

Expedition Field Techniques

FISHES

by Brian W. Coad

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FISHES

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About the author

Brian W. Coad has worked in the field and laboratory on fishes for over 25 years and has led and participated in expeditions in Asia, Europe and North America. He works as a Research Scientist in ichthyology at the Canadian Museum of Nature, Ottawa and was the Curator of Fishes for the National Collection. Formerly he was an Associate Professor at Shiraz University, Iran where he taught Ichthyology, Vertebrate Zoology and General Zoology. His research interests centre on the systematics and zoogeography of the freshwater fishes of Southwest Asia, in particular Iran, the systematics of Cyprinidae (minnows and carps) and the ecology and systematics of fishes in unusual environments. Dr. Coad has published over 200 books, papers and popular articles on fishes. He has only been detained three times by military authorities while collecting in the field.

Cover illustration

The cover drawing is of *Schedophilus medusophagus* Cocco, 1839. Length 2.8cm. Collected by the Albatross at 27°49'N, 76°12'W, north of the Bahamas. Drawn by H. L. Todd. Taken from Jordan and Evermann (1896) "The Fishes of North and Middle America" courtesy of the Division of Fishes, Department of Vertebrate Zoology, National Museum of Natural History, Washington.

Section One

FISHES AND EXPEDITIONS

1.1 Introduction

Fishes are the most diverse group of vertebrates, numbering over 24,000 species, and are found in fresh and salt waters around the world from high mountain streams over 5000m to the depths of the oceans. This diversity means that little is known of the biology of many species and new species are regularly being discovered. This book is directed at those who wish to observe and collect fishes for systematic or ecological studies. The expensive and specialised world of the oceanographic expedition or experimental fishery survey is not dealt with here although many of the basic techniques are similar, except for the size/scale of the vessel and the fishes caught.

Fishes can be included in a general expedition's plans because of their ease of capture, their abundance, the simple preservation techniques required, the amount of data which can be derived from the preserved material later in a laboratory (thus leaving time for other organisms to be studied in the field), their value as indicators of water health, and because basic life history data can be acquired rapidly. Problems do exist however. The large number of species, the large size of some species, secretive habits, the heavy equipment needed for deeper waters, lack of regional or country guides, poorly known taxonomy, variations in abundance and species densities on yearly and seasonal bases, and the use of fishes by local people as a food resource can complicate access and studies. The important season for ecological work is often the spring when flood waters are high and collecting difficult.

1.2 What can be done

The expedition can make a considerable contribution to science by collecting fishes. Many smaller freshwater and shore fishes can be caught and preserved easily for later study. The ichthyofauna of many areas of the world is poorly known and the collections can fill gaps in museum collections of the host country or in any large national museum. The collection will serve to detail what species are found in a region, thus contributing to zoogeographical and biodiversity studies. The habitats and habitat requirements of species will be revealed by recording environmental data. The collection will give a measure of abundance such that conservation requirements can be determined and management plans formulated.

Systematic studies, both classical and molecular, can be carried out on collected material. A collection made in a study area where the expedition has a base camp for several weeks or months can contribute to the knowledge of life history and ecology of one to several species. Dietary choice of local people can be assessed with a view to recommending measures to conserve the food resource or increase intake of protein. Angler surveys can determine which species are being taken, when and in what numbers, leading to recommendations on catch limits and closed seasons. Local fishing methods can be described and their efficiency assessed. Fish kills through pollution or other causes can be analyzed. Even preserved specimens can be used to yield information on aspects of ecology such as parasites, age and growth, reproduction, and diet.

However it is essential to assess as objectively as possible what can be accomplished in the time available and with the equipment at hand. Behavioural studies requiring elaborate, controlled aquarium set-ups, and long-term tagging studies and intricate ecological experiments are unlikely to succeed.

1.3 Preparatory work

The first step in preparing for field work involving fishes is to familiarise yourself with the collection and recording equipment, its operation and repair. Some equipment is potentially fatal if misused, e.g. electroshockers. Using nets and other gear includes both the obvious element and a more subtle one; there is often a knack to using the gear which cannot be derived from books. Teamwork in net use is an important part of success. The field techniques should be tried out before departure, preferably with the aid of an experienced person.

Field guides should be obtained, studied with the aid of museum material and lists made of the species liable to be encountered. The localities of rare or unusual species can be determined from scientific papers; often only a few specimens have ever been collected and a surprising number of species are known only from a single specimen. In the absence of a field guide, it may be worthwhile to invest the time and effort to compile a key, written, photographic, or both, to the species liable to occur in the area of study. This may require expert help but can be an invaluable tool in assessing the ichthyofauna for rare or new species. It also serves to train you in the characters important in fish recognition.

Consult experts on the groups of fishes and on the area you plan to visit. *The Newsletter of Systematic Ichthyology*, Department of Ichthyology, California Academy of Sciences, Golden Gate Park, San Francisco 94118 annually lists current research projects of scientists working on fishes by group and by country. The Food and Agriculture Organisation, Via delle Terme di Caracalla, 00100, Rome, Italy is a source of information on fish and fisheries. This organisation has funded annotated and illustrated catalogues on a world-wide basis, e.g. "Sharks of the World", fish identification sheets for large areas of ocean, books, reports, surveys and other investigations of fishes in many parts of the world. *The Tropical Fish Hobbyist*, Neptune City, New Jersey publishes synoptic works on fish families and on areas of the world and reprints some of the older, classical guides. Other guides to the literature are listed in Section Eleven: Regional ichthyofaunas. *Zoological Record (Pisces)* or on-line computer searches can be used to bring this source up-to-date. Computer searches can be expensive and key words should be linked by geography (country, province, state or physical area), by the word fish or fishes, or even by selected groups of fishes using the scientific name for families. This reduces the number of "hits" and therefore the expense. The search can also be limited initially by asking for only the most recent one or two years to be searched. Most papers have extensive lists of references and this provides an entry point to the literature.

Many governmental and other organisations maintain a library of "grey" literature, unpublished manuscript reports used for planning purposes and these contain much valuable information on fish distributions and biology. Some of these may be available by writing to conservation, nature and fisheries organisations, angling clubs, commercial fishing companies, and museum, university and government libraries. An extended expedition should consider spending several days trying to track down such materials in the country where collections are to be made before heading out into the field.

The American Peace Corps often assisted in production of such reports and wrote them in English. The British Council has libraries in many countries and can be a useful source of books, papers and information.

Design experiments before you set out. Have them looked at by an experienced field biologist to check for feasibility in the time allotted.

Take first aid and vehicle and boat maintenance courses. A course in packing and shipping dangerous goods (formalin or alcohol preserved fish) is a legal requirement for transport of your collected material in some countries.

4 Expedition Field Techniques

Arrangements may have to be made to have formalin and other chemicals shipped especially to the host country, or bought there. Passenger airlines will not transport flammable alcohols and noxious formalin. Paraformaldehyde, a convenient powder form of formalin, can be carried more easily than heavy, liquid formalin. However, both this chemical and the anaesthetic MS-222 should be retained in their original, labelled containers with seals intact. Strange white powders are difficult to explain in a foreign language! A letter of explanation in the language of the host country can smooth the way.

Batteries for electroshockers contain acid which leaks easily and may not be acceptable by airlines. It is wise to check that suitable batteries are readily available in the host country. Buying batteries on arrival saves on weight too.

One of the most effective ways of operating in a foreign country is to cooperate or liaise with local institutions such as universities and museums. Indeed an official liaison may be a pre-requisite of the host country. Local scientists can smooth the way by pointing out customs which should not be transgressed, provide information on habitats and species which are poorly known, act as or provide interpreters, and be fruitful collaborators in writing up the results.

It is essential that a collector obtain the necessary licences for scientific purposes before setting out. It can take 6 months to over a year to obtain these! They include national and state or provincial licences, and also licences for parks and protected areas. Fish collecting licences may be so specific that they limit what can be caught or determine precisely which specimens in a series can be taken out of the country. Such restrictions should be ascertained before extensive planning of an expedition is undertaken. Angling licences may also be needed if any of the more active or large species are to be taken with rod and reel. Import licences are often required for specialised scientific equipment. Liquid nitrogen, dry ice and the various chemicals associated with tissue sampling present problems for airline transport and customs clearance. Living or frozen tissues may require special permits for their importation. Transport of live fishes is subject to various restrictions and licensing.

The Convention on International Trade in Endangered Species (CITES) regulates the movement of threatened, rare and endangered species between countries, even as preserved specimens. There are various categories for such species and movement of some is forbidden. The purpose is to prevent the capture and sale of endangered species. Customs officials have no way of

knowing whether your packed and sealed material falls under the CITES convention and may impound your collection. A CITES certificate can prevent this. Information about CITES and UK customs requirements can be obtained from the Department of the Environment, Tollgate House, Houlton Street, Bristol BS2 9DJ.

A letter of intent from an internationally recognised museum stating that materials from the expedition will be deposited there often helps in exporting specimens. The host country is then aware that you have academic credibility, that the specimens are not for a private collection or commercial venture, and that the specimens are available for study by their own scientists through loans.

Host countries may have a collection of appropriate papers in their museums or universities but often this is not the case. Copies of the relevant literature make excellent gifts for scientists, creating academic links, and may lead to further work on the fishes.

Learn the local names for fish, fish species, water bodies, net types, sizes and colours. A few phrases of greeting in the local languages should be committed to memory. Ideally one team member should be fluent in the host country language.

1.4 Ethics

The expedition members are responsible for carrying out their studies in an ethical and scientific manner. The American Society of Ichthyologists and Herpetologists (1987) has published guidelines for the use of fishes in field research with a bibliography on this topic.

Collections should be made for a specific and valid purpose. Habitats should not be damaged; for example, rocks turned over in pursuit of fish should be replaced to conserve the sheltering habitat and the food organisms clinging to the undersurface. Care should be exercised particularly when collecting rare species or in unusual or restricted habitats. For example, a hot spring of limited area which may contain a unique population or even an endemic species should not have its fish fauna denuded. Care should be taken in the breeding season when habitat disturbance involved in capturing fishes or removal of too many breeding adults can result in a severely depleted population.

Gill nets and trap nets can catch large numbers of fish. They should be checked at regular intervals to avoid excessive mortalities. Gill nets should

be firmly anchored so they do not drift away. Drifting gill nets of non-rotting plastic continue to catch fish which decay and drop out, sometimes for years.

Fish should always be anaesthetized before being dropped into formalin as a humane measure. This also reduces struggles which can splash formalin onto the unwary and personal injury is less likely from spines or teeth. Anaesthetics include MS-222 (tricaine methanesulfonate), quinaldine and etomidate among others and instructions from the manufacturer should be adhered to for safe usage and dosage. Immersion in ice water will numb fish too. Schreck and Moyle (1990) have a recent review of fish anaesthesia.

If fish are to be handled and then released, anaesthesia can reduce stress. Fish should never be handled with dry hands as this removes protective mucus and scales. Many fish species live constantly surrounded by the thick and cushioning medium of water and have little contact with hard objects. Merely catching them will cause massive mortalities. This is unavoidable when making preserved collections but large seine hauls should not be made for tagging studies in such species as the catch will mostly die.

Experiments must be designed to minimise distress for the fishes. Analgesics and anaesthesia are a necessary part of some experimental designs (Ross and Ross, 1984).

Fishes can be marked with tags, by fin clipping, freeze marking, or by permanent or semi-permanent stains. Semi-permanent stains or minor fin clipping is probably sufficient for short-term expeditionary uses but team members should be sensitive to concerns local anglers or food fishers may express about any of these processes. Use of radioisotopes as tags requires licensing and special training courses. Their potential hazards to fish and people must be carefully assessed. A predator may eat much of a school of radioactive fish, for example, and then be caught unknowingly for human consumption.

An examination of the literature on the country or area under study may reveal adequate collections of specimens preserved in a museum and available for study. More time can then be spent on searching for species or localities which are inadequately represented in museum material. Another ethical consideration is that collecting large numbers of fish and discarding unwanted ones on a bank is a waste of resources, a potential health hazard and poor public relations. Excess fish should be returned alive to the same water body, providing their ability to survive is ensured. Release in another

water body may introduce predators, competitors, parasites or diseases and disrupt the ecology, not to mention confuse zoogeographers.

The number of specimens collected should be constrained by the research needs. Too many specimens cannot be catalogued or analyzed, too few provide inadequate or misleading data. In a restricted habitat, a representative sample may comprise 5-10% of the visually estimated population. A sample taken at one time and place for systematic or ecological studies might require 30-50 specimens, perhaps more. Sample sizes of a single species in the thousands are excessive in most cases. Some ecological studies of common species with many age groups may require a few hundred specimens but selectivity of the fishing gear should be taken into account and efforts made to obtain representative samples of all age groups.

Species listed under CITES (see 1.3 Preparatory work) should not be collected unless they are the object of a detailed, approved, scientific study and the appropriate documentation has been obtained in both the host country and the UK.

Local authorities should be advised of planned field work as a courtesy; they may also be of assistance in providing data on the environment, unusual habitats, localities for rare species, the presence of exotic species, boundaries of reserves and parks, and a source of unpublished data on fishes. Letters of introduction in the local language (with your own copy in English) can be obtained from embassies, scientists, local authorities and various organisations with connections abroad. These may be addressed to political leaders, local authorities, angling clubs, fisheries organisations and the like and are often expected in the culture of the host country. They ensure that your purpose is understood and may well elicit valuable aid in attaining your objectives.

1.5 Safety

Safety is good science. An awareness of safety procedures enables work to be carried out effectively while protecting the individual and the environment. Nielsen and Johnson (1983) has a chapter on safety in fishery field work with details on using waders, boats and trailers, and operating on ice.

Protective eye goggles or safety glasses should be worn when handling any noxious chemicals such as the preservative formalin. Formalin, used to fix fish tissues, is an irritant to the eyes and nose and in skin cuts. It may be carcinogenic and repeated exposure can cause allergic reactions. Formalin

fumes are also an irritant and this chemical should only be used in concentrated form in a fume cupboard, under extraction fans or in the open air. The anaesthetic quinaldine can cause allergic reactions and may be carcinogenic. Museum workers who handle large volume of preservatives such as alcohols and formalin use breathing masks while working, steel-capped boots, heavy aprons and gloves as protective gear. Work breaks are also advisable. A first aid kit, eye wash station and spill control station should be readily available. Workers should be trained in the use of this equipment. This type of equipment would be necessary on board ship or when preserving large catches in a laboratory after field capture. In the open air of the field, gloves and goggles should be sufficient. Care must be taken not to breathe in the often powdery chemicals use in preservation and anaesthesia.

