing growth and production. Such studies are going on in another Danish stream.

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Sample article for:

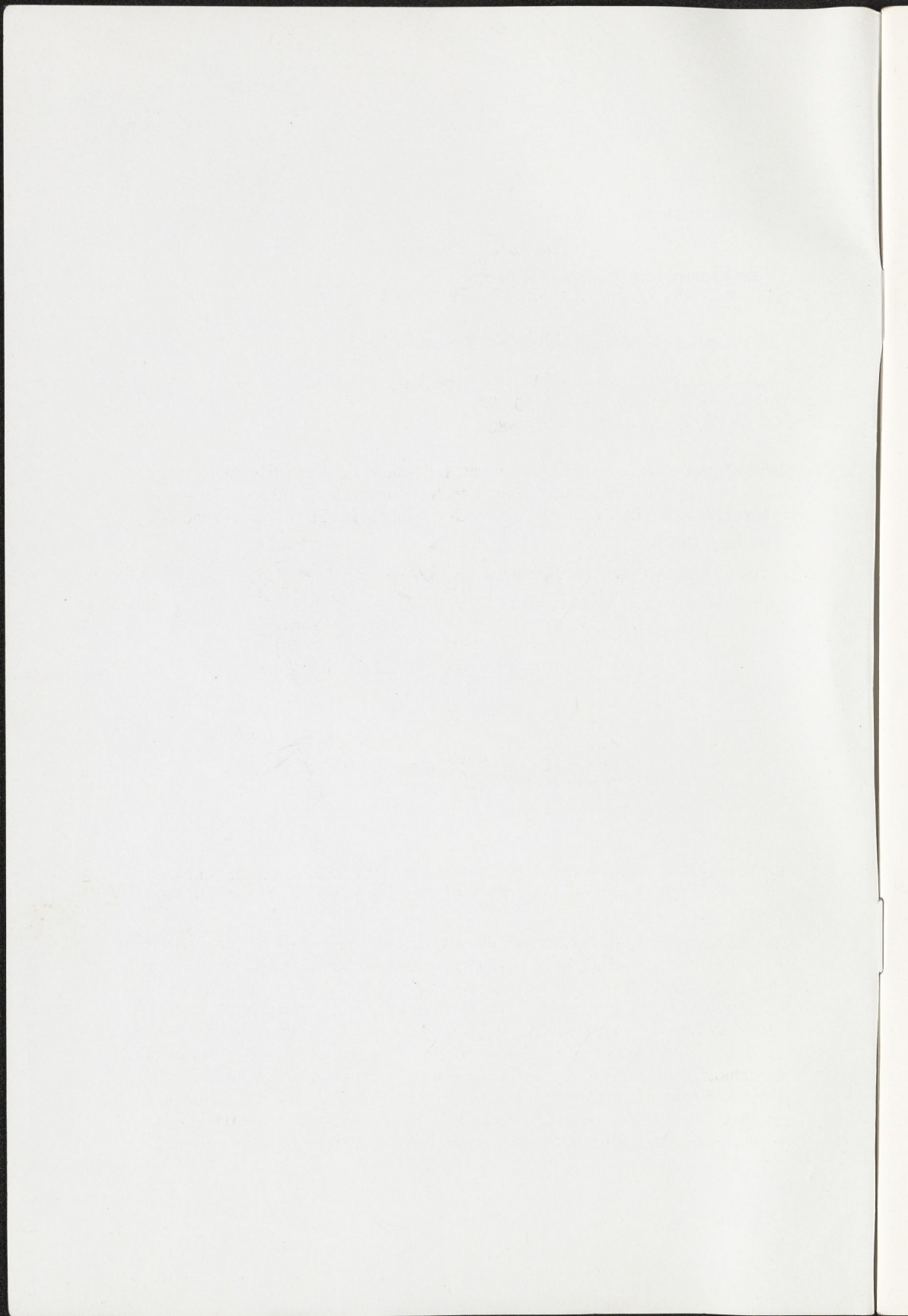
The Freshwater Fishes of Europe

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Contents

Hucho hucho

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Hucho Günther, 1866

E = huchen, F = huchon, G = Huchen, R = taimen

Juraj Holčík

Hucho (subg.) Günther, 1866, VI:125 (type *Salmo hucho*)*Epitomynis* (subg.) Schulze, 1890:174*Hucho* Jordan and Snyder, 1902:580

Typical salmonine fishes. The tooth crest is developed only on the anterior part of vomer, and together with palatine teeth, it forms a continuous transverse ridge. The vomer is short with no teeth on its shaft (Fig. 1). Basibranchials

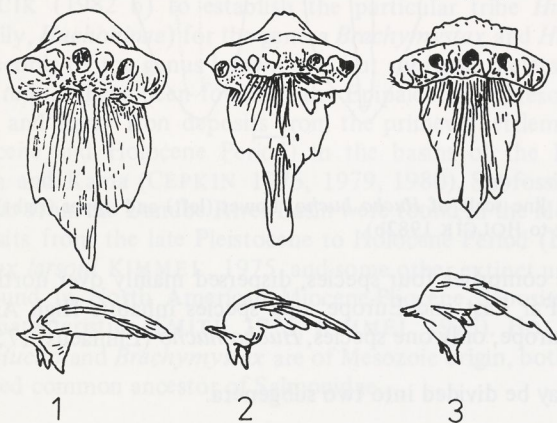


Fig. 1: Vomer of *Hucho hucho* (1 - *H. h. hucho*, 2 - *H. h. taimen*) and that of *Hucho perryi* (3). Ventral (top) and lateral (bottom) view (according to SHAPOSHNIKOVA 1968). L d

mostly without teeth. Postorbitals average no more than 45 % of the distance between the posterior edge of the orbit and preoperculum. The distance from tip of mouth to posterior end of maxilla usually more than 45 % of the head length. Skull wide, with relatively short supraethmoid possessing lateral processes. Head laterally flattened. The hinge of the upper jaw with skull behind the vertical of the posterior edge of orbit. Number of vertebrae: 56-72, number of branchiostegals: 9-14. Body cylindrical, elongated and covered with 100-200 transverse rows of small scales. Number of pored scales in lateral line less than the number of transverse scales. Lateral line scales markedly modified in comparison with the normal ones: they appear only as ossified tubes, broadly open

on their inner side, with no apparent circuli and with little anterior or posterior overlap with scales in front and behind. In shape and structure they are similar to small ellipsoidal bony plates (Fig. 2). Adipose fin large, its base is usually longer than half of the base of the anal fin. The spots, appear on the flanks and back of the body and cheeks are only black and usually circular; but frequently also semilunar or X-shaped. Number of chromosomes ($2n$): 82-84. Piscivorous fishes of medium and large size. Early spawners.

/ 6

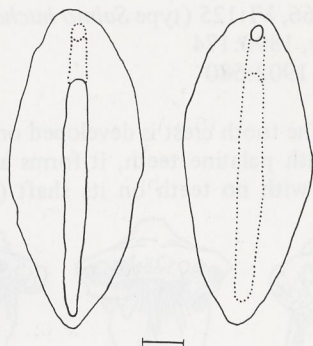


Fig. 2: Lateral line scale of *Hucho hucho*. Lower (left) and upper (right) view. Schematized according to HOLČÍK 1982b).

The genus comprises four species, dispersed mainly over northeastern Asia, part of the Far East and Europe; one species inhabits High Asia (Himalayean region). In Europe, only one species, *Hucho hucho* (Linnaeus, 1758), occurs.

The genus may be divided into two subgenera:

a) subgenus *Hucho* (*sensu stricto*)

Basibranchial plate without teeth, lingual plate with teeth only at its edge, external part of frontalia without process above sphenoticum, hypethmoideum absent, about 70 vertebrae, number of scales markedly higher than the number of pores in the lateral line. Three freshwater species: *Hucho hucho* (Linnaeus, 1758), *Hucho ishikawai* Mori, 1928 and *Hucho bleekeri* Kimura, 1934.

b) subgenus *Parahucho* Vladykov et Gruchy, 1972

Basibranchial plate toothed, lingual plate with median row of small teeth, external edge of frontalia forms a projection above sphenoticum, hypethmoideum present, number of vertebrae about 60, number of pored scales slightly higher or equal to the number of scale rows. Only one species, *Hucho perryi* (BREVOORT, 1856), which is diadromous (BERG 1948, NORDEN 1961,

LINDBERG and LEGEZA 1965, SHAPOSTNIKOVA 1967, 1968, 1975, HOLČÍK 1982 a, b, HOLČÍK *et al.* 1981, VLADYKOV 1963, VLADYKOV and GRUCHY 1972).

Formerly, the huchens were included in the genus *Salmo* or *Salvelinus*. GÜNTHER (1866), however, pointed out the differences between the huchens, trouts, salmons and charrs and established the subgenus *Hucho*. JORDAN and SNYDER (1902) first used this as the generic name (for *H. perryi*). NORDEN (1961) hypothesized an intermediate position for *Hucho* between *Salmo* and *Brachymystax*. The most recent investigations dealing with morphology, osteology, protein specificity, DNA homology, chromosomal characteristics, ecology and geographic distribution, as well as the finding of natural hybrids between *H. hucho taimen* and *Brachymystax lenok* (SHAPOSHNIKOVA 1967, 1968, NYMAN 1967, BEHNKE 1968, DOROFEEVA 1977, TUTUROV and OMELCHENKO 1976, SÊ *et al.* 1959), CAVENDER 1980, RÁB and LIEHMAN 1982, HOLČÍK 1982 a, b), clearly show that *Hucho* is intermediate between *Brachymystax* and *Salvelinus* but closer to the former. This kinship has led HOLČÍK (1982 b) to establish the particular tribe *Huchonini* (or even a subfamily, *Huchoninae*) for the genera *Brachymystax* and *Hucho*.

No fossil records of the genus known yet, but subfossil skeletal remains of *Hucho hucho taimen* have been found in the Epipaleolithic (Mesolithic), Neolithic, Bronze and Early Iron deposits from the primeval settlements of man (early Pleistocene and Holocene Period) in the basins of the Rivers Lena, Aldan, Angara and Kama (CEPKIN 1976, 1979, 1980). Subfossil remains of *H. hucho hucho* from the Danube River Basin were found in the Mesolithic and Neolithic deposits from the late Pleistocene to Holocene Period (LEPIKSAAR 1973). *Paleolox larsoni* KIMMEL, 1975, and some other extinct unidentifiable salmonines found in North American Miocene-Pliocene deposits bear some huchen-like characteristics (SMITH 1975, KIMMEL 1975). HOLČÍK 1982a) suggests that *Hucho* and *Brachymystax* are of Mesozoic origin, both being close to the presumed common ancestor of Salmonidae.

Hucho hucho (Linnaeus, 1758)

E = common huchen, F = huchon, G = Huchen, R = obyknovennyi taimen, taimen, dunaiskii losos

Juraj Holčík

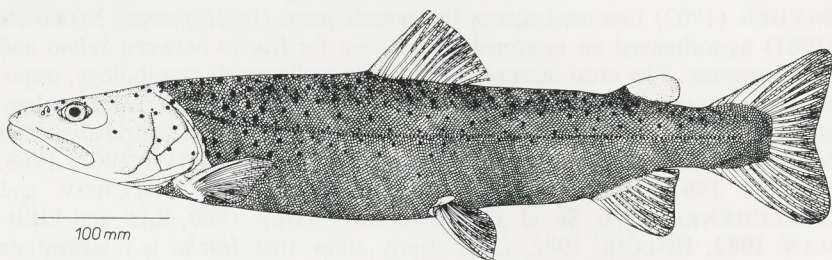


Fig. 3: *Hucho hucho* (Linnaeus, 1759) Danube (river km 1749), 14.V. 1967. Orig. by Miriam Baradlai.

Synonyms

- Salmo hucho* Linnaeus, 1758:309 (Danube River at Vienna)
Salmo taimen Pallas, 1773:216, 716 (Tura River, Siberian rivers emptying into the Arctic Ocean)
Salmo Schiefermülleri Bloch, 1782:157
Salmo fluviatilis Pallas, [1814]:359
Salmo (Salvelinus) lossos Günther, 1866:140
Salvelinus (Hucho) taimen Berg, 1909:40
Hucho hucho Berg, 1916:69
Hucho taimen Berg, 1916:70
Salvelinus hucho Spillmann, 1961:61
Hucho hucho Holčík, 1982a:5

Holotype

Holotype not designated and therefore specimens coming from the Danube R. should be considered as typical. The lectotype of *Hucho hucho taimen* (labeled as *Salmo fluviatilis* Pall. Var. *S. Taimen* Pall.) is preserved in Zoologisches Museum der Humboldt-Universität zu Berlin under No. 23561 (SVETOVIDOV 1978).

Ethymology

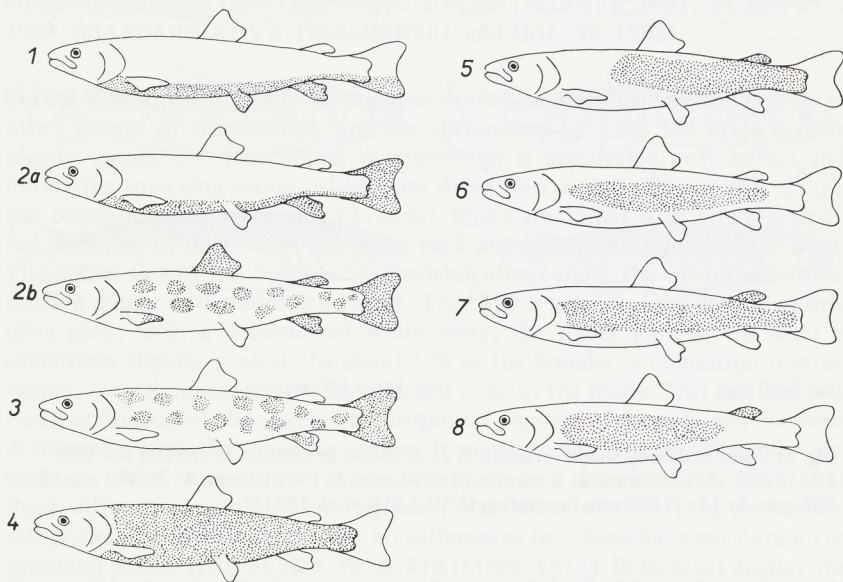
Name *hucho* is derived from **der Huchen**, the German vernacular name of this species.

Description

D III-V 8-14, A III-V 7-11, $\varnothing\varnothing$ 107 $\frac{25-38}{25-39}$ 194, Squ. 131-245, Sp.br. 9-19 (including rudimentary gill rakers), PC 150-284, BR 9-16, Vert. 60-72.

Large species attaining 2100 mm Fl in length and 105 kg. From *Hucho perryi* (BREVOORT, 1856), that inhabits the rivers and coast of Sakhalin, the eastern slopes of the Sikhote Alin Mountains and water bodies on the islands of Hokkaido, Honshu and Kunashir in the Far East, it differs by possessing more scale rows, lateral line scales and vertebrae; a toothless basibranchial plate; and no median rows of small teeth on the lingual plate. *Hucho bleekeri* Kimura, 1934, which lives in some left tributaries of the Yangtze River, has fewer rays in dorsal fin and is significantly smaller, reaching 720 mm Tl and 4 kg. (Kuo 1981). *Hucho ishikawai* Mori, 1928, from the Yalu River in Korea seems to be conspecific with *H. hucho* (HOLČÍK 1982a). The two latter species, however, are poorly known.

Morphology: Body elongated, low (its max. depth 10.5-23.7 % of Fl), with a more or less laterally flattened head (its depth 40.4-67.4 % of head length).



4e
 Fig. 4: Distribution of the red pigment in *H. h. taimen* (1 - Amur, 2a, 2b - Lena, 3 - Baikal Lake, Angara), 4 - rivers of the Ural Mountains) and in *H. h. hucho* (5 - Pielach, 6 - Vah, 7 - Orava, 8 - Turie) (from various sources compiled by GRICENKO (1-4) and HOLČÍK (5-8); according to HOLČÍK *et al.* 1981).

Adipose fin long and robust, its length 46.1–93.0 % of the anal fin base length. Mouth large, length of upper jaw 25.3–56.0 % of head length, length of lower jaw 48.2–74.6 % of head length. Coloration varies from greyish-green to dark brown with greenish tinge on the anterior part of back and on top of head. Belly whitish. Most parts of body sides, back and, in ssp. *taimen*, also the belly is either entirely red or the red pigment is arranged in the form of large red spots. Anal and caudal fins brownish or red. Distribution of red pigment differs in particular populations, and it is the main characteristic for distinguishing the subspecies (Fig. 4). During the spawning season, the coloration is brighter. Paired fins yellowish with brownish or reddish edge, adipose fin golden-brownish or reddish, sometimes with black spots. Dorsal and caudal fins, with dark spots or bands. Head, back and body sides with small black or brownish spots of different shapes: elliptic, circular or irregularly oval on head, semilunar and X-shaped on sides. Similar spots on the dorsal and caudal fins. Juvenile specimens silvery-greyish, dark on dorsum and lighter on sides and belly with 7–12 dark transverse bands or "parr marks" (Fig. 5) (BERG 1948, HOLČÍK 1982a, b, HOLČÍK *et al.* 1981, HENSEL and HOLČÍK 1983).

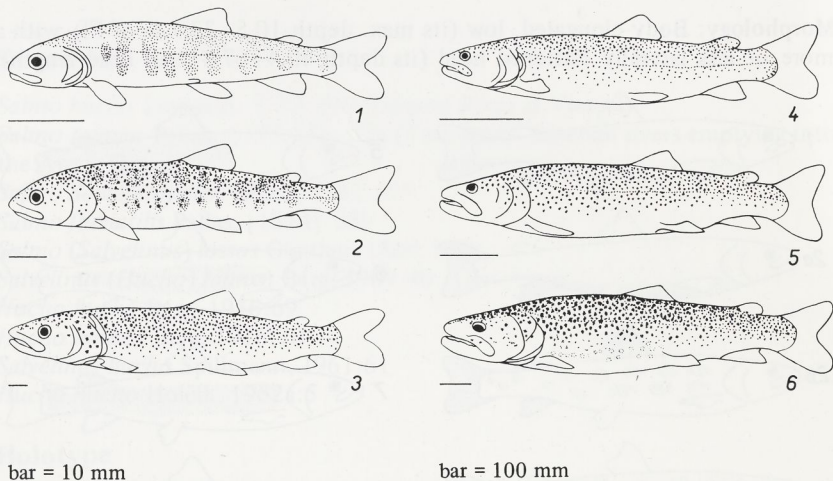


Fig. 5: Color and body shape variation in *H. h. hucho* in relation to age and size (SI). 1: 6 weeks (0+), 40 mm, 2: 6 months (0+) 90 mm, 3: 1+, 210 mm, 4: 2+ 402 mm, 5: 5+, 602 mm, 6: 11+, 1210 mm (according to HOLČÍK *et al.* 1981).

Karyotype: $2n = 82-84$ (13 pairs of metacentric, 2–3 pairs of submetacentric, 6 pairs of subtelocentric and 19–20 pairs of acrocentric chromosomes), $NF = 102-126$ (DOROFEEVA 1977, SOFRADŽIJA 1979, RÁB and LIEHMAN 1982).

Protein specificity: According to NYMAN (1967), the serum protein and the liver esterase patterns of *Hucho hucho* and *Salvelinus namaycush* do not show any pronounced similarity. The serum esterases of these species were indistinguishable when the buffer system of ASHTON and BRADEN was used at pH 8. When, however, other buffer systems were used, the *Hucho* esterase zone differed from all other *Salvelinus* species and their artificial hybrids by its slightly slower speed of migration at pH values above 4.0.

Osteological characteristics: The skull is wide and low, its width being 45.3–50.5 % of its length, measured within the outer edge of pterotica, and its maximum height measured at the supraoccipital, 30.6–34.6 % of the length from the vomer to the end of the basioccipital. Supraethmoid frayed into many processes. Caudal part of this bone is wedged between frontal bones. Vomer relatively short, having a single row of teeth near its rostral edge (Fig. 1), and no teeth on its shaft. Teeth also form a continuous band across the palatine bones and vomer. Posterior edge of ossa maxillaria behind the posterior edge of orbit in adult specimens. Jaws relatively thick with strong conical teeth; small teeth deeply embedded in the skin. Teeth, always arranged in two marginal rows, are also present on the lingual plate. There are three pairs of uroneural bones in the caudal fin (including the caudal plate), two epural bones (occasionally three) and 7 hypural bones (NORDEN 1961, VLADYKOV 1963, SHAPOSHNIKOVA 1968, HENSEL and HOLČÍK 1983).

Sexual dimorphism: There is no pronounced sexual dimorphism known in other genera of Salmoninae, and the differences between the sexes involve mainly coloration. This sexual dichromatism is manifested only before and during the spawning season, which lasts about four months. During this period, the coloration in both sexes is brighter. Males are darker with bright copper-red, dark red or dark violet sides and back and blue-green on top of the head. The paired fins of the males are yellowish without spots; the caudal and dorsal fins are darker with undulated bands. The belly is greyish. Females are mostly olive green with a pronounced white belly; the lower part of the sides is sometimes slightly pinkish. In about 1 % of the females, a coloration reversal occurs, i. e., they display the same bright color as the males. This can lead to a visual confusion of the sexes. The urogenital papillae of females may be more developed during the spawning season. It may become red, star-like and wide, while in males, it is narrow and has the form of a slot (IVAŠKA 1951), but these differences usually do not appear (HOLČÍK *et al.* 1981). In the eastern subspecies, the *taimen*, there are no differences in coloration even during the spawning season (NIKOLSKY 1956, KIRILLOV 1972). Both sexes display the same color, which is, however, more pronounced during spawning. Nuptial coloration, i. e. more red on the belly, caudal and anal fins, may appear in this subspecies long before the actual spawning season and may persist long afterwards (MISHARIN and SHUTILO 1971, KIRILLOV 1972). In contrast to

other salmonines, the males of both subspecies of huchen do not develop the hook-like curvature of the lower jaw (kype) typical for the genera *Salmo* and *Salvelinus*, nor does a deformation of the visceral skeleton occur, as in the genus *Oncorhynchus*. The presence of a kype is mentioned by SCHINDLER (1953) and by LADIGES and VOGT (1966), but this is evidently a mistake. There is however, a significant dimorphism involving the skin, which is much thicker and rougher in the male than in the female during the breeding season. Obviously, this is due to the greater abundance of mucous cells in females than in males, which was reported for several salmonines by various authors (STOK-LOSOWA 1966, 1970, PICKERING 1977). This observation seems to be generally valid for all egg-burrying species of Salmoninae (NOAKES 1980). However, the skin structure of the huchen is not known in detail. PAPPENHEIM (1909) mentioned nuptial tubercles in the vicinity of the anal fin in both sexes; however, this observation was not confirmed by any other author (HOLČÍK *et al.* 1981).

Variations: Little is known about the variability of counts and measurements of the huchen within individual river systems because few specimens were thoroughly examined. However, according to data gathered by HENSEL and HOLČÍK (1983) on both subspecies of the common huchen within their entire distribution area, little variation in counts and measurements was recorded (Tables 1 and 2). It is true that real differences between individual populations may exist, but no regular clinal trend in particular characteristics was found. Moreover, some of the differences are evidently exaggerated due to the kind of material investigated or the methods of measuring. This is especially true for the scale formulae of this species. For example, BERG (1948) reported too few scales above and below the lateral line in the nominate form (18–20 and 20–24, respectively), and for this reason, his data were excluded from the diagnosis. BOHL (1982) described a peculiar gas bladder shape in huchens from some Bavarian streams. The organ was markedly curved in its cranial part and bent downward. According to HENSEL (pers. comm.) the huchens from Slovakia and Mongolia also display the same pattern of the gas bladder, in contrast to all other salmonids investigated by him (*S. trutta m. fario*, *Salvelinus fontinalis*, *Brachymystax lenok*, *Thymallus thymallus*). Some color variations among particular populations were observed and described, and, some of them are illustrated in Figure 4.

Age and size variability: KULMATYCKI (1931a) found that the number of all scales along the lateral line of the huchen increases with age, while the number of pored scales seems to be constant. According to SHAPOSHNIKOVA (1968), the number of teeth on the jaw and palatine bones changes as the fish grows. This change is especially noticeable on the upper jaw, and the number remains constant only after the fish has attained about 300 mm of FL. In adult specimens, the upper jaw reaches the rear edge of the eye, but in the young ones, it is shorter. The number of parr marks decreases with age and size, averaging 9.7 in two-month-old young and only 8.8 in the one-year-olds (calculated accord-

Table 1: Counts and measurements of *Hucho hucho* from individual European rivers

| subspecies | <i>Hucho hucho hucho</i> | | | | | | | | | | | | <i>Hucho hucho taimen</i> | | | | | |
|-------------------|--|--------------|---------------|-------------|--------------|-----------------------|-------------|--------------------|---------------|------|--------|---------|---------------------------|----------------|---------------|------|--------|---------|
| river | Slovakian rivers (Váh, Orava, Turiec) | | | | | Danube n=2 | Tisa n=? | Czeremosz | | | | | Danube river basin/n=? | Vishera | | | | |
| | n | \bar{x} | $s_{\bar{x}}$ | s | ranges | ranges | n | \bar{x} | $s_{\bar{x}}$ | s | ranges | ranges | n | \bar{x} | $s_{\bar{x}}$ | s | ranges | |
| Du | 23 | 10.65 | 0.17 | 0.83 | 9-12 | 11-11 | 9-11 | - | - | - | - | - | 8-11 | 64 | 11.28 | 0.09 | 0.69 | 8-13 |
| AW | 23 | 9.26 | 0.09 | 0.45 | 9-10 | 9-9 | 8-9 | - | - | - | - | - | 7-9 | 59 | 9.29 | 0.06 | 0.49 | 8-10 |
| Pu | - | - | - | - | - | - | 14-17 | - | - | - | - | - | 16-16 | 48 | 13.25 | 0.09 | 0.66 | 12-15 |
| Vu | - | - | - | - | - | - | 8-9 | - | - | - | - | - | 8-9 | 47 | 8.4 | 0.08 | 0.52 | 7-9 |
| ℓ.ℓ. | - | - | - | - | - | 152-156 | - | 23 | 132.83 | 1.83 | 6.63 | 115-145 | - | 51 | 160.90 | 3.33 | 23.90 | 130-210 |
| Squ. | 19 | 185.16 | 1.34 | 5.84 | 175-194 | - | 207-233 | 23 | 253.90 | 5.12 | 25.30 | 172-302 | 180-200 | - | - | - | - | - |
| ℓ.ℓ. ₁ | 20 | 31.85 | 0.55 | 2.46 | 28-34 | 32-32 | 30-34 | 23 | 34.35 | 0.55 | 2.27 | 29-38 | 18-20 | - | - | - | - | - |
| ℓ.ℓ. ₂ | 20 | 29.20 | 0.52 | 2.31 | 25-33 | 26-28 | 25-33 | 23 | 29.48 | 0.63 | 3.01 | 24-35 | 20-24 | - | - | - | - | - |
| Sp.br. | 23 | <u>11.91</u> | <u>0.22</u> | <u>1.04</u> | <u>10-14</u> | 15-15 | 17-19 | 26 | 13.08 | 0.24 | 1.21 | 11-16 | 10-18 | 59 | 11.58 | 0.16 | 1.12 | 9-15 |
| | | 14.12 | 0.19 | 0.92 | 10-19 | | | | | | | | | | | | | |
| BR | - | - | - | - | - | V | - | - | - | - | - | - | 10-11 | - | - | - | - | - |
| PC | - | - | - | - | - | - | - | - | - | - | - | - | 200-200 | 35 | 237.10 | 3.96 | 23.40 | 190-284 |
| Vert. | - | - | - | - | - | - | 66 | - | - | - | - | - | - | 29 | 65.48 | 0.36 | 1.90 | 60-69 |
| author | HENSEL and PIVNIČKA (1980) | | | | | BALON VLADYKOV (1968) | (1931) | KULMATYCKI (1931)a | | | | | BERG (1948) | BUKIREV (1967) | | | | |
| | | | | | | BLAHÁK (1972) | | | | | | | | | | | | |

Note: Squ. in the Czeremosz R. includes also ℓ.ℓ.; Sp.br. in Slovakian rivers gives the non-rudimental gill rakers in numerator and all rakers in denominator

