A Field Guide to Counting and Measuring Salmonids Using the Silhouette Imaging and Counting System (SIACS)

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A FIELD GUIDE

to

COUNTING AND MEASURING SALMONIDS

using the

Silhouette Imaging And Counting System

(SIACS)

by

John H.C. Pippy, W. Gordon Whelan and Michael F. O'Connell

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Abstract

Pippy, John H.C., W. Gordon Whelan, and Michael F. O'Connell. 1997. A Field Guide to Counting and Measuring Salmonids Using the Silhouette Imaging and Counting System (SIACS). Can. MS Rep. Fish. Aquat. Sci. 2386: xi + 88 p, 3 appendices.

This report is the result of several years of research on automated counting and measuring of upstream migrating salmonids (mainly adult Atlantic salmon) in Biscay Bay River, Newfoundland. Fish passed trough a specially designed transparent tunnel installed in a counting fence. Images of of fish were obtained by closed circuit television and a motion detector and processed with a video tape recorder or a computer. Stereo images of fish in the form of a silhouette were produced through the use of a semi-transparent mirror, a retroflective material lining the far wall and floor of the tunnel, and a unique lighting system. Two systems are described, which could be operated independently or simultaneously. One is a semi-automatic system wherein counts and length measurements are determined by manually reviewing video-taped images. The other is a computer-based fully automatic system, with software that enhances and digitizes the silhouette image, and stores counts (upstream, downstream, and net direction), length measurements, time, and date. The theory of the technique and step-by-step installation, operational, and troubleshooting procedures are presented in a user-friendly format.

Résumé

Pippy, John H.C., W. Gordon Whelan, and Michael F. O'Connell. 1997. A Field Guide to Counting and Measuring Salmonids Using the Silhouette Imaging and Counting System (SIACS). Can. MS Rep. Fish. Aquat. Sci. 2386: xi + 88 p, 3 appendices.

Le présent rapport marque l'aboutissement de plusieurs années de recherche sur le dénombrement et la mesure automatisés des salmonidés (surtout des saumons de l'Atlantique adultes) de la rivière Biscay Bay, à Terre-Neuve, au cours de la montaison. Les poissons devaient traverser un tunnel transparent spécial installé à un barrage de dénombrement. Des images des poissons étaient saisies par télévision à circuit fermé et par un détecteur de mouvement, puis traitées au moyen d'un magnétoscope ou d'un ordinateur. Au moyen d'un miroir semi-transparent, d'un enduit rétroflecteur sur le sol et le mur du fond du tunnel et d'un système d'éclairage unique, on a pu obtenir des images stéréoscopiques des poissons sous forme de silhouettes. Le rapport décrit deux systèmes, qui peuvent être utilisés séparément ou ensemble. Le premier, semi-automatique, confie à un opérateur le soin de compter et de mesurer les saumons saisis sur image vidéo. L'autre, un système informatique complètement automatisé, dispose d'un logiciel qui accentue et numérise l'image de silhouette et enregistre les décomptes (vers l'amont, vers l'aval, direction nette), les longueurs, l'heure et la date. Le rapport décrit enfin, de façon conviviale, les fondements théoriques de cette technique, ainsi que les procédures d'installation, de fonctionnement et de dépannage étape par étape.

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PATENT NOTIFICATION

The Silhouette Imaging and Counting System (SIACS) is subject to a Canadian patent application, and US Patent Number 5,222,458, dated June 29, 1993, entitled *Apparatus for Monitoring Moving Aquatic Organisms*. Although at the time of publication of this manual, SIACS was already licensed for commercial exploitation, the Department of Fisheries and Oceans (DFO) may issue one more license. Anyone interested in having information on the licensee, or in being considered for a license, should get in touch with Salmonids Section, Science Branch, DFO, Newfoundland Region, at (709) 772-4409; or contact the *Technology Transfer Office*, Canada Department of Fisheries and Oceans, Centennial Towers, Kent Street, Ottawa, Canada, K1A 0E6 in Ottawa, at (613) 990-9819.