Other chemicals should not be used in ichthyology until the dangers have been ascertained from such references as the “Merck Index”, “Hazardous Chemicals Desk Reference”, “Prudent Practices for Handling Hazardous Chemicals in Laboratories”, and similar sources, the appropriate safety equipment bought, written procedures made available to workers, and training programmes completed.

Field work should never be undertaken alone. A simple slip and fall into water can result in a fatality. Researchers should work in pairs at least. Extended field trips should be planned and a route deposited with a responsible person. This applies particularly to work in remote areas.

Vehicles and boats should be mechanically sound, supplied with a first aid kit, repair kit, fire extinguisher, emergency water, food and fuel supplies, and operated by someone with experience and mechanical knowledge.

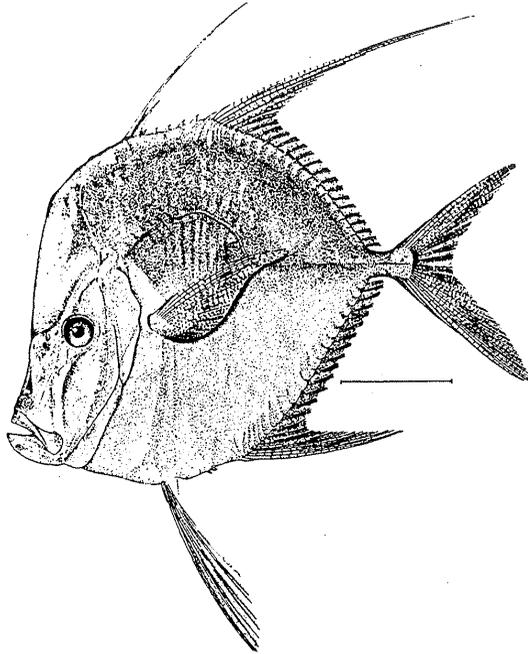
Field gear should be in good working order and the researchers should be well versed in its use. This applies particularly to electroshockers.

All the research team should be able to swim, and have taken life-saving and first-aid courses. Life jackets should be worn at all times in boats or when working near deep or fast water. The danger of flash floods should be explained to teams working in desert areas and of ice types to those working in the Arctic or under winter conditions.

Water from lakes and streams should not be drunk unless you are certain it is not contaminated with bacteria. In some areas water-borne diseases and parasites are prevalent and it may not be advisable to collect fishes without being protected by waders and gloves against skin contact with the water.

Theft of static gear or camp equipment may be a problem but can be offset by explaining your purpose to local people and the local authorities. Some field biologists have stuck radioactive warning labels on their gear to scare off thieves but this may get you into trouble with the authorities who are understandably nervous about equipment so marked.

And last, but not least, the ichthyologist in the field should be aware of poisonous and venomous fishes, the dangers of secretive fish with large teeth (don't poke your hands in crevices), and the behaviour patterns of large predatory fishes such as sharks.



Lookdown, Selene vomer (Linnaeus, 1758). Young specimen from Stapleton, Staten Island, New York, U.S.A. From Jordan and Evermann (1896) "The Fishes of North and Middle America" courtesy of the Division of Fishes, Department of Vertebrate Zoology, National Museum of Natural History, Washington. Drawn by H. L. Todd.

Section Two

CAPTURE TECHNIQUES

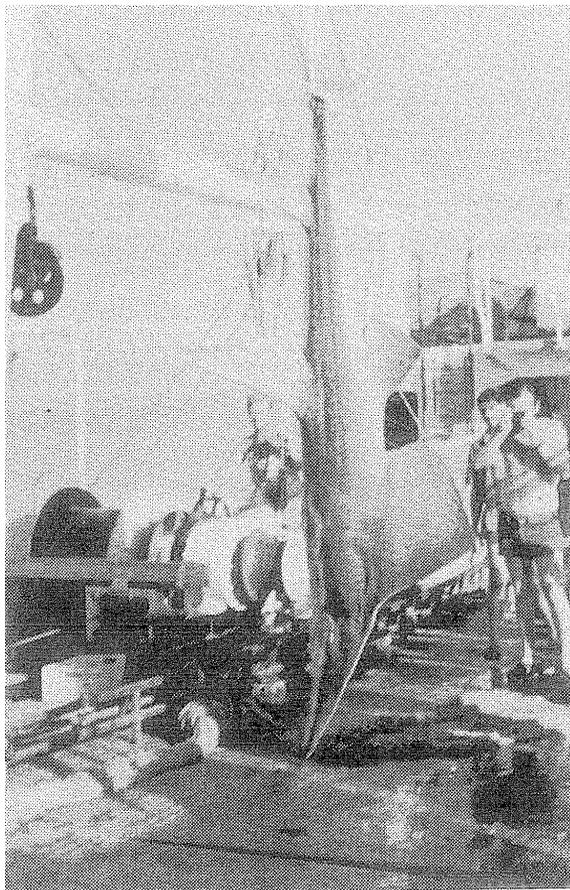
2.1 Introduction

Fishes may be studied in the field by observation. Live specimens can be transported home if there is ready access to air carriage or other means of rapid transport and the appropriate equipment, such as oxygen, is available. Berka (1986) reviews methods.

However many areas of ichthyology require the collection and preservation of specimens. Good sampling requires a series of specimens, at least 30-50, for each locality where a study of variation is being examined statistically. Such samples should include both males and females and adults and young as body proportions change with growth and vary between sexes, and food and other ecological parameters also vary and must be assessed. A conscious effort should be made to avoid selecting fish from the catch, whether by size, colour or “typical” appearance. Random samples are best. However, unusual specimens should be sought after and kept (and this selection recorded) as they may be aberrant specimens or even a new species.

There are innumerable methods of collecting fishes but the best is ingenuity. All types of habitat in the water body should be examined, from under rocks and in weeds, to the mud bottom and the open waters, at all times of day and night and at all seasons if possible. In remote areas a collector may have to make do with very simple equipment while near a major urban centre gear may be used that takes a day or more to set up. Luck plays a part even in scientific collecting as discovery of new species in areas previously sampled demonstrates. Repeated visits to areas already sampled may prove rewarding. Large, marine fishes on the sea bed or swimming in the open ocean require heavy equipment and large ships. Studies on such species require an experimental fishery vessel or close liaison with commercial enterprises.

All nets are apt to tear when in use and repair kits and some replacement nets should be carried (Libert *et al.*, 1987). Netting is very light and easy to pack. You may consider taking netting and constructing traps of your own or other peoples’ design using local materials such as wood or wire for frames.



Large specimen. "Soos", Rhynchobatus djiddensis taken by trawl on the French vessel *Thalassa* in the Sea of Oman off Baluchestan, Iran. Such large specimens cannot easily be preserved and photography from a variety of angles can record the salient features for later identification (Brian W. Coad).

Some of the more commonly used collecting techniques using light, transportable equipment are outlined below. An excellent illustrated guide to use of nets is by Peden (1976) and von Brandt (1984) surveys a wide range of techniques. Various fishery texts (cited in Section Ten under “General Ichthyology Texts”) also give a general overview of fishing techniques in addition to more specific references in Section Ten on “Collecting and Preserving Fishes”. These capture methods can be used by one to several people working in freshwater springs, streams, rivers, ponds and lakes and on marine beaches and tidal pools. New techniques are continually being devised and tested and papers on this topic are listed under “Techniques” in the *Zoological Record - (Pisces)* published by Biosis and the Zoological Society of London.

Larvae require somewhat different equipment than adult fishes and are dealt with in Section 5.5.

The principal methods can be conveniently divided into active and static.

2.2 Active techniques

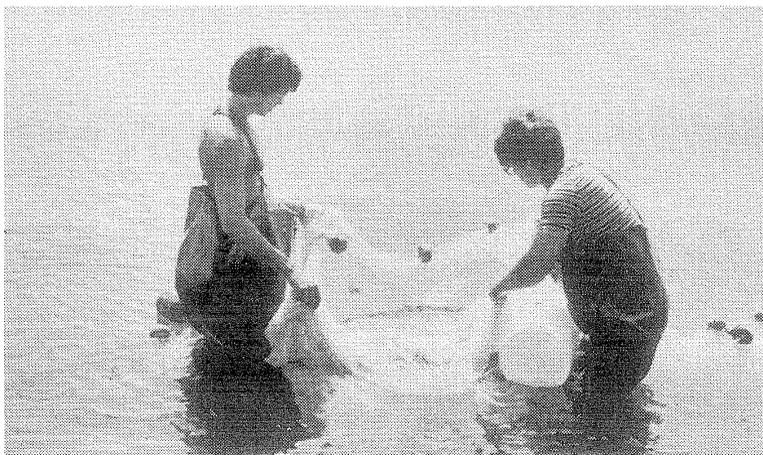
2.2.1 Seine

The most generally applicable method of catching fishes in freshwaters and shallow marine waters is seining. Seines are stretches of net of varying length but usually small mesh size. Smaller meshes catch more fishes but are harder to pull against water resistance. The upper edge has floats and the lower edge lead weights. Both the length and the depth of the net are variable. Seines can be 100m long or more and 3m deep, while those used in a small stream can be 2-5m long and 1m deep. Some larger seines have a fine-mesh bag in the middle which makes them more effective at trapping fishes. Very large seines require a boat to set and winches or teams of men to pull to shore.

The seine is used to surround fishes and is pulled in a semi-circle to the bank. The lead weights keep the net on the bottom and the floats keep the net vertical in the water column or the top floating at the surface. Each end of the seine is pulled by one or more people, who loop the lead line around a foot and holding the float line, pull vigorously such that the net billows out behind them in an arc, forming a bag in which the fish become trapped as the ends of the net are brought together onto the shore. In a stream, the net is best pulled against the current so that the flow of water does not roll up the net. In the fast currents of larger streams and rivers this is not possible and the seine must be pulled with and ahead of the current. The seine can get “hung-up” on



Two people hauling a seine with the float line visible and a central bag bulging out behind. The seine has brails, wooden poles to aid in hauling and keeping lead and float lines correctly positioned.



The seine can be hauled completely on to shore or, as here, the bag pulled up to remove specimens alive and undamaged, perhaps for later release (courtesy of G. Caron, Fisheries and Oceans Canada, Ottawa).

rocks or other debris or roll up as it passes over vegetation so some intelligent planning or clearance of the area to be fished is necessary.

Some workers attach a pole to each end of the net from float line to lead line to make it easier to handle. The essential factor is to keep the lead line on the bottom so fishes do not escape under the net as it is brought in. Deeper holes and backwaters are often very productive when seined. A small seine is effective for a majority of streams, small rivers, marshes, ponds, springs, the shores of larger rivers and of lakes, and on marine beaches. Campana (1982) details a technique for modifying a seine for one person operation.

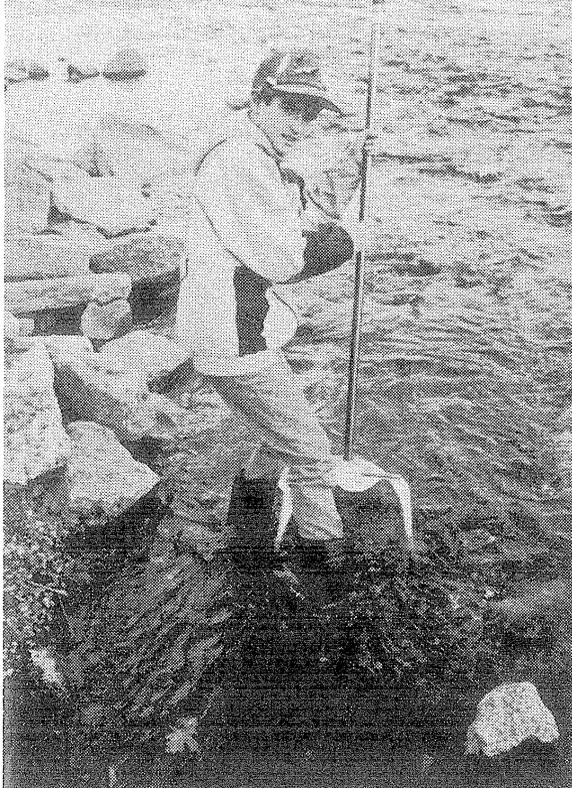
A seine can also be used to block off a section of stream while another seine or dip net is fished towards it. Alternatively, a seine can be used to block a stream with its lead line secured on the bottom with rocks and then fishes scared downstream towards it by energetic splashing, stamping, rock turning and weed thrashing. As the splasher(s) reaches the net, two colleagues quickly lift it completely out of the water to capture the fishes.

A seine for sampling larval fish in shallow water is described by Leslie *et al.*, (1983).

2.2.2 Dip net and push net

Dip nets are comprised of a triangular, rectangular or square bag on the end of a pole. The net mesh may be very fine for young and larval fishes or coarser for larger fishes. Some dip nets have a wooden pole but aluminium ones are lighter, if less sturdy, and can be telescopic. Larger fishes can easily evade a dip net as they can swim faster than water resistance allows a dip net to be pushed through the water. Occasionally fish can be fooled by swinging the dip net overhead and bringing it down onto the water surface and through the water to the stream bottom with considerable force and speed. Dip nets are good for smaller fishes in open water, in weeds and under banks and for catching fishes which hide under rocks. A dip net is placed downstream of a rock which is then kicked over to disturb the fishes and the net is scooped through the area previously occupied by the rock. Most dip nets are small, less than 50cm across, but larger ones are used by some artisanal fishers to search out large species from deep holes under banks.

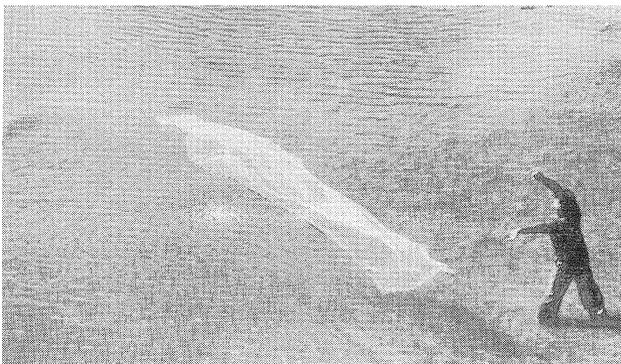
The push net is larger than a dip net and is shoved ahead of the operator over sandy bottoms or through weed beds. Shrimp nets can be used for fishes in this way too. Small fishes and larvae can be caught with a push net attached to an outrigger canoe or to an air boat (Hermes *et al.*, 1984; Rogers, 1985).



This dip net can trap small, fleeing, cryptic fishes when rocks are kicked over, here being used by Nicholas Coad to catch mottled sculpins in the Ottawa River. The turned-over rock should be replaced to preserve the microhabitat (Brian W. Coad).



A large, artisanal version of the dip net, here being used in the Gholab Ghor River, Gilan, Iran to catch the giant European catfish for food (Brian W. Coad).