Hucho hucho

Table 2: Measurements of *Hucho hucho* from individual European rivers

| subspecies | <i>Hucho hucho hucho</i> | | | | | | | | |
|----------------------------------|--------------------------|--|---------------|-----------------------------------|------------------|-----------------|-----------------|----------------------------|-----------|
| | river | Slovakian rivers (Váh, Orava, Turiec) | | | | Danube (n=2) | Tisa (n=18) | Viseul, Rus- cova (n=4) | |
| | n | \bar{x} | $s_{\bar{x}}$ | s | ranges | ranges | ranges | ranges | |
| H 26,7 H 128,2 H 29,0 H 135,1 | Sl (mm) | 23 | 528.48 | 12.67 12.82 | 12.82 | 290-797 | 517-556 | - | - |
| | Fl (mm) | 23 | 575.52 | 2.90 13.91 | 13.91 | 315-866 | 548-607 | 450-900 | 575-710 |
| | in % of Fl: | | | | | | | | |
| | lc | 23 | 24.21 | 0.15 | 0.69 | 23.2-25.8 | 23.7-24.7 | 22.7-24.9 | 22.8-24.3 |
| | pD | 23 | 46.57 | 0.21 | 0.98 | 44.9-48.1 | 44.6-46.3 | - | - |
| | pV | 23 | 56.25 | 0.26 | 1.26 | 53.5-58.3 | 53.4-55.6 | - | - |
| | pA | 23 | 73.17 | 0.90 | 4.32 | 54.8-77.2 | 70.5-77.1 | - | - |
| | poD | 23 | 34.73 | 0.18 | 0.86 | 33.0-36.8 | - | - | - |
| | H | 23 | 17.16 | 0.35 | 1.67 | 14.1-20.6 | 17.2-23.7 | 15.1-18.5 | 17.6-20.1 |
| | lpc | 23 | 11.92 | 0.13 | 0.63 | 10.2-12.9 | 9.4-12.0 | 19.1-22.8 | 18.4-11.4 |
| | h | 23 | 7.10 | 0.06 | 0.31 | 6.5-7.6 | 6.6-7.2 | 6.1-6.8 | 6.3-7.3 |
| | P-V | 23 | 34.30 | 0.32 | 1.56 | 30.7-37.0 | 33.6-34.1 | - | 34.5-35.4 |
| | V-A | 23 | 19.01 | 0.16 | 0.76 | 17.4-20.4 | 19.0-20.0 | - | 20.4-20.7 |
| | A-C | 23 | 6.63 | 0.11 | 0.54 | 5.1-7.6 | - | - | - |
| | ad-C | 20 | 6.39 | 0.11 | 0.47 | 5.1-7.0 | - | - | - |
| | ID | 23 | 10.83 | 0.19 | 0.93 | 8.6-12.8 | 11.5-11.8 | 10.3-11.1 | 10.7-11.5 |
| | IA | 23 | 8.16 | 0.08 | 0.37 | 7.3-8.8 | 7.5-8.4 | 7.3-8.2 | 7.9-8.6 |
| | IC ₁ | 23 | 13.67 | 0.20 | 0.95 | 12.1-16.4 | 10.9-13.4 | - | - |
| | IC ₂ | 23 | 7.92 | 0.13 | 0.64 | 6.6-9.3 | - | - | - |
| | IC ₃ | - | - | - | - | 10.2-14.3 | - | - | - |
| | IP | 23 | 12.57 | 0.13 | 0.62 | 11.5-13.9 | 11.7-12.7 | - | 11.5-12.8 |
| | IV | 23 | 10.40 | 0.08 | 0.45 | 9.8-11.1 | 9.5-10.2 | - | 8.9-10.0 |
| | hD | 23 | 8.58 | 0.17 | 0.81 | 7.6-10.7 | 9.5-11.0 | 9.9-11.7 | 10.3-11.0 |
| | hA | 23 | 10.35 | 0.12 | 0.57 | 9.4-11.5 | 9.5-11.4 | 10.0-11.1 | 11.1-12.3 |
| | in % of lc: | | | | | | | | |
| | prO | 23 | 28.83 | 0.21 | 1.02 | 26.3-30.5 | 27.0-30.4 | 25.2-32.4 | 26.2-28.2 |
| | Oh | 23 | 12.24 | 0.26 | 1.25 | 9.4-14.9 | 11.8-13.8 | 12.1-16.4 | 12.6-12.9 |
| | poO | 23 | 60.27 | 0.38 | 1.81 | 55.9-63.4 | 62.9-63.9 | - | - |
| | hc | 23 | 53.75 | 0.57 | 2.72 | 49.3-58.8 | 56.8-57.9 | - | - |
| | pop | 23 | 78.37 | 0.29 | 1.41 | 69.6-88.0 | - | - | - |
| | io | 23 | 28.43 | 0.28 | 1.32 | 25.7-31.0 | 31.1-39.6 | - | - |
| | lmx | 22 | 39.31 | 0.35 | 1.64 | 34.4-44.4 | - | 34.8-39.8 | 37.9-41.2 |
| | hmx | 23 | 10.80 | 0.20 | 0.96 | 8.6-14.5 | - | - | 9.0-10.6 |
| | lmd | 23 | 62.17 | 0.53 | 2.53 | 52.9-73.9 | - | 54.3-62.9 | 59.4-63.5 |
| author | | HENSEL and PIVNIČKA (1980) | | | | BALON (1968) | VLADYKOV (1931) | FRANK (1971) | |
| | | | | | | BLAHÁK (1972) | | | |

note: data from Viseul and Ruscova rivers (Tisa R. basin) calculated from Frank's figures in centimeters

ing to the data of BASTL and KIRKA 1959). Fishes 15 to 18 months old still have about 50 % of the parr marks (IVAŠKA 1951), and some of them may be seen in two and even four-year-olds (MISHARIN and SHUTILO 1971). Statistically, the number of normally developed gill rakers in the nominate form shows a significant positive correlation with the size of fish ($y = 10.008 + 0.003$

11 mm

| subspecies | <i>Hucho hucho taimen</i> | | | | |
|-----------------|---------------------------|-----------|---------------|--------|-----------|
| river | Vishera | | | | |
| | n | \bar{x} | $s_{\bar{x}}$ | s | ranges |
| SI (mm) | — | — | — | — | — |
| Fl (mm) | 64 | 515.63 | 18.24 | 146.00 | 262–1080 |
| in % of Fl: | | | | | |
| lc | 64 | 21.92 | 0.13 | 1.03 | 18.6–24.4 |
| pD | 64 | 44.25 | 0.23 | 1.91 | 39.0–49.6 |
| pV | 64 | 54.37 | 0.49 | 3.92 | 48.0–69.2 |
| pA | 64 | 73.61 | 0.38 | 3.05 | 67.0–80.0 |
| poD | 64 | 37.80 | 0.22 | 1.73 | 33.0–41.1 |
| H | 64 | 16.33 | 0.22 | 1.74 | 12.2–21.2 |
| lpc | 64 | 13.11 | 0.13 | 1.08 | 9.5–14.5 |
| h | 64 | 6.17 | 0.09 | 0.70 | 4.9–8.9 |
| P–V | 64 | 32.97 | 0.31 | 2.51 | 27.3–42.2 |
| V–A | 64 | 19.19 | 0.14 | 1.09 | 16.6–22.0 |
| A–C | — | — | — | — | — |
| ad–C | — | — | — | — | — |
| ID | 64 | 10.52 | 0.09 | 0.74 | 9.1–12.8 |
| IA | 64 | 7.22 | 0.09 | 0.69 | 5.8–9.9 |
| IC ₁ | 40 | 11.95 | 0.17 | 1.09 | 9.5–15.8 |
| IC ₂ | 40 | 5.38 | 0.13 | 0.81 | 3.5–7.3 |
| IC ₃ | 40 | 11.51 | 0.25 | 1.60 | 5.6–13.3 |
| IP | — | — | — | — | — |
| IV | — | — | — | — | — |
| hD | 64 | 10.94 | 0.14 | 1.08 | 8.9–13.5 |
| hA | 64 | 10.55 | 0.13 | 1.04 | 7.0–13.7 |
| in % of lc: | | | | | |
| prO | 64 | 27.20 | 0.39 | 3.09 | 22.1–41.8 |
| Oh | 64 | 13.80 | 0.23 | 1.81 | 10.0–20.4 |
| poO | 64 | 60.11 | 0.41 | 3.32 | 49.0–67.5 |
| hc | 64 | 54.41 | 0.54 | 4.32 | 45.5–69.6 |
| pop | — | — | — | — | — |
| io | — | — | — | — | — |
| lmx | 64 | 37.98 | 0.25 | 1.98 | 31.2–43.7 |
| hmx | 64 | 10.42 | 0.11 | 0.85 | 7.4–12.2 |
| lmd | 64 | 59.16 | 0.35 | 2.78 | 48.0–64.0 |
| author | BUKIREV (1967) | | | | |

Fl, $r = 0.434$, $P < 0.05$, d.f.21), but in *H. hucho taimen* (from Mongolia), it seems to be constant ($y = 10.920 - 0.0005 \text{ Fl}$, $r = -0.089$, $P > 0.05$, d.f. 69), as shown by HENSEL and HOLČÍK (1983). BASTL and KIRKA (1959) studied the variation of some measurements in 25–150 mm (SI) huchens and found that the absolute values for all of them (body depth and width, predorsal distance, prefrontal distance, preanal distance, head length and depth, upper jaw length, diameter of eye, depth of D, depth of A and caudal peduncle length)

increase with the size of the fish. Some of them did not show a linear regression, but breaks were detected, indicating a change of rate with increasing size of the fish (head length, body depth, caudal peduncle depth, depth of D and A, diameter of eye). The change of body shape and coloration is shown in Figure 5.

Subspecies

HENSEL and HOLČÍK (1983) gathered all available information on *H. hucho* and *H. taimen* and found that both taxa must be considered one species, the name of which, according to the Priority Law, is *Hucho hucho* (Linnaeus, 1758). The only differences between them is the coloration and geographic distribution. These are sufficient to allow them the subspecific status. The nominate form, *Hucho hucho hucho* (Linnaeus, 1758), lives in Europe, while *H. hucho taimen* (Pallas, 1773) is the eastern subspecies, mainly confined to northeastern Asia. A key for distinguishing them follows:

A. Caudal and anal fin usually red; the belly and a lower part of caudal peduncle raspberry red or orange. In some populations, the red pigment forms large red spots. Upper Volga and Pechora Basins (in Europe).

..... *Hucho hucho taimen* (Pallas, 1773)

B. Caudal and anal fins brownish, sides red, belly whitish (very rarely with a few large red spots). Danube River System.

..... *Hucho hucho hucho* (Linnaeus, 1758)

Although there is some variation in color among different populations of both subspecies (Fig. 4), the two main features described in the key are valid.

Hybrids

Se et al. (1959) reported the case of hybridization between *H. hucho taimen* and *Brachymystax lenok*. The diagnosis of one specimen 485 mm in TL caught in the Amur R. is as follows: D II 10, A III 9, $\ell.\ell.$ 123, Sp.br. 21 or 22. According to latter two counts this hybrid is probably the product of crossing between the female of *B. lenok* and male of *H. hucho taimen*. No other interspecific hybrids of *H. hucho* are known.

Distribution

The hucho is an Eurasian species with a disjunctive distribution (Fig. 6).

In Europe, it occurs in the Danube, Volga and Pechora River Systems. However, it does not inhabit all tributaries in these systems. In the Danube



Fig. 6: Geographical distribution of *H. hucho*. 1 – *H. h. hucho*, 2 – *H. h. taimen* (its European and part of Siberian area). Dots mean introductions of *H. h. hucho*.

LN
 Basin, this species inhabits only the foot-hill rivers flowing from the Alps, Dinarian₁ Mountain, Carpathians and some of those in the Bohemian-German Highlands and the Böhmer and Weinsberger Forests. It does not occur in water bodies of the Pannonian and Wallachian Lowlands. The statements of KOLLER (1907) and IVAŠKA (1951) that this species inhabits the left tributaries of the Danube and the rivers flowing from the limestone mountains exclusively is therefore not true. In the Volga and Pechora Systems, the huchen inhabits the foot-hill rivers along the western slopes of the Ural Mountains and the Northern Dale (Severnye Uvaly). Thus, there is a wide gap between the ranges of the two geographic races of the common huchen, formed by the extensive Podolye and East European Lowlands. In Asia, the common huchen is distributed in rivers from the eastern slopes of the Ural Mountains eastward through the river systems. It is also found in lakes on the Middle Siberian Plateau and the Verkhojanskiy Khrebet in the North, in the rivers draining the Altai Mountains, Sayany, Khangai, Khentai, Yablonovyi Khrebet and Khingan in the South, and as far as the rivers rising in the Dzhugdzhur Khrebet, Stanovoy Khrebet and Sikhote Alin Mountains to the East. It does not occur in water bodies in the West Siberian or North Siberian Lowlands or on the Yamal, Gydanskiy and Taymyr Peninsulas.

The rivers inhabited by the common huchen are located in the Atlantic (Black Sea), Caspian, Arctic (Barents, Kara and Laptev Sea) and Pacific (Sea of Okhotsk) Watersheds. They belong to the following river systems: the Danube (Black Sea), Volga (Caspian Sea), Pechora (Barents Sea), Ob, Yenisei, Pyasina (Kara Sea), Khatanga, Anadyr, Olenek, Lena, Omoloi, Yana (Laptev Sea), Uda, Tungur and Amur (Sea of Okhotsk).

According to zoogeographical classification, the common huchen occurs in the Holarctic (Palearctic) and Sino-Indian* regions. The Danube huchen (*H. h. hucho*) is limited exclusively to the North Ponto-Caspian district of the Ponto-Caspian Province of the Euro-Mediterranean Subregion of the Holarctic. The taimen (*H. h. taimen*) is spread throughout the Circumpolar and Baikal Subregions of the Holarctic Region, as well as the East-Asian Subregion of the Sino-Indian Region*, according to the classification of Banarescu (1960).

The distribution of the common huchen has been recently determined by HENSEL (1980), who critically evaluated all available data. A summary of his comprehensive paper (completed with data of HARSÁNYI, 1982) is given below with emphasis on the main river systems.

Distribution of *Hucho hucho hucho* (Fig. 7): This subspecies is endemic to the Danube River System. In the Danube itself, it inhabits only those sections in which conditions are similar to those in the mountain or foot-hill rivers. Thus, it occurs in the upper Danube as far as the section from Štúrovo to Budapest, and also at the end of the middle Danube near the Cataracts (Iron

* Assuming that *Hucho ishikawai* Mori, 1928, which inhabits the Yalu River (Korea), is conspecific with *H. hucho taimen* (HOLČÍK 1982a, HOLČÍK *et al.* 1981)

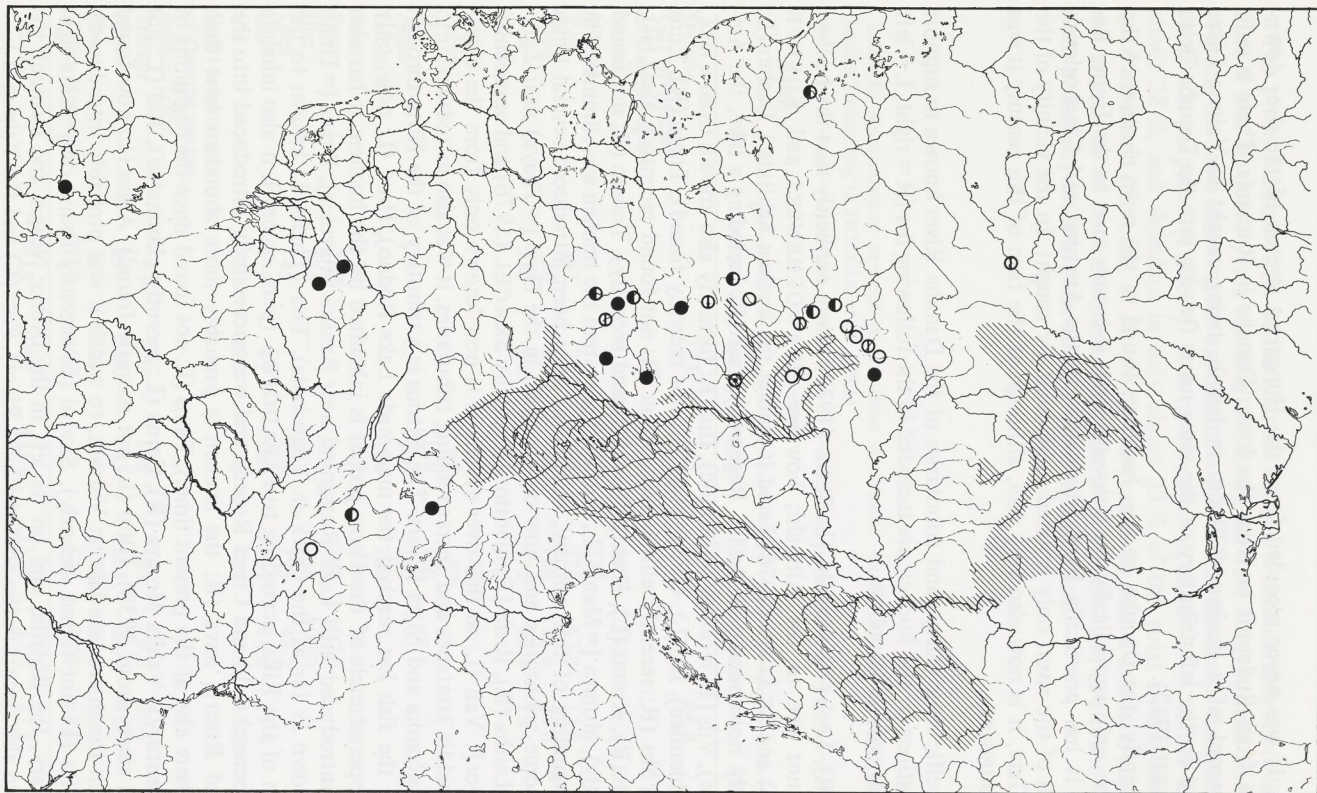


Fig. 7: Original area of distribution and introductions of *H. h. hucho* in Europe. ○ – successful introductions (established populations regardless of the eventual later disappearing), ● – failed introductions, ● – reproduction not observed but fish still occur, ⊕ – result of introduction unknown, ⊖ – successful reintroduction.

Gate). It was never recorded from the Hungarian stretch of the river downstream from Budapest or from the lower Danube in Rumania. There is only one record of a huchen, 330 mm in length, being caught in Yalpug Lake, located on the left tributary of the same name flowing into the Danube Delta (IENTSH 1912).

Recently, the Danube huchen has been found in the main channel of the Danube only sporadically. In Schwabenland, it is very rare; in the Upper Bavaria, it has practically been eliminated. In the Austrian and Czechoslovak stretch of the river, only isolated individuals are caught. In the vicinity of the Iron Gate, it is now also very rare, although at the turn of this century it was still abundant.

Specific river valleys and tributaries of the Danube River known to support populations of the huchen are included in the following list (R = right, L = left tributary of the Danube):

Iller (R), Lech (R) Altmühl [L; SEEZ (1939) wrote explicitly that the huchen does not live in the Altmühl; however, PRAWOCHENSKI and KOLDER (1968) and SKÁCEL (1976) listed it among the huchen habitats.] Laaber (L; recently not found), Naab (L), Regen (L), Isar (R; including a lake, the Ammersee), Vils (L; recently not found), Inn (R; formerly also known from a lake, the Chiemsee), Ilz (L), Grosse Mühl (L; not recently found), Traun (R), Enns (R), Ybbs (R; recently eliminated), Erlau (R; not found recently), Melk (R), Pielach (R), Krems (L), Kramp (L; not found recently), Traisen (R; not found recently), Morava [= March, L; in this river system the huchen was eliminated at the beginning of this century, but it has since been introduced several times into some tributaries and now occurs again in the Dyje (= Thaya) near Znojmo], Leitha (R), Raab [R; mentioned only by SKÁCEL (1976) and apparently an error], Váh (L; in this river system it is now known only from the upper and middle stretches and corresponding tributaries, it was also introduced into the Rajčianka and Nitra Rivers. The Nitrica is a tributary of the Nitra through which the fish has reached the man-made Lake Rudno), Hron (L; now, only the upper stretch of the Hron proper is inhabited by the huchen; it has also been introduced into Lake Rosgrund near Banská Štiavnica), Dráva (= Drau; R; known as far as the Osjek in Yugoslavia), Tisa [Theiss, L; known to the mouth of the Rika; according to PAPADOPOLO (pers. comm.), it also inhabits the Somesul Cald and Crisul Repede and was successfully introduced into the Hornád River], Sava (R; the huchen is probably more abundant here than anywhere else at the present time.), Timis (L; not found since the beginning of this century), Velika Morava (R), Cerna (L; recently eliminated), Jiul (L; not found since about 1930), Oltul (L; not recently found), Arges (L; now found only in the man-made lake at Vidraru, to which it was probably introduced), Ialomita (L; not found recently), Siretul (L; recently found only in its right tributary, the Bistrita, and on its left in the Doma, Neagra and Barnaul; the huchen also occurs in the artificial Lake Bicaz), Prut (L) and the Yalpug (L).

The present distribution of the Danube huchen is considerably more limited than it was 30 or 40 years ago (Fig. 8). Based on data from various literature sources, the table showing the approximate recent distribution of the nominate form was prepared (Table 3). It is now extinct in about 39 %, rather rare in about 28 %, and abundant in only about 33 % of the total stream length it once inhabited (HOLČÍK *et al.* 1981). The reason for such a dramatic change is the alteration of the environment by human activities, such as stream regulation, pollution, deforestation and improper management.

Table 3: Approximate present distribution of *Hucho hucho hucho* in particular river basins (according to HOLČÍK *et al.* 1981)

| Basin | kilometres | | | | % | | |
|---|-------------|-------------|-------------|--------------|-------------|-------------|-------------|
| | common | rare | disappears | total | common | rare | disappears |
| Danube | — | 333 | 625 | 958 | — | 34.8 | 65.2 |
| Left tributaries of Danube up to | | | | | | | |
| Morava r. | — | — | 350 | 350 | — | — | 100.0 |
| Morava | — | — | 275 | 275 | — | — | 100.0 |
| Váh | 363 | 75 | 138 | 576 | 63.0 | 13.0 | 24.0 |
| Hron | 50 | 50 | 88 | 188 | 26.6 | 26.6 | 46.8 |
| Tisa | 313 | 63 | 95 | 471 | 66.4 | 13.4 | 20.2 |
| Mures | — | — | 295 | 295 | — | — | 100.0 |
| Timis | — | — | 50 | 50 | — | — | 100.0 |
| Cerna | — | — | 50 | 50 | — | — | 100.0 |
| Olt | — | — | 150 | 150 | — | — | 100.0 |
| Arges | — | — | 300 | 300 | — | — | 100.0 |
| Ialomita | — | — | 100 | 100 | — | — | 100.0 |
| Siret | 170 | 400 | 38 | 608 | 28.0 | 65.8 | 6.2 |
| Prut | 288 | — | — | 288 | 100.0 | — | — |
| Iller | 125 | — | — | 125 | 100.0 | — | — |
| Lech | 145 | — | 150 | 295 | 49.2 | — | 50.8 |
| Isar | 175 | 43 | 143 | 361 | 48.8 | 11.9 | 39.6 |
| Inn | 203 | 195 | 53 | 451 | 45.0 | 43.2 | 11.8 |
| Right tributaries of Danube within stretch Traun- | | | | | | | |
| Traisen | 53 | 120 | 395 | 568 | 9.3 | 21.1 | 69.5 |
| Drava | 350 | 588 | 283 | 1221 | 28.7 | 48.9 | 23.2 |
| Sava | 1320 | 825 | 775 | 2920 | 45.2 | 28.3 | 26.5 |
| Velika Morava | 163 | 363 | — | 526 | 31.0 | 69.0 | — |
| Total | 3718 | 3055 | 4353 | 11126 | 32.3 | 27.5 | 40.2 |

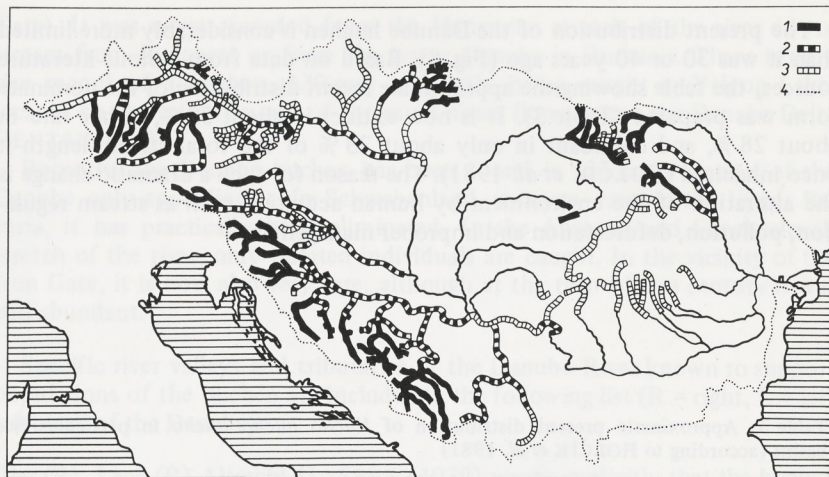


Fig. 8: Changes in the distribution of *H. h. hucho* in its original area of distribution. 1 – constant occurrence, 2 – occasional findings, 3 – species disappeared, 4 – boundary of the Danube river basin (according to HOLČIK *et al.* 1981).

Distribution of *Hucho hucho taimen* (Fig. 9): In Europe, the taimen inhabits only the Volga and Pechora River Systems. It does not occur in the basin of the Severnaya Dvina, although the Severnaya Kel'tma River, a left tributary of the Vychehga in this system, is connected to the Yuzhnaya Kel'tma, a right tributary of the Kama River in the Volga Basin, through extensive marshes. SHAPOSHNIKOVA (1964) challenged the report of NAVOZOV (1912) that the taimen occurs in the Malyi Ik River of the Ural River System.

In the Volga River Valley, the taimen inhabits only the drainage area of the Kama River, which is a left tributary of the Volga. Formerly, it also descended on rare occasions into the middle Volga as far as Tetyushi or even Stavropol. However, the recent formation of the Kuybyshevskoie (an artificial lake) has changed the conditions, and the occurrence of the taimen has not since been reported. The taimen is abundant mainly in the upper reaches of the Kama River before its confluence with the Chusovaya River. It also rarely occurs near Perm and Sarapul', and isolated individuals were caught even farther downstream. After the formation of the Kama Impoundment, the taimen adapted to that habitat, as well. Most inhabit the tributaries of the Kama River, which include the Veslyana, Lupa, Kosa, Yuzhnaya Kel'tma, Lop'a, Vishera, Velca, Uls, Yaz'zva, Melmysa, Kolchima, Kol'va, Berezovaya, Yayva, Kos'va, Chusovaya, Koyva, Kusa, Syl'va, Barda, Belaya, Ufa, Nyaza, Kukozara, Yazyasha, the Vyatka (upstream from the town of Slobodskoye), Kobra, Pashnyak and Soz Yuzhnyi.

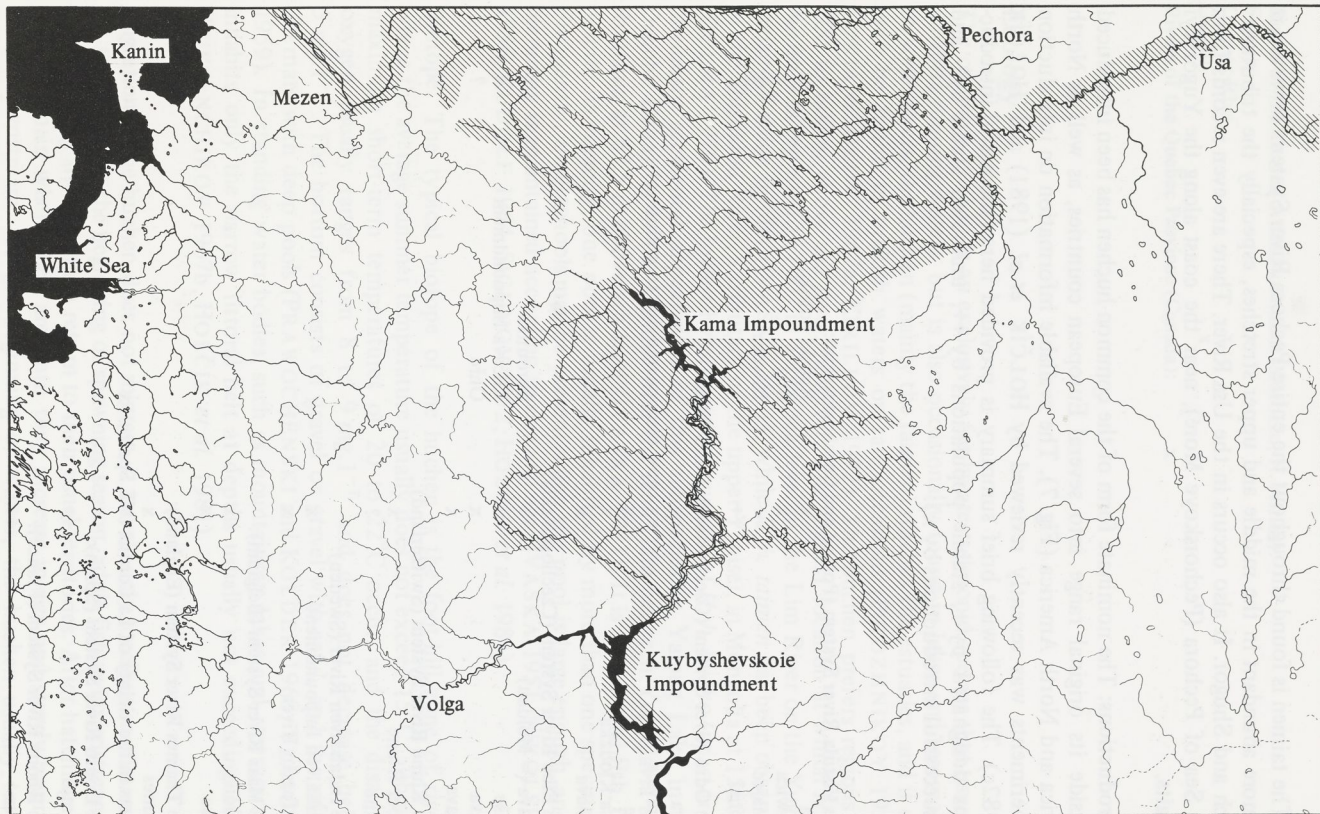


Fig. 9: European and part of Siberian area of *H. h. taimen* distribution.

The taimen is found throughout the entire Pechora River System; however, it is more abundant in the middle and upper stretches, especially the tributaries Ilych and Shugor. It also occurs in the Usa River. There are even records from the Sea of Pechora (Pechorskoye More), near the coast along the Yugorskiy Straits.