PART I: INTRODUCTION

THEORY OF OPERATION

The Silhouette Imaging and Counting System (SIACS) is based on a combination of the two optical concepts: (1) Stereo Imaging and (2) Retroreflective Illumination. These concepts are incorporated into SIACS as follows:

1. Stereo Imaging

The geometric design of the tunnel and mirror assembly produces two stereo images of a fish as it passes through the tunnel; one image is a side view while the other is an overhead view as seen through an overhead mirror (see **Figure 1**). Positional data from the two images in the stereo view (A & B in the figure) are used to calculate the distance of the fish from the camera. From this, as well as the apparent length of the fish on the monitor's screen, and an appropriate conversion factor, the actual length of the fish is calculated.

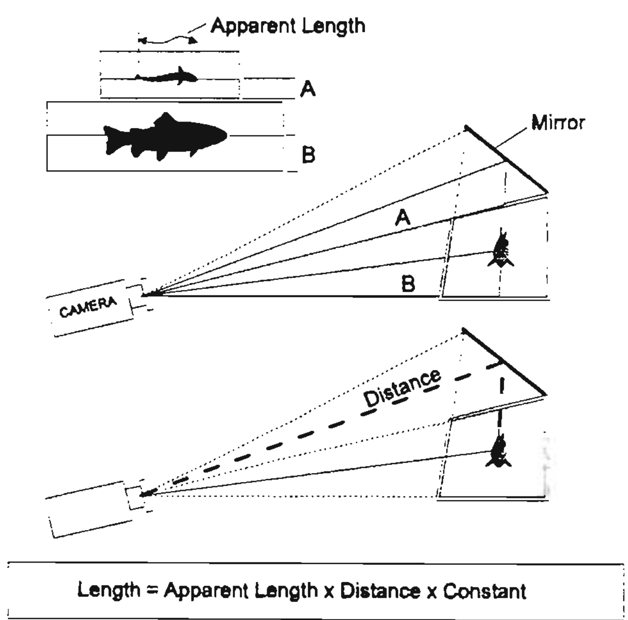


Figure 1. Background to determination of fish length.

2. Retroreflective illumination

While standard silhouette production techniques require the light to be behind the subject, and thus producing an illuminated background, a special type of front lighting called *retroreflective illumination* can also be used to produce the same effect. Retroreflective illumination creates a high quality silhouette of a fish against a brightly lit background; it involves the use of a light placed as shown in **Figure 2**, and a *retroreflector* which reflects light back in same direction from which it came. Common examples of retroreflectors include traffic signs, safety reflectors, and automobile tail lights.

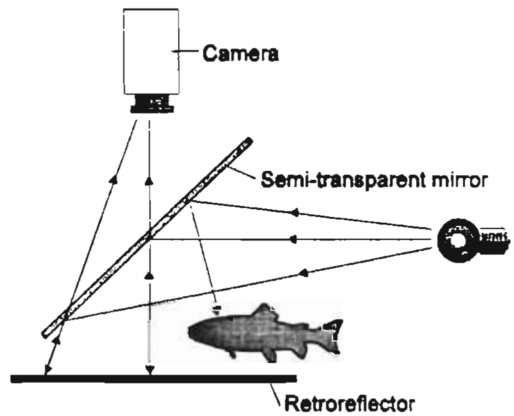


Figure 2. Light reflected from the retroreflective background creates a bright background. A passing fish obstructs light rays and causes the image of the fish to appear as a silhouette.

Silhouette images are ideal for machine vision because the subjects are so easily distinguished from the brightly lit background, and when the images are produced in stereo pairs as they are in the SIACS, they enable accurate and rapid automated fish detection and length measurements.

Combining stereo imaging & retroreflective illumination

The SIAC technique involves the use of a specially designed tunnel, the inside of the rear and bottom walls of which are covered with a high quality retroreflective material. A semi-transparent mirror in front of the camera and below the light acts as a beam splitter to ensure that the light reflected is directly in line with the camera's view, thereby ensuring maximum brightness of the background, and maximum contrast in the silhouette image as in **Figure 3**.

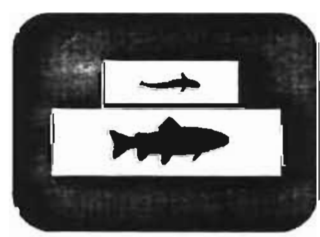


Figure 3. Normal silhouette image made with SIACS's.