Skilled use of the cast net in the Sarbaz River, Baluchestan, Iran by Abbas Tofangdar. The pool was fishless! (Brian W. Coad).

2.2.3 Cast net and enclosure trap

The cast net is used in many parts of the world to catch fish for food. It comprises a circle of medium mesh net ringed with weights and attached to a central rope. The rope is connected to a draw string. When used properly, which requires some skill, the net is cast from a coiled position on the arm onto the water surface, landing some distance away in a circle and sinking rapidly to entrap the fish below. A pull on the rope draws the lead-weighted circumference inward to trap the fish. Cast nets can also be useful in an unorthodox fashion, as can any of the nets and techniques mentioned here. They are very useful in boulder-strewn streams where seines and dip nets are ineffective against larger fish because there is no open water to operate them. A cast net can be thrown over the boulders where some of it hangs high and dry but where parts fall into the water between the boulders because of the lead weights, entangling the fishes.

Enclosure traps are similar in purpose to throw traps; they are designed to suddenly surround a body of water and trap the fishes contained there. They are also known as throw traps or drop traps, depending on how they are used, and come in various sizes such as 1-metre square (Kushlan, 1981). Pop nets, in contrast, are set in place on the bottom of a water body and are triggered to pop up and enclose a volume of water with its fishes (Larson *et al.*, 1986).

2.2.4 Poison

Poisoning should only be used by an experienced ichthyologist and with great care as many more fishes can be killed than are needed and some fishes are killed but remain hidden, an unnecessary waste. The usual poison (also called a piscicide or ichthyocide) is rotenone, and is fortunately biodegradable and does not harm higher vertebrates including man. Potassium permanganate counteracts the effects of rotenone and can be used to prevent the poison from spreading too widely. Various anaesthetics can be used in confined spaces to numb fish for easy capture. These include MS-222, quinaldine, etomidate, and others. A flexible, plastic bottle holds the solution which is squirted into holes, crevices and burrows. Fish are scooped up by hand or in a dip net or by blocking a stream with a seine. Power and Colman (1967), Ober (1981) and Nielsen and Johnson (1983) give details of rotenoning techniques.

Local people may know of and employ plant extracts which act as a poison and facilitate fish capture.

2.2.5 Explosives

Explosives are not recommended although they are used illegally in many countries and may provide a source of non-food fishes for the collector.

2.2.6 Angling

Fish can be caught by angling and this is one way to obtain large, wary specimens. However, catches made by angling are difficult to quantify because of the element of luck and skill involved and are poor indicators of abundance. Local anglers can be consulted for techniques and good fishing spots. The travelling ichthyologist may not have time for such leisurely pursuits and purchase from the anglers is a good means of obtaining large and rare specimens. Hook and line is often the easiest way to catch larger fishes. Spearing or archery can be used on spawning runs, when night lighting or for large and slow fishes, when regulations permit.

2.2.7 Night lighting and attracting

This technique, which uses strong light from lanterns or an electrical power source, can be very effective at attracting fishes at night, both adults and larvae. Ben-Yami (1976; 1988) reviews methods. The light is placed near the water surface or even in the water if waterproof. Submerged lights eliminate reflection from the water surface. It is banned in many countries for sport fish because it is so effective but may be used under licence. The fish, both attracted and blinded by the light, are dip netted out of the water. Fine mesh nets are required for larvae which are so transparent as to be almost invisible, requiring regular scoops through the water near the light to secure them. Alternatively, a broad, flat net stationed in the water under a light can be lifted at intervals. This type of lift net also works during the daytime if baited. Night lighting is especially effective at catching rapid-moving fishes in boulder-strewn streams. A variation of night lighting is to seal a torch in a glass jar and sink it inside a minnow trap overnight.

Ben-Yami (1989) reviews fish aggregating devices, which help to attract fishes in one spot for easier capture.

2.2.8 Tow net, trawl and dredge

Tow nets are light, fine mesh nets which can be pulled behind a boat powered with an outboard motor. The depth of tow can be adjusted by means of a weight attached to the tow line about 3m in front of the net and by varying the speed of the tow. Nester (1987) describes a tow net system for

larval fishes and Burch (1983) an unusual modification where the net is pushed. Tow nets catch larvae and the smaller fishes.

In very large rivers, lakes or in the sea, trawls can be used from boats with powerful motors or from ships. These large bags of varying size and design are dragged along the bottom or through mid-water and are large enough to scoop up most fishes in their path. The mouth of the trawl is kept open by floats and weights and by the planing effect of otter boards, rectangular pieces of wood or metal attached to the towing lines. Trawls require some skill to use so that the tow lines, weights and otter boards do not become tangled, closing the mouth of the trawl. Dadswell (1975) describes an otter trawl which can be operated by two people in a small boat powered by a 9.5hp outboard motor while López-Rojas et al. (1984) explain how even dugout canoes can be used in trawling. Enzenhofer and Hume (1989) detail a closing midwater trawl for small boats. Closing trawls enable particular depths to be sampled without catching other fishes when the net is hauled to the surface.

Dredges have a heavier design than trawls and unlike them can be used on rough bottoms.

Trawls and dredges are particularly prone to damage and even loss.

2.2.9 SCUBA and snorkelling

SCUBA and snorkelling can be used to locate and spear or suck up fishes with a slurp gun. Some fish can even be caught by hand. Small, hand-held dip nets or seines for encircling fish can be used too. These techniques are also invaluable for observing the behaviour and ecology of fishes under natural conditions.

2.2.10 Electroshocking

Electrofishing or shocking is a process where an apparatus is used to stun fishes or attract them to an electrode in the water, enabling them to be scooped up with a dip net. Alternating current stuns the fish while direct current brings the fish to the anode which may be part of a net. Electrofishing is effective for extracting those fishes which lie buried in mud, such as lamprey larvae. Some stunned fish may not be caught as they become trapped in weeds or under rocks. Electrofishing works only in fresh and moderately brackish water. Mineral poor waters are too weak in conductivity for electroshockers to work while the sea is too conductive. The manufacturers instructions for safe and effective usage should be adhered to. Waterproof waders, rubber gloves and dip nets with wooden handles are, of

course, essential. Cowx (1990) and Bohlin et al. (1989) are recent summaries of techniques and safety.

2.2.11 Ice fishing

Most expeditions seem to set out in the warmer months but those who brave cold conditions can still catch fish under ice. Ice fishing is described in angling books and gill nets can be set under ice using devices known as jiggers to jerk the net from one hole to another (Sprules, 1949). Manual or powered augers are used to open holes. SCUBA can be used to catch fishes under ice. Power and Colman (1967) detail a method for collecting fish under ice in streams using the poison rotenone.

2.2.12 Hand

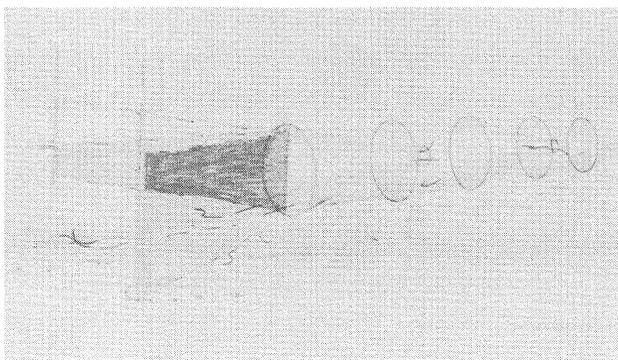
Small fishes can be caught by hand under rocks in streams and lakes and in tidal pools. “Tickling” fishes actually works but requires both patience and skill. Some species bury themselves in mud or sand, or construct burrows, and can be caught by rapid digging. Other fish take refuge in sponges and sea cucumbers and these should be examined for specimens.



A powered ice auger is the easiest way to make a hole for ice fishing. Transport by helicopter is an optional extra (courtesy of G. Caron, Fisheries and Oceans Canada, Ottawa).



Daniel Nadon with a car-battery powered back-pack and Claude Renaud electrofishing with a dip net to scoop up stunned fish. This apparatus caught mottled sculpins, longnose dace, logperch and American eels in this stretch of the Ottawa River (Brian W. Coad).



This hoop net is being used here to catch eels but will take a wide variety of species in rivers and lakes (courtesy of G.Caron).

2.3 Static techniques

2.3.1 Trap net

Various kinds of stationary nets may be used. They are called eel traps, pots, hoop nets, fyke nets, flume nets, weirs, cod traps and bag nets, among other names. These devices are fixed in or across rivers or along the shores of lakes and seas. Subsidiary netting, boulders, matting, etc. are set in the water to guide the fish into a central net or trap which the fishes enter through a small hole and become trapped because of an inability to relocate the entrance. These traps can be quite large and emptied by boats with heavy lift nets. Trippel and Crossman (1981) describe a small, collapsible trap which is easy to transport and Beamish (1973) and Swales (1981) portable, lightweight designs for a trap net. McLemore et al. (1989) detail the structure of a floating trap to collect migrating fishes.

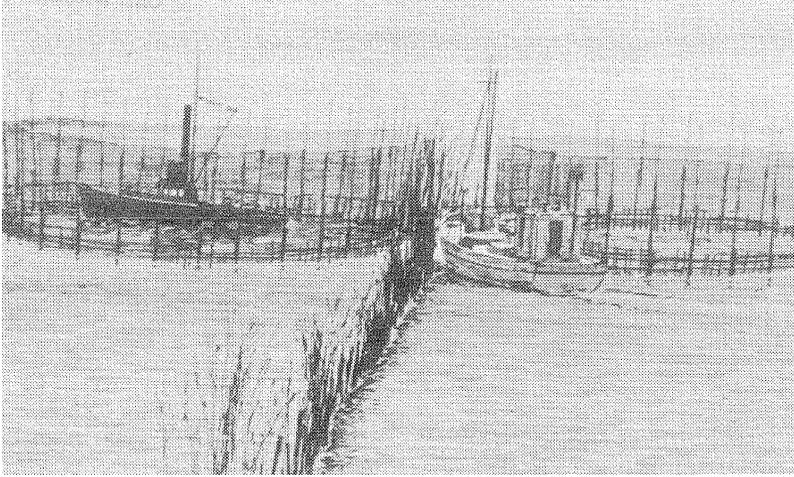
A smaller version is the minnow trap, about 0.5m long, which is a wire or plastic mesh basket with a funnel entrance. It may be placed on the bottom or at varying depths below the surface depending on the habits of the fishes to be caught. Kushneriuk and Paloheimo (1984) describe how to make a light, inexpensive trap of this nature for small fishes.

A variation on the trap net is the nest trap, any device which is attractive to fishes as a nesting cavity. Bechler et al. (1990) describe one such device.

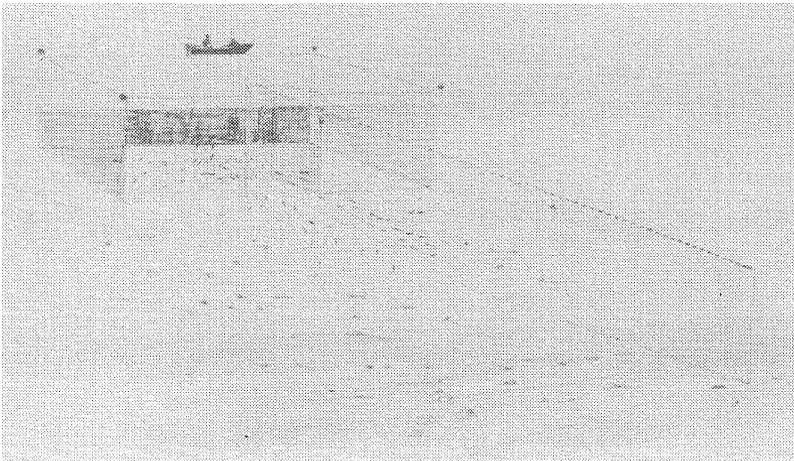
Traps can be baited with offal or other food to attract fish and placed in various habitats including those with rocks and heavy vegetation which defeats other nets. Trap nets left overnight are often more effective than those set and pulled during daylight. Even baited plastic food containers with a small hole cut out of the lid will attract fish and retain them if hauled rapidly out of the water. Trap nets generally take fish alive and healthy unlike most other techniques.

2.3.2 Gill net

Gill nets are used in open waters. They capture fishes by entanglement around the gills, spines or other parts of the body. The fish are usually retrieved dead or moribund after an overnight set, as the mesh is less visible to the fish in darkness. Gill nets can be strung together in a series of panels of varying mesh size and may extend for hundreds of metres. Mesh size will determine the species and size of fishes caught. Gill nets can be set as a wall of netting on the bottom, in mid-water or at the surface with the correct balance of floats and weights. They may also be set vertically (Hansson, 1988). Long lines with anchor weights on the end enable gill nets to be set



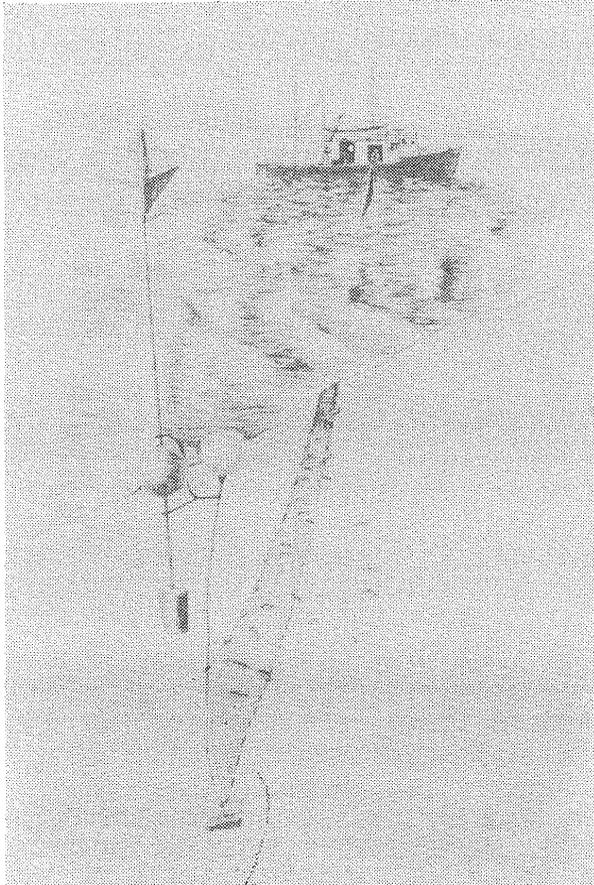
Weirs are fixed structures, here made of poles, in which fish become disorientated and swim in circles until removed by dip netting or pumping (courtesy of G. Caron, Fisheries and Oceans, Ottawa).



This cod trap is made of netting anchored to the sea floor and buoyed at the top. The entrance is closed and the trap hauled across a boat to concentrate fish in one corner of the netting where they are taken out with a dip net. (Courtesy of G. Caron).