Introductions: The nominate form of the common huchen has been introduced outside its original range into several European countries, as well as North Africa and North America (Fig. 7). The available information on introduction experiments was recently reviewed by HOLČÍK *et al.* (1981) and HOLČÍK (1982c). The following brief summary is provided here (successful introductions designated by +, stabile populations by ++, unknown status by ? and unsuccessful introductions by x):

The Vistula River System (Poland and Czechoslovakia):

| | | | |
|---------|----|--------------|---|
| Sola | x | Rabski potok | x |
| Skawica | x | Bug | x |
| Dunajec | ++ | Drweca | x |
| Poprad | ++ | | |

The Odra River System (Czechoslovakia and Poland):

| | | | |
|--------------|---------------------------------------|--|--|
| Odra | x | | |
| Moravice | xx (now disappeared due to pollution) | | |
| Olše | x | | |
| Nysa Klodzka | x | | |
| Sténava | x | | |

The Elbe River System (Czechoslovakia)

| | | | |
|-------------------|---|---------------------|---|
| Vltava (= Moldau) | + | Berounka | x |
| Malše | x | Klíčava Impoundment | x |
| Otava | x | Ohře | ? |
| Sázava | x | | |

The Rhine River System (Switzerland):

| | | | |
|-------------|---|--|--|
| Upper Rhine | x | | |
| Sarine | ? | | |

The Indalsälven River (Sweden):

| | | | |
|-------------------------|---|--|--|
| Indalsälven Impoundment | x | | |
| Rexforsån River | x | | |

The Maas River System (Belgium):

| | | | |
|--------|---|--|--|
| Semois | x | | |
| Lesse | x | | |

The Thames River System (England):

| | | | |
|--------|---|--|--|
| Thames | x | | |
|--------|---|--|--|

Rivers in the vicinity of La Coruna (NE Spain): x

The Douro River System (Spain):

| | | | |
|--------|----|--|--|
| Tormes | ++ | | |
|--------|----|--|--|

The Rhone River System (France):

| | | | |
|-------|----|--|--|
| Usses | ++ | | |
|-------|----|--|--|

Rivers of the Central Atlas Mountains (Morocco, N. Africa):

| | |
|-------------|---|
| Fellate | x |
| Oum-er-Rbia | x |
| Guigou | x |

Rivers of the Quebec Province (Canada): x**Ecology**

The common huchen is an exclusively freshwater salmonid species that usually inhabits running waters, but is also occasionally found in lakes and reservoirs. In some rivers, the huchen (mainly the taimen) reaches the estuaries, and it can even be found in brakish waters on rare occasions (PIROZHNIKOV 1955, LUKIANCHIKOV 1967a, KIRILLOV 1972). The huchen prefers regions of 200 to 600 m above sea level, however. The highest location at which *H. h. hucho* was reported is 1007 m above sea level in the Lim River on the Yugoslavian-Albanian border (IVAŠKA 1951), while *H. h. taimen* has been observed in the Shishkhd River, a tributary of the upper Yenisei, in Mongolia at 1560 m (DULMA 1979). The lowest hypsometric occurrence of *H. h. hucho* (apart from obviously accidental appearances of this subspecies in Yalpug Lake in the Danube Delta), is in the Danube near the Iron Gate between Yugoslavia and Rumania at 67,5 m above sea level (IVAŠKA 1951). It is a territorial fish, but despite its voracity, one pool is usually inhabited by more than one specimen. Frequently, small schools may be present when the pool is large enough, and a hierarchy is maintained according to size and age (IVAŠKA 1951, NIKOLSKY 1956, RUDOLF 1964, SIGUNOV 1972, HOLČÍK *et al.* 1981).

Biotope: The typical biotope of the huchen is the foot-hill zone of rivers, where the average summer temperature usually does not exceed 15°C, although maximum short-term temperatures of 20 to 22°C occur, and the dissolved oxygen usually ranges from 8 to 9 mg.l⁻¹ and does not decrease below 5 mg.l⁻¹. The bottom consists of gravel or gravel with sand, and the riffles alternate with deep pools (PRAWOCHENSKI and KOLDER 1968, VLASOWA 1959). In standing water bodies, such as mountainous lakes and reservoirs, it inhabits only the narrow littoral belt at depths usually not exceeding 10 m (LUKIANCHIKOV 1967b, HOLČÍK *et al.* 1981).

Migrations: The huchen does not migrate, it travels only locally a maximum of 10 to 25 km. At the beginning of spawning season, adult fish swim upstream to the spawning sites and then return to their usual territories. After hatching, the young remain where they are until they increase in size and slowly begin to move downstream. At the beginning of winter, the huchen usually travels

downstream, undertaking what can be classified as a feeding migration. Local downstream or upstream movements are provoked by the changes in temperature and water level, and in salinity in the lower sections of rivers inhabited by taimen (VLADYKOV 1926, IVAŠKA 1951, PRAVDIN 1949, BUKIREV 1967, LUKIANCHIKOV 1967a, LEVANIDOV 1959, PIROZHNIKOV 1955, SIGUNOV 1972, NIKOLSKY 1956, HOLČÍK *et al.* 1981). Lateral movements toward and away from the shore are undertaken mostly in search of food during the day (PIROZHNIKOV 1955, KIRILLOV 1962, 1972). KRAUSS (1933) found that marking may induce short (only 1 to 3 km) downstream (adults) or upstream (young huchens) movements. Adult huchens migrating to their spawning places are able to overcome various obstacles up to 150 cm in height (IVAŠKA 1951).

Hardiness: Huchen eggs are less sensitive to mechanical shakes than those of other salmonid species and therefore their handling and transportation is relatively easy (PEŇÁZ and PŘÍHODA 1981). However, they are sensitive to a lack of oxygen and to water temperatures above 15 °C (PRAWOCHENSKI and KOLDER 1968). Hatched fry withstand temperatures up to 20 °C, but those in aquaria lost their spatial orientation at 16 °C (PRAWOCHENSKI and KOLDER 1968). The huchen is very sensitive to damage during handling in hatcheries or battles in the spawning season, and such external injuries facilitate the penetration of parasitic aquatic moulds (IVAŠKA 1951). The huchen seems to be more resistant against pollution than other salmonids (HOLLY 1934, IVAŠKA 1951, HOLČÍK *et al.* 1981).

Feeding habits: The common huchen is a piscivorous fish as an adult. After its transition to exogeneous nutrition, the food of the young fish consists of invertebrates, mainly larvae and pupae of insects (*Chironomidae*, *Dixinae*, *Ephemeroptera*, *Trichoptera* and also terrestrial insects), crustaceans (*Cladocera*, *Copepoda*, *Amphipoda* and *Decapoda*), worms, and molluscs (PRAVDIN 1949, LEVANIDOV 1951, IVAŠKA 1951, NAGY 1976). Fishes appear in the diet of the huchen very soon, after it reaches 50 to 98 mm in fork length (LEVANIDOV 1951, NAGY 1976). Some authors, however, reported fishes in the stomachs of huchens only after they were 3 to 5 years old (NIKOLSKY 1956, MISHARIN and SHUTILO 1971, KIRILLOV 1972). Young huchens feed mainly on the fry of various cyprinids. In Europe, the fry of *Chondrostoma nasus* is preferred as this species usually spawns in the same places as the huchen. However, the fry of *Chondrostoma nasus* is not indispensable for the young huchen, as once thought (KRAUSS 1933). When the supply of cyprinids is small, the young huchen hunts for other species, such as salmonids (LEVANIDOV 1951, 1959, TEPLOV 1951).

The diet of older and larger huchen is variable, consisting mainly of fishes. The list of fish species found in each subspecies is different (Table 4), but this is due to geographical differences in the available food items and not to specific

Table 4: Review of fish species found in stomachs of *Hucho hucho*. Only full species, i. e. not geographic forms are listed (according to HOLČÍK *et al.* 1981)

| Species | <i>Hucho hucho hucho</i> | <i>Hucho hucho taimen</i> |
|---------------------------------|--------------------------|---------------------------|
| <i>Petromyzontidae</i> | | |
| <i>Lethenteron japonicum</i> | | + |
| <i>Acipenseridae</i> | | |
| <i>Acipenser ruthenus</i> | | + |
| <i>Acipenser baeri</i> | | + |
| <i>Esocidae</i> | | |
| <i>Esox lucius</i> | + | + |
| <i>Esox reicherti</i> | | + |
| <i>Salmonidae</i> | | |
| <i>Oncorhynchus keta</i> | | + |
| <i>Oncorhynchus gorbuschae</i> | | + |
| <i>Salmo salar</i> | | + |
| <i>Salmo trutta m. fario</i> | + | |
| <i>Salvelinus sp.</i> | | + |
| <i>Hucho hucho</i> | + | + |
| <i>Brachymystax lenok</i> | | + |
| <i>Stenodus leucichthys</i> | | + |
| <i>Coregonus sardinella</i> | | + |
| <i>Coregonus tugun</i> | | + |
| <i>Coregonus autumnalis</i> | | + |
| <i>Coregonus ussuriensis</i> | | + |
| <i>Coregonus lavaretus</i> | | + |
| <i>Coregonus muksun</i> | | + |
| <i>Thymallus baicalensis</i> | | + |
| <i>Thymallus thymallus</i> | + | + |
| <i>Cyprinidae</i> | | |
| <i>Rutilus rutilus</i> | + | + |
| <i>Leuciscus leuciscus</i> | + | + |
| <i>Leuciscus cephalus</i> | + | |
| <i>Leuciscus idus</i> | | + |
| <i>Leuciscus souffia</i> | + | |
| <i>Leuciscus waleckii</i> | | + |
| <i>Phoxinus lagowskii</i> | | + |
| <i>Phoxinus phoxinus</i> | + | + |
| <i>Leucaspius delineatus</i> | + | |
| <i>Chondrostoma nasus</i> | + | |
| <i>Chondrostoma polylepis</i> | + | |
| <i>Xenocypris macrolepis</i> | | + |
| <i>Pseudorasbora parva</i> | | + |
| <i>Gobio gobio</i> | + | + |
| <i>Saurogobio sp.</i> | | + |
| <i>Barbus barbus</i> | + | |
| <i>Barbus meridionalis</i> | + | |
| <i>Hemibarbus labeo</i> | | + |
| <i>Alburnoides bipunctatus</i> | + | |
| <i>Vimba vimba</i> | + | |
| <i>Erythroculter mongolicus</i> | | + |
| <i>Hemiculter leucisculus</i> | | + |
| <i>Rhodeus sericeus</i> | | + |

Table 4: continued

| Species | <i>Hucho hucho hucho</i> | <i>Hucho hucho taimen</i> |
|----------------------------------|--------------------------|---------------------------|
| <i>Acanthorodeus macropterus</i> | | + |
| <i>Carassius carassius</i> | | + |
| <i>Carassius auratus</i> | | + |
| <i>Cyprinus carpio</i> | + | |
| Cobitidae | | |
| <i>Noemacheilus barbatulus</i> | + | + |
| <i>Cobitis taenia</i> | | + |
| Bagridae | | |
| <i>Pseudobagrus fulvidraco</i> | | + |
| Anguillidae | | |
| <i>Anguilla anguilla</i> | + | |
| Gadidae | | |
| <i>Lota lota</i> | + | + |
| <i>Perca fluviatilis</i> | | + |
| <i>Gymnocephalus cernuus</i> | | + |
| Gasterosteidae | | |
| <i>Pungitius pungitius</i> | | + |
| <i>Gasterosteus aculeatus</i> | + | + |
| Eleotridae | | |
| <i>Perccottus glehni</i> | | + |
| Cottidae | | |
| <i>Mesocottus haitei</i> | | + |
| <i>Cottus poecilopus</i> | + | + |
| <i>Cottus gobio</i> | + | + |
| <i>Cottus sibiricus</i> | | + |
| <i>Paracottus kessleri</i> | | + |

preferences. There are only few papers dealing with the feeding habits of the Danube huchen. The relative size of the fish eaten by the huchen decreases with its size, being 11 to 40 % in young taimen measuring 50 to 190 mm (F1), and 22 to 34 % in the young Danube huchen with 53 to 351 mm (F1) (LEVANIDOV 1951, NAGY 1976). In adult huchen, the mean sizes of fishes eaten in Slovakian, Polish, Carpathian-Ukrainian and Amur populations was 13 to 45, 15 to 37, 15 to 29 and 10 to 30 %, respectively (NAGY 1976, WITKOWSKI and KOWALEWSKI 1982, SHNAREVISH and MOSHUK 1957, LEVANIDOV 1951). The size of the prey also varies with season. In autumn, the fishes eaten are larger than those taken in summer, winter or spring (LEVANIDOV 1951). The number of fishes eaten depends on their size and the size of the huchen. The index of fullness for young-of-the-year taimen feeding on invertebrates varied from 1 to 2.8 %, while for piscivorous yearlings, it ranged from 2 to 5.5 %. In older fishes, the index of fullness varied from 0.9 to 5.1 %, depending on the season. The highest values (3 to 5 %) were recorded in winter, and the lowest (0.9 %) in summer (LEVANIDOV 1951, WITKOWSKI and KOWALEWSKI 1982). In addition to fish, the adult huchen often prey

upon amphibians, reptiles, birds and even small mammals (HERMAN 1887, SABANEJEV 1911, IVAŠKA 1951, KIRILLOV 1972, MISHARIN and SHUTILO 1971). During periods of overpopulation, some rodents (*Lemmus*, *Eutamias*, *Sciurus*) migrate and frequently provide the only food for the taimen (SIGUNOV 1972). Cannibalism occurs rarely and seems to be induced by a lack of other food (MISHARIN and SHUTILO 1971, PIROZHNIKOV 1975, LEVANIDOV 1951). It is more frequent in captivity (IVAŠKA 1951).

Longevity: The maximum age of *H. h. Hucho* was found to be 20 years (1150 mm SL, 19 kg; KRAUSS 1933), while *H. h. taimen* reached 55 years (1720 mm SL, 56 kg; PODLESNY 1958). However, using the parameters of the von Bertalanffy growth equation derived from the known data on the growth rate and maximum size attained by this species, the potential life span of the huchen may be 60 to 100 years, and that of *taimen*, 100 to 170 years (Table 10).

Growth: The growth in length and weight of the huchen has been recorded in many habitats throughout its range. Growth data for *H. h. hucho* can be found in papers by HAEMPEL (1910), MUNDA (1925), KULMATYCKI (1931c, 1935), KRAUSS (1933), SEEZ (1939) VLASOVA (1959), KIRKA (1963, 1975), BALON (1968), SABIONCELLO *et al.* (1970), HOLČÍK (1970), SVETINA (1970), HAVELKA and VOSTRADOYSKÝ (1974), and SEDLÁR and STRÁŇAI (1975); those for *H. h. taimen* in the works of BORISOV (1928), REVNIVYKH (1939), PRAVDIN (1949), PIROZHNIKOV (1955), NIKOLSKY (1956), PODLESNY (1958), KIRILLOV (1964, 1972, 1976), BUKIREV (1967), LUKIANCHIKOV (1967b), MISHARIN and SHUTILO (1971), CHITRAVADIVELU (1972), OLIFER (1977) and KALASHNIKOV (1978). All growth data were evaluated and discussed by HOLČÍK *et al.* (1981), and only a summary is provided here (Tables 5–7). Growth in length is given as standard length, calculated from the original data in total or fork length, using equations derived from 174 huchen from Slovakia ranging from 42 to 940 mm in SL, ($S L = -4.748 + 0.903 T$; $S L = 0.098 + 0.920 F$). Growth in weight (Table 8) for particular size groups was determined according to the length-weight equation for the Sava and Ljubljana populations (Table 9) of the Danube huchen and from an equation for obtaining a simple average “a” and “b” coefficient for the data on six populations of the taimen ($\log w = -5.19619 + 3.09738 \log S L$, 95 % confidence limits for “b” = 3.04588 and 3.14888; HOLČÍK *et al.* 1981). The ranges for the particular growth rate classes (Table 10) were calculated from all available growth data according to the method suggested by SZCZERBOWSKI (1977). Conclusions which may be drawn from the growth data on the huchen include the following (HOLČÍK *et al.* 1981): the growth in weight of fry at the end of embryonic, during larval and at the beginning of the juvenile stage (SL 20 to 58 mm) is more rapid than that of juveniles (54 to 240 mm SL); females are heavier than males initially but

Table 5: Comparison of the growth rate in length of *H. h. hucho* and *H. h. taimen* (Sl in mm) in the period of first 15 years of life. Data of various authors were combined (according to HOLČÍK *et al.* 1981)

| Age | <i>Hucho hucho hucho</i> | | | | | <i>Hucho hucho taimen</i> | | | | | t - test | C. D. test |
|-----|--------------------------|--------|---------------------|-------|----|---------------------------|--------|---------------------|-------|----|----------|------------|
| | \bar{x} | s | $\frac{s}{\bar{x}}$ | c.v. | n | \bar{x} | s | $\frac{s}{\bar{x}}$ | c.v. | n | | |
| 1 | 193.00 | 78.22 | 20.20 | 40.53 | 15 | 173.25 | 70.43 | 20.33 | 40.65 | 12 | 0.68 | 0.13 |
| 2 | 325.93 | 51.35 | 13.26 | 15.75 | 15 | 259.73 | 61.33 | 15.84 | 23.61 | 15 | 3.21** | 0.59 |
| 3 | 442.53 | 55.40 | 14.30 | 12.52 | 15 | 344.44 | 65.20 | 15.37 | 18.93 | 18 | 4.60*** | 0.81 |
| 4 | 545.07 | 61.44 | 15.86 | 11.27 | 15 | 412.79 | 63.39 | 14.54 | 15.36 | 19 | 6.12*** | 1.06 |
| 5 | 621.69 | 84.17 | 23.24 | 13.54 | 14 | 510.71 | 86.53 | 18.88 | 16.94 | 21 | 3.99*** | 0.65 |
| 6 | 703.20 | 109.20 | 32.93 | 14.33 | 11 | 583.55 | 49.91 | 11.16 | 8.55 | 20 | 4.20*** | 0.75 |
| 7 | 790.78 | 88.67 | 29.56 | 11.21 | 9 | 655.28 | 64.09 | 15.11 | 9.78 | 18 | 4.56*** | 0.89 |
| 8 | 846.71 | 73.77 | 27.88 | 8.71 | 7 | 765.56 | 114.47 | 26.98 | 14.95 | 18 | 1.73 | 0.43 |
| 9 | 892.80 | 79.23 | 35.43 | 8.87 | 5 | 809.50 | 103.33 | 25.83 | 12.76 | 16 | 1.65 | 0.46 |
| 10 | 955.20 | 106.32 | 47.55 | 11.13 | 5 | 844.92 | 126.66 | 35.13 | 14.99 | 13 | 1.72 | 0.47 |
| 11 | 955.67 | 55.43 | 32.00 | 5.80 | 3 | 877.75 | 141.58 | 40.87 | 16.13 | 12 | 0.91 | 0.40 |
| 12 | 975.00 | 71.39 | 41.22 | 7.32 | 3 | 949.11 | 89.29 | 29.76 | 9.41 | 9 | 0.45 | 0.16 |
| 13 | 1009.67 | 60.18 | 34.74 | 5.96 | 3 | 1014.22 | 107.37 | 35.79 | 10.59 | 9 | 0.07 | 0.03 |
| 14 | 1074.50 | 95.46 | 87.50 | 8.88 | 2 | 1022.00 | 109.16 | 48.82 | 10.68 | 5 | 0.59 | 0.26 |
| 15 | 1181.00 | 111.72 | 79.00 | 9.46 | 2 | 1030.20 | 141.12 | 63.11 | 13.70 | 5 | 1.33 | 0.74 |

** = $P < 0.01$, *** = $P < 0.001$

Table 6: Parameters of the *von Bertalanffy* growth formula [$l_t = K_{\infty}(1 - e^{-K(t-t_0)})$] for some populations of *Hucho hucho*. For comparison some Asiatic populations are listed (according to HOLČÍK *et al.* 1981)

| <i>Hucho hucho hucho</i> | | | | <i>Hucho hucho taimen</i> | | | |
|--------------------------|--------------|------|-------|---------------------------|--------------|------|-------|
| River | L_{∞} | K | t_0 | River | L_{∞} | K | t_0 |
| Tormes | 979 | 0.40 | 0.08 | Loz'va | 911 | 0.20 | 0.58 |
| Orava | 771 | 0.35 | 0.54 | Angara | 1044 | 0.16 | 0.50 |
| Hron | 832 | 0.28 | 0.37 | Shishkhid | 999 | 0.14 | 0.50 |
| Drava | 1024 | 0.24 | 0.58 | Vilyui (lower) | 1093 | 0.14 | 1.17 |
| Tisa | 916 | 0.23 | 0.87 | Vilyui (upper) | 1500 | 0.11 | 1.33 |
| Turiec | 1118 | 0.18 | 0.41 | Lena | 2061 | 0.06 | 0.32 |
| Kupa | 1103 | 0.17 | 0.13 | Amur | 3018 | 0.04 | 0.45 |

Table 7: Theoretical maximum age attained by two subspecies of *Hucho hucho* derived from the *von Bertalanffy* growth formula. Age in years, standard length in mm. L_{∞} in the left columns is the maximum hypothetical length derived from available combined growth data (Table 8), that in the right one is the actual maximum length recorded (according to HOLČÍK 1982 a).

| <i>Hucho hucho hucho</i> | | | <i>Hucho hucho taimen</i> | | |
|--------------------------|---|---|---------------------------|---|---|
| Age | $L_{\infty} = 1252$ $K = 0.13$ $t_0 = 0.52$ | $L_{\infty} = 1650$ $K = 0.08$ $t_0 = 0.84$ | Age | $L_{\infty} = 1447$ $K = 0.08$ $t_0 = 0.27$ | $L_{\infty} = 1930$ $K = 0.05$ $t_0 = 0.85$ |
| 1 | 153 | 127 | 1 | 111 | 94 |
| 2 | 286 | 244 | 2 | 214 | 184 |
| 3 | 404 | 352 | 3 | 309 | 269 |
| 4 | 507 | 452 | 4 | 396 | 350 |
| 5 | 598 | 544 | 5 | 477 | 427 |
| 10 | 910 | 909 | 10 | 797 | 759 |
| 20 | 1158 | 1317 | 20 | 1155 | 1220 |
| 30 | 1126 | 1500 | 30 | 1315 | 1499 |
| 50 | 1249 | 1620 | 50 | 1420 | 1772 |
| 60 | 1251 | 1635 | 60 | 1435 | 1834 |
| 80 | — | 1647 | 80 | 1445 | 1895 |
| 100 | — | 1649 | 100 | 1446 | 1917 |
| 102 | — | 1650 | 167 | — | 1930 |

Table 9: Length-weight equations of some populations of *Hucho hucho* (I = before stripping; II = after stripping)

| Locality | Length ranges (mm) | log w = a + b log S1 log w = a + b log T1 log w = a + b log F1 | | n |
|---|-----------------------|--|---------|-------|
| | | a | b | |
| <i>Hucho hucho hucho</i> | | | | |
| Sava & Ljubljana (1) | 390–1180 T1 | –5.47791 | 3.14420 | 527 |
| | 347–1060 S1 | –5.25958 | 3.11972 | |
| Váh, Turiec, Orava (2) | 55–140 S1 | –5.313 | 3.216 | 50 |
| Tisa r. basin (3) | 145–850 F1 | –5.73588 | 3.19889 | ? |
| Czechoslovak rivers (4) | 44–1215 S1 | –4.88035 | 2.99662 | 243 |
| | 54–240 S1 | –4.85148 | 2.98598 | 63 |
| | 289–1018 S1 | ♂♂ –5.463433 | 3.21075 | 52 |
| | 253–955 S1 | ♀♀ –5.698177 | 3.28874 | 26 |
| Kláštor pod Znievom – fish ponds (2) | 25–120 S1 | –4.756 | 2.900 | 606 |
| Podsúcha – fish ponds (12) | 19.9–57.7 S1 | –5.06274 | 3.10455 | ? |
| | 21.7–66.8 S1 | –5.09151 | 3.00618 | ? |
| fish ponds of Slovak Angler's Union (5) | 573–1016 S1 | ♀♀ –4.40946 | 2.86707 | 46 I |
| | 573–1016 S1 | –5.43456 | 3.18580 | 28 II |
| <i>Hucho hucho taimen</i> | | | | |
| Kama (7) | 767–1200 F1 | –5.68910 | 3.23867 | 42 |
| | 706–1103 S1 | –5.58242 | 3.24216 | 42 |

(1) MUNDA (1925) (2) BASTL & KIRKA (1959), (3) VLASOVA (1959), (4) & (6) our data, (5) PANÁZ & PRÍHODA (1981), (7) BUKIREV (1967).

Only data published are those of BASTL & KIRKA (1959), all other were calculated according to information registered by quoted authors

their growth rate is lower, and females are heavier than males of the same length; there are no substantial differences between the weights of *H. h. hucho* and *H. h. taimen* in the same size class; the longitudinal growth rate of the *taimen* is slightly less than that of *H. h. hucho* during the first 10 to 15 years of life, but thereafter it is higher. There are no differences between the growth rates of males and females, except that the coefficient of condition is slightly higher for the latter ($K = 1.35$ in 56 females 300 to 1050 mm in S1; $K = 1.27$ in 26 males 250 to 950 mm in S1; all from Slovakian waters). It may be added that age determinations for recently caught huchens indicate an increase in the growth rate over that calculated two decades earlier in the same water bodies. For instance, one huchen caught in the Váh River on December 30, 1982, that

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was 1070 mm in SL and weighed 19 kg, had lived 12 years. Another huchen that was caught in the Dunajec River on November 9, 1982, was 1054 mm in standard length and weighed 18 kg with an age of only 9 years. Two other huchens taken from the Orava River in December 1981, measuring 1090 and 1180 mm in SL and weighing 15.9 and 18.9 kg, were aged at 10 and 11 years, respectively, remarkably low ages when considering older data for the same rivers reported by KIRKA (1963).

Population dynamics: There are only few data dealing with population dynamics of this species. JUNGWIRTH (1977a) and NIKOLSKY (1956) wrote that the sex ratio is 1 : 1, but SABANEEV (1911) and JAGODITSCH (1930) indicated that males are more abundant. SHNAREVICH and MOSHUK (1956) found the sex ratio in the Czeremosz River to be 7 : 1 in the favour of males. It seems that the preponderance of males at least in the populations of the Danube huchen is due to selective fishing. According to HOLČÍK *et al.* (1981), 66 % of the huchens caught by anglers in Slovakian waters were females. The age composition of some populations of the nominate form is provided in Table 11. Data from the Dobra and Kupa Rivers were obtained by electrofishing and those from the Sava and Ljubljana River are derived from figures published by MURNA (1925) and apply to the huchens taken by anglers between 1900 and 1925. In the Kama River, a large proportion of the commercial taimen catch comprises fishes 3 to 5 years old (BUKIREV 1967). The population density of the huchen in the Turiec River between the years 1926 and 1931 has been estimated by BASTL *et al.* (1976) to have been about 1540 one-to six-years-old fishes weighing 400 kg per km of stream, i. e., about 770 fishes weighing 200 kg per hectare of water surface. According to BASTL *et al.* (1982), the density of huchen in the same river from 1968 to 1981 was very low, and he estimated it to be 0.1 to 5 fishes weighing 0.12 to 6.4 kg per hectare. SHNAREVICH and MOSHUK (1957) estimated the density of huchen in the Czeremosz River to be 2 to 8 specimen per km of river.

Table 11: Age composition (%) of some samples of *H. h. hucho* (According to HOLČÍK *et al.* 1981)

| River | Age class | Age class | | | | | | | | | | | | |
|--------------------|-----------|-----------|-----|------|------|------|------|-----|-----|------|-----|-----|-----|-----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Kupa | (1) | 4.8 | 9.7 | 35.5 | 24.2 | 6.5 | 6.5 | 8.0 | 3.2 | — | 1.6 | | | |
| Dobra | (1) | 4.0 | 4.0 | 30.0 | 8.6 | 16.0 | 18.0 | 4.0 | 4.0 | 10.0 | 2.0 | | | |
| Sava and Ljubljana | (2) | — | — | — | 39.8 | 27.7 | 17.4 | 1.2 | 0.1 | 6.6 | 1.3 | 4.0 | 0.1 | 1.8 |

Derived from data introduced by SABIONCELLO *et al.* (1970) (1) and by MUNDA (1925) (2).

Reproduction biology

Maturity: The first spawning of both subspecies is at an age of roughly three years in males and four years in females, after the male has attained a weight of about 1 kg, the female about 2 kg. As *H. h. taimen* ranges farther to the north, the age for its sexual maturation is generally greater than that of *H. h. hucho*, while the size of both at the first spawning is similar (Table 12).