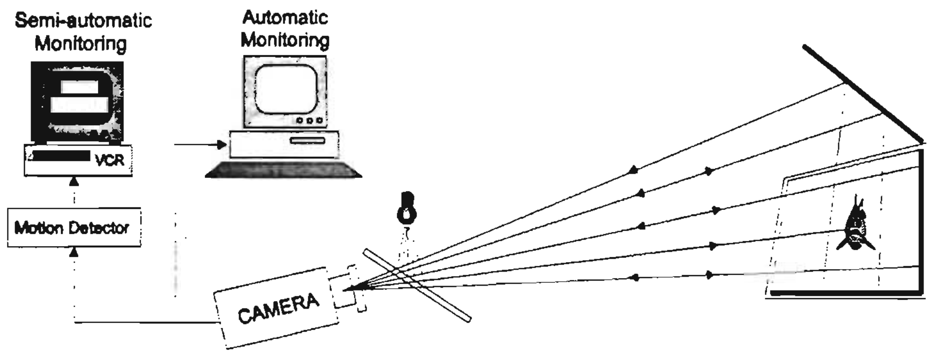


Figure 4. Retroreflective surfaces on the bottom and rear walls of the tunnel coupled with an overhead mirror enables silhuette images of the fish from both side and overhead viewpoints.

The side-view silhouette is produced by viewing the fish against the brightly lit retroreflecive wall of the tunnel while the overhead view of the same fish is produced by viewing it through the overhead mirror and against the brightly lit retroreflective bottom wall. A brief conceptual drawing of the semi-automatic and automatic fish monitoring systems are given in **Figure 4** and the essential components of the imaging system itself are shown in **Figure 5**.

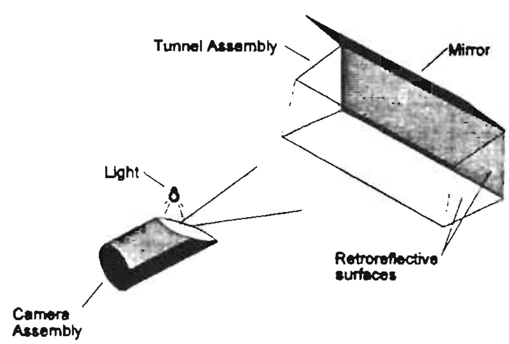


Figure 5. Components required to create silhouette images.

FIELD SETUP

The field set-up is based on an imaging system installed in either a counting fence or a fishway so that fish are forced to swim through the tunnel (see **Figure 6**). The image produced by the camera is transmitted from the river site through a co-axial wire or fibre-optic cable to a nearby cabin containing either a video recorder or a computer, or both . An alternative scheme might employ a self contained camera and computer system which would continuously operate submerged at the river site; such stand-alone systems would be ideal for use in remote fishways and will be discussed in some detail later.

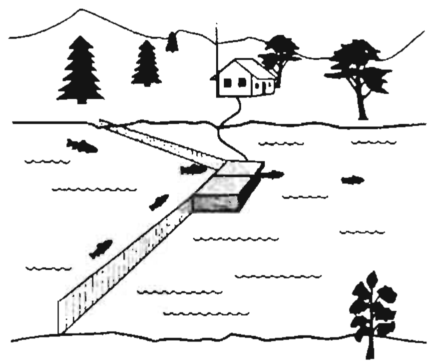


Figure 6. The camera and lighting assembly is mounted above an opening in the counting fence and the video signal is transmitted to shore via cable.

PART II - THE IMAGING SYSTEM

SYSTEM COMPONENTS

A waterproof *camera assembly* containing a camera is attached to a *triangle piece* and aimed at the *tunnel assembly* which, in turn, is attached to the far end of the triangle piece as shown in **Figure 7**. This unit is lowered into a box, or *enclosure*, as shown in **Figure 8** and the entire assembly is placed in a strategic location in the river as shown in **Figure 6**.

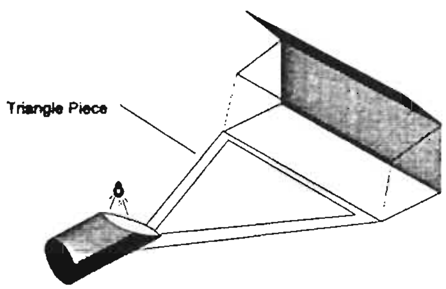


Figure 7. Triangle piece with camera and tunnel attached.