These small minnow traps, stackable and easily portable traps can be set in a variety of waters, anchored to a tree by a length of rope or suspended in mid-water by a well-sealed empty plastic container (Brian W. Coad).

A dome-shaped “Gargool” trap set in shallow waters of the Persian Gulf to take groupers, emperors, grunts and others. Here aboard a “dhow” at Kangan, Bushehr, Iran (Brian W. Coad).



A commercial gill net is shown here. Research or experimental gill nets are more suited to operation by individuals from small boats or the shore and usually consist of a variety of mesh sizes (courtesy of G. Caron).

over very deep water. Gill nets should always be firmly anchored so they do not drift away. Nylon, monofilament nets can drift for years catching and killing fish. Buoys are used to mark their position in large bodies of water. Buoys can be made of empty plastic containers.

A boat is often required to set gill nets properly but they can be tied to a tree or dock and thrown out into the water with a weight on the lower end. The nets can be set at right angles to the shore to catch fishes moving laterally, parallel to the shore to catch those moving inshore to feed at night or at an angle to catch a selection of both. Gill nets can also be used in an unorthodox fashion, as seines in larger rivers to capture larger fishes. Their mesh size (e.g. 10cm stretched) is such that resistance against strong currents is less than for a seine.

2.3.3 Trammel net

A trammel net consists of two panels of wide mesh netting enclosing a finer mesh net between them. Fish swim through the larger mesh and push out a pocket of the finer mesh in which they are trapped. Trammel nets are set in much the same way as gill nets.

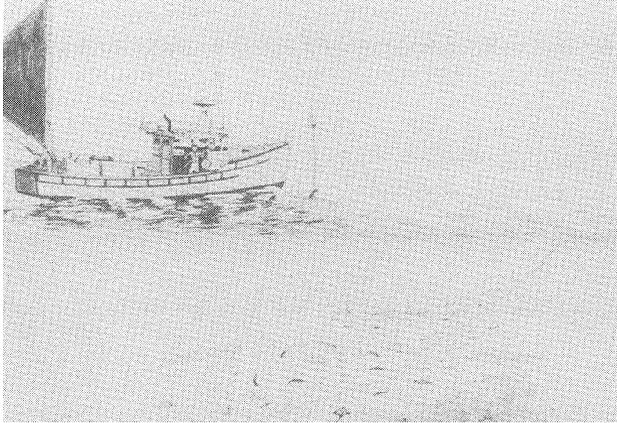
2.3.4 Baited lines

Baited lines can be set overnight or during the day at various depths. These may be short and fished vertically with only a few hooks dangling off the main line (drop lines), or very long and often touching the bottom (long lines). Commercial long lines may run for kilometres in the sea. Baited lines require a float or marker buoy at the surface and a weight or anchor on the bottom. Extra floats can be used to suspend the hooks near the surface or at varying depths. Lines are usually set from a boat but short lines may be tied to a tree or dock and cast out. Lines should be checked regularly, perhaps every few hours, as predators will damage or destroy any catch.

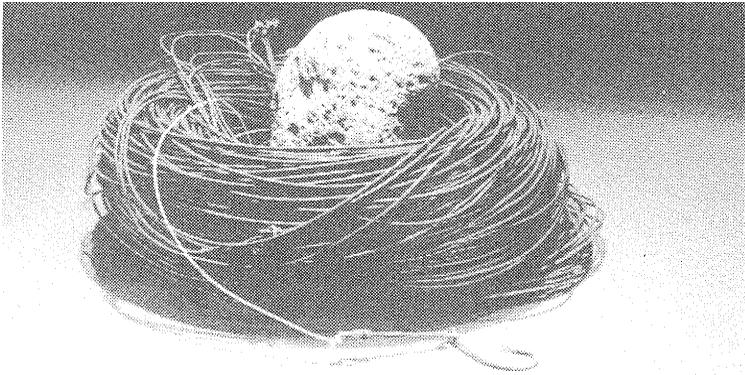
Compared to nets, line techniques are subject to an element of luck; fish may not be biting. Hook size and bait type are selective. Lines are not a good means of measuring abundance.

2.3.5 Purchase

Fish markets may yield valuable material but with modern transport care must be taken to confirm that fishes were caught locally. Accompanying commercial fishermen on their trips ensures fresh material, accurate locality data and sometimes saves specimens not marketable which the fisherman would otherwise discard.

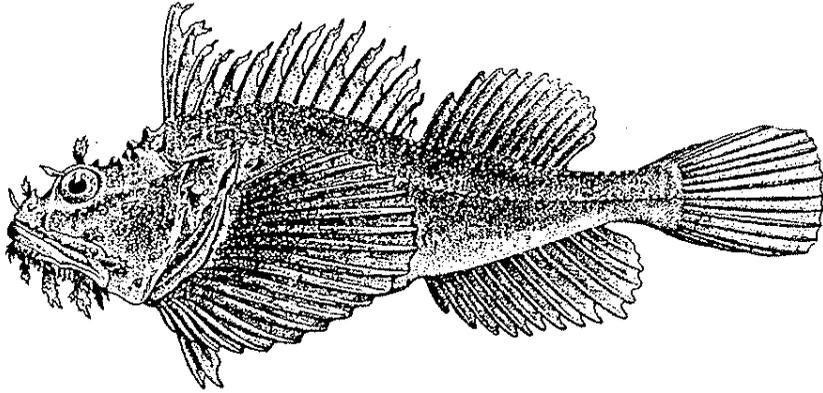


Longlining is used to catch “groundfish” (bottom dwellers) commercially by a mechanized system which automatically hauls, baits and shoots the line out. It can also be very effective when done by hand, although labour intensive (courtesy G. Caron).



This simple hook, line and sinker is used in the Comores Islands to catch the famous coelacanth, a “living fossil” (P. M. Youngman, Canadian Museum of Nature, Ottawa).

The small boy technique should not be overlooked; children often have the time, patience and local knowledge to catch large, non-commercial species. Such fish can be bought in passing or the boys may be hired to bring in fish of a certain kind and size at so much per specimen.



Sea raven, Hemitripteris americanus (Gmelin, 1789). Total length 30.5cm. Collected from Purcells Cove, Nova Scotia, Canada by R. M. Rankin, 28 August 1960. Drawn by C. H. Douglas, Canadian Museum of Nature, Ottawa.

Section Three

PRESERVATION

3.1 Introduction

Captured fishes which cannot be identified or seem unusual enough to warrant further attention should be preserved. Labelled, preserved specimens deposited in a museum are a permanent record of species identity and distribution. Some taxa present problems of identification even for experts so that misidentifications are often a nuisance if there is no material to examine. Samples from ecological or experimental studies as well as systematic and distributional works may be preserved and sent to a museum where their identity can be confirmed and where they are available to workers in the future. Samples for ecological studies are often preserved in the field for later, time-consuming analysis in the laboratory. Major museums in a number of countries welcome exotic material to enhance the variety of their collections. Arrangements for deposition should be made before setting out on the expedition and the needs of the local museums should be addressed first.

3.2 Methods

Specimens should be preserved whole, without removal of the guts or gills so that no key characters are lost. Specimens may be frozen, or even salted, but the best method and the one used by scientists is to drop fish into 1 part full-strength formalin to kill the fish quickly and then immediately add 9 parts of water to form a 10% preserving solution. Formalin becomes acidic over time and can damage specimens by decalcifying bones and scales. This can be avoided by adding three teaspoons of calcium carbonate to a litre of 10% formalin. A precipitate will be left in the bottom of the container. Borax (sodium borate) is often added to formalin as it acts as a buffer but it soon accelerates acid formation. It can be used temporarily but any formalin solution should be properly buffered for long term storage. Ethanol is the preservative of choice for permanent storage.

Large specimens (larger than about 15cm) should have a small slit made in the right side of the belly to allow formalin to penetrate the tissues. Ichthyologists cut the right side of the fish and leave the left side undamaged for illustration and scale counting. A pair of scissors can be used but larger fish may require a scalpel or knife. Hypodermic syringes are used to inject

the abdominal cavity and muscle blocks of very large fish with formalin, otherwise the preservative will not penetrate all the tissues before decay sets in. This is especially important in a hot climate. Syringes should have a capacity of up to 100ml and be capable of taking needles of various sizes. Particular care should be taken when injecting formalin into tissues; the needle should be withdrawn gradually while injecting the formalin solution to avoid a sudden spurt of liquid under pressure from the injection site.

Formalin should be handled with care as it is a noxious chemical which irritates the eyes and nose and is painful in skin cuts. It may be carcinogenic and repeated exposure can trigger allergic reactions in the skin. Gloves and safety glasses are useful when diluting full-strength formalin. It should only be handled in well-ventilated rooms or in the open air. MS-222 is an anaesthetic which can be made into a solution in which fishes are immersed, relaxing them for formalin fixation.

Paraformaldehyde, a white, easily portable but noxious, powder, can be made into a liquid preservative. It is mixed in a 4:1 ratio with anhydrous sodium carbonate and a small amount of a wetting agent such as Alconox to help it dissolve. This powder mixture is dissolved in water at a 1g:20ml ratio to give a 10% buffered formalin solution. Specimens should be transferred to alcohol as soon as possible.

Alcohols should be used as a preservative only after specimens have been well fixed in formalin, as specimens have been known to deteriorate rapidly in alcohol alone.

Larvae are best preserved in unbuffered, 4% formalin to retain important pigment characters. Fresh, rather than sea, water should be used to mix the formalin to avoid shrinkage. Unbuffered formalin eventually decalcifies the skeleton so phosphate buffering is used where material is to be stained for bones and cartilage (Markle, 1984; Taylor and Van Dyke, 1985).

Collections made in the same watershed or geographical area should be separated and stored temporarily in different vehicles or boats, different base camps or towns, and mailed home separately as an insurance against accidental loss or damage.

3.3 Containers

It may be necessary to store collections for a year or more before they can be studied or deposited in a museum. The best containers for long-term storage are made of glass with tightly-sealing polypropylene lids. Plastic containers

deteriorate with time and tend to crack. Metal containers and metal lids eventually rust. Very large fish may require some sort of drum, such as a clean oil drum but it should be noted that formalin eventually corrodes metal and the drums should be lined with plastic or lacquered. Fluid levels in a stored collection should be checked regularly and alcohol concentrations maintained at the recommended values or the specimens will deteriorate. Collections should be kept in the dark to reduce fading of pigments and at a constant, cool temperature.

3.4 Packing

In the field, care should be exercised in packing specimens for transport so that leakages do not occur. Most field collections are transported in formalin. Glass containers can easily break and plastic bottles or buckets with tight-fitting lids should be used. Plastic containers are also not as heavy as glass ones. Padded boxes with cut-outs for glass containers can be used where space is not at a premium. Small fishes can be preserved in small plastic bags and sealed in plastic buckets. The plastic bags can be doubled to insure against leaks and the bags should be of sufficient depth and flexibility to allow a strong knot to be tied easily at the opening as a seal.

Plastic bags with metal twist ties are not advisable as the metal may rust or pierce the bag and the seal is not always effective. Plastic bags with a self-sealing mechanism do not always stand up to field conditions.

Fish which have been preserved for a week in formalin, more for larger fishes, or transferred to alcohol can be sent to a museum for identification. Glass containers full of formalin or alcohol should not be mailed because of the danger of breakage. The fish should be wrapped in cheesecloth or some other absorbent packaging, with the label, the cheesecloth dampened with preservative, and tightly sealed in several, leak-proof plastic bags before being placed in a padded box for mailing. Spiny fish should be especially well wrapped to avoid puncturing the plastic bags. A tightly-sealed package retains the preservative which keeps the fish in good condition. The box may be labelled "Scientific specimens, no commercial value".

Transport regulations are becoming increasingly restrictive for such chemicals as formalin and alcohols. They are classed as hazardous chemicals and in some countries special training courses and licences are required simply to pack and ship such materials. Merely driving around with them in a vehicle may require special signage and a shipping manifest in case of accidental spillage.

Long-term preservation in formalin is not advisable as the solution becomes acidic and rots the fish. It also wrinkles and hardens the specimens. Most museums store their specimens in alcohol for the long term. The formalin-fixed specimens are washed briefly in water and then transferred to 45% iso-propyl alcohol or 70% ethanol. These chemicals are pleasanter to work with when carrying out systematic or ecological studies on the preserved material.

Some care should be taken such that specimens are not twisted and bent inside the preserving container. It is difficult to make counts and measurements necessary for identification on badly deformed specimens. Each specimen or group of specimens should have at least an equal volume of preservative, as water in the fish tissues tends to dilute the preserving fluid. Specimens may be stepped through 30%, 50% and 70% alcohol solutions to reduce wrinkling and ensure a fuller penetration of alcohol into tissues and a final storage solution of at least 70% ethanol. Ethanol may be difficult to obtain in Islamic countries and undrinkable iso-propyl alcohol can be substituted.

Section Four

RECORDING DATA

4.1 Introduction

A collection of fishes, like any collection, is much enhanced by the associated data. An accurately labelled and catalogued assemblage of fishes can be used as a reference collection to verify the distribution and identification of subsequent material. A more extensive collection data base can form an invaluable research tool for systematic and ecological studies as field data does not have to be made anew for every study.

Working with fishes can be wet and slimy. If team numbers permit, one person remains “dry” and records all the data on Field Sheets, writes labels, takes photographs and makes supplementary notes. Waterproof notebooks are available from diving shops but are only necessary for underwater observations.

4.2 Labels

The label is as important as the fish itself. An interesting specimen is of little or no scientific value if there is no locality data. Labels should be written at the time of capture. Faulty memory and good intentions to label specimens later make a poor combination and often result in collections with no data, or worse with incorrect data. The label should bear the place of capture, such as a stream, lake, spring, tidal pool, etc., including a reference to the nearest town (local names may not be on maps or in gazetteers and some village names are very common), latitude and longitude, province, date, name of collector, notes on the habitat and live colour of the specimens, and any other items likely to be useful. Colour photographs of fresh fish are most useful, especially if the fins are pinned erect, as many species fade rapidly on death or in preservative. Photographs of live fish can be made in an aquarium against a natural background. With care these may be of publishable quality. Emery and Winterbottom (1980) and Flescher (1983) outline fish photography methods. Habitat photographs can also be taken as a supplementary record.

Pencil or India ink should be used on stout, waterproof paper which will not disintegrate in liquid. The label must be dropped in the jar or plastic bag with the fish. Labels on the outside of jars always fall off and lids with labels always get put on the wrong jar! Permanent labels are written in India ink in

the laboratory or museum. Such labels usually have pre-printed areas for catalogue number, number of specimens, locality, collection date, identifier, etc. to ensure a consistent procedure. They can also be used in the field. The original, field label should be kept for reference with the collection in the jar with the fishes in case of transcription errors or other recording errors which may need to be checked against the original data.