Table 12: Age (in years), standard length (in mm) and body weight (in kg) of *Hucho hucho* females at the time of first spawning. For comparison also the data for *H. h. taimen* from Asian rivers are stated (except of European river Vishera)

| River | Age | Sl | W | Author |
|---------------------------|-----|---------|-----|----------------------------|
| <i>Hucho hucho hucho</i> | | | | |
| Danube R. basin | 4 | 564 | 1.7 | Siebold 1863, Svetina 1970 |
| Sava R. basin | — | 627 | 3 | Munda 1925, 1926 |
| Ammer | — | — | 1.5 | Seez 1939 |
| Drava | 4 | 627 | 3 | Krauss 1933 |
| Drava | 4 | — | 2 | Vokac 1959 |
| Turiec and Orava rivers | 5 | 582 | 3 | Ivaska 1951 |
| <i>Hucho hucho taimen</i> | | | | |
| Vishera | 7–8 | — | — | Bukirev 1967 |
| Amur | 4–6 | 368–460 | — | Nikolsky 1956 |
| Lena | 7 | 414–644 | 1.5 | Karantonis & al. 1956 |
| Yenisei | 6–8 | 442 | 2.5 | Podlesny 1958 |
| Vilyui | 6 | 552 | 2 | Kirillov 1962 |
| Khatanga | 8–9 | 552–644 | 3 | Lukianchikov 1967 |
| Angara | 7 | 644 | 2 | Misharin & Shutilo 1971 |
| Angara | 6–8 | 552–745 | 2.1 | Olifer 1977 |
| Yakutian rivers | 7 | 598–644 | 1.5 | Kirillov 1972 |
| Anabar | 7–8 | 568–632 | 1.9 | Kirillov 1976 |
| Vitim | 7 | 644 | 3.2 | Kalashnikov 1978 |

Gonads: The weight of the ovaries of the fully ripened females, 573 to 1016 mm in S1 and weighing 3 to 16.3 kg, ranged from 250 to 4010 grams, and the coefficients of maturity were 2.15 to 35.06 %, averaging 15.53 % (HOLČÍK *et al.* 1981). The number of eggs per female, reported by various authors (KULMATYCKI 1931a, KRAUSS 1933, MUNDA 1935, PRAVDIN 1949, IVAŠKA 1951, NIKOLSKY 1956, SHNAREVICH and MOSHUK 1957, KIRILLOV 1962, BUKIREV 1967, MISHARIN and SHUTILO 1971, OLIFER

Table 13: Fecundity parameters of *Hucho hucho hucho* females from Slovakian hatcheries. (according to HOLČIK *et al.* 1981)

| Size class (mm) | S1 | Body weight (kg) | | Absolute fecundity | Relative fecundity | Diameter of egg (mm) | Volume of eggs (ml) | n |
|-----------------|-----------|------------------|----------|--------------------|--------------------|----------------------|---------------------|----|
| | (mm) | 1 | 2 | | 1 | 2 | | |
| 501-600 | 576 | 3.2 | 2.5 | 8517 | 2680 | 4.3 | 388 | 3 |
| | 573-582 | 3.0-3.5 | | 8100-9000 | 2443-3000 | 3.8-4.6 | 335-450 | |
| 601-700 | 652 | 5.0 | 4.0 | 10535 | 2162 | 4.3 | 558 | 12 |
| | 609-700 | 3.5-7.5 | 3.8-4.3 | 7850-14000 | 1160-2642 | 3.8-4.7 | 350-940 | |
| 701-800 | 741 | 6.3 | 4.8 | 10996 | 1849 | 4.6 | 678 | 14 |
| | 709-799 | 4.5-8.8 | 3.6-7.2 | 3580-15000 | 430-2960 | 3.8-6.0 | 450-800 | |
| 801-900 | 861 | 10.1 | 8.5 | 15229 | 1501 | 4.9 | 1175 | 6 |
| | 826-880 | 9.0-10.8 | 7.1-9.8 | 8300-22900 | 869-2130 | 4.8-5.1 | 1600-1950 | |
| 901-1000 | 961 | 14.1 | 11.9 | 15533 | 1162 | 4.9 | 1400 | 8 |
| | 907-989 | 11.8-16.4 | 9.5-14.3 | 9490-22375 | 772-1463 | 4.5-5.4 | | |
| 1001-1100 | 1034 | 18.0 | 14.5 | 23558 | 1311 | 5.0 | 1750 | 3 |
| | 1016-1043 | 16.2-20.8 | | 18600-26700 | 1088-1562 | | | |
| Mean | 780 | 8.4 | 7.7 | 12785 | 1772 | 4.6 | 732 | 46 |
| | 573-1043 | 3.0-20.8 | 2.5-14.3 | 3580-26700 | 430-3000 | 3.8-5.4 | 335-1950 | |

Notes: 1 – weight of fish before stripping, 2 – weight of fish after stripping. Relative fecundity calculated in accordance with 1 and 2 respectively

1977) varies from 1600 to 35000, depending on the size and weight of the fish. Table 13 presents the data for 46 females stripped in Slovakian hatcheries. The absolute fecundity increases with the size and weight of the fish ($F = 16602.8849 + 37.7031 \text{ Sl}$; $F = 3311.0564 + 1.1431 \text{ w}$; F = absolute number of eggs, Sl = standard length in mm, w = weight of female in grams), while the relative fecundity (FR , i. e. number of eggs per kg of live weight) decreases ($\text{FR} = 5622.5557 - 4.9346 \text{ Sl}$; $\text{FR} = 3025.9508 - 0.1487 \text{ w}$).

Spawn: The eggs of the huchen are amber-yellow, orange-red, or sometimes even red. They are slightly sticky, oligoplasmatic and contain a large supply of yolk and a small concentration of plasma. The yolk is liquid, homogeneous and transparent ichthulin without yolk granules but with a large number of oil globules, 10 to 180 μ in diameter, regularly distributed around the surface of the yolk immediately below the vitelline membrane. The egg shells are very tough, and in live eggs, quite transparent. The stickiness of the chorion is very slight, and it disappears after washing (KOROVINA 1978, SOIN 1980, PEŇÁZ and PŘÍHODA 1981, HOLČÍK *et al.* 1981). The diameter of living eggs (before swelling) ranges from 3.6 to 6.0 mm (SVATON 1966, KOROVINA 1978, PEŇÁZ and PŘÍHODA 1981, HOLČÍK *et al.* 1981). It increases with the size and weight of the female ($D = 2.2056 + 0.0031 \text{ Sl}$, $D = 3.8277 + 0.0001 \text{ w}$; D = diameter of eggs in mm) and also with the size of the ovary ($D = 3.6921 + 0.0011 \text{ v}$; volume of ovary in ml^3 ; HOLČÍK *et al.* 1981). The milt of the huchen has the color and consistency of cream. The density of the sperm is about 12 million per mm^3 . The tail of a sperm measures 36.7 μm , and its head is 3.84 μm long and 3.10 μm wide, on the average (HARSÁNYI 1982).

H. conspurcator
cf

Spawning period: The common huchen is an early spawner. Its arrival at the spawning site coincides with the thaw. (PRAVDIN 1949, SIGUNOV 1972, OLIVER 1977, JUNGWIRTH 1977, WU 1979), which may occur in February in the South but as late as July in the North (KULMATYCKI 1931a, b, MUNDA 1935, PIROZHNIKOV 1955, KOMÁREK 1955, NIKOLSKY 1956, VLASOVA 1959, BUKIREV 1967, MISHARIN and SHUTILO 1971, KIRILLOV 1972, OLIVER 1977). The average water temperature in the spawning season varies from 5 to 10 °C, and extremes of 3 and 14 °C occur (NOVÁK 1932, KULMATYCKI 1931b, VLASOVA 1959, MISHARIN and SHUTILO 1971, JUNGWIRTH 1977, OLIFER 1977, HOLČÍK *et al.* 1981, HARSÁNYI 1982). The duration of spawning is usually short, totaling 10 to 14 days (HOLČÍK *et al.* 1981). KULMATYCKI (1931b) and SVATOŇ (1966) reported that spawning lasts only 2 to 3 days, but their information concerned only one mating pair and not the whole population. If weather is unfavourable, the spawning may last as long as three weeks. Eggs are laid by each female in several batches over a period of 2 to 5 days (VLASOVA 1959, HOLČÍK *et al.* 1981).

Spawning sites: Huchen reproduces in mountain brooks and small rivers or in such sections of large rivers with similar temperature and hydrological conditions. Spawning redds are dug into the clear bottom composed of gravel 16 to 70 mm in size. The water depth ranges from 0.2 to 1.2 m, the current velocity from 0.5 to 1.0 m.s⁻¹ (IVAŠKA 1951, PRAVDIN 1949, VOKAČ 1959, BUKIREV 1967, SCHULZE and PIERY 1982). In the Danube river basin the spawning place of the huchen usually coincides with that of *Chondrostoma nasus*. The redd is elliptical, its usual size is 120 to 200 length x 60 width x 10 to 100 cm in depth (ROBIDA 1902, JAGODITSCH 1930, HOLLÝ 1934, IVAŠKA 1951, VOKAČ 1959), but huchens over 7 kg construct larger redds ranging from 2 to 6.5 m in length and 1.5 to 2.4 m wide. After the end of spawning, the rear part of the redds is 5 to 10 cm shallower than the front part (HOLČÍK *et al.* 1981). SCHULZ and PIERY (1982) reported one huchen redd in the Drau River (Austria) to have the following dimensions and characteristics (the authors did not mention the size of mating fish): max. length, 6.5 m; max. width, 2.4 m; area of redd, 13 m²; mean depth, 80 mm; maximum depth, 230 mm; weight of gravel removed, 1.15 metric tons; stream velocity at spawning ground, 5 to 70 cm.s⁻¹. The stream velocity inside the redd was less than 10 cm.s⁻¹, and at its centre near the bottom, the back current was measured at 0 to 5 cm.s⁻¹. The distance between neighbouring redds varies from 10 to 75 m (HOLČÍK *et al.* 1981). LC

Mating habits: At the beginning of spawning season, the huchens start to form schools and migrate to the spawning sites. The first schools are composed of small fishes, while the larger ones, probably females, appear later. The fishes arrive at the spawning sites during a 3 to 7 day period (MISHARIN and SHUTILO 1971, HOLČÍK *et al.* 1981). Then the spawning school begins to disperse into groups of 2 or 3 fishes (usually 1 female and 1 or 2 males). (IVAŠKA 1951, HOLČÍK *et al.* 1981). Surplus males fight lively battles that usually produce severe injuries on the dorsal and caudal fins and sides of the body (SIGUNOV 1972, HOLČÍK *et al.* 1981). Victorious males then join the females, and pairs approach the selected spawning sites. There is no correlation between the sizes of the males and females of each pair. Frequently, males weighing 3.5 to 5 kg mate with females weighing 15 to 20 kg, and vice versa (HOLČÍK *et al.* 1981). The search for a suitable place to spawn may last 2 to 4 days and is performed by the female. She periodically approaches the bottom and examines it by touching the sediment with her extended anal fin and tail. From time to time, the female characteristically opens her mouth wide and gapes (HOLČÍK *et al.* 1981). After a suitable place has been selected the spawning redd is constructed mutually by both sexes, but the female is more active. The digging of the redd lasts several days. The fishes deepen it by strong movements of their tails and caudal fins, as well as with their mouths (IVAŠKA 1951). Not only the surface sediment, sand and rough gravel, but even the stones as large as a man's head are removed (VOKAČ 1959). During

this time, the aggressivity of the female increases, and together with the male, she attacks and drives away other males and fishes of other species that approach the redd. These attacks may produce severe injuries and even cause fatalities (HOLČÍK *et al.* 1981).

Spawning habits: Spawning occurs for short periods during several days, usually nocturnally (IVAŠKA 1951, BUKIREV 1967) but also in the afternoon (HOLČÍK *et al.* 1981). The male tilts his body toward the female, which is bent over the redd. The fins of both are erected; the mouths opened, gaping and quivering violently. The sperm and eggs are released simultaneously. During spawning, the pair slowly moves forward, and the female covers the fertilized eggs with substrate in the redd by a strong trembling of her tail (HOLČÍK *et al.* 1981). Fertilization is external and lasts a short time because the mobility of sperm in water averages only 30 to 45 seconds (WUNDER 1936, PAVLÍK 1957). HARSÁNYI (1982) observed that at 10 °C some sperm may remain active for 120 seconds. During spawning the fishes lose their timidity and may be easily caught (KÖTTL and KAFKA 1927, KULMATYCKI 1931b, IVAŠKA 1951, REŽNÝ 1951). If scared away, they return to the redd after periods lasting as long as 30 minutes (HOLČÍK *et al.* 1981).

Early ontogeny: The eggs start to swell 30 minutes after fertilization and continue for 3 days. The enlargement is most rapid during the first 2 hours. The egg diameter increases by 10 to 15 %, and its volume, by 30 to 50 %. (PEŇÁZ and PŘÍHODA 1981, HOLČÍK *et al.* 1981). The incubation period varies according to the water temperature. The time from fertilization until hatching is completed, may be related to the temperature as follows (temperature-units = day-degrees): 202–232 at 4–11 °C (IVAŠKA 1951), 294.2 at 6–7 °C (PRAWOCHENSKI and KOLDER 1968), 238.4 (beginning of hatching) to 300.1 (all eggs hatched) at 6–7 °C (HOLČÍK *et al.* 1981), 266 (beginning of hatching to 331 (end of hatching) at 4.8–15.5 °C (PEŇÁZ and PŘÍHODA 1981). According to these authors, the entire embryonic development lasts 45 days, i. e. 457 TU. HARSÁNYI (1982) gives 76 days at a constant temperature of 4 °C, or about 30 days at 10 °C. Under natural conditions (Central Europe), fry hatch at the end of May or at the beginning of June and begin with exogenous feeding 16 days later (HARSÁNYI 1982). MISHARIN and SHUTILO (1971) give 30 to 35 days as the incubation period of *H. h. taimen*, but they do not mention the water temperature. Characteristic periods and steps, distinguished by qualitatively significant features, are shown by Table 14.

Table 14: Early ontogeny in *Hucho hucho hucho* (according to PENZ and PRIHODA 1981)

| Embryonic period | | | | |
|------------------|------------------------------------|------------------|-----------|---|
| step | interval from start of development | TU (days-degree) | Tl (mm) | characteristics |
| 1 | 0–10 h. | 0–2.5 | – | formation of perivitelline space and concentration of plasma at animal pole |
| 2 | 10–123 h. | 2.5–15.3 | – | cleavage up to appearance of morula |
| 3 | 63–123 h. | 15.3–33.3 | – | appearance of blastomere and epithelial blastulae, onset of protoplasmatic motion |
| 4 | 123–190 h. | 33.3–52.8 | – | gastrulation and neurulation |
| 5 | 9–13 d. | 52.8–99.3 | – | formation of head and trunk organs to appearance of tail bud |
| 6 | 13–17 d. | 99.3–134.5 | 5.4–7.5 | development of tail, pelvic fins and embryonic finfold, pulsation of heart |
| 7 | 17–23 d. | 134.5–188.6 | 7.5–9.3 | separation of front of head, circulation of colourless blood, muscle movements |
| 8 | 23–27 d. | 188.6–299.1 | 9.3–10.4 | end of segmentation; formation of 42.2 trunk segments, 29.5 tail segments, appearance of hepatic blood circulation, pigmentation of eye perimeters |
| 9 | 27–32 d. | 299.1–287.5 | 10.4–13.4 | Development of eyes, differentiation of finfold, perforation of mouth opening, complete vascularization of surface of yolk sac, onset of hatching |
| 10 | 32–36 d. | 287.6–339.1 | 13.4–16.2 | completion of hatching, onset of branchial respiration, upward curved notochord, appearance of body surface pigmentation |
| 11 | 36–45 d. | 339.1–457.1 | 16.2–21.4 | absorption of embryonic finfold, growth of pelvic fins to ½ finfold, appearance of ventral cones of somites, first signs of septum in nasal or., start of skeleton calcification, calc. ends of teeth, o. dentale, o. maxillare, o. praemaxillare |
| Larval period | | | | |
| 1 | 45–53 d. | 457–545 | 21.0–24.0 | separation of unpaired fins, mixed nutrition, complete division of nasal or., yolk sac covered by somites, its shrinkage, calc. of the bones of the mouth, operculum, primary pectoral girdle, radii branchiostegi, lepidotrichiae of caudal and anal fins |
| 2 | 54–90 d. | 545– | 23.2–30.0 | yolk sac has disappeared, exclusively ext. nutrition, app. of homocercal caudal fin, filling of swim bladder, pelvic fins protrude beyond finfold, body proportions close to those of adults, ossif. of opercular bones ends, ossif. begins in axial skel., ribs and supporting bones, lepidotrichiae of all fins calcified |
| Juvenile period | | | | |
| 1 | 90– | – | 30.0– | appearance of 6–10 juv. parr marks, disapp. of unpaired finfold, beginning of calcif. of neurocranial skeleton. Formation of scales |

Lk

Important parasites and diseases.

A list of parasites already found in *H. hucho* is provided in Table 15. The most important parasite of the Danube huchen is *Basanistes huchonis*, which is specific for its host and attaches to the inner sides of the opercula and the palate. It attacks predominantly the young huchens (WITKOWSKI and BLACHUTA 1981), damages the issues, and facilitates the penetration of the parasitic aquatic moulds, *Saprolegnia* and *Achlya* (IVAŠKA 1951, VOLF and HAVELKA 1958). Other important parasites of wild *H. h. hucho* are *Raphidascaris acus* and *Cystidicola farionis*. ŽITŇAN (1976) found that 83.3 % of the huchens from Slovakian waters he investigated were infested by parasites, mostly *R. acus*, *C. farionis* and *B. huchonis*. Young huchens in fish farms are attacked by *Chilodonella*, *cyprini*, *Ichthyophthirius multifiliis* and *Myxosoma cerebralis* (ŽITŇAN 1976, JUNGWIRTH 1977b, HARSÁNYI 1982). Serious damage and heavy losses of huchens in fish farms are caused by infections of UDN (ulcerative dermal necrosis, a disease of unknown origin) and by IPN (infectious pancreatic necrosis, a virous disease). In a few cases, a trout disease, VHS (viral haemorrhagic septicaemia), was also reported (BOHL 1979, HOLČÍK *et al.* 1981, HARSÁNYI 1982). IVAŠKA (1951) and HAVELKA and IVAŠKA (1954) noted the mass mortality among huchens bred in fish ponds due to a bacterium, *Aeromonas salmonicida*. A bacterial disease of the gills is caused by *Myxobacteria* (HARSÁNYI 1982).

Table 15: List of parasites found in *Hucho hucho* (compiled from papers of SCHULZE 1890, ZAKHVATKIN 1951, BYKHOVSKY 1962, KIRILLOV 1962, BRGLEZ 1966, ROJTMAN 1967, MORAVEC and ERGENS 1970, ERGENS *et al.* 1975, MORAVEC 1975, LUKIN 1976, ŽITŇAN 1976 and HARSÁNYI 1978)

| | <i>H. h. hucho</i> | <i>H. h. taimen</i> |
|-------------------------------------|--------------------|---------------------|
| Protozoa | | |
| <i>Chilodonella cyprini</i> | x | |
| <i>Ichthyobodo necatrix</i> | x | |
| <i>Ichthyophthirius multifiliis</i> | x | |
| <i>Myxosoma cerebralis</i> | x | |
| Plathelminthes | | |
| <i>Asymphylogora imitans</i> | x | |
| <i>Asymphylogora merkwetschi</i> | x | |
| <i>Asymphylogora tincae</i> | x | |
| <i>Azygia robusta</i> | | x |
| <i>Azygia lucii</i> | x | x |
| <i>Cyathocephalus truncatus</i> | x | |
| <i>Diphylobothrium strictum</i> | | x |
| <i>Eubothrium crassum</i> | | x |
| <i>Eubothrium salvelini</i> | x | x |
| <i>Orientocreadium pseudobagri</i> | | x |
| <i>Sanguinicola sp.</i> | | x |

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Table 15: continued

| | <i>H. h. hucho</i> | <i>H. h. taimen</i> |
|--|--------------------|---------------------|
| <i>Scolex pleuronectis</i> | | X |
| <i>Tetraonchus huchonis</i> | | X |
| <i>Tetraonchus skrjabini</i> | | X |
| <i>Tetraonchus spasskyi</i> | | X |
| <i>Triaenophorus nodulosus</i> | X | |
| Aschelminthes | | |
| <i>Camallanus lacustris</i> | | X |
| <i>Capillaria brevispicula</i> | | X |
| <i>Contracaecum aduncum</i> | | X |
| <i>Cucullanus truttae</i> | X | X |
| <i>Cystidicola farionis</i> | X | X |
| <i>Cystidicoloides ephemeridarum</i> | X | X |
| <i>Pseudocapillaria salvelini</i> | | X |
| <i>Rhabdochona denudata</i> (?) | X | |
| <i>Raphidascaris acus</i> | X | X |
| Acanthocephala | | |
| <i>Echinorhynchus cryophilus</i> | | X |
| <i>Echinorhynchus salmonis</i> | | X |
| <i>Neoechinorhynchus rutili</i> | X | X |
| <i>Paracanthocephalus tenuirostris</i> | | X |
| <i>Pomphorhynchus laevis</i> | X | |
| Hirudinea | | |
| <i>Cystobranchus respirans</i> | X | |
| <i>Limnotrachelobdella taimeni</i> | | X |
| <i>Taimenobdella amurensis</i> | | X |
| Arthropoda | | |
| <i>Argulus coregoni</i> | X | X |
| <i>Basanistes enodis</i> | | X |
| <i>Basanistes huchonis</i> | X | |
| <i>Basanistes woskoboinikovi</i> | | X |
| <i>Salmincola stellata</i> (?) | | X |

Note: species marked with (?) probably incorrectly determined

Economic importance

The huchen is among the most valuable game and pan fishes. Its utility value is high: its edible part accounts for 57 to 58 % of the total weight (BUDAGIAN 1961, SKALIN 1976), and it is composed of 74.7 % water, 18.9 % proteins, 4.8 % fat and 1.6 % ash. The energy value of 100 g of the edible part is 510.8 kcal (= 122 kcal), and this amount of flesh contains 316 mg of K, 21 mg of Ca, 25 mg of Mg, 217 mg of P and 1 mg of Fe (BUDAGIAN 1961). One gram of huchen liver contains 2910–3800 IU (= 0.87–1.14 mg) of vitamin A, and

1 gram of liver oil contains 55000 IU (= 16.5 mg) of this vitamin (HIGASHI 1961). That the huchen has been caught for food since ancient times was proven by archeological excavations of primeval human settlements in both Siberia and Europe (CEPKIN 1976, 1980a, 1980b, LEPIKSAAR 1968, 1973, pers. comm.). In some parts of Siberia, the skin of taimen was used until recently to manufacture clothes and footwear (CEPKIN 1980b). As there are no officially published statistics on the catch of the huchen in individual countries and this species is not mentioned in the FAO Yearbook of Fishery Statistics, only a very rough estimate of the present catch may be provided. HOLČÍK *et al.* (1981) estimated that the entire annual European catch is roughly 2000 to 2500 huchens weighing 11 to 14 metric tons, and the annual taimen catch in its entire area of distribution may be about 36000 fishes weighing about 200 metric tons. The catch has been continuously decreasing, especially in the case of the taimen, according to data provided by MISHARIN and SHUTILO (1971). Before 1950, the greatest catch of this subspecies in Siberia and the Amur River was 300 metric tons, and the average was about 200 metric tons. In 1960, however, the catch decreased to only 100 MT. In spite of regular stocking the catch of the Danube salmon is also decreasing. The long-term proportion (1954–1980) of huchen among the total Slovakian catch varied from 0.03 to 0.56 % ($\bar{x} = 0,18$ %). In Slovenia (Yugoslavia), the proportion of the huchen in 1966 was 0.45 %, and in 1971, 0.40 % (VERCE 1973). The proportion of taimen in the total catch has, in some places recently, been increasing, according to data provided by Soviet authors writing about the Siberian rivers, where this fish usually accounts to between 1 and 4 % (Lena – PIROZHNIKOV 1955, KIRILLOV 1972). In some regions, however, this percentage has reached 10 and even 29 % (the Angara River at Nizhne-Ilimsk and Bratsk in 1934, the Vitim River in the Chitan Region in 1962–1967; OLIFER 1977). The mean weight of fish caught by rod and line in Slovakia and Slovenia varies from 4 to 8 kg; specimens over 20 kg are rather rare (HOLČÍK *et al.* 1981). The mean weight of taimen in the catches of commercial fishermen is similar: in the Ilych River (Pechora Basin), it was 1.5 to 4 kg, rarely reaching 6 to 8 kg, and 16, 20 and 30 kg specimens have been caught (TEPLOV 1951). The most frequent weight of taimen from the Amur river is in the range from 5 to 10 kg (NIKOLSKY 1956), in the Khatanga River, it is 2.9–7.4 kg (LUKIANCHIKOV 1967a). The mean weight of fish from the Lower Lena varies from 3.9 to 6.7 kg (PIROZHNIKOV 1955). Similar figures are provided by MISHARIN and SHUTILO (1971). The maximum weight of taimen taken most frequently from Yakutian rivers is 15–20 kg (KIRILLOV 1976). The size of taimen found in Neolithic human settlements along the Angara River varied from 500 to 800 mm in FL (CEPKIN 1980a), which corresponds to a weight of about 1.1 to 4.8 kg. The Danube huchen is now a prized trophy fish and is bred in hatcheries in Austria, Czechoslovakia, the Federal Republic of Germany, Poland, Rumania and Yugoslavia.

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List of Abbreviations and Symbols

List of symbols and abbreviations recommended for use in the text and tables of all volumes of the Handbook of European Fresh Water Fishes

A. Lampreys

| | |
|--------------------------------|--|
| a-C | tail length |
| AC | anterior circumoral row of teeth (= cusps) |
| AF | anterior area (field) of the disc |
| B ₇ -a | trunk length |
| B ₁ -B ₇ | branchial length |
| d | disc length |
| d-B ₁ | prebranchial length |
| hD ₂ | second dorsal fin maximum height |
| IO | infraoral lamina |
| IT | intermediate disc teeth (cusps) |
| LC | lateral circumoral row of teeth (cusps) |
| LF | lateral area (field) of disc |
| LL | longitudinal (posterior) lingual lamina |
| MA | median anterior tooth row |
| MG | marginals |
| O | eye length |
| PC | posterior circumoral row of teeth (cusps) |
| PF | posterior area (field) of disc |
| SO | supraoral lamina |
| Tℓ | total length |
| TL | transverse (anterior) lingual lamina |
| w | individual weight |

B. Fishes

| | |
|------|--|
| ad-C | distance between adipose fin and caudal fin |
| A | anal fin |
| A-C | distance between base of anal and base of caudal fin |
| Ab | branched (soft) rays of anal fin |
| Au | unbranched rays (spines) of anal fin |
| b-mc | distance between base of barbels and cartilaginous arch of mouth |

| | |
|------------------|---|
| BR | branchiostegal rays |
| C | caudal fin |
| C ₁ | upper lobe of caudal fin |
| C ₂ | median part of caudal fin (central rays in forked caudal fin) |
| C ₃ | lower lobe of caudal fin |
| Cb | branched rays of caudal fin |
| Cu | unbranched rays of caudal fin |
| D (ID, IID) | dorsal fin (first D, second D) |
| D-ad | distance between end of D base and adipose fin |
| D-D | distance between dorsal fins |
| Db | branched (soft) rays of dorsal fin |
| Du | unbranched rays (spines) of dorsal fin |
| Fℓ | fork (Smitt's) length |
| Fu | fulcræ |
| h | minimum body depth (= least depth of caudal peduncle) |
| hA | depth of anal fin |
| hD (hID, hIID) | depth of dorsal fin (depth of ID, depth of IID) |
| hc | head depth (at nape) |
| hco | head depth (at centre of eye) |
| hmx | depth of upper jaw |
| hpc | depth of caudal peduncle (maximum depth of caudal peduncle) |
| H | body depth (maximum body depth) |
| ina | distance between nostrils |
| io | interorbital distance (skull width) |
| K | coefficient of condition |
| ℓac | head width |
| ℓaco | body width |
| ℓad | length of adipose fin base |
| ℓam | width of mouth |
| ℓapc | width of caudal peduncle |
| ℓas | width of snout |
| ℓasa | width of snout area |
| ℓb | length of barbel |
| ℓbr | length of gill arch |
| ℓc | length of head |
| ℓ.ℓ. | lateral line (pored) scales |
| ℓ.ℓ ₁ | scales above lateral line |
| ℓ.ℓ ₂ | scales below lateral line |
| ℓ.ℓ-ad | scales between lateral line and adipose fin base |
| ℓmd | lower jaw length |
| ℓmx | upper jaw length |
| ℓpc | length of caudal peduncle |

| | |
|---|---|
| ℓsa | length of snout area |
| ℓA | length of anal fin |
| ℓC (ℓC ₁ , ℓC ₂ , ℓC ₃) | length of caudal fin (length of upper, centre, and lower lobe of caudal fin respectively) |
| ℓD (ℓID, ℓIID) | length of dorsal fin (length of first and second dorsal fin respectively) |
| ℓP | length of pectoral fin |
| ℓPbs | length of pectoral fin base |
| ℓSp.br. | length of gill rakers |
| ℓV | length of ventral (pelvic) fin |
| ℓVbs | length of ventral fin base |
| L. | lake |
| Oh | horizontal diameter of eye |
| Ov | vertical diameter of eye |
| Or | diameter of orbit |
| pop | preopercular distance |
| poD | postdorsal distance |
| poO | postorbital distance |
| prO | preorbital distance (snout length) |
| pP | prepectoral distance |
| PoV | postventral distance |
| pA | preanal distance |
| pD | predorsal distance |
| pV | preventral distance |
| P | pectoral fin |
| P-an | distance between base of pectoral fin and anus |
| Pb | branched (soft) rays of pectoral fin |
| PhF | formula of pharyngeal teeth |
| Pu | unbranched rays of pectoral fin |
| PC | pyloric caeca |
| P-V | distance between pectoral and ventral fin |
| R. | river |
| Res. | reservoir |
| Ripo | pouch rings (in pipefishes) |
| Risd | subdorsal rings (in pipefishes) |
| Rita | tail rings (in pipefishes) |
| Rito | total rings (in pipefishes) |
| Ritr | trunk rings (in pipefishes) |
| s-an | distance between snout and anus |
| s-b | distance between snout and barbels |
| s-m | distance between snout and mouth |
| s-mc | distance between snout and cartilaginous arch of mouth |
| Scp | caudal peduncle scales |
| Sℓ | standard length |

| | |
|--------|--|
| Sp.br. | branchial spines (gill rakers) |
| Squ. | longitudinal rows of scales |
| SA | abdominal scutes (keeled scales in clupeids) |
| SD | dorsal scutes (in sturgeons) |
| SL | lateral scutes (—"") |
| SV | ventral scutes (—"") |
| Tℓ | total length |
| TU | temperature unit (degree-day) |
| V | ventral (pelvic) fin |
| Vb | branched (soft) rays of ventral fin |
| Vert. | vertebrae |
| Vu | unbranched rays of ventral fin |
| V-an | distance between ventral fin and anus |
| V-A | distance between ventral and anal fin |
| w | individual weight |

List of Counts and Measurements

Index of counts, measurements and other terms with competent symbols and/or abbreviations recommended for use in the text and tables of all volumes of the Handbook of European Fresh Water Fishes.

A. Lampreys

Area

- anterior area of disc (AF)
- lateral area of disc (LF)
- posterior area of disc (PF)

Branchial length (B₁-B₇)

Cusps (see Teeth)

Field (see Area)

Height

- second dorsal fin (hD₂)

Lamina

- infraoral (IO)
- longitudinal (posterior) lingual (LL)
- supraoral (SO)
- transverse (anterior) lingual (TL)

Length

- disc (d)
- eye (O)
- tail (a-C)
- total (Tℓ)
- trunk (B₇-a)

Marginals (MG)**Teeth**

- interior circumoral (AC)
- intermediate disc (IT)
- lateral circumoral (LC)
- marginal (MG)
- median anterior (MA)
- posterior circumoral (PC)

Weight

- individual (w)

B. Fishes

Branchial spines (= gill rakers) (Sp.br.)