4.3 Field Sheets

In fact the amount of information which should be usefully recorded cannot be put on a small label. Instead, extensive Field Sheets are used and related to the specimen or sample by a field number. These Field Sheets may be designed for a specific study by the individual researcher. Museums use Field Sheets as the basis for cataloguing their collections, a collection being all the fish caught at one place at one time. A collection may then be a single fish or several hundred specimens comprising several species. The several species receive the same catalogue number but are stored in separate jars on shelves with other collections of the same species.

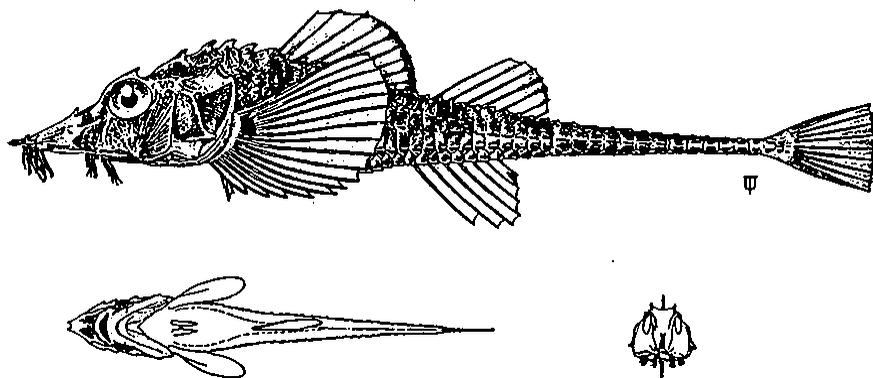
For example, the Canadian Museum of Nature, Ottawa (formerly the National Museum of Natural Sciences) has Field Sheets with over 70 categories which can, potentially, be filled in and some categories have as many as 30 alternatives, e.g. Category 17, Environment includes fresh spring, cave, canal, stream/river, river-lake junction, flooded area, fresh pool, pond, lake, marsh (treeless), swamp (with trees), reservoir, ditch, etc. Having all these categories on pre-printed or photocopied sheets greatly relieves the need to remember which parameters to measure and ensures consistent record keeping. As an insurance against loss of Field Sheets or confusion of numbers, the jar label should carry minimal locality data as well as the field number. The Canadian Museum of Nature Field Sheets are entered into a computer data-base which can be searched (hence "Input Sheet") for any category or combination of categories. Expedition members intending to use such a Field Sheet should be trained in the details of filling one out accurately.

Wherever possible, photocopies of Field Sheets should be made and mailed home or deposited in a safe place, at a base camp, or kept in a separate vehicle or container from the originals. Detailed capture information is best recorded on a standard form such as the two-sided sheet used by the Canadian Museum of Nature, Ottawa (see facing page and over).

Field Sheet

Field sheet, side 2.

If funds permit, the expedition can use a Global Positioning Device to link with a satellite and obtain a readout of latitude and longitude for entry on the Field Sheet. This is more accurate than fumbling around with maps, to within about 100m or with two machines 2-5m. This device also enables you to return to the same sampling site, feeding you data on direction, istance to go, speed you are travelling and time to arrival. Data loggers, a form of small computer, are available and these enable the field data to be entered directly into a standard format. A small, portable printer should be used to make hard copies in case of a drive crash. The information entered into or recorded by these devices can be stored into a Geographical Information System (GIS) for later analysis.



Sturgeon poacher, Agonus acipenserinus Pallas in Tilesius, 1813. Standard length 16cm. Collected from Monti Bay, Alaska, U.S.A. by D. E. McAllister, 25 June 1961. Drawn by John L. Tottenham, Canadian Museum of Nature, Ottawa.

Section Five

OTHER TECHNIQUES

5.1 Introduction

Field work with fishes need not be restricted to simply making a collection. Valuable work can be carried out as part of ongoing research programmes in such modern techniques as mtDNA analyses. Some work with fishes, such as parasitology, requires processing in the field to preserve or prepare material while in its freshest form. Some observations must be carried out in situ, including behavioural studies, observation of migrations and tagging studies. The methodologies involved are many and varied. Introductory texts are cited in Section 9.2 Analysis.

5.2 Ecology and behaviour

Fish may be tagged, marked or tracked in various ways to study their movements, behaviour and growth. Tags are usually serially numbered and attached to a fin or punched through the flesh with a special tagging dart gun. The ideal tag is easily observed and read, is permanent, unique to an individual, and has no effect on survival, growth, behaviour and catchability by predators or scientists. Injections or immersion in various stains, fluorescent dyes, radioisotopes and plastics have also been used. Fish have also been fin clipped, tattooed, freeze-branded or electrocauterised. Minor fin clips are probably the easiest. A review of marking techniques is given in the various fisheries books and in Jones (1979).

Electronic tags can transmit data on such internal factors as heartbeat and internal and external temperatures as well as permit tracking. Transmitters can be force-fed or attached externally. Echo sounding equipment can be used to locate fish schools, monitor their movements, estimate numbers and sometimes determine the species (Burczynski and Ben-Yami, 1985). Such equipment is usually employed in large rivers and lakes or in the ocean.

Large fish present problems of transport home. Both they and smaller fishes can be sampled for ecological studies by recording weight, total and fork length, girth, removing some scales, otoliths (ear stones), opercula (gill covers), vertebrae or spines, preserving guts or stomach contents, and preserving ovaries and testes. Scales and other body parts can be used to age fish, calculate growth and check for spawning times. Gut contents can be

analyzed for diet. Ovaries and testes provide information on fecundity, time of maturation, and other features of the reproductive cycle.

Scales are usually placed dry in a numbered folder or envelope with length and weight data written on the outside. They can be “read” later like tree rings. Power (1964) gives an alternative method which works well with small scales and uses thin plastic slides overlain with a plastic film. These techniques can be used to obtain data on a commercial fishery since the edible bulk of the fish is left intact for sale by the fishermen.

Observations on fishes may be made visually from land, at spawning sites, on migrations, and in restricted areas like stream pools or tide-pools. Sedberry and Beatty (1989), for example, published a visual census of fishes from a dock. Polaroid glasses help remove surface reflections. This method can yield valuable data on abundance and behaviour and does not require fish to be killed. However visual censuses need to be verified by some collecting technique which captures the more cryptic species.

Fish kills are sudden events which may have great significance for the fish populations and the health of local consumers. Valuable information can be obtained by the person on the spot, before conditions change, since scientists may only become aware of the event some time after the fact (Nielsen and Johnson, 1983; Meyer and Barclay, 1990: American Fisheries Society, 1992; 1993).

The expedition member familiar with underwater techniques such as SCUBA and snorkelling can make a contribution to our knowledge of fish behaviour in the wild including spawning, feeding, home ranges, activity patterns, habitat preferences, and movements. Diver surveys are counts of species or observations on behaviour along a chosen or randomly selected transect. Bohnsack and Bannerot (1986) describe a stationary technique for assessing coral reef fish communities. Environmental variables can be measured and recording gear placed in microhabitats. Underwater photography and video equipment can be used to record behavioural data for later analysis. Film allows a more accurate analysis as it may be run again, slowed or stopped. Nielsen and Johnson (1983) review underwater techniques and point out that observation platforms, glass-bottom boats and lookboxes can be used in clearer water to view fishes in their natural habitat.

5.3 Parasites, diseases and anomalies

Parasites may be obtained from freshly-caught fish by autopsy. Various body organs should be searched starting from the skin and working inwards. Data

sheets are a useful means of summarising the organs searched, the numbers of parasites found, any discernible effects of the parasites, fish species and collection data, and preservatives used.

Various fish diseases are known and can affect growth, reproduction or survival. Notes should be taken on any growths, ulcers, inflammations or fungal infestations as these may be important monitors of environmental health and the viability of the fishes as a food resource.

Anomalies include deformed fins, vertebral columns, jaws or gill covers, albinism and other colour abnormalities, asymmetry, fin losses, and also injuries resulting from angling, predator attacks, parasitic lamprey scars, and boat damage.

Various fishery biology texts give information on these topics. Particular references are Dogiel et al. (1961), Reichenbach-Klinke and Landolt (no date), Sinderman (1990), Amlacher (1970), Van Duijn (1967), Post (1983) and Wolf (1988) and Schaperclaus (1990) for general biology and Fernando et al. (1972), Austin and Austin (1989) and Roberts (1989) for techniques. Parasitologists may have their own preferred solution for preservation of material they are requesting from you and should be consulted.

5.4 Molecular sampling

Various tissue samples and blood can be taken from fishes for later analysis. These samples are of value to scientists working in immunology, DNA studies, karyology, hybrid studies, molecular systematics and population definition (see Denton (1973), Dessauer et al. (1984) and Hillis and Moritz (1990) for collection methods). The whole specimen may need to be preserved after samples are removed to verify identification. Generally expedition members would collect such material for the specific research projects of a scientist but museums are now beginning to maintain deep-frozen tissue collections.

Field kits may require liquid nitrogen tanks or dry ice to freeze the tissues and these are heavy and awkward and re-supply can be difficult or impossible in some countries. However, valuable material can now be extracted using chemicals at room temperature. The expedition members are best advised to check for applicable techniques, training and tissues needed with a scientist active in this field of research.

5.5 Larvae

Smith and Richardson (1977), Bagenal (1978) and Moser (1984) summarise the specialised techniques of capture and preservation of fish larvae. Faber (1981) describes a light trap which can be left unattended for varying periods of time and Doherty (1987) an automated light trap. Baugh and Pedretti (1986) explain how to construct a small and portable fry trap.

5.6 Archaeology

Expeditions devoted to archaeological work often retrieve fish bones. A collection of contemporary fishes from waters around the site is most helpful in determining the species at the dig. Estimates of current abundance can be related to past environments. Various techniques exist for making bone preparations of extant fishes for both systematic and archaeological study (Cailliet et al., 1986; Moser, 1984; Taylor and Van Dyke, 1985). Casteel (1976) and Wheeler and Jones (1989) give further information on fish remains in archaeology.

5.7 Community surveys

Fishes are an important element in various communities as food or for sport. Local fishing methods and gear can be described and their efficiency assessed. Catches made by anglers can be recorded, catch records of clubs surveyed and trends analyzed. Samples from catches, such as scales, gonads and stomachs, may be kept and preserved for later analysis. One of the easiest ways to analyse catches is to circulate a printed or photocopied form with a series of questions, encompassing such factors as species caught, weight and length of each fish, time spent fishing, number released, number retained, number eaten while out fishing and their weight and length, estimate of number killed through handling, gear used, angler satisfaction, and so on. From this elementary data, called a creel census, the effect of anglers on the fish populations can be assessed. The data enables determination of total yield of the water body as numbers or weight of game fishes caught, angling success in fish/angler/hour, the monetary value of the fishery, a measure of angling pressure on the water body, comparisons of catches by seasons, by days of the week, by times of day, and by types of lure or bait, the need of regulations to restrict take of spawners or large adults, and the need of other management recommendations to improve the fishery. Accuracy is increased if the angler is interviewed by the census worker, or the forms are compulsory for a licence or for access to the fishing grounds, rather than relying on voluntary cooperation. Nielsen and Johnson

(1983) have chapters on sampling recreational and commercial fisheries and Guthrie et al. (1991) describe creel and angler surveys. Pollock *et al.*, (1994) review angler survey methods and their use in social and market analyses and in biological studies.

A valuable form of study is an assessment of a subsistence fishery. Also known as domestic, harvest or food fisheries, a subsistence fishery is one carried out to satisfy local food needs and is distinct from commercial and recreational fisheries. The statistics obtained form important information for biological and socio-economic research. Data can be gathered by direct observation of species caught, their numbers and weights, methods used and when and where, age and sex of fishers, and usage. Usage may be for human consumption, as bait, or as animal food. Data on a yearly basis can be obtained by the recall method, where community members are asked to remember catches through interviews or questionnaires. Accuracy of recall can be checked or enhanced by interviewing fishing partners separately and comparing replies, by checking against written sources such as diaries and administrative records, by asking fishers to keep diaries, or against your own direct observations, e.g. of fish laid out to dry on racks. An example of a subsistence fishery study is that of Hopper and Power (1991).

Dietary surveys of the local people can be carried out and assessed with a view to recommending measures to conserve the food resource, increase intake of protein, or recommend steps to decrease intake of fish-borne pollutants. Fish are only part of a dietary survey. Consult a nutritionist or dietician on relevant studies for your area of work. The procedure usually consists of a dietary history, a food frequency interview or questionnaire and a 24-hour diet recall. You may wish to prepare standard forms to ensure consistency and these can be translated into the local language and serve to explain the study you are carrying out. The dietary history is an interview of the elders or community leaders to gain an overview of the species now eaten, food preferences, what was eaten in the past, where the fish are found, whether the size and population of the fishes are increasing or decreasing, how fish are cleaned and prepared, preservation methods (dry, smoked, frozen) and what parts are eaten. Food frequency studies are carried out household by household, asking them to recall what was eaten in the past year on a seasonal, monthly or weekly basis, and what the portion sizes were per person. 24-hour diet recalls are carried out on an individual basis, asking each person to remember everything that was eaten over the past day, meals, snacks and beverages. Such a recall should be carried out at least twice in a one year period and ideally cover the seasons since availability of species

varies. Data are usually segregated by age groups and by sex of the consumers.

These studies require an intimate knowledge of local customs and culture and a knowledge of the local language. When dealing with a food or monetary resource, tact is a prime ingredient of the surveys. Do not underestimate the time needed to be spent in the community establishing cordial relations. Your purposes should be fully explained to the local people or the angling club and should have their full support. Participation must be voluntary. You must also guard against inaccuracies in the data you receive from individuals. Relying on translators or local informants alone can be misleading; you may be “fed” the answers you expect to hear or seem to want. And cultural habits may require that capture success be exaggerated: this is not restricted solely to sport fishermen!

5.8 Biotic integrity indices

Fishes may be used to determine the health of the aquatic ecosystem and to formulate management priorities. An index of biotic integrity (Karr, 1991; Fausch *et al.*, 1990) is derived from the number of species, the number of individuals, community structure and some simple environmental parameters. The value obtained will be lower in unhealthy or polluted habitats than in pristine ones, for example. The index can also be used to compare changes in biodiversity along the course of a river, seasonal variations, and variations due to diverging geographic histories. The method must be adapted to the particular community of fishes in the area under study, e.g. feeding types are recorded, but this can be determined rapidly by examining stomach contents and by analogy to the anatomy of the mouth and digestive system (large teeth and short gut usually indicates a predator, for example). The methodology has the advantage that much of the work can be performed in the field and the captured fishes released unharmed although some voucher specimens may have to be preserved to confirm identities later.