Branchiostegal rays (BR)

Coefficient, of condition (K)

Degree-day (= temperature unit) (TU)

Depth

- anal fin (hA)
- body (maximum) (H)
- body (minimum) (h)
- caudal peduncle (hpc)
- caudal peduncle (least) (hpc)
- dorsal fin (hD)
 - first dorsal fin (hID)
 - second dorsal fin (hIID)
- head (at nape) (hc)
- head (at eye) (hco)
- upper jaw (hmx)

Diameter

- eye (horizontal) (Oh)
- eye (vertical) (Ov)
- orbital (Or)

Distance

- adipose fin - caudal fin (ad-C)
- anal fin - caudal fin (A-C)
- barbels base - cartilaginous arch of mouth (b-mc)
- between dorsal fins (D-D)

- between nostrils (ina)
- dorsal fin - adipose fin (D-ad)
- interorbital (= skull width) (io)
- pectoral fin - anus (P-an)
- pectoral fin - ventral fin (P-V)
- postdorsal (poD)
- postorbital (poO)
- postventral (poV)
- preanal (pA)
- predorsal (pD)
- preopercular (pop)
- preorbital (= snout length) (prO)
- prepectoral (pP)
- preventral (pV)
- snout - anus (s-an)
- snout - barbules (s-b)
- snout - cartilaginoid arch of mouth (s-mc)
- snout - mouth (s-m)
- ventral fin - anal fin (V-A)
- ventral fin - anus (V-an)

Fin

- anal (A)
- caudal (C); upper lobe (C₁), median lobe (C₂), lower lobe (C₃)
- dorsal (D)
 - first dorsal (ID)
 - second dorsal (IID)
- pectoral (P)
- ventral (pelvic) (V)

Fin rays (see Rays)

Fulcræ (Fu)

Gill rakers (= branchial spines) (Sp.br.)

Lake (L.)

Lateral line (ℓ.ℓ.) (see also scales)

Length

- adipose fin base (ℓad)
- anal fin (ℓA)
- barbel (ℓb)
- caudal fin (ℓC); upper lobe (ℓC₁), median lobe (ℓC₂), lower lobe (ℓC₃)
- caudal peduncle (ℓpc)
- dorsal fin (ℓD)
 - first dorsal fin (ℓID)
 - second dorsal fin (ℓIID)
- fork (Fℓ)
- gill arch (ℓbr)

- gill raker (ℓ Sp.br.)
- head (ℓ c)
- lower jaw (ℓ md)
- pectoral fin (ℓ P); pectoral fin base (ℓ Pbs)
- Smitt's (= fork length (FL))
- snout (= preorbital distance) (prO)
- snout area (ℓ sa)
- standard (S ℓ)
- total (T ℓ)
- upper jaw (ℓ mx)
- ventral fin (ℓ V); ventral fin base (ℓ Vbs)

Pharyngeal teeth, formula (PhF)

Pyloric caeca (PC)

Rays. branchiostegal (BR)

in fins

- branched in anal fin (Ab)
- branched in caudal fin (Cb)
- branched in dorsal fin (Db)
- branched in pectoral fin (Pb)
- branched in ventral fin (Vb)
- unbranched (spines) in anal fin (Au)
- unbranched in caudal fin (Cu)
- unbranched (spines) in dorsal fin (Du)
- unbranched (spines) in pectoral fin (Pu)
- unbranched (spines) in ventral fin

Reservoir (Res.)

Rings (in pipefishes)

- pouch (Ripo)
- subdorsal (Risd)
- tail (Rita)
- trunk (Ritr)

River (R.)

Scales

- caudal peduncle (Scp)
- keeled (= abdominal scutes) (SA)
- lateral line (pored) (ℓ . ℓ .)
 - above lateral line (ℓ . ℓ ₁)
 - below lateral line (ℓ . ℓ ₂)
 - between lateral line and adipose fin (ℓ . ℓ .-ad)
- longitudinal rows (Squ.)

Scutes

- abdominal (= keeled scales) (SA)
- dorsal (SD)
- lateral (SL)
- ventral (SV)

Spines (see Rays)

Temperature unit (= degree-day) (TU)

Vertebrae (Vert.)

Weight (individual) (w)

Width

- body (λ aco)
- caudal peduncle (λ apc)
- head (λ ac)
- mouth (λ am)
- skull (= interorbital distance) (io)
- snout area (λ asa)

Stocking and natural recruitment of larval coregonines in the Bodensee*

By THOMAS N. TODD, Ann Arbor

With 2 figures and 2 tables in the text

Abstract

The active propagation programs for Blaufelchen (*Coregonus lavaretus wartmanni*) in the Bodensee (Lake Constance) have contributed greatly to the strength of the whitefish fishery in this lake. Previous research demonstrated that the hatcheries supplied an average of 17 % of the fry contributing to a year class. However, examination of published data suggested that the stocking rate was underestimated and actually averaged 41.4 % from 1924-1963. Per cent survival from egg to recruitment was estimated to equal 0.030 in the absence of stocking, and the statistical uncertainty about this estimate suggested that stocked fry would have to number in excess of 41 % of total fry in the Bodensee to produce a detectable change in it.

1. Introduction

The Bodensee (Lake Constance) of Austria, Germany, and Switzerland has been the object of vigorous propagation programs for Blaufelchen (*Coregonus lavaretus wartmanni*) since 1877 (Grim, 1983). Although some researchers have tried to assess the success of *Coregonus* hatchery programs in terms of increases in commercial catches subsequent to plantings of fry (Van Oosten, 1942; Miller, 1946; Batias, 1954; Lapworth, 1956; Christie, 1963), researchers on the Bodensee have attempted to attribute positive changes in their estimates of survival of Blaufelchen survival from egg to recruitment as evidence of success in their propagation efforts (Nümann, 1967). Monthly sampling in the lake allowed estimation of the total number of spawning fish in each of several weight classes from which the total number of eggs laid in a given spawning season were calculated. The survival of each year class was calculated 2 or 3 years later from an estimate of the total year class strength, based on captures in the fishery, i. e., total fish in a year class divided by total eggs laid in lake from which the year class developed. These calculations, made over many spawning periods, demonstrated that in no cases were survival estimates high when the numbers of fry stocked were low. The lowest survival estimate occurred in a season in which the stocked fry equalled less than 10 % of those estimated to have hatched in the lake (Nümann, 1967).

* Contribution 638 of the Great Lakes Fishery Laboratory.

2. Methods

To explore the relation between survival estimates and percentages of stocked fry in the natural population, I performed a simple regression using data from Nümann (1967). The regression model empirically suggested by the data was $1/y = (a-bx)$, which yielded 0.030 as an estimate of per cent survival from egg to recruitment in the absence of stocking (Table 1, Fig. 1). As a test on this regression equation, I created a set of test data derived from calculations on expected relations between per cent stocking and survival based on the assumptions that eggs laid in the lake hatch at a rate of 10 % (Elster, 1944) and that the survival of hatchery fry and wild fry is equal. A constant value of 0.30 was multiplied into my test data to make my estimate of survival in the absence of stocking approximate that observed in the Bodensee, and this constant value can be considered to represent an estimate of the per cent survival from hatching to recruitment. Hence, my expected values of per cent survival from egg to recruitment were calculated as $y = 0.3(0.1e + s)/e$, where y = per cent survival, e = number of eggs laid in the lake, and s = number of fry stocked in the lake. My values of the percentages of fry stocked were calculated as $x = 100[s/(0.1e + s)]$ where x = per cent stocked, e = number of eggs laid in the lake, and s = number of fry stocked in the lake. The number of eggs laid (and, hence, the number of fry hatched) were assumed to be constant for convenience. The regression model empirically suggested by the test data was $1/y = (a-bx)$, the same as that for Nümann's, and the fit of the regression curve was essentially perfect (Table 1, Fig. 1).

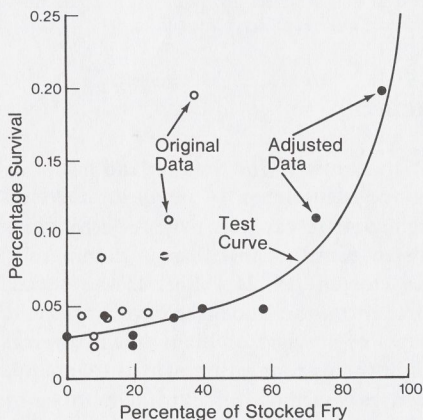


Fig. 1. Percentage of stocked fry compared with percentage survival from egg to recruitment of Bodensee Blaufelchen (*Coregonus lavaretus wartmanni*). Original data (open circles) are from Nümann (1967). The test curve was derived empirically, assuming that survival in the absence of stocking was equal to 0.030 (after Nümann, 1967) and survival of stocked fry and wild fry was equal. Data from Nümann (1967) were adjusted (closed circles) to conform to an empirical model (the test curve) by reducing the estimate of fry hatched in the wild.

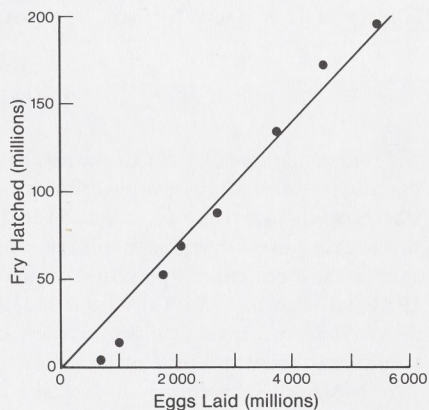


Fig. 2. Number of Blaufelchen (*Coregonus lavaretus wartmanni*) eggs (in millions) laid in the Bodensee compared with an estimate of fry hatched in the wild that conforms to expectations from an empirical model.

Table 1. Relation of percentages of *Coregonus* fry stocked and per cent survival from egg to recruitment.

| Test data | | Nümann (1967) | |
|------------------|-------------------|-------------------------------|-------------------|
| Per cent stocked | Per cent survival | Per cent stocked ¹ | Per cent survival |
| 0 | 0.030 | 4.3(4) | 0.045 |
| 10 | 0.032 | 7.8(9) | 0.024 |
| 20 | 0.036 | 7.8(8) | 0.031 |
| 30 | 0.041 | 11.8(13) | 0.083 |
| 40 | 0.047 | 12.3(13) | 0.043 |
| 50 | 0.054 | 16.2(19) | 0.048 |
| 60 | 0.064 | 19.2(23) ² | 0.159 |
| 70 | 0.079 | 23.6(30) | 0.046 |
| 80 | 0.104 | 29.8(42) | 0.108 |
| 90 | 0.150 | 37.7(60) | 0.192 |
| 99 | 0.250 | | |

¹ Numbers in parentheses are the ratio ($\times 100$) of stocked fry to wild fry from Nümann (1967) Table 3, column 8.

² These data were excluded from analysis because they are based on an uncertain number of stocked fry and appear to be aberrant when plotted with the others.

3. Results

The test data and Nümann's data were not in agreement. The regression equations were $1/y = (33.6 - 0.30x)$ for the test data and $1/y = 33.4 - 0.736x$ for Nümann's data. The constant values of 33.6 and 33.4 represented the inverse of the per cent survival in the absence of stocking ($x = 0$) and the value for the test data was intentionally set at 0.030^{-1} ($= 33.6$), as previously noted, to approximate the field data. The other constant values, 0.30 and 0.736, reflected how much the stocking rate altered the survival estimate of the year class.

The difference between my test data and the Bodensee data suggested that some of the assumptions used as a basis for the calculation of stocking rate and survival in the Bodensee program were invalid. Either the percentage of hatchery fry in a year class was underestimated or the percentage survival from egg to recruitment was overestimated. I personally believe that, because of their magnitude and quality, the assessment programs on the Bodensee provided reliable estimates of year class strength at post-recruitment ages and numbers of eggs deposited during each spawning season. I therefore believe that the estimates of survival were probably accurate; however, the estimate of fry produced in the lake was based on old measurements (Elster, 1944) that may no longer be valid. If 10% of the estimated eggs hatched in the lake was indeed an overestimate of the number of fry produced naturally, the percentage of hatchery fry in a year class would be underestimated and this underestimate would create the type of difference observed between my test data and Nümann's field data.

A simple alteration of Nümann's data provided a regression curve nearly identical to my curve based on hypothetical data (Fig. 1). The difference was found in the constant b of the regression equations. Nümann's estimate of the percentage

Table 2. Numbers (in millions) of *Coregonus* eggs laid in the Bodensee, fry hatched in the lake (wild), fry stocked, and the per cent survival from egg to recruitment¹.

| Year | Eggs laid ² | Wild fry ³ | Stocked fry ⁴ | Per cent stocked ⁵ | Per cent survival ⁶ |
|---------|------------------------|-----------------------|--------------------------|-------------------------------|--------------------------------|
| 1924-40 | 3684.9 | 130.9 | 31.1 | 19.2 | 0.031 |
| 1954/55 | 2058.8 | 67.3 | 26.5 | 29.0 | 0.083 |
| 1955/56 | 5398.2 | 191.9 | 45.6 | 19.2 | 0.024 |
| 1956/57 | 4466.8 | 168.7 | 20.0 | 10.6 | 0.045 |
| 1958/59 | 1757.4 | 51.4 | 34.0 | 39.8 | 0.048 |
| 1959/60 | 2693.6 | 86.3 | 39.5 | 31.4 | 0.043 |
| 1960/61 | 1005.7 | 15.6 | 42.7 | 73.2 | 0.108 |
| 1961/62 | 554.6 | 12.4 | 17.1 | 58.0 | 0.046 |
| 1962/63 | 700.0 | 3.4 | 42.3 | 92.6 | 0.192 |
| Mean | 2480.0 | 80.9 | 33.3 | 41.4 | 0.069 |

¹ The basic data come from Table 3 of Nümann (1967).

² From column 2 of Nümann's Table 3.

³ Calculated from the equation $w = s(1-x)/x$, where w = the number of wild fry, s = the number of hatchery fry stocked, and x = the revised estimate of the percentage of stocked fry (column 5 of this table).

⁴ Taken from column 6 of Nümann's Table 3.

⁵ Revised from Nümann (given in column 3 of Table 1 of the present paper) by multiplying this estimates by 2.45 so that they conformed to the empirical model as presented in the text.

⁶ Taken from column 4 of Nümann's Table 3 (also given in column 4 of Table of the the present paper).

of stocked fry in the lake may therefore have been too small by a factor of 2.45, i. e., 0.736/0.30. Hence, multiplication of his estimates by 2.45 produced the expected empirical relation between stocking rate and survival (Table 2, Fig. 1) suggesting that less than 10% of the eggs spawned in the Bodensee actually hatched.

A revised estimate of the actual number of fry produced in the Bodensee was calculated from the new estimate of percentage of stocked fry from the equation $w = s(1-x)/x$, where w = the number of wild fry, s = the number of hatchery fry stocked, and x = the new estimate of the proportion of stocked fry (Table 2). Comparison of the revised estimate of fry produced in the wild with the number of eggs estimated to have been spawned in the Bodensee suggested that only about 3.5% of those eggs actually hatched (Fig. 2). Recent data revealed that perhaps as few as 1.7% of eggs laid in the lake hatch (Hartmann & Brenner, 1983).

4. Conclusions

Nümann (1967) showed that survival estimates were low when hatchery fry contributed less than 10% to a year class. From this finding he inferred that stocking at a rate of less than 10% of the annual hatch was not profitable because it resulted in a negligible contribution to the fishery. My analysis of Nümann's data suggested, however, that the stocking effort in the Bodensee was more intensive than Nümann suspected (Table 2) and, indeed, more recent findings suggested that 53% of the captured whitefish may have been planted fish (Nümann, 1973; Braum

& Quoss, 1981). I conclude, therefore (based on the 95 % confidence interval about the estimate of survival in the absence of stocking, i. e., the y-intercept, which equals $0.022 < 0.030 < 0.047$), that changes in the survival rate were probably undetectable when the percentage of stocked fry in a year class was less than about 41 %.

Quantitative figures aside, though, the Bodensee propagation program has been demonstrably successful. The quality and magnitude of the fishery assessment program on the lake must certainly receive most of the credit. Without the detailed knowledge of fish stocked in the Bodensee that the Austrians, Germans, and Swiss obtain, the contribution of hatchery fry to the fishery would be as unknown as it is virtually everywhere else in the world where a substantial wild population is being augmented with unmarked hatchery fish.

Summary

Stocking of Blaufelchen (*Coregonus lavaretus wartmanni*) in the Bodensee (Lake Constance) has been shown to increase the estimate of per cent survival from egg to recruitment (Nümann, 1967). My analysis of Nümann's (1967) data for 1924–1963 suggested that stocking had supplied an average of 41.4 % of the population compared to his estimate of 17.0 % (Table 2). The size of the natural hatch of fry in the lake was the main reason for the difference between our estimates – only 3.5 % of the eggs laid in the lake appeared to have hatched compared to Nümann's estimate of 10 % (Fig. 2, Table 2). Nümann (1967) concluded that stocked fry needed to be in excess of 10 % of total fry in the lake to produce a detectable increase in the estimate of per cent survival from egg to recruitment. However, my calculations suggested that stocked fry would have to number in excess of 41 % to produce a statistically significant increase in the estimate of per cent survival.

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January 26, 1990

Dear Mr. Behnke

EM (Riv?)

Many thanks for your letter 12:29:89 and the copy of Trout magazine. I noticed your addition you made on p.43 concerning angling writer still using old species fishnames in books, articles, etc. I agree with you and in my article 29th December 1989 "Bookparty for fishlovers" I wrote a little about it. To many books are still using old synonyms, specially books from Germany and a few from Sweden and England, this time 1989. I have not so far checked other countries books but I noticed that Dr. Axelrod's Atlas from USA have correct name on rainbow trout. So there are many contactproblems concerning confusing species names to readers.

An exemple, a danish fishbook first printed 1965 and then reprinted, reprinted, reprinted, reprinted ~~is~~ still using old synonyms today. The Swedish publisher of this danish book is only intressed to sell, not echange - it costs money. And the readers are confused many times.

So many of mine readers were very confused when I wrote the new specie name of rainbow trout, December 1988, but then very happy to have updating information. Including explanation and nomenclature in the beginning of 1989. I also wrote that the nomenclature can be changed later and not definitive for all years. If I did not published the new name, Sweden still should used the old name today. I hope, and I think, you will have ~~good~~ positive response from the readers and I also like your article. Let me know the response.

Yes, I do not understand why they use the name "Carl von Linne" of the award in this case to Svårdson and also why so much money as his systematic work do not always fit Linne's taxonomy even if Svårdson is deserving a award. Yes, why put them together, Linne & Svårdson? My article in this case was only giving as an information to the readers and it was no responce.

Enclosed are more information on Lake Vänern and I will send you more later.

Yes, the figures on map are the numbers of smolts of salmon and trout into Vänern 1989. Yes, "Gaperhult"/GÖ 21.500 means - 21.500 smolts (2 years old) of the Gullspång race of Salmo trutta were stocked at this site/bay "Gaperhult". I do not yet have the information comparing the growth and survival of the Gullspång and Klarälven but I will later sent you the information - if I get it, I hope so.

The Drottningholm people have it but need long time to send it or make the list. Anglers are very interested to report tagged fishes but there is very small interesting from professional fishermen and fishshops so far. I know that Gullspångs races grows much faster than Klarälven's races. A few days ago I got a report from a privat netfisherman who found a big trout, weight 11-12 kgs, in his net. The last 3 weeks ago anglers, using trollingmetod, have got a few perfect trouts, weight 6-8 kgs each, they say and I think all of these trouts are Gullspångs race. Perhaps I get ~~photos later~~ photos later.

Have a nice time.

Sincerely



Kent Andersson
Norumshöjd 11 bv
417 45 Gothenburg
Sweden

* "Putting them back alive" quotes.

This is a special article for Skåne Province in south Sweden and there are lot of Salmo trutta "trutta" at their's cust and also in southeast Sweden, the last half year. From September the 1st 1989. To many trouts are there or to be more correct: South Sweden do not have enough with spawninggrounds in the rivers - yet.

To few spawninggrounds, very little water in the rivers this winter, resulted that many trouts killed each other. Fight each other to protect it's district. Many trouts dead.

The trouts are missing spawning grounds

Öringarna saknar lekplatser

More biologic adapted reproductions areas should save the fish

Fler biologiskt anpassade reproduktionsområden skulle rädda fisken

kraftiga uppgång ska vi här förklara.

- Vandringsfiskens lekplats är skyddat året runt.
- Periodvis förbud för allt fiske. Lika för alla principen, lätt övervakning.

- Avgiftsbelagd sportfiskelicens med maximerat fiskantal för lax och öring som måste hålla ett visst minimått i total-längd.

- Endast odlad märkt lax och öring får fångas. Den vilda ska återsättas.

- Fiskekrokar med hullingar får ej användas.

- Fångst ska redovisas. Fisk-art, vikt och längd ska noteras i dagsrapporten.

Detta var i stora drag vad några amerikanska fiskeplatser använder. En del använder en kombination av reglerna. Huvudprincipen är att fiskens bestånd måste skyddas och utökas, när detta mål är uppnått kan man tänka sig att låta på bestämmelserna. Om man av misstag råka få en fisk som måste återsättas omedelbart har man därför förbjudet hullingförsedda krokar för att minska skador på fisken.

Slutligen kan sammanfattas att flera amerikanare anser att den vilda fisken som individ går före människans behov att fånga och behålla den, så länge som fiskbeståndet kan utsättas för överfiskning. Var

FISKA MED Arbetet



Fisketurer

CONFIDENT LILLY, BRIS
från Landskrona
tel 0418-701 31, 231 59
010-42 71 76

SYLVIA
från Viken
042-422 97, 010-43 24 69

SVALANDIA
från Råå
Tel 042-22 19 29 el 010-42 57 84

VANDIA
Helsingborg
Tel 0418-258 82 el 010-46 10 76

FALKEN
Öresund, södra Östersjön
Tel 040-873 75 el 040-96 71 08

KERMITH
från Helsingborg
Tel 0435-605 70, 040-31 60 68

EDA
från Barsebäcks hamn
Båttel 010-41 39 24

SKÅNE: Det finns mer havsöring utmed Skånekusten än vad vandringsfiskens lekplatser i åarna orkar ta emot under lektiden. Fredningstidens senaste testperiod 1 september-31december 1989 visade detta. Rapporterna avslöjar ihjälstressad leköring i Skånes två län.

Läget beskriver egentligen hur sydsveriges värdefulla havsöringsbestånd på Skånes kust skulle kunnat räddas helt genom kraftig utbyggnad av biologiskt anpassade reproduktionsområden för lax och öring som måste skyddas till varje pris. Då skulle alla grupper av fiskeintresserade bli nöjda.

Skåne har på tok för få lämpliga lekplatser för vandringsfisk och detta anses av

många vara den största anledningen till fiskdöden.

Rekordmängder
Redan nu kan man dra en viss slutsats av försöksverksamhetens 4 fredningsmånader som blev cirka fyra veckor längre än tidigare. Effekten av kustnärens frånvaro gav rekordstora uppvandringsmängder av lekmogen havsöring som nådde slutmålet - lekplatsen.

Men där var trängseln ibland så stor att slagsmål uppstod mellan havsöringarna på grusbottenarna, eftersom lax och öringfisk är revirhävande försöker lekparet naturligtvis försvara sin utvalda lekplats tills lekbestyren är över.

Endast de starkaste klarar matchen på begränsat vattenutrymme och motståndarna blir utslagna eller undanträngda. Den svagaste individen dör av stress eller utmattning.

Upp till 6-kilos havsöringar hittades döda i några mindre vattendrag. Mölleån och vissa delar av Rörumsån drabbades speciellt av fiskdöd men även i andra åar upptäcktes också död fisk.

Dålig vattentillgång bidrog i många fall att observera fann fisk som vänt buken uppåt. Men det finns positiva aspekter på fiskeförbundet som gällde alla fiskare lika.

— Det kommer att bli en mycket god tillväxt av havsöring de närmaste åren och detta gynnar många parter i framtiden, uppger Johan Pettersson på fiskeförbunds Kristianstad till Arbetet.

Härligt resultat
Han berättar också att det finns planer på att skydda vårens besor (=urlekt lax eller öring, dåligt skick). Den måste få chans att komma till havet och återhämta sig där för se-

nare återvandring till våra vattendrag. Fiskeförbundsrepresentanten har ytterligare ett glädjeämne.

— Simrishamns Fiskevårds- & Sportfiskeförbund räknade fisk i Tommarpsån den 1 oktober-15 november som gav 3.038 uppvandrande havsöringar och detta är ett fantastiskt resultat mot tidigare noteringar.

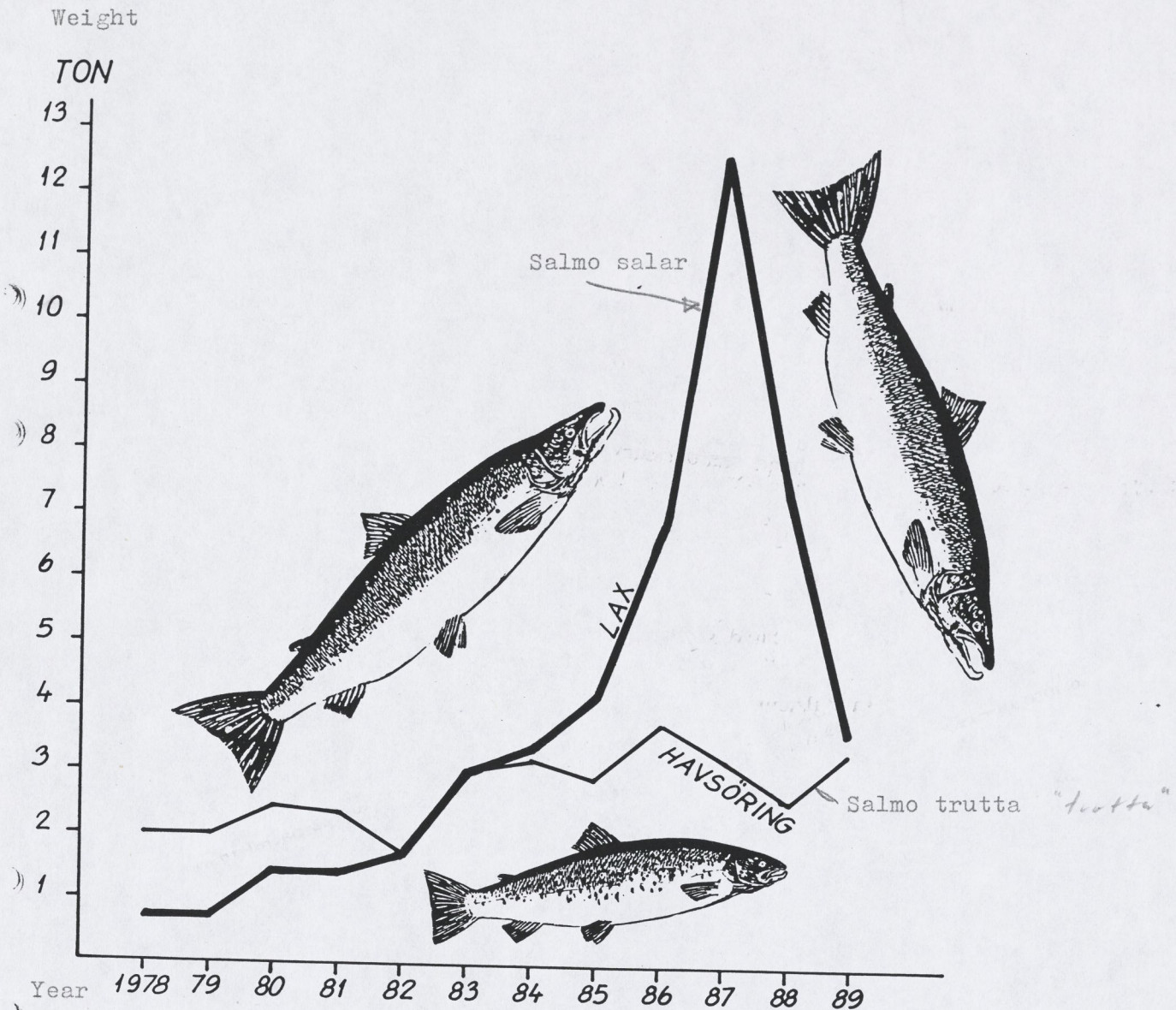
Korrekt så, men tittar man på antalet som helhet får man fram att knappt hälften bör vara honor som avger cirka en miljon romkorn. Endast några få procent överlever till fullvuxen ålder och detta ger för långsam tillväxt av fiskebeståndet, om vi jämför nordamerikas uppfattning.

Där har man i många avseende gått mycket långt för att skydda laxar och öringar. På vissa platser i USA har öringsbeståndet 5-dubblats på fem år. Bakgrunden till denna

Fredag 19/1-90 January 19, 1990

Province HALLAND, Westsweden

Total, only sportfishing



SPORTFISKET EFTER LAX OCH HAVSÖRING I HALLANDSÅRNA 1978-1989.
1978 var det sämsta laxåret någonsin i Halland. Genom fiskevårdsåtgärder, förlängd fisketid och ökat fisketryck har fångsterna av lax och havsöring ökat.
1989 var ett dåligt laxår på grund av giftalger i havet 1988 (dödade laxsmolt) och ringa vattenflöde i åarna under torrsummarens 1989. Havsöringfisket var särskilt bra i Nissan där fångsten ökade från fjolårets 140 till årets 450 fiskar.