Section Six

SPECIMEN IDENTIFICATION

6.1 Introduction

Specimen identification may require expert assistance where field guides and fish books are unavailable for the area of study. The taxonomy may have undergone great changes since the last general guide was written and this is beyond the scope of the non-specialist. The demands on the time of museum staff may be such that they are unable to help unless a prior agreement has been reached. Certain scientists, specialists in a particular group of fishes or an area of the world, will welcome material but again courtesy demands prior contact and not the sudden arrival of overwhelming volumes of pickled fish. See Section 1.3 (Preparatory work) for a source of experts on fish groups and areas.

Identification can be done by the expedition member who has access to scientific literature, a museum collection for comparative purposes and the time to carry out this task. The best collection may be in the host country where most identifications should be made. Preparatory work should have revealed where the best collections are, the relevant literature sources and at least the beginnings of a familiarity with technical terms needed to identify the fishes.

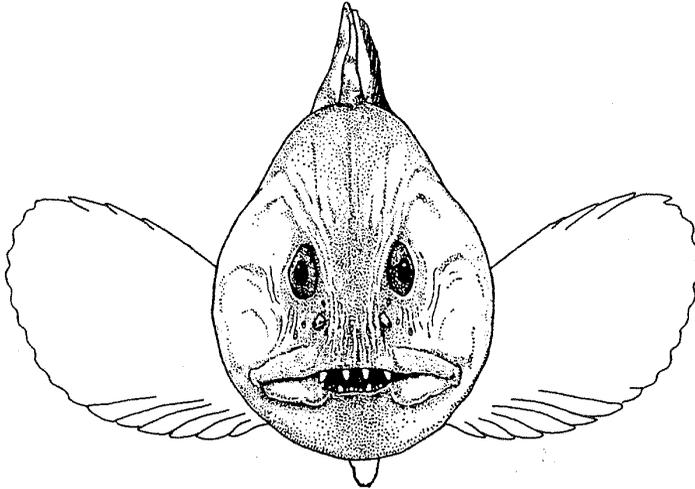
6.2 Keys

The principles of keys should be familiar to the expedition member. They are the easiest way to ascertain identity. This is made considerably easier if the alternative in each couplet is available in a reference collection. Once identified the fish should be compared with illustrations and detailed descriptions for verification. Its geographic range should accord with published records. Specimens which do not key out or have an unusual distribution may be a new distribution record or representatives of a new species. Given the complexity of the rules of nomenclature, expert assistance should be sought before making a formal description of a new species for publication.

Keys may not be available and the original descriptions, recent revisions and any other sources of descriptive information must be compiled and analyzed to obtain a clear picture of the correct names for the species of an

area. The construction of keys can be a valuable contribution to science in itself as well as a tool for other studies.

A species which does not key out may be new. However, exotic fish species have been widely introduced for food, malarial control, sport, research, ornamentation, weed control or accidentally. Even remote areas can have goldfish released from aquaria which have reverted to the wild type and lost their golden colour. The Food and Agriculture Organisation, Rome maintains data on fish transfers (Welcomme, 1988).



Bering wolffish, Anarhichas orientalis Pallas, 1814. Total length 45.5cm. Collected from Bathurst Inlet, Northwest Territories, Canada by the Arctic Unit, Fisheries Research Board of Canada, 7 September 1969. Drawn by C. H. Douglas, Canadian Museum of Nature, Ottawa.

Section Seven

FISH PHOTOGRAPHY

7.1 Introduction

There are three methods of photographing fish - on land in a special aquarium, as a dead specimen or underwater in their own habitat. It is easier to take pictures of them on land, the necessary equipment is less expensive and, indeed, much of the close-up footage of fish and other marine creatures which is shown in wildlife films has been shot in specially prepared tanks. Siting them on the shore or on a boat also means the specimens can be returned easily to the sea. Another important factor is that some fish lose their coloration or body patterns in death, even if photographed very soon after they have been caught. Taking pictures of them underwater requires considerable proficiency as a diver or snorkeller as well as being more time-consuming and considerably more expensive. Such pictures, however, do have the merit that the fish is portrayed in its natural habitat and that specimens are not needlessly killed.

7.2 Aquarium photography by Peter Burgess

7.2.1 Equipment

The standard 35mm single-lens reflex (SLR) camera with through-the-lens metering is ideal. Certain models have an autofocus system which relies on an infra-red beam, however this facility should not be used for aquarium photography as the beam may reflect off the glass and give an erroneous reading.

Auxiliary close-up equipment is necessary for photographing very small fish (below 5cm length) and for recording details on larger specimens, this is because the standard 50mm lens will magnify only up to about one seventh life size. Such equipment includes: close-up lenses, which are fitted to the front of a standard lens; extension tubes, fitted between the standard lens and camera body; bellows unit, also fitted between lens and camera, allowing variable magnification. A special "macro-lens", which replaces the standard lens, can provide up to 0.5x magnification, such that a 1.5cm fish will almost fill the picture frame. Higher magnifications can be achieved by using a combination of macro-lens and bellows unit (giving up to 4x life-size), or by reversing a 35mm lens (with the aid of a reversing ring) onto a bellows unit (giving up to 6x life-size). A slide focuser, which is inserted between camera

and tripod, allows the camera to be racked in and out of focus. For close-up work, it is essential to use a sturdy tripod or other camera support plus a cable release, in order to achieve a sharp image.

7.2.2 The photo-tank

The photo-tank should be sufficiently small to be easily portable in the field. It should be narrow in width (i.e. distance between the front and rear glass) to ensure that the fish remains close to the front glass, avoiding the need to constantly refocus the camera. Glass tanks are preferable to plastic ones because they can be constructed from high optical quality material and are less prone to being scratched.

7.2.3 Materials and construction

Frameless, all-glass tanks can nowadays be built using silicone adhesives, and can be conveniently transported as glass sheets, pre-cut to size, for assembly in the field. It is advisable to have two or more different sized photo-tanks in order to accommodate a range of fish sizes, e.g. 10x10x5mm (length x height x width) up to about 40x30x15mm. (Much larger tanks tend to be awkward to transport). Glass thickness of 2mm is adequate for small tanks, and 4mm for large ones. It is useful to have an additional glass sheet which is cut to the same height as the tank, but a few millimetres shorter than its internal length. This piece serves as an adjustable tank divider which is used to retain very small fish close to the front glass in order to aid focusing. The divider can also be inserted at an angle for positioning dead or sedated specimens (Figure 1). A glass cover will prevent escapes.

For assembly, the base glass is laid flat and the four sides held in position using strips of adhesive tape attached to the exterior corners. The glass must be clean and grease-free in order to ensure adhesion of the sealant. The silicone is applied along the inner joins and smoothed with a finger. It sets in 48 hours after which the tank can be filled and checked for leaks. (Warning: the sealant will evolve acetic acid fumes during the curing process which may irritate the eyes).

7.2.4 Use under field conditions

For field use, the photo-tank is placed on a firm, flat surface and positioned so that the sun is behind the photographer and shines directly into the tank. Daylight is generally the most convenient source of illumination and allows continuous monitoring for any distracting light reflections within the tank. Reflected glare from the sun may occur on the front or rear glass but this can usually be avoided by rotating the tank a few degrees. Reflected

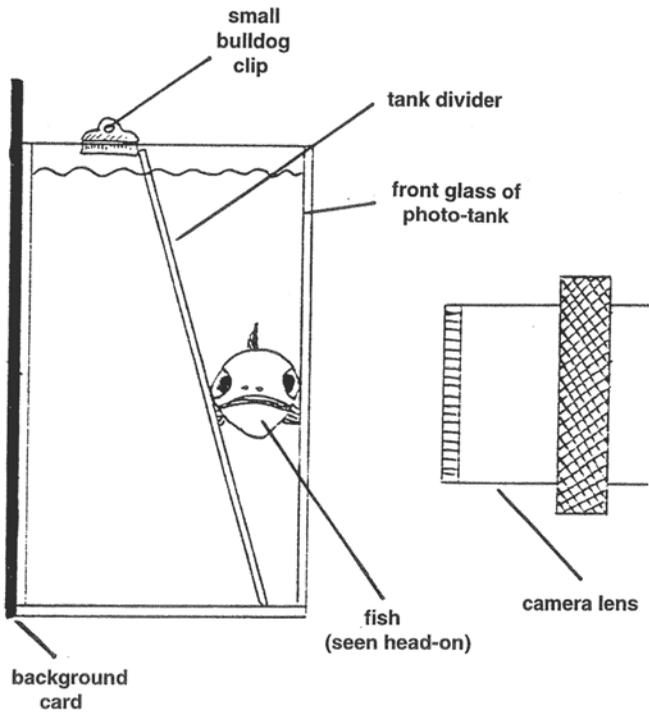


Figure 1: Side view of photo-tank, showing position of tank divider

images of the camera or photographer can be eliminated with the aid of a sheet of matt black cardboard (circa 30x30cm), which has a central hole cut to fit firmly over the camera lens (Figure 2). A polarizing filter will help reduce any residual reflections.

The photo-tank can be furnished with substrate (e.g. sand or fine gravel - thoroughly washed), small rocks and aquatic plants, in order to give a natural effect. Alternatively, rocks and vegetation can be positioned behind the tank (and slightly out of focus) in order to give a pleasing but non-distracting background. For a plain background, a sheet of grey (or other non-distracting colour) card is positioned against the rear glass.

7.2.5 Improving water clarity

It may be necessary to use natural water sources (e.g. river, lake, sea) for filling the photo-tank in which case the clarity may be poor. Suspended particles in the water will adversely affect image quality and will produce a “snow-storm” effect if flash is used. Water may be partially clarified by leaving it to stand for a while, to allow the particles to sediment. Alternatively, it can be filtered through a plastic funnel packed with fine nylon wool (aquarium filter wool, available from pet stores, is ideal).

7.2.6 Photographing fish in a tank

If the fish is not too large, it should be photographed within the tank as this will usually give superior results as compared with photographing it out of water. Film of medium to fast speed (100 - 400 ASA) is required when photographing live fish under natural lighting conditions, enabling the selection of fast shutter speeds for highly active specimens.

There is no need to kill a fish simply in order to photograph it. Bear in mind, however, that fish are capable of experiencing pain and stress and must therefore be treated humanely. Fish are likely to dash about when first introduced into the tank, but they generally settle within a few minutes. The tank should, however, be covered at all times to prevent escapes. Sedation may be required if the fish does not calm down or when high-power close-up work is required (see section 7.2.11). Fish may lose their colours in response to stress or bright lights. This problem can sometimes be remedied by covering the photo-tank with a dark cloth for a few minutes in the hope that the fish settles down and regains its colours. Slowly remove the cloth and be ready to take photographs as soon as possible

The temperature of the water in the photo-tank must be similar to that from where the fish was caught and should be frequently monitored,

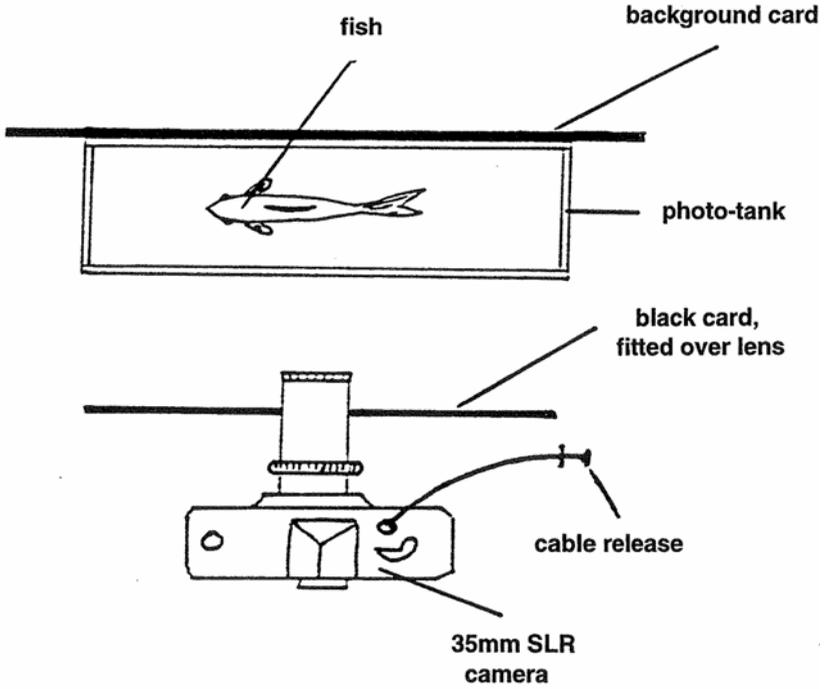


Figure 2: Photo-tank and camera set-up, as viewed from above

especially in hot environments where it will quickly warm up. Frequent water changes will help prevent overheating and ensure adequate levels of dissolved oxygen for the fish. Water changes will also prevent excessive accumulation of epithelial mucus which is secreted in substantial quantities by certain fish (e.g. some species of catfish), particularly when stressed.

Water which has warmed in the tank may evolve gas bubbles on the glass and other surfaces. These will appear unsightly in the photograph and should be dislodged using a piece of cloth or non-abrasive instrument. Also be sure to remove any water droplets from the front glass.

Dead fish can also be photographed under water in a photo-tank, and this will often produce life-like results. The fish is gently wedged between the front glass and a sloping glass divider, the latter held in position with bulldog clips or clothes pegs (Figure 1).

7.2.7 Photographing fish on land

Fish which are too large for the photo-tank will need to be photographed on land. Live fish can be held out of water for a few minutes without harm, provided they are protected against overheating and their skin is kept wet. The specimen is laid on its side onto a damp cloth, ensuring that its delicate skin is protected against abrasive surfaces. A plain grey background gives good results, but avoid lying the fish on coloured paper or card as these materials change shade when wet. Fish tend to stop struggling after a short while and can often be calmed by briefly placing a wet cloth over their eyes. Specimens which persistently struggle may require sedation (see section 7.2.11). Freshly killed specimens should be photographed as soon as possible, before their colours fade. The dead fish can be laid onto polystyrene or cork and the fins pinned out and soaked in formalin in order to keep them erect for photography. Any light reflections from the fish's body can be eliminated with the use of a polarizing filter.

7.2.8 Recording fish size and colour

A plastic ruler can be placed alongside the fish to provide scale. To assess colour balance, a special colour separation guide (comprising a strip of 17 colour patches) is positioned near the edge of the frame. Comparison of the original guide with its reproduction in the print or slide will reveal the degree of colour fidelity.