Province HALLAND, Westsweden

Total Both sportfishing and netfishing

Weight
TON

40

35

30

25

20

15

10

5

Year

1978

79

80

81

82

83

84

85

86

87

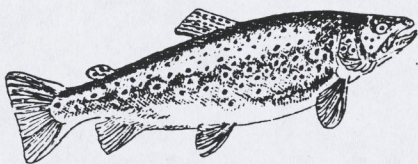
88

89



LAX

Salmo salar

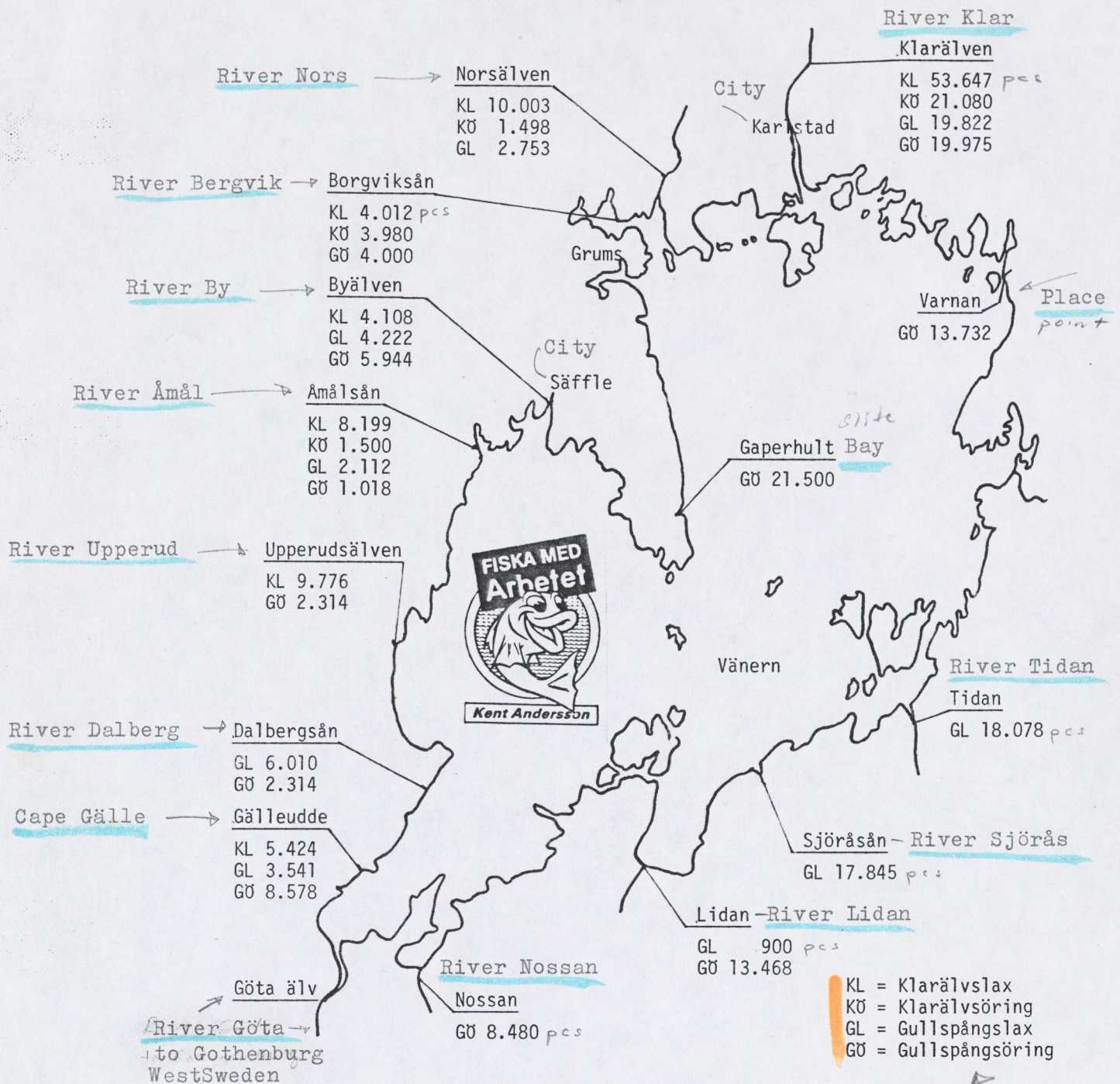


HAVSÖRING

Salmo trutta "trutta"

LAX- OCH HAVSÖRINGFÅNGSTEN I HALLAND 1978-1989
(statistik och beräkningar)

year 1989



Totala antalet utsatta smolt i Vänern år 1989

Total qty stocking smolt in lake Vänern 1989 - Sweden

| | |
|------------|----------------------------------|
| 95.169 pcs | KL= Salmo salar, race River Klar |
| 28.058 " | KÖ= Salmo trutta, " " " |
| 75.283 " | GL= Salmo salar, " " Gullspång |
| 107.917 " | GÖ= Salmo trutta, " " " |

306.427 " =total qty (incl. 6.000 pcs marked)

| Swedish | - | English |
|---------|---|---------|
| Lax | = | Salmon |
| Öring | = | trout |

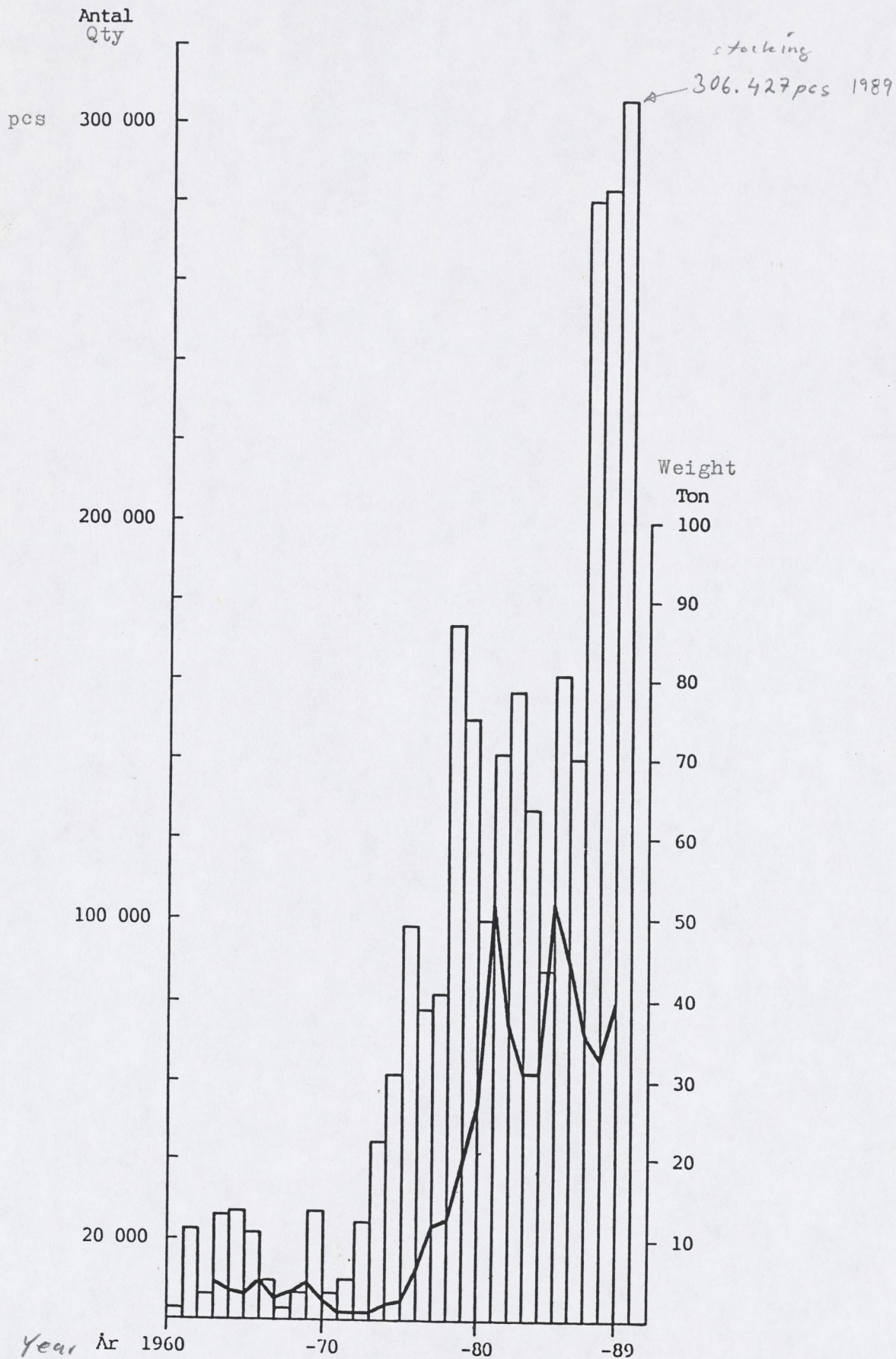
UTSÄTTNING OCH FANGST

Stocking av salmon and trout in lake Vänern and river Klar to dec 31st 1989

□ Utsättningar av lax och öring i Vänern och Klarälven t o m 1989 (306 427 st)
pcs

— Fångsten av lax och öring i yrkesmässigt fiske i Vänern t o m 1988

The catch of salmon and trout by professional fisherman to Dec 31st 1988



2 photos
Sweden - fishes



Angler: Mr. Patrik Holmesson
15 year.

Hometown: Alafors
Westsweden

Date of rodcatch: March 8, 1990
Place of catch: Sköld River (small),
down town Alafors, in connection
with Göta River (big).

Rainbow trout

Weight: 4.340 grammes.
certified scales.

Totallength: 72 cms

Girth: 47 cms

Empty stomach

Breeding male in spawning colours.

Photo: Kent Andersson
Norumshöjd 11 bv
417 45 Gothenburg
Sweden



Godda 14.75 kg

Rick
Utv

Northern pike - *Esox lucius*. 1989
Weight: 11,75 kgs. Length: 116 cms
Date of catch: Sunday November 5.
Place of catch: Lake Vänern, south
part, outside city Vänersborg, Sweden
Method of catch: Trolling, wobbler.
Angler: Mr. Göran Ottosson from the
town - Brålanda, Dalsland,
Sweden

19

Photo: Kent Andersson
Norumshöjd 11 bv
417 45 Göteborg
Sweden

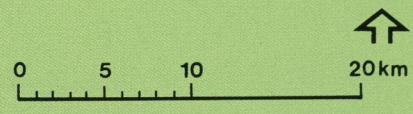
Hollinger Corp.
pH 8.5

VÄNERN

— a sea in the middle of Sweden

Legend

-  Tourist information
-  Guest harbour
-  Harbour (large, for commercial traffic)
-  Rubbish bins
-  Drinking water
-  Aid radio station
-  Nature reserve
-  Bird sanctuary
-  Fish sanctuary; perch-pike (see p. 11)
-  Fish sanctuary; salmon and trout (see p. 11)



IMPORTANT

In an emergency

Telephone: Dial 90 000 and ask for "Sjöräddningen" (Sea Rescue)

VHF radio: Call Göteborg Radio on channel 16

PR radio: Call base radio station and nearby boats on channel 11A

Aid radio stations and telephones are marked on yachting charts.

If you change your plans: telephone, drop a line, or use the communication radio. Then your family won't need to worry and unnecessary rescue exercises can be avoided.

ALWAYS wear a life jacket.

ALCOHOL — A THREAT TO SAFETY



Most boating accidents involve alcohol. Putting out to sea when drunk and drinking out at sea is irresponsible. You endanger your own and others lives.

Facts about Vänern

| | |
|-------------------------------|------------------------------|
| Area | 5 650 km ² |
| Greatest depth | 106 m |
| Volume | 153 km ³ |
| Distance Karlstad—Vänersborg | 82 n. miles (approx. 150 km) |
| Length of coastline | 2 000 km |
| Islands, islets and skerries | approx. 22 000 |
| Water level (above sea level) | 43,16—44,85 m |
| (Nautical chart ref. level) | 43,80 m |

Göta river/Trollhätte canal:

| | |
|------------------------------|------------------------|
| Rainfall area | 50 000 km ² |
| Distance Vänersborg—Göteborg | 51 n. miles (93 km) |
| Average water flow | 544 m ³ /s |
| Electricity production | 1,3 TWh/year |
| Number of locks | 6 |
| Minimum depth | |
| — in channel | 6,3 m |
| — in locks | 5,8 m |
| Breadth of channel | 40—50 m |
| Ships max. length | 88 m |
| Ships max. depth | 5,3 m |
| Ships max. breadth | 13,1 m |
| Max loading capacity | more than 3 500 tons |

AROUND VÄNERN

About 350,000 people live in the 16 municipalities around Vänern and Göta river. Here is a presentation of the municipalities and their largest companies. (The information in brackets indicates sector and number of employees.) The tourist offices in the various municipalities can give you information about places of interest, facilities etc. You can find the addresses here.

SÄFFLE:

Population: 18,200
Largest companies:
 Billeruds Bruk (pulp and paper, 385)
 Swanboard Masonite (wood fibre products, 350)
 Electrolux Constructor (engineering products, 315)
 Euro-Control Källe (engineering products, 225)
 Säffle Karosseri (bus body-work, 215)
 ☎ Billerudsgatan 3-7, tel 0533 - 106 00, 816 66

ÅMÅL

Population: 13,100
Largest companies:
 Elektrolux CE AB (vacuum cleaners, 210)
 Sv Elektromagnet (electrical ignition systems, 253)
 SJ Huvudverkstad (railway repairs, 285)
 Dal Väst (contract automatic lathing, 130)
 Nordiska Kardan AB (cardan axles for vehicles, 120)
 ☎ Hamngatan 5, tel 0532 - 170 98, 170 00

MELLERUD

Population: 10,400
Largest companies:
 Häfrestroms AB (coated printing paper, 444)
 Hellbergs dörrar (fire doors, gates, 154)
 ☎ Landsvägsgatan 55, tel 0530 - 116 70, 120 50

VÄNERSBORG

Population: 35,800
Largest companies:
 Teli (telephone products, 930)
 Holmens Bruk Vargön (paper, 600)
 Wargön Alloys AB (iron alloys, 311)
 Toppfrys (frozen vegetables, 275)
 VBG-produkter (trailer couplings, 230)
 ☎ Hamnplan, tel 0521 - 715 41

TROLLHÄTTAN

Population: 49,500
Largest companies:
 SAAB SCANIA AB (cars, 9 300)
 Volvo flygmotor AB (airplane engines, 3 400)
 GMA Printing Systems (graphic printing presses, 280)
 CERBO AB (plastic packaging, disposable products, 250)
 Wärtsilä Diesel AB (diesel engines, 220)
 ☎ Malgöbron, tel 0520 - 140 05, 870 00

GRUMS

Population: 18,200
Largest companies:
 Gruvöns Bruk (pulp, cardboard, paper, 1665)
 Stora Timber (sawmill products, 215)
 ☎ Kommunhuset, tel 0555 - 116 94

KARLSTAD

Population: 74,500
Largest companies:
 FFV Ordonance Div Grovkaliber (defence materials, 900)
 Konsum Karlstad (685)
 Valmet KMW (paper-machines, 500)
 KF Affärsavdelningen (food stuffs, 450)
 Svenska Rayon (rayon fibre, 390)
 ☎ Tingvallagatan 1 D, tel 054 - 19 59 01, 19 59 02

HAMMARÖ

Population: 12,900
Largest companies:
 Billerud AB, Skoghallsverken (pulp, cardboard, paper, chemical products, 1 610)
 Passac (paper sacks, 150)

KRISTINEHAMN

Population: 26,100
Largest companies:
 KaMeWa (engineering products, 680)
 Saab-Scania (engineering products, 650)
 Bäckhammars Bruk (pulp paper, 350)
 Casco Nobel (chemical products, 350)
 Teli (telephones, telex machines, 320)
 ☎ Västerlånggatan 22, tel 0550 - 105 73, exch. 153 40

GULLSPÅNG

Population: 6,300
Largest companies:
 Vänerply AB (wood sheets, 282)
 Nimoverken (engineering products, 125)
 Wabco-Westinghouse (brake systems, 108)
 ☎ Alhöjden, tel 0511 - 207 86, 0506 - exch. 306 80

MARIESTAD

Population: 24,300
Largest companies:
 Elektrolux AB (domestic machines, 1 145)
 Holmens Hygien AB (soft paper, 1 124)
 AB Dekorationslist (metal products, 182)
 SCA-emballage AB (corrugated cardboard, 133)
 ☎ Hamnplan, tel 0501 - 100 01

GÖTENE:

Population: 13,000
Largest companies:
 Dafgårds AB (food stuffs, 670)
 Arla AB (dairy products, 534)
 Bröderna Larsson (plastic articles, 255)
 AB Götenehus (wooden houses, 200)
 Rockwool AB (insulation material, 171)
 ☎ Centrumhuset, tel 0511 - 592 10

LIDKÖPING

Population: 35,100
Largest companies:
 Lidköpings mek verkstad (metal products, 579)
 Rörstrand (porcelain, 525)
 PLM AB (plastic products, 346)
 Sandvik AB (metal products, 230)
 Armco-Bundy Rör AB (metal products, 180)
 ☎ Gamla Rådhuset, tel 0510 - 835 00



LILLA EDET

Population: 12,000
Largest companies:
 Edet AB (soft paper, 750)
 Inlands AB (cardboard boxes, 180)
 ☎ Josuadalsvägen 3, tel 0520 - 502 42, 503 04, exch. 514 40

GRÄSTORP

Population: 5,900
Largest companies:
 Jörnlius Konfektion AB (clothing, 85)
 AB Vingbröd (food stuffs, 35)
 Knutsilplåt AB (metal products, 30)
 ☎ Torget 1, tel 0514 - 105 63, exch. 113 30

ALE

Population: 23,400
Largest companies:
 ESB Tudor AB (batteries, 850)
 EKA NOBEL AB (chemicals, 770)
 AB Wicanders (cork and vinyl tiles, 260)
 Ledu AB (car accessories, fittings, 140)
 Carlmark AB (ropes, twine, 110)

BOATS FOR HIRE

Köpmannebro båt och kanotuthyrning
 Pl 815
 464 00 MELLERUD
 Tel. 0530 - 311 10, 310 97

BT-Marin
 Box 86
 464 00 MELLERUD
 Tel. 0530 - 309 98

Vågens båtuthyrning
 Boteredsvägen 2
 462 00 VÄNERSBORG
 Tel. 0521-169 92

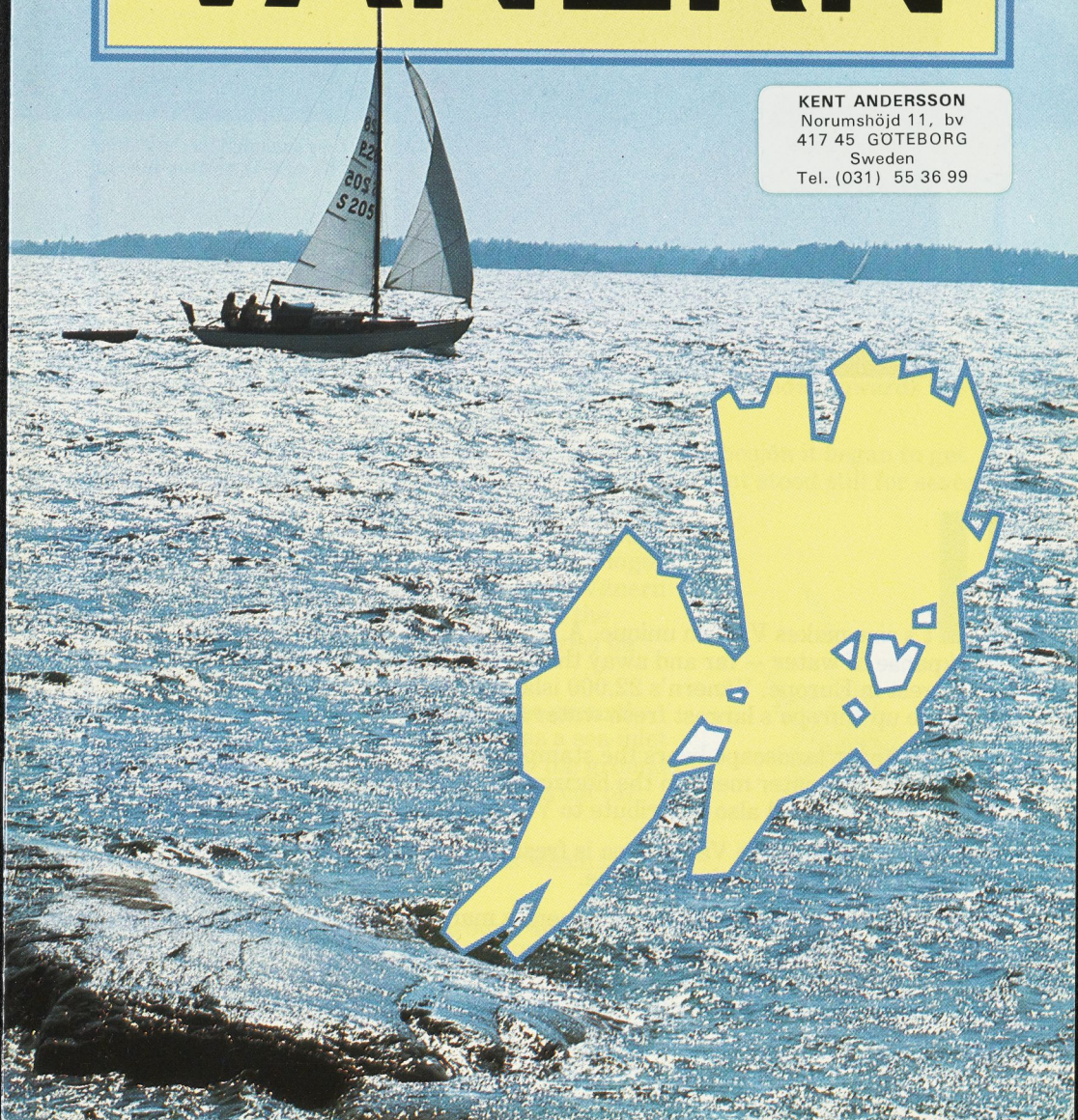
Vänercharter
 Rudsvägen 7
 654 63 KARLSTAD
 Tel. 054 - 15 14 50

English

SOME INTERESTING FACTS ABOUT

VÄNERN

KENT ANDERSSON
Norumshöjd 11, bv
417 45 GÖTEBORG
Sweden
Tel. (031) 55 36 99



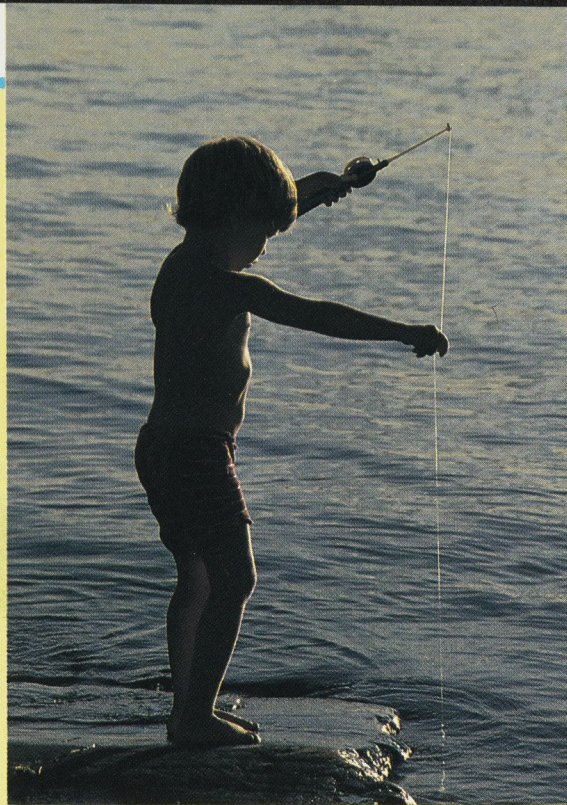


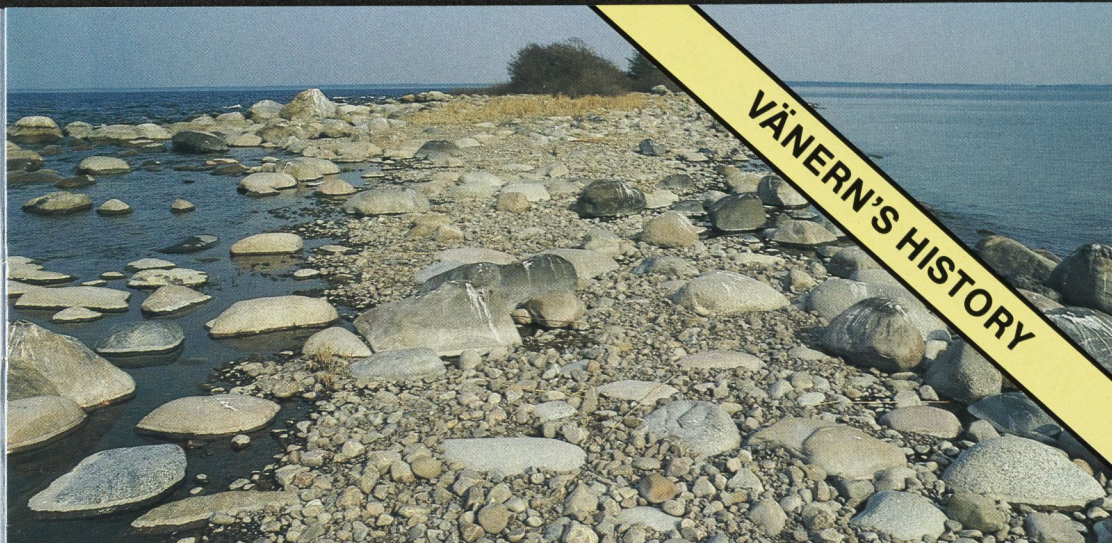
Photo: Kjell Westerdahl

It's size makes Vänern unique. A more than 5600 square kilometer expanse of water — far and away the largest lake in Sweden and the third largest in Europe. Vänern's 22,000 islands, islets and skerries together make up Europe's largest fresh water archipelago.

The Vänern landscape bears the stamp of the sea. It's shores are coasts, and sky and water meet on the horizon. Fisheries and merchant shipping are extensive and also contribute to Vänern's character as an inland sea.

But the water in the Vänern sea is fresh, and compared with the "real" sea Vänern is tiny and vulnerable.

This leaflet gives an account of Vänern's many assets, and what we can do to protect them.



Hindens reef (Hindens rev), on the west side of Kålland, was formed during an interruption in glacial melting. (Photo: Claes Grundsten/N)

From glacial sea to fresh water lake

The main features of the Vänern area were formed towards the end of the last ice age, 11.000–12.000 years ago, as the edge of the ice receded towards the north.

But when the edge of the ice lay across what is now Dalbosjön it began to get colder again and the ice stopped melting. The glacial front stood still for several hundred years. Boulders, gravel and sand, which the ice had carried with it, gathered in a long ridge along the edge of the ice. Today this glacial fringe zone can be traced right across Sweden. In Vänern it forms Hjortens point (*Hjortens udde*) on the Dalsland side and Hindens reef (*Hindens rev*) on Kålland.

Once the ice had receded the level of the ground began to rise. To begin with Vänern was a sea inlet with salt water. Around 8000 years ago the ground level had risen so much that the inlet was cut off from the sea. Vänern became a lake.

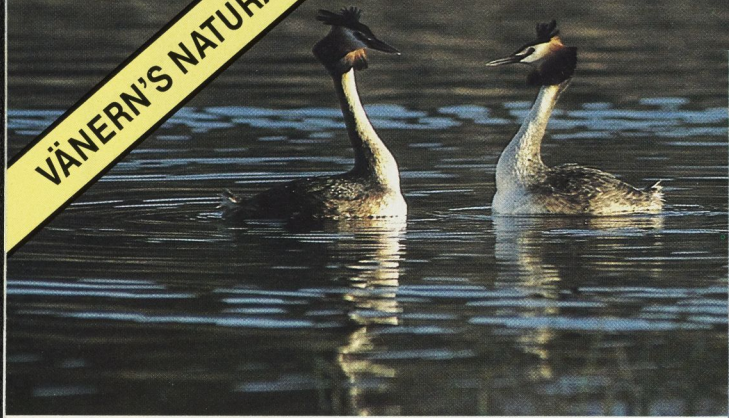
"Greater Vänern" covered wide areas which today are dry land.

Today the surface of Vänern is around 45 metres above sea level. The ground level is still rising, by 3,5 mm per year at Karlstad and by 2,6 mm per year at Vänersborg.

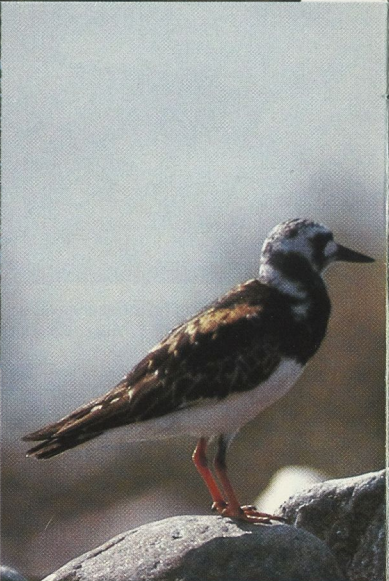
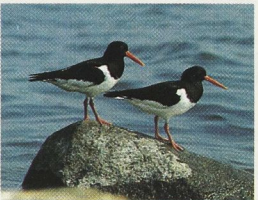


Greater Vänern about 7000 years BC.

VÄNERN'S NATURAL LANDSCAPE



Great Crested Grebes courting (above, photo: Ulf Risberg/N). The Oyster-catcher (left) is one of Vänern's sea bird species (Photo: Bengt Lundberg /N)



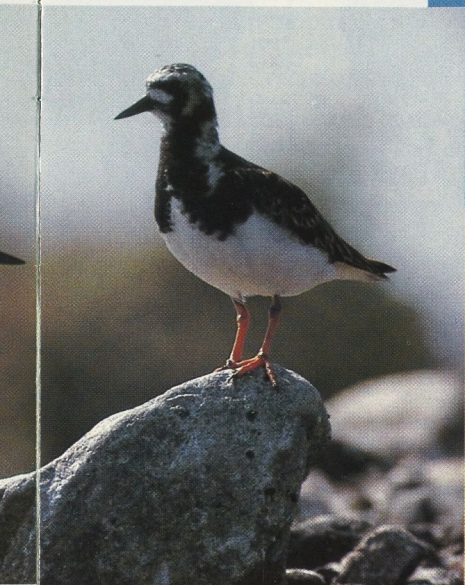
Nature is their home

Vänern's shores and archipelagos have a rich and fascinating plant and animal life. Most species living here are typical of the lakes of southern Sweden. But here you'll find something else too – a touch of the seaside.