7.2.9 Flash photography

In situations where there are inadequate levels of natural light it will be necessary to use flash. For tank photography, it is important to position the flashguns correctly otherwise the light beam may reflect into the lens, causing a “hot-spot”. One satisfactory position is directly over the tank so that the flash shines onto the dorsal surface of the fish. It is, however, wise to experiment with flash photography for tanks, before embarking on the expedition. Also, fish in a tank in daylight often blanch, so dark conditions suddenly illuminated give more colourful photos.

7.2.10 Photographing aquatic habitats

Photographs of the fish’s habitat provide useful information to supplement field notes. Wide-angle lenses (e.g. 28 - 35mm focal length) are useful for recording large water expanses such as lakes or stretches of river. If the water is clear and calm, it may be possible to photograph fish *in situ* whilst standing near the water’s edge or from a boat. A polarizing filter reduces any surface reflections.

7.2.11 Sedatives

Sedatives are useful for immobilising highly active fish in order to achieve a sharp image. Two anaesthetics are recommended for sedation: MS222 and benzocaine, both added to the water (= immersion anaesthetics). MS222 is water soluble, whereas benzocaine must first be dissolved in a small volume of alcohol or acetone. The fish is placed in water containing anaesthetic at 50 - 100mg per litre and held there until it loses equilibrium. The sedated fish is then quickly photographed either on land or in the photo-tank, followed by recovery in clean anaesthetic-free water (preferably well aerated). It is unwise to add anaesthetic to the photo-tank as the fish is liable to fall into deeper states of anaesthesia, leading to medullary collapse and death.

7.2.12 Protecting film and camera equipment

Photographic equipment should be protected from humid atmospheres (relative humidity above 60%) as these conditions can give rise to the growth of mould on film emulsions and lenses, the latter resulting in picture fogging. Certain types of zoom lenses appear particularly susceptible, as mould spores may be drawn into the extending lens barrel during the zooming process. The storage of photographic equipment in air tight containers with desiccant (e.g. silica gel or calcium chloride) will reduce the chances of mould. Where possible, photographic film should be stored below 25°C (even lower for professional type films).

Covering the camera with a plastic bag during the addition or removal of fish from the photo-tank will protect it against the inevitable water splashes. Seawater is particularly corrosive.

7.3 Underwater photography by Colin Doeg

It is never easy to photograph a wild creature in its natural habitat, especially if it lives underwater. Unlike land photography, it is not possible to use extreme telephoto lenses to avoid having to get close to the subject. Instead, it is usually essential to take pictures within a few inches of the subject because the water itself as well as the matter suspended in it reduce the quality of the slide or print.

It has long been considered that, as a rule of thumb, pictures should never be taken from further away than a third or a quarter of the visibility. This is especially true when one is taking natural history or marine life pictures.

7.3.1 Photographic equipment

The ever-increasing interest in diving and underwater photography has led to a selection of amphibious still and video cameras being available. The still models range from viewfinder cameras to those with through the lens viewing facilities, including the world's first amphibious SLR. Amphibious video cameras are also available. The alternative is to use a land camera in a special underwater housing and this combination is increasingly popular because they are often cheaper than the amphibious version and yet you can also use the camera on land.

Water absorbs the colours of the spectrum so rapidly as you sink beneath the waves that it is essential to use some form of artificial light to reveal the actual colours of fish. A burst of flash light or the beam of a tungsten lamp will reveal that the fish is a dazzling red or a vivid blue whereas at 10 or 20m it may only look black or a dark colour. For scientific accuracy, it is also essential to use artificial light unless one is trying to convey the mood or atmosphere of the moment.

The world's first amphibious camera was launched in 1959. It was developed by Jacques Cousteau and De Wouters, a Belgian engineer. The manufacturing and distribution rights were bought by Nikon and the model was renamed the Nikonos. It was a viewfinder camera with a range of lenses, from extreme wide-angle to medium telephoto, which could be changed on land. The latest versions have sophisticated electronics which provide through the lens exposure and flash metering (TTL).

A similar concept of camera is marketed by Sea & Sea Ltd. The body is constructed from plastics rather than metal, it operates at only one shutter speed but has TTL exposure metering.

A wide range of accessories is available for both cameras, ranging from push-on close-up and wide-angle supplementary lenses to underwater flashguns. Extension tubes are also available for the Nikonos for macro photography. All these close-up lenses have framers which make it easier to compose the pictures accurately.

For really accurate composition, especially with close-up and macro photography, there is nothing to beat an SLR camera. Nikon have produced the world's first amphibious SLR, the Nikonos RS. It is accompanied by a range of lenses which are interchangeable on land, including macro, zoom and wide-angle optics.

A cheaper alternative is to use a land camera in an underwater housing and operate it by external controls or by a mini-computer inside the housing which is controlled by a touch-pad. There is a variety of housings available for most of the leading SLR cameras but most divers remain loyal to Nikon and use the latest models in commercial housings of which the Subal is particularly popular.

A selection of underwater flashguns is on the market as well as housings for some land flashguns, notably the Nikon range.

Of particular interest for macro photography, which is the technique most likely to be used when photographing the majority of fish, is the combination of the Nikon F90 camera, 60 or 105mm D series lens and SB26 flashgun because of the highly sophisticated and accurate way in which flash exposures are measured for close-up and macro-pictures.

Land cameras can be protected in Ewa Marine cases for use in very shallow water. The controls are operated through the walls of the plastic container. A number of compact cameras are available which are waterproof in shallow water. Their use is limited by the fact they usually only have a standard lens focusing to about 1m, so are only suitable for clear, well lit waters. Their flashguns are built into the camera body - a far from desirable position because it will always illuminate particles suspended in the water.

7.3.2 Choice of film

While excellent photographs can be taken with black and white materials, most general and scientific work is in colour. All films are rated by their

speed, which is expressed as a number. The slower the film speed the better quality the results. Therefore, unless the circumstances or the requirements are unusual, most underwater pictures are taken with 100 or 50 ASA films.

The preference among most experienced underwater photographers is to use Fuji's 50 and 100 ASA slide films, especially Fujichrome Velvia for close-ups and even general shots. However, the intense competition among manufacturers is such that new, improved emulsions are constantly coming on the market.

For colour prints, it is not so essential to use a slow film but it would still be sensible to stick to 100 or 200 ASA films.

The use of slow films also dictates that the natural light falling on the subject has to be supplemented by artificial light. For general shots, a burst of flash will help to paint in the colours and details of the subject. This technique is called fill-in flash because the intensity of light from the flashgun is less than the general level of illumination. The electronics in modern cameras make this method easy and most effective. With close-up and macro-photography, the entire subject is lit by the flash.

When choosing film for any type of expedition it is important to buy 'amateur' stock. Do not be misled into choosing 'professional films' - unless an amateur version is not available, as with Fuji Velvia - because they are less suitable for expedition photography.

Amateur films are designed to be abused - left out in the sun, used in humid climates and left for months before being processed. Professional films are for use in 'professional' circumstances. The manufacturer allows them to ripen until the emulsion reaches optimum condition. At this point the films are kept in refrigerators - in the store and in the studio - until required. Then they are warmed up for a few hours, exposed and processed immediately or returned to a 'fridge until they can be developed.

The other slide film which should be considered is Kodak Kodachrome. It is available in speeds of 25, 64 or 200 ASA and the universal choice is usually 64 ASA though many change to the 25 ASA version for close-ups and macro shots. It is renowned for its archival qualities but many underwater photographers still prefer the more vibrant colours of some of its rivals.

The majority of slide films - not Kodachrome - are processed in E6 chemicals. If they are not process paid the films can be developed in colour laboratories used by professional photographers - more expensive but better

than your average chemist! - or on site using kits of chemicals obtainable at photographic stores. To do so you also need a developing tank, a thermometer and a few other gadgets but the facility enables you to develop at least a few films so you can be reassured - or dismayed - by your results. Many overseas centres popular with divers as well as live-aboard boats also offer E6 processing because most underwater photographers like to see their results as quickly as possible while there is still an opportunity to retake a shot if it needs to be improved. If E6 processing is not easily available an alternative way to check your equipment and results may be to expose a colour negative film - many areas can process them rather than slides.

7.3.3 Underwater techniques

Before one ventures underwater to take pictures it is essential to be a proficient diver because photography demands so much attention. It is also important to be thoroughly proficient in precision buoyancy control to avoid damaging fragile eco-systems. This requirement becomes reality when hovering a few centimetres above a coral head which has taken several hundred years to reach maturity while you are staring through your viewfinder trying to compose and focus your shot of a small fish that wants to dart away.

The use of a buoyancy control device or 'stab' jacket and plenty of prior practice in a swimming pool or the sea are vital before you venture out with a camera. All the major diving organisations emphasise the importance of good buoyancy control and now a new system has been launched in the UK which adds an element of fun to this training while making the diver doubly aware of any inadequacies in technique.

If you are exceptionally proficient, many good pictures can be taken while snorkelling. This gives greater flexibility and means you do not have to have your compressed air cylinders constantly recharged.

Photographically, the best results will always be obtained in shallow water - 10 or 20m if not less. The background in your general shots will be better lit and you will be able to see more. Your air supply will last longer, giving more time to look for good subjects. The only reason for ever going deeper for a picture is if the subject is unobtainable in shallow water.

Many fish are territorial, especially in the tropics. This makes them easier to find and photograph. But they are wild creatures and, therefore, should be approached slowly and considerately. Most are startled by the noise of bubbles being exhaled so you should breath as slowly and gently as possible.

You must be very patient as you wait for the right picture to develop - it is nothing for an experienced underwater photographer to wait for half an hour for a fish to settle down or peer out of its protective hole.

The real workhorse for fish photography is the 60mm macro lens (with a housed camera) or the close-up kits or extension tubes available for the Nikonos and Sea & Sea Motormarine. To obtain good quality shots of larger fish, like sharks, it is necessary to change to wide angle lenses - 15mm on the Nikonos, a wide-angle adapter on the Nikonos or Motormarin or 18/20mm with a housed camera. The use of such lenses also means it is necessary to work very close to those particular fish, for which it is necessary to have studied and be aware of their behaviour patterns! Other fish, such as moray eels, can produce awe inspiring threat postures and so should also be treated with caution. Silvery coloured fish are difficult to photograph because flash will flare off their scales. Autofocus does not usually work with sleek, streamlined fish such as sharks.

Other photographic techniques - composition, angle of lighting, focusing - are similar to those for land photography and best learned on terra firma before you venture on your expedition. Much can also be learned by practicing your underwater techniques in a swimming pool with wooden fish suspended from the bottom. There are also a number of specialist courses in underwater photography which can be most helpful and many dive centres and live-aboard boats in areas like the Red Sea hire Nikonos outfits on a day basis. Membership of the British Society of Underwater Photographers, still the only photographic society in the UK devoted entirely to underwater photography, can also provide useful contacts and a storehouse of knowledge.

Production of a video showing fish in their natural habitat can also be useful. All the general requirements of underwater proficiency apply to filming beneath the waves. The general techniques are best learned on land but it is always important to hold the camera steady and allow the action to happen within the frame. It makes for easier viewing if facilities such as zooming are never over-used. Otherwise the audience will depart before they become seasick. As with still photography, it is usually important to light the scene to restore the natural colours of the fish and background unless you are shooting an atmospheric sequence.

APPENDICES

Check-list of photographic gear

- 35mm single lens reflex camera with standard lens
- Wide-angle lenses
- Close-up equipment (e.g. macro lens / close-up lenses / extension tubes / bellows unit)
- Camera support (e.g. tripod)
- Slide focuser
- Electronic flash unit and support
- Photographic film (range of film speeds, e.g. 64 - 400 ASA)
- Polarizing filter
- Cable release
- Glass sheets (optical quality, ready cut to size) for constructing photo tanks
- Silicone adhesive
- Adhesive tape
- Matt black card
- Small nets (to fit inside photo-tank)
- Aquarium thermometer
- Fish anaesthetic (in pre-weighed quantities)
- Ruler or scale bar
- Colour separation guide
- Plastic filter funnel
- Filter wool
- Bulldog clips or clothes pegs (to restrain tank divider)
- Desiccant
- Plastic bags (for transporting fish and protecting equipment)

Sources of equipment:

- Silicone adhesive. Dow Corning® and other manufacturers. Available from D.I.Y stores and aquarium fish shops.

- Calcium chloride desiccant. Available from hardware shops (sold as a moisture absorber for windows and damp rooms).

- Fish anaesthetics. MS222 (= Tricaine methanesulphonate; also known as 3-aminobenzoic acid ethyl ester) and Benzocaine (= Ethyl-p-aminobenzoate). Both available (in powder form) from Sigma-Aldrich Co Ltd., Fancy Road, Poole, Dorset, BH17 7NH, England.

- Colour separation guide (sold with a grey scale): catalogue 1527654. Manufactured by Kodak Ltd., Swallowdale lane, Hemel Hempstead, Hertfordshire HP2 7EU.

A number of underwater photography and diving publications are available from specialist suppliers, such as Ocean Optics, 13 Northumberland Avenue, London WC2N 5AQ (Tel. 0171 930 8408, Fax. 0171 839 6148).

Section Eight

POST-FIELDWORK ACTIVITIES

8.1 Introduction

The expedition is not complete when the field work is over. Your collections and data sheets must be divided and duplicated between yourself and the host country, paperwork essential to legal transfer of collections out of the host country completed, and finally an interim and final report written.

8.2 Specimen distribution

Do not leave the host country with the worst specimens, retaining the best for yourself. This merely muddies the waters for those who follow after you and leads to charges of neo-colonialism. Adhere to return dates for specimens borrowed from host country museums or promised in collecting agreements. It may prove possible to identify the bulk of the commoner species at a host country museum, retaining only the problematical ones for later return once they have been identified and worked up. Copies of Field Sheets, other notes, and photographs must accompany the relevant collections deposited in the host museum.

8.3 Customs

Scientific collections usually require an export licence from the host country and an import licence to the UK may be necessary. These documents should have been arranged before departure but sometimes this is not possible at long distance. Allow several days at least to make these arrangements at the end of the expedition in the host country. It may be worthwhile to send one team member to the point of exit or the capital of the host country several weeks before the expedition is due to leave, to begin the round of visits and filling out of paperwork. Patience is essential. Never attempt to smuggle out specimens: they can be confiscated at either end of the journey, your work is lost, your credibility is destroyed, and you hinder the work of responsible scientists and expeditions. A CITES certificate may be necessary for your material as it can be impounded by UK customs (see Section 1.3 Preparatory work). See also Section 3.4 Packing for acceptable methods of sending material through the mail or by other transport.