It's estimated that over 70,000 pairs of 62 different species of water and marsh fowl are breeding around Vänern! Here are just a few of them. The Vänern landscape is their home and they depend entirely on their living environment remaining clean and undisturbed.

Purple Loosetrife (above right) brings colour to the shore line during the late summer. Bell Heather (right) thrives best nearer the sea but can be found along the shores of Vänern (Photo: Tore Hagman /N, Edgar Eriksson/N).

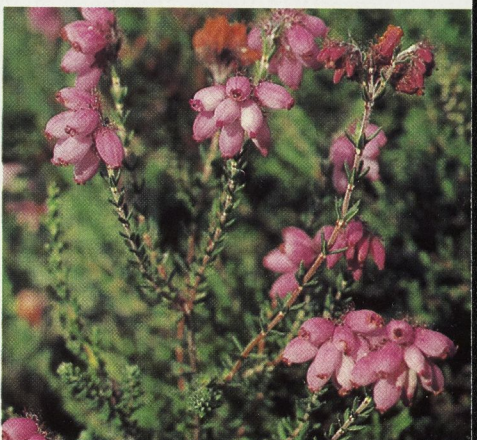
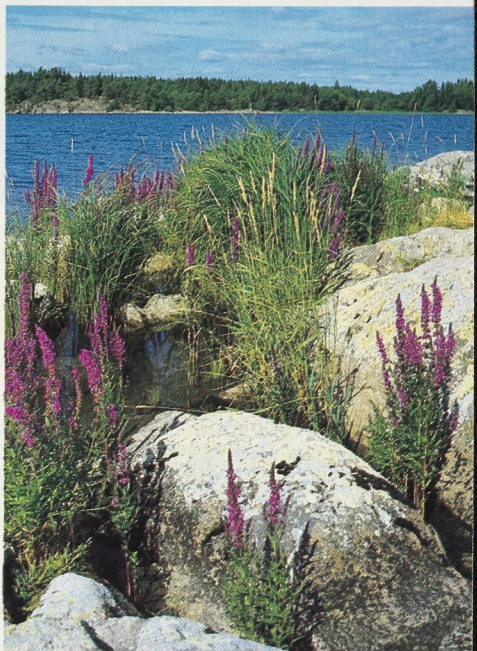
Turnstone (below), yet another species of sea bird on Vänern, and the Arctic Tern which is otherwise to be found mainly along the coasts and in the mountains (Photo: Torbjörn Lilja /N).



The Turnstone frequents bare skerries and is sensitive to disturbance during the breeding season.

Birds only

It's during the breeding season that the birds are particularly sensitive to disturbance. In order to protect them there is a series of bird sanctuaries on Vänern. Within these areas it is prohibited to go ashore or approach within 100 metres of the land during spring and early summer (usually 1 April—31 July). The bird sanctuaries are marked on the yachting chart and on the map accompanying this brochure. They are also indicated by yellow signs along the shores.



SHIPPING ON VÄNERN



Down the Göta river by cargo boat. Inset: a profile of the route Gothenburg—Vänern with the locks in Lilla Edet, Trollhättan and Vänersborg. (Photo: Trollhätte kanalverk)

160 000 lorry loads

Almost four million tons of freight per year are shipped along Vänern/Göta river, the equivalent of 160 000 lorry loads. The amount of freight has been the same since the end of the 1960's but as ships have become bigger, the number of trips has decreased. Today ships with a load of up to 3900 tons can pass through the Trollhätte canal.

Freight going up the Göta river consists of oil products, raw materials for forest industries, coal, fertilizers, chemicals etc. Down the river go paper, pulp, sawmill products, iron ore, grain, stone and general cargo (mainly machines). Since 1974 Vänern has been open to traffic all the year round.

The five ports of Karlstad, Lidköping, Kristinehamn, Gruvön and Otterbäcken are the largest and are responsible for 4/5 of the total freight turnover.

Vänern has one of the lowest accident rates among Swedish shipping routes. But an accident involving discharge of oil or chemicals could cause serious damage to drinking water supplies, fisheries, bird life and all other life in and around Vänern/Göta river.

In order to further improve safety and reduce the risk of dangerous pollution, all ships carrying generally dangerous or environmentally harmful cargos must be piloted on Vänern. This applies to other shipping too if the captain is not familiar with the lake's shipping lanes.

Some canal history

The building of the Trollhätte canal was one of the first major steps towards industrialising the whole of Sweden society. The idea of building a canal had been thought of as early as the 1500's, but it wasn't until the year 1800 that the continuous shipping route Vänern—Gothenburg could be opened. In one swoop the whole of Central Sweden with its mines, forest areas and agricultural districts moved closer to the continent.

The first ironworks had already started. These quickly grew and multiplied. Gradually the scope of businesses increased. Sawmills, pulpmills and papermills were built. Further canal systems into Dalsland, Värmland and to lake Vättern opened up new regions for industrialisation.

Vänern has been open for year round traffic since 1974. State ice breaker "Ale", here seen at Vänersborg, keeps the shipping lanes navigable. (Photo: Trollhätte kanalverk)

- 1607 LOCKGATES AT LILLA EDET OPEN THE ROUTE BETWEEN GOTHENBURG AND ÅKERSTRÖM (BELOW TROLLHÄTTAN).
- 1752 KARLS GRAV CANAL WITH BRINKEBERGSKULLE LOCK IS OPENED.
- 1800 TROLLHÄTTE CANAL FINISHED. SHIPS OF UP TO 140 TONS CAN NOW GO ALL THE WAY FROM GOTHENBURG TO VÄNERN.
- 1844 RECONSTRUCTION OF THE CANAL INCREASES CAPACITY TO 300 TONS.
- 1910 THE FIRST POWER STATION IS OPENED AT OLIDEN IN TROLLHÄTTAN.
- 1916 FURTHER RECONSTRUCTION INCREASES CAPACITY TO 1500 TONS.
- 1937 COMMENCEMENT OF WATER LEVEL REGULATION IN VÄNERN ACCORDING TO POWER GENERATION REQUIREMENTS.
- 1975 THE CANAL IS DEEPEMED AND IMPROVED. CAPACITY IS INCREASED TO OVER 3500 TONS.



Fish worth millions

Today Vänern's fisheries are big business. The number of full-time fishermen is currently around 200 and a further 3500 people are registered for fishing with nets. Together they catch almost 1000 tons of fish with a value of a good 9 million kronor.

Vänern fish have even become an export commodity. Pike are exported to France by plane!

Most economically important is the catch of whitefish for making caviar, followed by perch-pike, landlocked salmon and brown trout. The most important by volume are whitefish, burbot, northern pike and perch-pike.

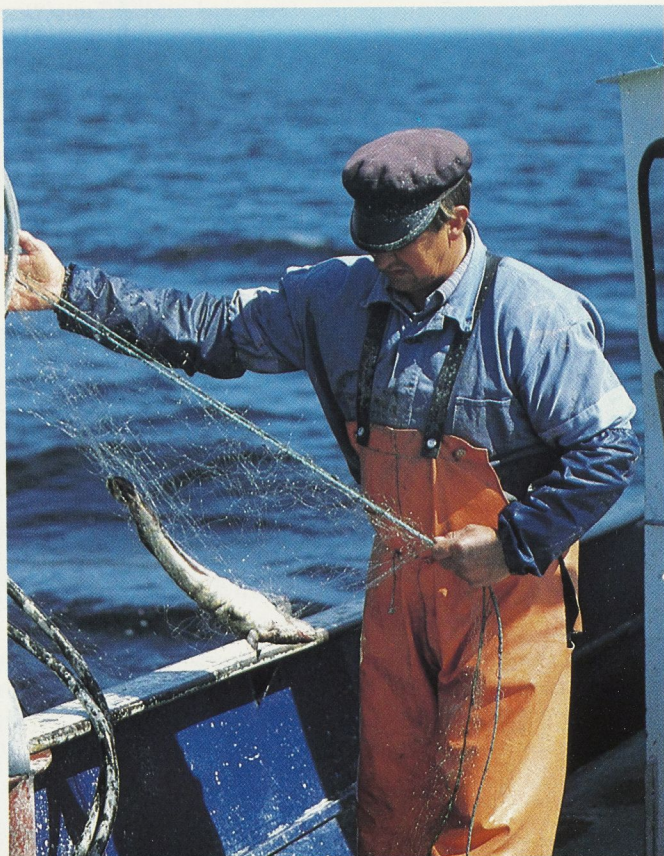
The development of hydro-electric power and water regulation reduced the stock of fish, especially landlocked salmon, brown trout and perch-pike. Power stations hinder the salmon's spawning migrations, so when the rivers started to be regulated, just after the turn of the century, the size of the salmon catch dropped drastically.

In recent years around 150,000 landlocked salmon and brown trout small fry have been released in the lake every year, which has increased the catches again.

Birger Johansson, fisherman from Spiken on Källandsö, examines and empties the nets. (Photo: Anders Eriksson)

Fishing is a profession

Vänern's fisheries provide many people with full-time work and an important source of income for many more. Nets and other tackle are valuable. Watch out that your boat doesn't damage any fishing tackle!



650 000 people drink the water

650 000 people get their daily water from lake Vänern and the Göta river. For their sake it is important that the water is protected from poisons and other pollutants.

Discharge of pollutants from industries and built up areas increased up until the end of the 1960's. Decomposition of organic discharges from forest industries and sewage used up the oxygen in the water. Oxygen shortage killed the fish and life on the lake bed.

Forest industries, the worst offenders, also discharged mercury and other poisons.

Mercury builds up in plants and animals. The worst affected are beasts of prey like pike and ospreys. The poison level grew so high that it was forbidden to sell fish caught in large areas of Vänern, so called "blacklisting".

Today the pollution has been considerably decreased and only a few small parts of the lake are "blacklisted".

The greatest treat to the water today is the use of fertilizers in agriculture, and the risk of accidents involving ships or industries, as well the many small, more or less unknown discharges of chemicals.



Photo: Agneta Arnesson-Westerdahl

Protect Vänern's water

Oil and petrol pollution have devastating effects both on the quality of the water and for all water life. Protect Vänern's water — handle oil and petrol with the greatest care!

Should you discover large quantities of oil on the water: report immediately to the coast-guard (*Kustbevakningen*), central emergency service (*larmcentralen*) or sea rescue (*sjöräddningen*) (see page 15)!

It is both discourteous and prohibited to throw rubbish into other peoples' drinking water. Furthermore it's unnecessary. Rubbish skips can be found at all harbours and rubbish bins at many places in the archipelago (see accompanying map).

THE VÄNERN BANG



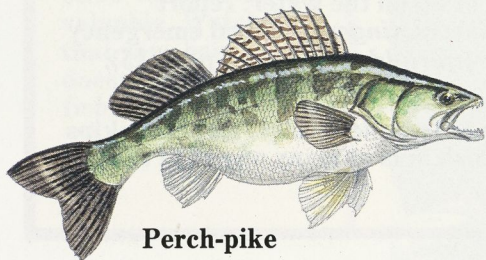
Wise fish protection work and new fishing methods can make catches like this daily fare for the Vänern angler. Photo: Jan Olsson.

First class angling

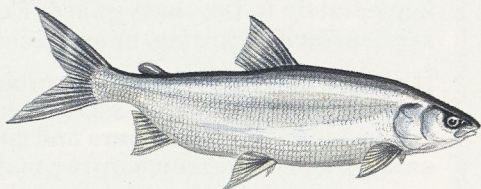
Vänern's pleasant and varied surroundings make it a very attractive angling arena, which is attracting more and more attention both within and beyond Sweden's borders. The wide variety of species also plays a part in this: there are 35 different species of fish in the lake.

All the year round fishing goes on in Vänern for several of the angling worlds most highly valued fish, eg. northern pike, perch-pike, perch, whitefish, burbot as well as brown trout and landlocked salmon.

Illustration: Peter Grahn



Perch-pike



Whitefish

These last two in particular, unusually large fresh water varieties of the Atlantic salmon family, are now focusing angling interest on Vänern. These are the subject of trolling, mainly during spring and autumn when the fish appear close to the surface and the land. A new angling technique in European waters, deep trolling, also makes the battling salmon varieties available for anglers during the summer.

Even for the shore bound angler opportunities will improve considerably with increased implantation of fish and regulation of net fishing. And not only in the case northern pike, perch-pike and perch but even more so for landlocked salmon and brown trout.

Angling facilities in the form of harbours and launching ramps are available in most municipalities around the lake. Some local authorities even hire out boats (see reverse of accompanying map). Up-to-date fishing information is available from tourist offices and sports shops.

Fishing regulations

There are no restrictions on normal fishing with hand tackle in Vänern, either from the shore or from boats. However your tackle should not have more than ten hooks.

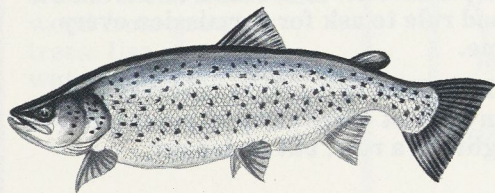
Foreigners just have the right to fish with handtackles.

A minimum size applies to landlocked salmon and brown trout. Fish which are shorter than 50 cm from the tip of the nose to the furthest point of the tail fin may not be landed. For perch-pike the minimum measurement is 40 cm.

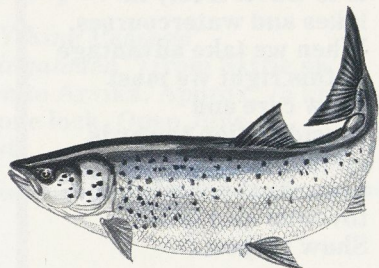
During the period 15 July—31 December it is prohibited to fish for salmon and trout at the mouth of the river Klarälv. A similar ban applies during the period 1 September—31 December at the mouth of the river Gullspångsälv. See accompanying map!

There is a ban on perch-pike fishing in 14 different areas of Vänern during parts of May and June when the fish are spawning. See accompanying map!

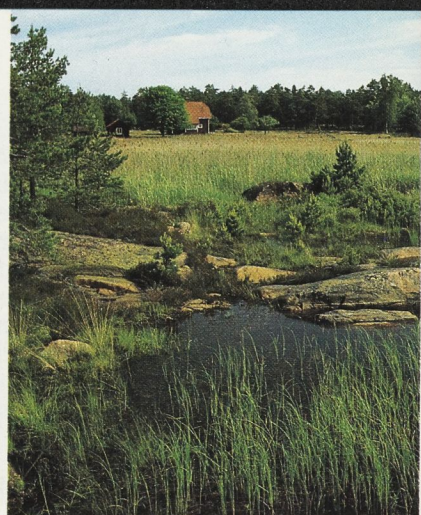
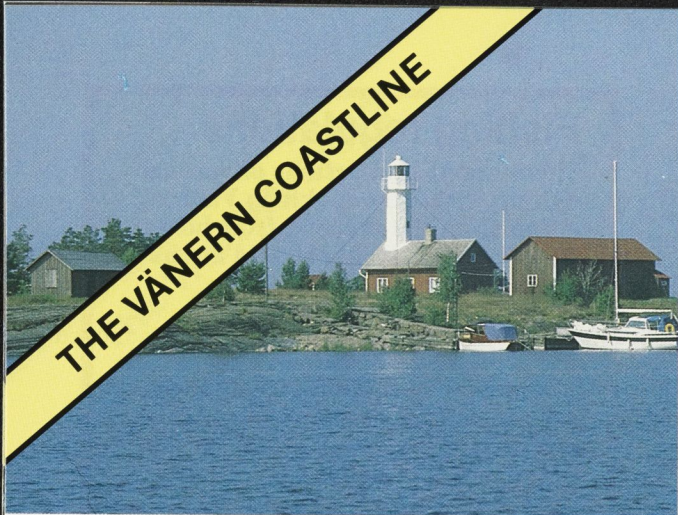
Special regulations apply to fishing with nets and fixed tackle. The Värmland County Fisheries Board (*Fiskenämnden i Värmlands län*) tel. 054 - 15 68 00 can give you information.



Brown trout



Landlocked salmon



22 000 islands and skerries

Vänern boasts Europe's largest lake archipelago. There are 22 000 islands and skerries in the lake. The archipelago is a fantastic asset for everyone who appreciates nature, sailing, fishing, bathing and the outdoor life. And an invaluable natural asset to take care of!

The right of common access

One of the opportunities that the right of common access gives us is to travel freely in lakes and watercourses. When we take advantage of this right we must show care and consideration towards all living things, towards the locals and towards each other. Show respect.

Camping, anchoring

You usually don't need any permission to camp for one night away from villages, private gardens and cultivated land. Use this opportunity wisely. If you want to camp longer you must ask the permission of the land owner. It's a good rule to ask for permission every time.

Within Vänern's nature reserves you can in most cases camp or moor for two nights in a row, but no longer.



Läckö mansion on Källandsö is one of the most popular spots. Art exhibitions at times. In foreground, the guest harbour. (Right. Photo Axel Ljungqvist/N). Djurö, in the middle of the lake, a collection of islands with interesting nature, eg, fallowdeer. Between the islands there are vast stretches of reeds with a varied range of bird-life. (Middle. Photo Axel Ljungqvist/N). Söötjöjan (Söökojan), lighthouse at the entrance to Karlstad. (Left. Photo Lars Furuholm)

Lighting fires

Avoid lighting fires in the summer, there is often a total ban on fires. *Never* light fires on bare rocks: the heat cracks them. *Never* take wood from growing trees. Use *plenty* of water to put out your fire.

The way ahead

The Göta river and the Trollhätte canal link Vänern with the sea to the west. There are canals leading in three different directions from Vänern.

The Göta canal

From Sjötorp on Vänern to Vättern, and beyond to the Baltic. The canal between Vänern and Vättern is 70 km long and has 21 locks. Open May—beginning of September.

Dalslands canal

From Köpmannebro on Vänern to the system of lakes in Dalsland—Nordmarken. Approx. 250 km long, 29 locks. Open June—August.

Säffle canal — river Byälven

”The Viking Passage” (“*Vikingaleden*”) from Säffle on Vänern to Arvika. Approx. 75 km long, one lock, Open June—August.

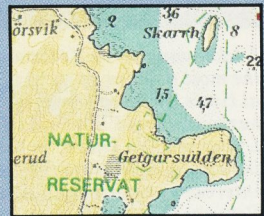
IMPORTANT

Nautical charts

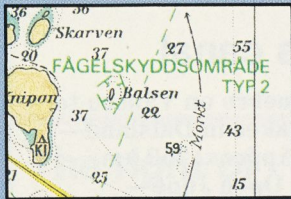
It goes without saying that you should never set out on Vänern without a nautical or yachting chart. The charts are sold by the Swedish Shipping and Navigation department's agent (usually bookshops) in the larger towns as well as by Trollhätte Kanalverk and Göta kanalbolag.

Have respect for nature reserves...

Some of the finest areas have been set aside as nature reserves to be protected and taken care of. All reserves are worth visiting but remember there are special regulations for camping, anchoring, making fires and picking flowers. It is against the law to break these rules.



...and birds sanctuaries



You are not allowed to visit Vänern's bird sanctuaries during spring and early summer. The sanctuaries are marked on the yachting charts.

There are two types of sanctuaries in the Värmland archipelago "Fågelskyddsområde typ 1" where you must not go on land or approach within 100 m of the shore. For "Fågelskyddsområde typ 2" the same

rules apply as in the southern part of the lake, ie. the limits of the prohibited area are indicated on the yachting charts.

Usually the prohibited dates are 1/4—31/7. At Prästöarna islands in Millesviks archipelago visiting is prohibited 1/4—30/9.

Nature reserves and bird sanctuaries are marked on yachting charts.

Let others know your change of plan

If you change your plans for your trip on Vänern, let your family know! Drop them a line, telephone or use the communication radio. In this way you can avoid causing unnecessary concern and possibly prompting costly rescue exercise in vain.

If an emergency:

If you need help:

If someone else is in danger:

ALWAYS RING 90 000 AND ASK FOR "SJÖRÄDDNINGEN"

(Sea rescue)

Telephones are marked with a prominent red symbol on yachting charts.

Aid radio stations can be found on Djurö in Malmberg Harbour and on the Timmeröarna islands outside Karlstad.

If you have radio equipment on board:

VHF: Call "Göteborg Radio" on channel 16.

PR-radio: Call the nearest base radio station on channel 11A. If you don't know which station is nearest — make a "general call" and ask if anyone hears you. If you can't get contact on channel 11A — try channel 16. There you can reach other base radio stations and boats.

Weather on Vänern

A storm on Vänern is no game! Listen to the sea weather reports on the radio which are transmitted on P1 at the following times: 06.20 (week days), 08.15, 13.00, 16.30, 18.30, 21.50.

More facts about Vänern

You can read more about Vänern in "Skärgårdar i Vänern" (Landin et al/ Prisma) and in the brochure "The Swedish Lake District", which is available from tourist offices around the lake.

SOME INTERESTING FACTS ABOUT VÄNERN

tells you, simply and in brief, what you won't find on nautical charts or in tourist brochures: about Vänern's shipping, fisheries and wildlife. About safety in boats and nature, about Vänern as a source of drinking water, shipping route and recreation area.

Vänern is a large and valuable natural asset. All those who use it, from tanker captains to sail-board enthusiasts and bathers, have a responsibility. With this brochure in your hand you are a little better equipped to take your share of that responsibility.

Länsstyrelsen i Skaraborgs län
Box 405
542 01 MARIESTAD
Tel. 0501 - 600 00

Länsstyrelsen i Älvsborgs län
462 82 VÄNERSBORG
Tel 0521 - 700 00

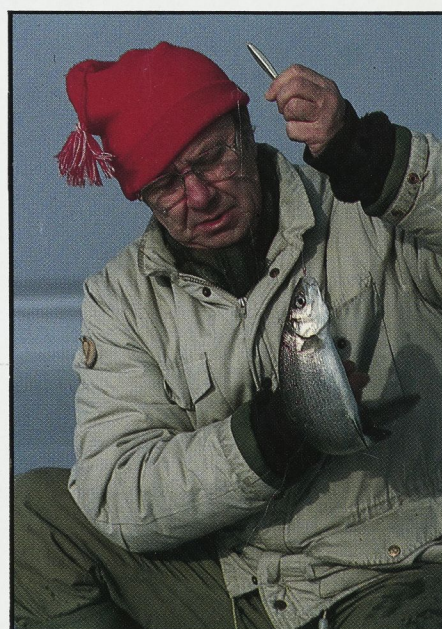
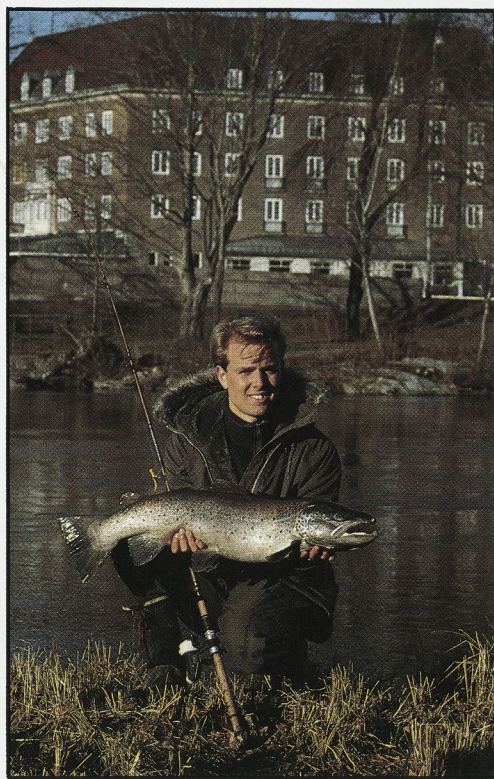
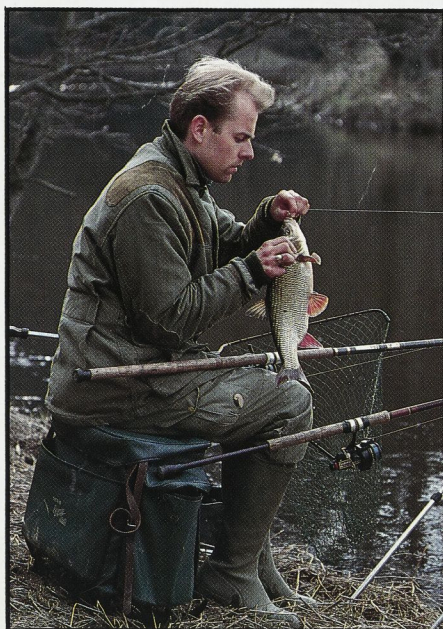
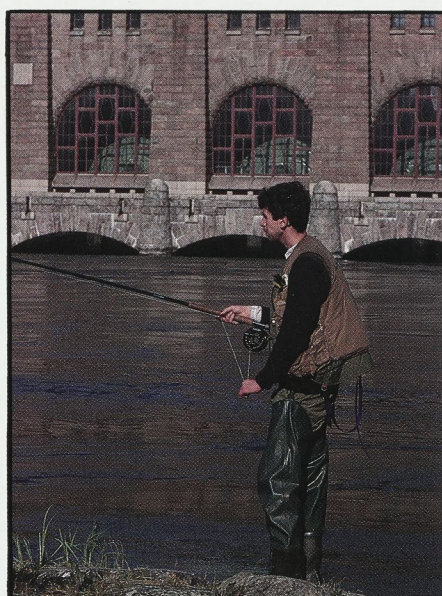
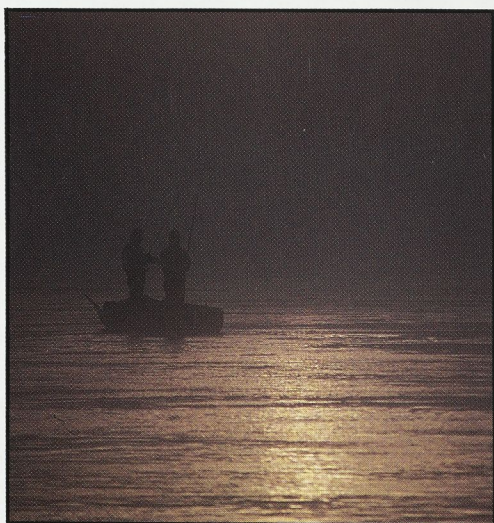
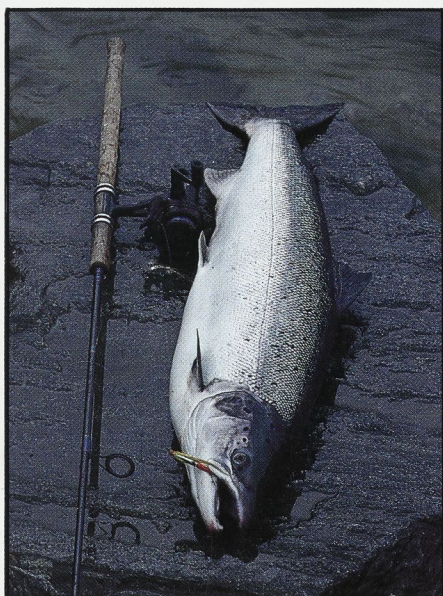
Länsstyrelsen i Värmlands län
651 86 KARLSTAD
Tel. 054 - 19 71 00

KENT ANDERSSON
Norumshöjd 11, bv
417 45 GÖTEBORG
Sweden
Tel. (031) 55 36 99

SPORTFISKE

= Sport Fishing

I SÖDRA DALSLAND, VÄNERN & GÖTAÄLVDALEN





Fiskelycka – i västsverige finner Du fiskelandet med närhet för hela familjen.

Fiskelandet omfattar södra Dalsland, sydvästra delen av Vänern och Göta älvdalen ner till Lilla Edet och Ale med omkringliggande naturområden.

Här kan Du som sportfiskare trollingsfiska efter lax och öring på Vänern. Blåsiga dagar spinn- eller flugfiskar Du laxen och öringen på fiskrika platser i Göta Älv. Du har också möjlighet att spinn- och flugfiska i något av de många äldfiskvatten som finns i området.

Vill Du meta eller sportfiska gädda, abborre och karpfiskar finns flera åar och sjöar i området.

Pröva på havsfiske någon dag, Du har bara en timmes väg till Västkustens bästa fiskevatten i mellersta Bohuslän.

Har du familjen med Dig, finns många andra fritidssysselsättningar för dem om de inte skulle vara "fiske-tokiga". På bara en timmes resväg har Du Göteborg, lika kort resväg till Borås "Knalleland" och Skara Sommarland samt till Dalsland – vårt Sverige i miniatyr.

Göta Älv – vattenvägen mellan Vänern och Västerhavet.

När inlandsisen drog sig tillbaka för ca 8000 år sedan befolkades älvdalen snabbt av stenåldersfolk, som till stor del levde på älvens rika förekomst av fisk. Förr kunde storlax på uppåt 30 kg fångas. Idag är Göta Älv fortfarande ett av Sveriges fångstrikaste lax- och öringvatten.

Vid Lilla Edet finns första vandringshindret för lax och öring. Under sommaren och hösten bedrivs här ett intensivt och välorganiserat sportfiske från såväl båt som land. Strömmarna nedströms kraftstationen bildar fina ståndplatser för fisken. Här fångas uppåt 1000 laxar och öringar årligen. Varje dag under sommaren visas laxtrappan och kraftstationen.