8.4 Writing reports and papers

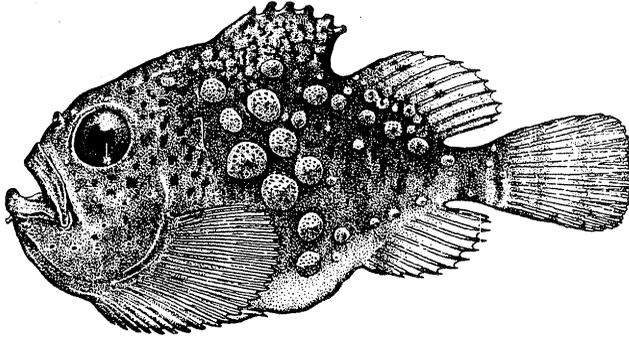
Much preliminary work on writing reports can be done in the field while memory and fish are fresh. Well organised data records are an essential basis to writing a clear and informative report. The interim report can broadly sketch what has been accomplished and should appear within weeks of your return home. It may be possible to complete an interim report while still in the host country, ideally in the local language but with at least a summary in that form. This helps to show serious intent to your hosts and focuses your own thoughts on what needs to be done for the final report appearing about a year later. These reports are an integral part of the expedition itself - without a written report, the information you gathered remains unknown. Illustrated lectures also serve to advertise what you have done and are the most entertaining and effective way for sponsors to see what you have accomplished. Scientific papers come later, sometimes after several years, since their preparation is time consuming and they are sent out for review to experts. Collections of fishes made in the 18th century are still being studied by scientists so your efforts may well have more than immediate value.

Reports, lectures and papers include acknowledgements of all persons and institutions who helped make the expedition possible. Copies of the reports and papers are sent to collaborators, sponsors and interested scientists, (particularly in the host country where they may be difficult to obtain), to the copyright libraries (British Library, London; National Library of Wales, Aberystwyth; National Library of Scotland, Edinburgh; and the libraries of the universities of Oxford and Cambridge) and to the Expedition Advisory Centre at the Royal Geographical Society (with IBG).

Scientific papers range in content from long, highly specialised tomes to short, readable notes on natural history. All have their value and receive wider dissemination and retrieval than expedition reports. Those new to writing for scientific journals may wish to start with a short note, remembering that these are most useful contributions as field guides and texts on fishes build on such sources. Longer, more detailed works can then be attempted. Some material can be published in journals of the host country in the host language where they may find their most relevance.

Study a variety of papers on fishes in journals to see how they are laid out. The beginner can often benefit from modelling his or her paper on a format which has met with success for others. Read such references as Day (1989) and Hunter (1990). Consult ichthyological journals such as *Copeia*, *Ichthyological Exploration of Freshwaters*, *Environmental Biology of Fishes*,

Journal of Fish Biology, *Transactions of the American Fisheries Society*, *Japanese Journal of Ichthyology*, *Cybium*, *Matsya*, *Indo-Pacific Fishes*, *Journal of Ichthyology*, general natural history journals and journals in the host country.



Smooth lumpfish, *Cyclopteropsis jordani* Soldatov, 1929. Standard length 54.4 mm. Collected in Wellington Bay, southern Victoria Island, Northwest Territories, Canada by the Arctic Unit of the Fisheries Research Board of Canada, 1 September 1965. Drawn by C. H. Douglas, Canadian Museum of Nature, Ottawa.

Section Nine

DATA ANALYSIS

9.1 Introduction

Data from a field collection of fishes comes in three forms. The specimens themselves are a source of data, providing information on systematics from measurements and counts of characters and from molecular analysis of tissues, age and growth from scales and other structures, reproduction from anatomical evidence of maturity and egg counts, parasitology, and toxicology from tissue analyses among others. A second form of information is derived from the Field Sheets and labels including zoogeography, environmental parameters governing distribution, habitat preferences, effectiveness of capture methods, abundance, biodiversity, and so forth. The third form of data is derived from experiments or sub-sampling carried out including tissue samples for molecular or toxicology techniques, data on weight and size, migratory and movement information based on tagging or tracking, ecological or life history data taken from scale samples, gut contents, egg samples, parasite preparations, behavioural information, and so on.

9.2 Analysis

The analysis of some or all this information can be a major task. You must decide what you can tackle in the time available to you and bring to a successful conclusion. Do not be afraid to ask for assistance from scientists in universities and museums but do set up appointments rather than dropping in unannounced.

Certain fields of endeavour may prove too time-consuming, too complex or require highly specialised equipment. Parasitological work requires a range of chemicals and a high-powered microscope and along with systematic studies takes time and training to become proficient in. A new species description can be a fairly short project and might be attempted with expert advice on taxonomy and literature. Samples for toxicological or molecular work require extensive laboratory set-ups and were presumably taken on behalf of a scientist with a specific interest in the materials you could supply. This material should be given to the scientist with copies of the relevant collection data as soon as possible. You may be able to collaborate with the scientist and work in the laboratory on the processing of your samples.

In a limited time period an expedition member can analyse and publish collection data. This would include distribution maps, keys, ecological and behavioural observations, habitat preferences and environmental data. The data should be organised and analyzed to extract the maximum amount of information and present it in a readable and understandable fashion without ambiguities. A series of books are listed in Section Ten: Recommended reading covering systematics and fisheries science. Good beginning books which explain how to analyse data include Lackey (1974), Lagler (1975), Bagenal (1978) and Cailliet et al. (1986).

9.3 Statistics

Scientists use various statistical procedures for examining systematic and ecological data. Programmes running on personal computers now come with handbooks which explain the appropriate techniques for a given set of data. Books such as Simpson et al. (1960), Sneath and Sokal (1973), Clifford and Stephenson (1975), Sokal and Rohlf (1981), Burnham et al. (1987), and Brooks and McLennan (1991), in addition to the fishery biology books cited, give explanations of statistical treatment of data at various levels of complexity. Mapping programmes, statistical packages, and spread sheets may facilitate sorting, organising and analysing your data. However, statistical analyses are not essential to publishing valuable information on fishes. Do not feel you have to include such analyses to lend authenticity to your observations

Section Ten

CHECK-LIST OF FIELD GEAR

10.1 Introduction

The type of field gear required will depend on the work to be done, the environmental conditions and space available for transport. Extended travel in a vehicle or small boat will severely limit the gear which can be carried, especially if food, water and camping supplies must also be taken. A collector on board an experimental fishery or oceanographic vessel or with several vehicles will have more latitude in the types of gear available and in the volumes of ichthyological supplies which can be transported.

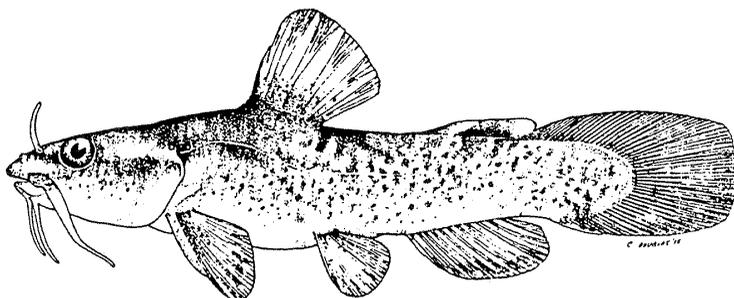
10.2 General items

- First Aid Kit
- List of hospital facilities and their phone numbers
- Personal medications
- Insect repellent
- Sunglasses
- Sunburn lotion
- Tool kit for vehicle and repair manual, spare tires, extra fuel, oil, transmission fluid, brake fluid, flares and accident triangles
- Boat, oars, life jackets, anchor
- Boat engines or outboard motors, spare parts, repair manual, repair kit, fuel, oil, shear pins, distress flares, radio
- Maps, charts, pilots
- Navigation gear
- Rope, cord, string
- Shovel, axe, saw and general tool kit
- Waterproof clothes; field clothes including heavy duty boots and wide-brimmed hat
- Food, drink
- Matches, flashlights, gas lanterns
- Camping gear including portable stove, cooking pans, utensils, tent, sleeping bag, mosquito netting
- Head-torch
- Plastic bags of varying sizes
- Compass

10.3 Ichthyology items

- Collecting Permits
- Letters of introduction
- Cameras, underwater cameras, video recorders, film, lenses, flashes, tripods, lens cleaning apparatus, waterproof containers, pins
- Aquaria, clear plastic containers for fish photography
- Keys and identification books
- Field Sheets and notebook
- Labels, pens, pencils, India ink
- Scale envelopes and slides
- Variety of nets including seines, gill nets, trap nets, dip nets, trawls, dredges, etc, with appropriate weights, floats, brails
- Net repair apparatus including needles and twine
- Hooks, line, lures, natural and artificial baits
- Electroshocker, battery, safety clothing including insulated rubber gloves and heavy waders
- SCUBA gear including suit, fins, masks, snorkels, regulator, tanks, depth gauge, dive watch, weights, knife, spears, slurp gun, dip net, grab-bags, writing slate and pencil or waterproof notebook for underwater, repair kit, underwater lights, hand tally counter, measuring tape
- Bottles, drums, cans, plastic bags, vials, jars, plastic buckets with lids
- Cheesecloth, hypodermic syringe with various needles, packing materials
- Formalin, paraformaldehyde, alcohol, glycerol, Alconox, borax, sodium carbonate, anaesthetics, ichthyocides, specialised chemicals for parasites, tissue samples, etc.
- Gloves and goggles
- Tape measure, metre stick, weighing scales
- Knives, scalpels, forceps, scissors, probes, pails, sorting trays
- Waders with repair kit
- Hand lenses, portable microscope
- Echo sounder
- Secchi disc
- Thermometers (reversing and variously accurate stick thermometers)
- Salinity kit
- Conductivity kit
- Water quality kit
- Current metre

- Altitude metre
- Global Positioning Device
- Data logger
- Portable computer, disks, printer



Brindled madtom, Noturus miurus Jordan, 1877. Total length 87.5 mm. Collected in Bear Creek, Lambton County, Ontario, Canada by C. G. Gruchy, 9 August 1972. Drawn by C. H. Douglas.

Section Eleven

RECOMMENDED READING AND REFERENCES

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- (* see note on page 99)

General Ichthyology Texts

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Section Twelve

REGIONAL ICHTHYOFAUNAS

Lindberg (1974) and Blackwelder (1972), cited above, should be scanned for regional ichthyofaunas prior to 1970. Many of these are still the only available synoptic works on fishes for their area of coverage. Eschmeyer (1990), Nelson (1994) and Berra (1981) give overviews of distribution and recent systematic, zoogeographical and distributional papers on fishes. Most European countries and North American states and provinces have their own field guides or weighty tomes on their fish faunas: only a brief selection of wide ranging guides are given here.

Checklists and bibliographies usually do not contain keys or descriptions of fishes but have extensive reference lists and are good place to start in searching out literature relevant to your expedition. Wherever recent, comprehensive checklists exist (e.g. Daget et al. (1984-1991) on the freshwater fishes of Africa) drainage basin and regional checklists within that area of coverage are not cited.

See Section 1.3 Preparatory work for further sources of information.

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Books marked with * are usually available only from a specialist supplier, such as Ocean Optics, 13 Northumberland Avenue, London WC2N 5AQ (Tel. 0171 930 8408, Fax. 0171 839 6148).

Section Thirteen

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)

Species Identification and Data Programme, Marine Resources Services, Fishery Resources and Environment Division.

Via delle Terme di Caracalla, 00100-Rome, Italy. Tel. 396-52256354,
Fax. 396-57973020

The FAO has an extensive list of publications, including the following:

FAO Species Catalogues, (as part of the FAO Synopses Series). Worldwide, annotated, and illustrated inventories of fishery resource groups. These publications include general information on the group and information by species comprising scientific nomenclature, international and local names, diagnostic features, geographical distribution, biology, fisheries, and relevant literature.

FAO Species Identification Sheets for Fishery Purposes. A series of regional publications addressed primarily to field workers in all sectors of fisheries. Each regional set of identification sheets is designed as a comprehensive, coded, annotated and illustrated inventory of the species used for food in the region it covers. These documents are mostly based on voluntary contributions of a large group of systematists and fishery workers. The more recent issues are printed on water - and tearproof material.

Field Guides for Spot Identification of Commercial Fishes. Catalogues of commercial species entering fish landings of individual countries, or groups of countries. They are aimed particularly at national data collectors in need of quick identification of species in markets and on landing places, for the specific purpose of improving statistical and other fisheries data by species. These publications are based primarily on illustrations, with a minimum of text, including nomenclature (scientific, FAO, national and local), size, habitat and fishing gear. They are intended as a summarial complement, at a national level, of the species identification sheets for the region concerned.

The FAO has also developed computer software for the identification of commercially important fish species:

SPECIESDAB, a Global Inventory of Commercially Important Species uses the information compiled by FAO's Species Identification and Data Programme. SPECIESDAB was created to offer quick and easy access to the fisheries and biological information in the FAO Species Identification Sheets and World Catalogues. SPECIESDAB represents FAO's standard authority on nomenclature and identity of aquatic species used by man. It constitutes a global framework for continuous storage and updating of information and for the exchange of data between FAO and fisheries institutions of Member countries.

Data on scientific and vernacular nomenclature, biology, fishing gears and geographical distribution are included for species which belong to certain marine resource groups. To date, some 25 major resource groups are covered. Among these are shrimps, lobsters, cephalopods, sharks, marine turtles and 20 families of bony fishes, which together form a significant component of world fisheries. In addition, information is included for many of the species listed in FAO's Yearbook of Fisheries Statistics.

The program uses a menu system to provide users easy access to the information contained in SPECIESDAB. The manual includes extensive examples of how to use the software. On-line help is also available. Extensive query and reporting capabilities are provided to access data on valid scientific names, synonyms, national and local names, official FAO trilingual names, size, habitat, behaviour, kinds of gear utilized in the fishery and level of interest to fisheries. Geographical information may be obtained by species, by country or by fishing area. Data may be extracted for either a single resource group or for all resource groups in combination. Furthermore, the user interested in using only the data of species occurring in a particular geographical area can create, with the Regional option, a sub-database including only the species found in the countries selected. This option can be useful for regional bodies and working groups. SPECIESDAB includes a bibliographic reference system, which may be updated by the user as well as utilities for exporting data.

Section Fourteen

INTERNET SOURCES

Various museums, universities, societies, government departments and other organizations, as well as individuals are now on the Internet and have searchable databases and other information. There are thousands of sites related to fish and to ichthyology, the ones below being a selection with wide links:-

Catalog of Genera of Recent Fishes, Species of Fish Catalog, and Newsletter of Systematic Ichthyology from the California Academy of Sciences:-

www.calacademy.org

Biosystematics and Life Sciences Resources:-

www.york.biosis.org (search on fish)

Food and Agriculture Organization, UN:-

www.fao.org

IUCN - The World Conservation Union:-

www.iucn.org

Natural History Book Service:-

www.nhbs.co.uk/booknet/booknet.html

Geography Outdoors: the centre supporting field research, exploration and outdoor learning-

www.rgs.org/go