I Trollhättan hindras havslaxens och öringens vandring av Trollhättefallen. På sommaren och under hösten utgör den ca 900 meter långa sträckan nedströms fallen och kraftstationerna en stor lockelse för laxfiskaren. Årligen fångas uppåt 1000-talet laxar, varav flera i tio-kilosklassen. Både spinn- och flugfiske bedrivs längs stränderna.

Platsen är en av de naturskönaste utefter hela Göta Älv – ett "Grand Canyon" i miniatyr.

Nedströms Vargön finns gott om storvuxen öring, regnbåge och gädda. Bästa tiden för fiske är vår och höst. Vid Vänerns utlopp i Göta Älv uppströms Vargöns kraftverk finns många fina fångstplatser för både öring och regnbåge.

Göta Älv har inte bara fina bestånd av lax och öring. I älven finns ytterligare drygt 20 arter (inkl. skrubbskädda!), vilket gör att den mellan Vänern och Västerhavet kan erbjuda alla sportfiskeintresserade en mångfald av fina fiskeupplevelser.

Vänern – västeuropas största sjö med 30-talet olika fiskarter.

Vänernsviken erbjuder Dig, som söker bra och variationsrikt sportfiske många utmärkta platser. På mycket kort gångtid finner Du utmärkta möjligheter till trollingsfiske och attraktiva platser för spinnfiske efter lax, öring, abborre och gädda samt för mete efter karpfiskar.

De senaste åren har ca 150.000 lax- och öringsyngel –smolt– satts ut varje år. Den nybildade stiftelsen "Laxfond för Vänern" kommer från 1989 att öka utsättningen av lax och öring med sikte på att göra Vänern till Europas bästa sportfiskesjö i mitten av 90-talet. Vänernsviken erbjuder trollingsfiskaren fyra trailerramper. Någon är alltid vindskyddad.

Här följer några exempel på attraktiva fångstplatser i Vänernsviken, som markeras på kartan enligt följande.

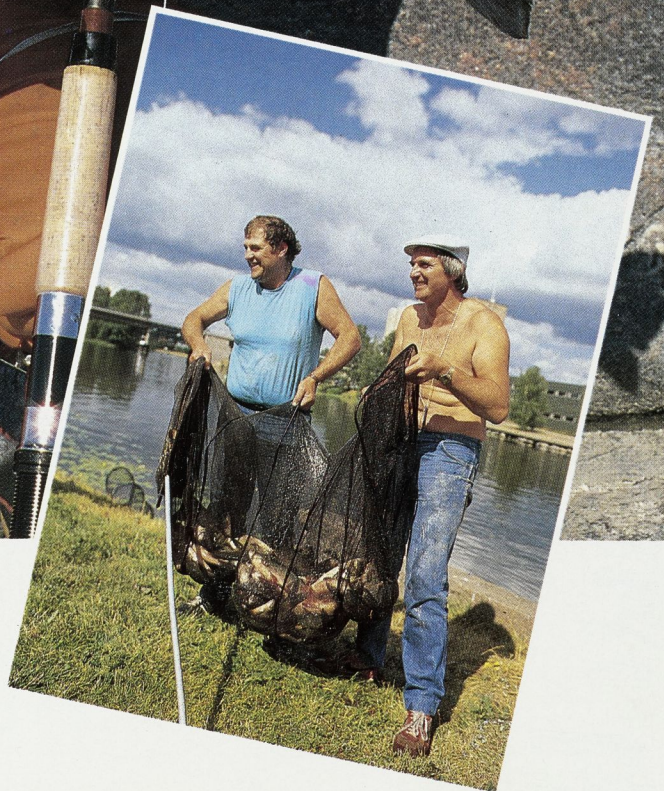
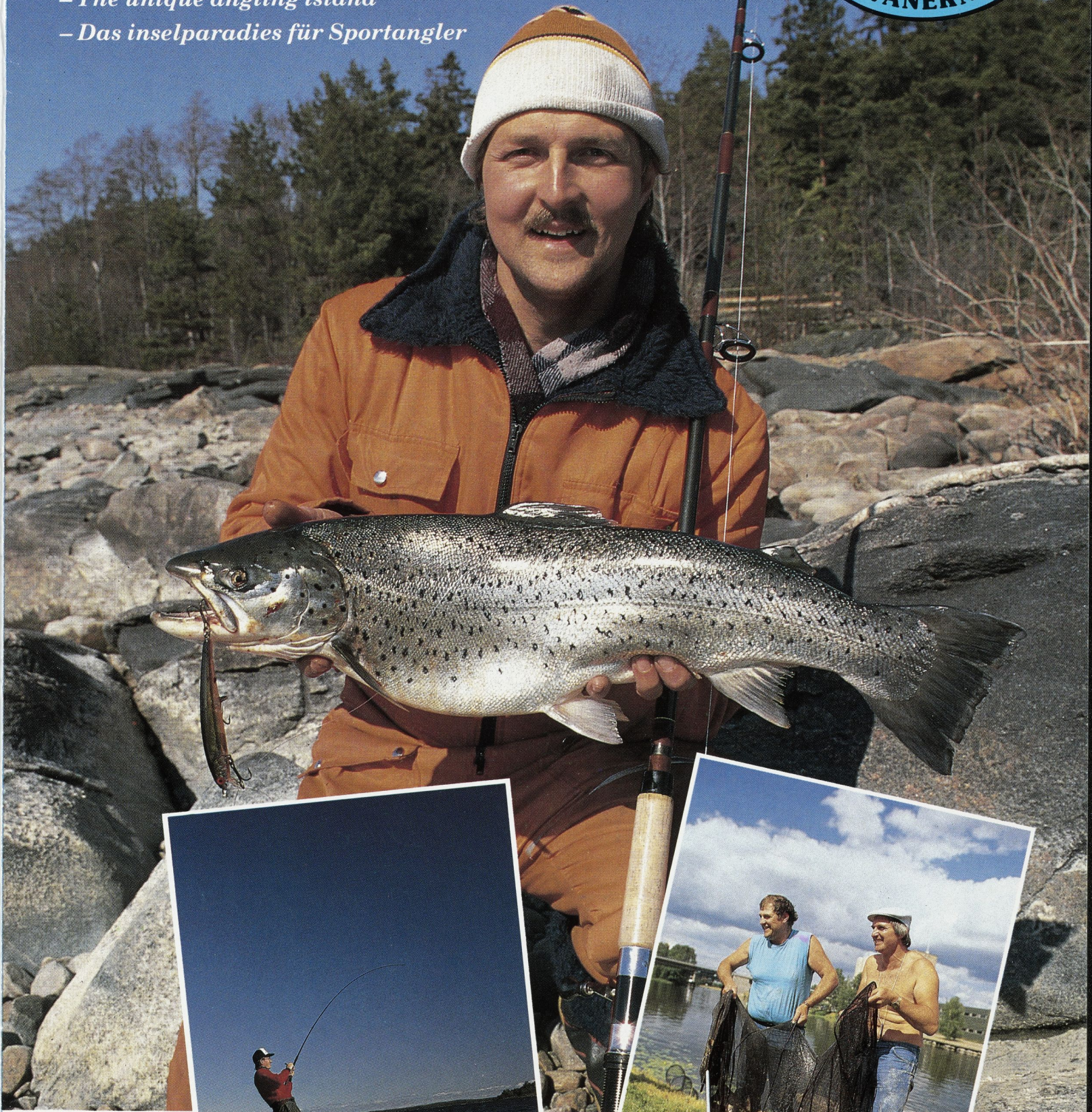
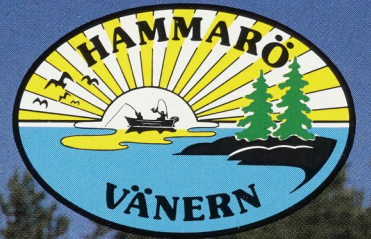
1. "Älvsuget" – under våren bra trollingsfiske. Hela sommaren bra spinnfiske efter stor gädda och abborre. Under början av maj chans till fångst av asp som kommer ner för att leka.
2. "Grunnarna" – under vår och höst bra trollingsfiske. Sommaren bra båtpimpel efter abborre.
3. "Hallesnipen" – brant klippstup. Trollingsfiske hela året. Bra isfiske. OBS! Fågel skyddsområde – landstigningsförbud 6 maj-31 juli.
4. "Gälleudden" Trollingsfiske hela året. Mycket bra isfiske. Udden erbjuder underbara badstränder.
5. "Vänernäs" – vattnet mellan Kåpeudden och Bockholmarna är mycket fiskrikt. Här kan man under lugna höstdagar se hoppande lax och öring.
6. "Vassbotten" – vegetationsrik vik med goda förutsättningar för mete efter sarv, brax, sutare m fl karpfiskar.



Sverige · Sweden · Schweden

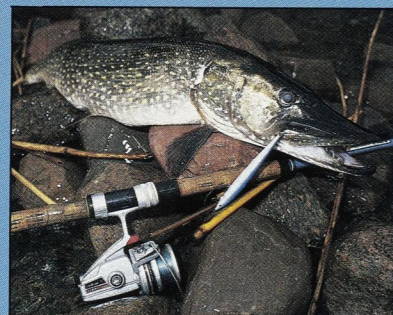
HAMMARÖ

- Den unika sportfiskeön
- The unique angling island
- Das Inselparadies für Sportangler





I Klarälvens delta lurar storfisken i skuggan av de överhängande träden.
 In the Klarälven river delta lurks the big fish in the shadows of the overhanging trees.
 Im Flußdelta des Klarälven lauern kapitale Fische im Schatten überhängender Bäume.



Abborre och gädda hör till de vanligaste av sportfiskarens byten.
 Perch and pike are some of the most common catches.
 Barsch und Hecht zählen zu den häufigsten Beutefischen der Sportangler.



Trolling är metoden att söka fisken på vänerhavets stora ytor.
 Trolling is the way to seek the fish on the open waterplains of lake Vanern.
 Das Schleppfischen ist die Angelmethode für den offenen Vanersee.



Lake VÄNERN
 north part

| Teckenförklaring/Key/Zeichenerklärung | |
|---------------------------------------|--|
| | Fiske Angling Angeln |
| | Gästhamn Guest harbour Gasthafen |
| | Sjösättningsramp Launching ramp Slipanlage |
| | Turistinformation Tourist information Touristik-Information |
| | Stugor, självhushåll Self-catering cottage Ferienhäuser für Selbsthaushalt |
| | Egen badstrand Your own beach Eigener Badestrand |
| | Rum Rooms Zimmer |
| | Matservering Restaurant Gaststätte |
| | Kafé Cafeteria Cafeteria |
| | Motionsslinga Training trail Markierter Trimm-Pfad |



I jakt på den berömda idyllen. Fågellivet är rikt.
 In the hunt for the famous idyllic vegetation of the delta.
 Auf der Jagd nach dem artenreichen Delta besonders vielfältig.



Den berömda Klarälven.
 The famous idyllic delta.
 Der kampfstärke...



Vinter och g...
 Vinter...
 the ice...
 Das i...
 Mär...



I Klarälvens delta lurar storfisken i skuggan av de överhängande träden.
In the Klarälven river delta lurks the big fish in the shadows of the overhanging trees.
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Lake VÄNERN
north part



I jakt på den berömda iden finner metaren sin plats i deltalands frodiga växtlighet. Fågellivet är rikt.

In the hunt for the famous ide the angler finds his place in the luxuriant vegetation of the deltalands. The birdlife is enormous.

Auf der Jagd nach dem kampfstarken Rohrkarpfen kommen Posenangler im vegetationsreichen Deltagebiet voll auf ihre Kosten. Das Vogelleben ist hier besonders vielfaltig.



Den berömda Klarälvs-iden!
The famous ide!
Der kampfstärke Rohrkarpfen!



Vinterfisket från is är mycket populärt. Abborre, lake, sik och gädda är den vanligaste fångsten.

Wintertime ice-fishing is very popular. Perch, burbot, whitefish and pike are the most common fish to catch from the ice.

Das Eisangeln ist bei uns sehr populär. Barsch, Aalquappe, Maräne und Hecht sind die häufigsten Fänge.

| Teckenförklaring/Key/Zeichenerklärung | |
|---------------------------------------|--|
| | Fiske Angling Angeln |
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| | Motionsslinga Training trail Markierter Trimm-Pfad |



Stugby och camping vid Vänerns strand.

- Sjösättningsramp
- Gästhamn
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- Kaffe
- Minigolf
- Fina bad
- Fiske
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VÄLKOMMEN TILL HAMMARÖ DEN UNIKA SPORTFISKEÖN.

Vid Vänerns norra strand, just där den mäktiga Klarälven mynnar, ligger Hammarön.

I dess 5.000-åriga historia har fisket spelat en viktig roll. Den rikliga tillgången på bl.a. lax i kustvattnen och älvdeltat var orsak till att människan en gång slog sig ned här. Annu långt in på 1900-talet var fisket en betydande näring för Hammaröns befolkning.

Dessa fisketraditioner lever vidare idag, om än i modernare former. Nu för tiden är det nämligen sportfisket som lockar. Och inte är det så underligt, för vad din favoritmetod än må vara; spinn, mete, fluga, trolling... kan du med framgång praktisera den i vattnen på och kring Hammarön.

Lägg så därtill en unik naturmiljö som trots sitt centrala läge är gudomligt befriad från trängsel och stress så förstår du varför alltför sportfiskare söker sig hit för att njuta sin sport. Att det dessutom finns utmärkta möjligheter till alternativa aktiviteter för såväl familjer som enskilda gör ju inte saken sämre.

Vänern, Västeuropas största sjö, bjuder ett varierat fiske av sällan skådat slag. I en storslagen skärgårdsmiljö med ett intressant växt- och djurliv kan du fiska efter inte mindre än 35 arter av vilka många när rekordstorlek. Vare sig du väljer trolling efter den berömda insjöloxen, lättspinn på ytjagande norsabborre eller flugfiske på verkliga monstergäddor i våröversvämmede lekvikar, finner du få ställen som kan mäta sig med Vänern. Är metet på vitfisk ditt gebit söker du dig till de grunda, varma vikarna där braxen, mört, sarv, sutare och björkna i kompakta stimmel drar fram efter vasskanter och stränder.

Att fiska i Klarälvens delta är en upplevelse för sig. Här finns, liksom i Vänern, de flesta arter. Framför allt är det den berömda Klarälvs-iden som får hjärtat att slå volter på metare från när och fjärran. Ryktet om denna vackra fisk och dess fantastiska fighterens egenskaper har på några år nått långt utanför landets gränser. Här lurar också grova gäddor i djuphålur och bakvattnen och har du tur kan du få på en lax eller öring som startat sin långa lekvandring mot forsarna i norr. I detta område med tät växtlighet finns också chansen att under ljumma sommarnätter stifta bekantskap med den rundbukiga och valsmakande gösen. Helt säkert får du även se någon av deltalands många bavarar ljudlöst simma upp för strömmen i älven.

Att fiska i ett nytt vatten kan till en början vara svårt. Att komma till ett helt nytt fiskeområde är ofta ännu svårare. Så ej på Hammarön. Här får du personlig information av duktiga guider som från första dagen visar dig till rätta och informerar dig om fiskeregler mm. Du kan också hyra båt, om du så önskar, eller boka en guidad tur på Vänern med skeppare. Här finns även all den utrustning, beten m m du behöver, att hyra eller köpa.

Ditt logi utformar du efter egna önskemål. Camping, självhushåll i fina små stugor eller helpension på hotell. Här finns det mesta, till mycket rimliga priser.

Och kom ihåg, när än du besöker Hammarön önskar vi dig varmt välkommen.



Med denna broschyr har du fått en första presentation av sportfisket på Hammarön. Är du intresserad av ytterligare information angående bokningar, logi, säsong, alternativa aktiviteter m m. Kontakta då:

Karlstad Turistbyrå
S-651 84 Karlstad
Tel. 054 - 19 59 01/02

WELCOME TO HAMMARÖ, THE UNIQUE ANGLING ISLAND

Hammarö is situated by the north shore of lake Vänern, in the middle of the mighty Klarälven river delta.

Throughout its 5.000 years, fishing has played an important role. As a matter of fact the main reason that people once settled down here was the richness of salmon in the coastline waters and the river delta. Still well into the 20th century fishing was a considerable way to make a living for the people on Hammarö.

This proud fishing heritage is still alive, all though in other forms. Ever since the discovery of the unique possibilities for the noble art of angling, anglers from far and near have wet their lines in Hammarö waters. And you can understand why when you know that whatever your speciality is – coarse, game, casting, fly-fishing, trolling... you can practise it with success on Hammarö.

Add to that a unique environment that, despite its central location, is divinely free from crowding and stress, you will understand why more and more anglers come here to enjoy their sport. There are also plenty of possibilities for alternative activities in the area for both families and individuals.

Lake Vänern, western Europe's largest inland lake, invites you to a fishing adventure of incredible quality and proportions. In a magnificent archipelago with a unique flora and fauna you can fish for no less than 35 different species with several reaching record weights. Whether you choose downrigger trolling after the famous landlocked salmon, ultra-light spinning for fat schooling perch, heavy duty fly fishing for real monster pike in spring flooded shallow bays, you will find few places that equals Sweden's lake Vänern. If coarse fishing is your sport try the shallow, narrow warmwater bays where bream, silverbream, roach, rudd, crucian carp and tench in huge shoals swim along shorelines and weedbeds.

To fish the Klarälven river delta is an experience in itself. Here, as in lake Vänern, you will find most species of fish. But above all it's the famous Klarälven ide that makes the heart jump on both local and foreign anglers. The reputation of this beautiful coarsefish and its incredible fighting qualities has during a few years spread far beyond the Swedish borders. Former world angling champion Kevin Ashurst said after his first visit to the Klarälven river "The ide is the nicest looking and best fighting fish I have ever caught". The delta is also the place where tenacious pikes lurk in the holes and if you are lucky you may hook a big Vänern brown-trout or salmon that started its spawning run towards the rapids of the north. During hot summer nights in this jungle-like area you can also get acquainted with the thick bellied and delicious zander. You are also likely to see some of the deltalands many beavers silently swimming up the gentle streams.

To fish a new water can be tricky. To fish a whole new area can be even more difficult. Not so on Hammarö. From the day of your arrival skilled guides give you personal information about the best places, fishing rules etc. You can also rent a boat, or book a guided tour with a skipper on lake Vänern. You can also buy or rent whatever you need in equipment, baits and so on.

You choose your accommodation as you please. Camping, self-catering in nice cottages or full-board in a hotel. You will find most alternatives, at very reasonable prices.

And remember, whenever you decide to visit us in Hammarö you will be very welcome!

This brochure is a first presentation of Hammarö "The Unique Angling Island". If you are interested in further information concerning booking, accommodation, season, alternative activities etc. Please contact:

KENT ANDERSSON
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WILLKOMMEN AUF HAMMARÖ – DEM INSELPARADIES FÜR SPORTANGLER

Am Nordende des Vänersees, im Mündungsbereich des imposanten Klarälv-Stromes, liegt Hammarö.

In der 5000jährigen Geschichte dieser Insel hat das Fischen eine große Rolle gespielt. Das reiche Vorkommen von u. a. Lachs in Uferzonen und Flußdelta war einst Grund für die Ansiedlung von Menschen. Bis weit in das 20. Jahrhundert hinein war das Fischen eine wichtige Erwerbsquelle für die Bewohner Hammarös.

Diese Fischertraditionen sind noch immer lebendig, wenn auch in anderer, moderner Form. Heute ist es das Sportfischen, das viele Angelenthusiasten wie Spinnfischer, Fliegenfischer, Schleppfischer und Posenangler zu den fangträchtigen Fischwassern auf und um Hammarö lockt.

Hinzu kommt eine wohl einmalige Natur, die trotz ihrer "zentralen" Lage eine Oase der Ruhe ohne Streß und Gedränge darstellt. Auch dies ist ein Grund, weshalb immer mehr Angler zu uns finden. Ein weiterer Pluspunkt: Ob Sie nun solo, mit Angelfreunden oder Familie reisen – das Angebot an alternativen Aktivitäten ist ausgezeichnet!

Der Vänern, Westeuropas größter See, bietet eine abwechslungsreiche Fischwaid. In einer einmaligen Schären- und Inselwelt mit interessanter Fauna und Flora erwarten den Angler nicht weniger als 35 Fischarten, wobei viele Arten Rekordexemplare hervorbringen. Ob Sie nun mit der Schleppangel den berühmten Binnenlachsen, mit leichter Spinnaustrüstung den an der Wasseroberfläche stinte jagenden Barschen oder mit Fluggerte und Streamer den kapitalen Hechten in vom Frühjahrshochwasser überschwemmten Laichbuchten nachstellen – es gibt nur wenige Angeltgewässer, die sich mit dem Vänern messen können! Und in den warmen, seichten, verschifften Buchten sorgen Brachsen, Rotaue, Rotfeder, Schleie und Güster dafür, daß auch Grund- und Stippangler zu ihrem Recht kommen.

Das Angeln im Delta des Klarälven ist ein Erlebnis für sich. Hier sind wie auch im Vänern die meisten Arten vertreten. Besonders der bekannte Klarälvs-Rohrkarpfen läßt den Puls eines jeden Posenanglers höher schlagen! Der Ruf, der diesem schönen, kampfstarken Fisch anhäftet, ist weit über die Grenzen Schwedens hinaus bekannt. Aber hier lauern auch kapitale Hechte in Uferunterspülungen und Rückströmungen. Wenn Sie Glück haben, geht Ihnen sogar ein Lachs oder eine Seeforelle an den Haken, die hier ihre Laichwanderungen zu den Flüssen des Nordens aufnehmen. In dieser Region dichten Unterwasserpflanzenbewuchses läßt sich in lauen Sommernächten auch Bekanntschaft mit dem rundbuckligen, wohlgeschmeckenden Zander machen. Und sicher werden Sie einen der zahlreichen Biber zu Gesicht bekommen, die das Delta bevölkern.

Das Angeln in einem unbekanntem Gewässer kann anfangs oft schwierig sein. Auf Hammarö ist das anders. Hier erhält der Gastangler vom ersten Tage an individuelle Informationen, Tipps sowie Hinweise auf Standplätze durch erfahrene Angelführer. Auch die Fischereibestimmungen werden erörtert. Natürlich können Sie ein Boot mieten; selbst Charterboote für einen Angeltörn mit Guide auf dem Vänern sind erhältlich. Außerdem können Sie Ihre Angelausrüstung bei uns ergänzen oder mieten und Köder kaufen.

Für Ihre Unterbringung ist bestens gesorgt, ob Campingplatz, Ferienhaus mit Selbsthaushalt oder Vollpension im Hotel. Und das alles zu günstigen Preisen! Herzlich willkommen!

Mit dieser Broschüre haben wir versucht, Ihnen einen ersten Eindruck von den vielfältigen Angelmöglichkeiten auf und um Hammarö zu vermitteln. Weiterführende Informationen hinsichtlich Buchung, Unterbringung, Saisonzzeiten, alternativen Aktivitäten etc. erhalten Sie von:



Kroppefjäll – ett av västsveriges största sammanhängande vildmarksområden.

Kroppefjäll är rikt på sjöar, ca 250 st flertalet dock tämligen små. Brålanda Sportfiskeklubb förfogar över fiskerätten i Kvarnemadsjön, Övre Idetjärn, Myrsjön (södra delen), Ötjärn, Olasvattnet och Stora Hallesjön. Sjöarna ligger ca 2 mil från Brålanda tätort. Flertalet har bilväg ända fram. God tillgång på både abborre och gädda, i några av sjöarna finns restbestånd av inplanterad öring. Fiskekort säljs bl a i Kaffestugan Granan under juni, juli och augusti. Över Kroppefjäll finns också en mycket bra turist- och fritidskarta.

Öresjö

På bara 15 minuters resavstånd från Trollhättan finner Du Öresjö. En mycket fiskrik sjö med fina bestånd av abborre, gädda samt även sutare, brax, sarv m fl karpfiskar. Här kan Du hyra båt och ta med hela familjen ut på ett avkopplande fiske efter våra vanligaste sötvattensfiskar.

Kronoparken Halle – Hunneberg

Hallsjön

På Halleberg vid Vargön ligger Hallsjön. En naturskön skogssjö med bl a mycket regnbåge. Vänersborgs kommun arrenderar sjön fr o m 1989. Under tiden maj-september kommer ca 2 ton regnbåge att sättas ut i omgångar ungefär var 14:e dag. Här har Du möjlighet att använda både spinnsjöt och flugan, samtidigt som Du kan få se någon av de många älgar som finns på berget. Du kommer nästan ända ner till sjöstranden med bilen. Flera grillplatser och vindskydd, liksom välröjda stigar, finns runt hela sjön.

Sjöarna på Hunneberg

På Hunneberg vid Vargön finns flera sjöar. I några av dessa, Igelsjön och Kvarnsjön, inplanteras årligen regnbåge, övriga innehåller mycket gädda och abborre. Fiskevattnen förvaltas av Domänverket och här gäller Domänfiskekortet. Missa inte att göra ett besök på Bergagårdens Naturum, Hunneberg. Utställning och servering.



Dalbergså, Nossan, Slumpån

Är Du intresserad av mete finns i området flera fiskrika åar. På våren och försommaren är dessa lekplatser för ett stort antal karpfiskarter. Grov brax, mört, färna, sarv, id m fl finns då i stora mängder i dessa vatten.

Liperedssjöarna

Liperedssjöarna ligger i Sjuntorp starx söder om Trollhättan. Fyra sjöar i ett naturskönt område med väl röjda stigar och rastplatser. I sjöarna finns inplanterad regnbåge och öring, dessutom grov abborre, sutare och ål.

Risveden – ca. 5 mil nordost om Göteborg

Stora Kroksjön

Omgivningen består av skogsmark av urskogskaraktär. Stränderna varierar mellan berg och moränmark.

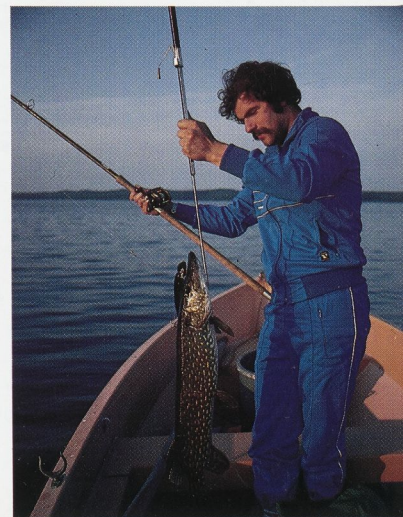
Sjön är mycket flugfiskevänlig och genom sin storlek lämpad för den som vill hitta sitt specialställe. Här finns regnbåge, öring, bäckröding och fjällröding.

Abborresjön

Omgivningen består av barrskog och sankta partier medan stränderna främst utgörs av berg och sten. I sjön finns regnbåge i normalstorlek (7 hg), fin bäckröding samt öring.

Havsfiske

En knapp timmes väg från Lilla Edet/Vänersborg/Trollhättan och Du är ute vid Sveriges västkust. Där kan Du ta turbotarna till de verkligt heta fiskeplatserna och fiska efter västerhavets alla fiskarter. Exempelvis torsk, långa, havskatt, sej, makrill och mängder av övriga arter.



Fiskeregler

Den som fiskar måste känna till de bestämmelser som gäller för fisket. Utöver bestämmelser som gäller för hela landet, finns lokala bestämmelser i länsfiskestadgan.

Allt normalt fiske med handredskap är fritt i Vänern, såväl från stränderna som från båt. Redskap får inte ha mer än 10 krokar. Utlänningar har samma fiskerätt som svenska medborgare. I övriga fiskevatten måste du ha fiskekort.

Minimimått

Den som fångar fisk som inte har det minimimått som anges skall genast släppa tillbaka fisken i vattnet.

Fiskekort

Information och försäljning

LILLA EDET
SFK LAXEN Tel. 0520/511 60

TROLLHÄTTAN
P-A Sport AB, Torggatan 1A
462 34 Trollhättan
Tel. 0520/171 51

VÄNERSBORG
Intersport, Kungsgatan 7
462 33 Vänersborg
Tel. 0521/109 06
Vargöns Järnhandel,
Lövvägen, 468 00 Vargön
Tel. 0521/201 30

Dessutom finns ett flertal försäljningsställen i Götaälvdalen som endast tillhandahåller fiskekort till lokala kortfiskevatten. Turistbyrå hjälper dig.

Turistbyråer i Götaälvdalen

Vi hjälper dig gärna om du vill veta mer.

ALE KOMMUN
Besöksadress
Bohus Centrum (12/6-7/8)
Älvängens Centrum (12/6-7/8)
Postadress
Box 142, 440 41 Nol.
Tel. 0303/300 00

LILLA EDETS KOMMUN
Besöksadress
Josuadalsvägen 3
Postadress
Lilla Edets Turist AB
463 00 Lilla Edet
Tel. 0520/597 91

TROLLHÄTTANS KOMMUN
Besöksadress
Stranna, Karl Johans Torg
(15/6-15/8)
Postadress
Kultur-fritidskontoret
461 83 Trollhättan
Tel. 0520/140 05 (15/6-15/8)
Övriga året 0520/870 00

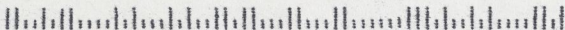
VÄNERSBORGS KOMMUN
Besöksadress
Hamnplan (15/6-15/8)
Postadress
Kultur- och Turistkontoret
Box 167, 462 22 Vänersborg
Tel. 0521/715 41 (15/6-15/8)
Övriga året
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Dr. Robert J. Behnke
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Colorado State University
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August 9, 1994

Dr. Robert J. Behnke
Department of Fish and Wildlife Biology
Colorado State University
Fort Collins, Colorado 80523

Dear Doctor Behnke:

A year or so ago I wrote you about an experiment in England early in this century wherein half of the brains of several trout were removed and the trout than seemed to act naturally. You very kindly wrote me and explained this phenomenon in a detailed letter.

At the time I was writing a book of trout fishing fiction, and while I did not use the information in it, it added to my knowledge.

I am sending you the result, entitled The Log Jam. I hope you will have time to read it. Just put it into the used book trade when you finish.

Very truly yours,

Harry H. Luton
Harry H. Luton

EAGLE-A

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