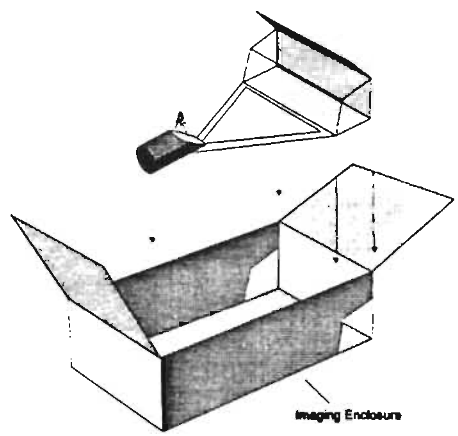


Figure 8. Placement of imaging components into an *unsealed enclosure*.

ENCLOSURES

An *enclosure* is essentially a light-proof box in which the imaging system is mounted. Its use is primarily required to reduce the impact of variations in ambient lighting. The camera's electronically controlled lens automatically adjusts to variations in ambient light, such as that which naturally occurs at dusk, when a cloud passes in front of the sun, when the sun reflects from a polished surface into the lens, or when surface ripples cause light beams to "dance" through the water in front of the camera; such automatic adjustments cause the overall image of the tunnel to occasionally darken or lighten and must therefore be minimized. For this reason, an enclosure is important when a computer is used to monitor fish passage.

The enclosure is also important when small fish are present in an area and can swim between the camera and the tunnel, thus triggering automated equipment set up to detect fish, such as a computer or video motion detector. Although use of an enclosure is not critical when using a video motion detector, as recordings of fish passage are normally manually reviewed at a later time, its use can greatly reduce the time required to view the video tapes.

Enclosures may be made from either of two types of materials, depending on local fish behavioral reactions and budgetary restrictions.

- **Opaque** material such as plywood (painted black), black Lexan®, plexiglass, fibreglass and etc. can be chosen based on price and desired lifespan of a unit. Since they all reduce the amount of light entering the tunnel, fish in some areas may not pass through the dark tunnel during daylight hours; if this is the case, a transparent material may be required. Nevertheless, experience with the experimental facility at Biscay Bay River indicates that neither salmonids nor eels hesitate to pass through the tunnel when opaque material is used.

- **Transparent Blue** material can be used in situations where fish will not pass through a darkened tunnel enclosure. In this modification, blue sunlight passes through the sides of the enclosure and illuminates the tunnel so that it is clearly visible to the fish. The camera, however, is equipped with a red filter which filters out blue light, so that it detects none of the ambient sunlight; It "sees" only the red light coming from its own light source. The camera thus behaves as if opaque material were used in the construction of the enclosure. The only disadvantage to using this material is that it is more expensive and less readily available in some localities.

There are two basic types of enclosures, the *unsealed enclosure* as shown in **Figure 8** and the *sealed enclosure* as shown in **Figure 9**.

1. THE *UNSEALED ENCLOSURE*

The basic layout of this type is illustrated above in **Figure 8**. Its main advantages are low cost and ease of construction. It works well when the river water is clean and clear and shallow (usually less than 0.7 meters). It does not work well, however, during times when the water is turbid, as during freshettes, or in intensely coloured water.

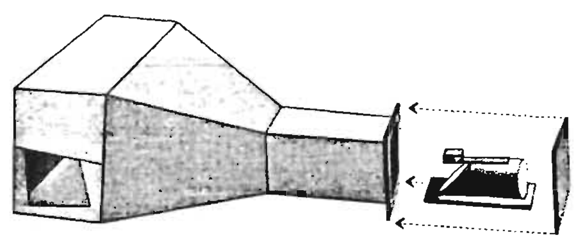


Figure 9. The *sealed enclosure* maintains a volume of clear water between the camera and the tunnel and has a number of advantages over the *unsealed enclosure*.

2. THE *SEALED ENCLOSURE*

The sealed enclosure (**Figure 9**) consists of a water tight box housing the camera and lighting assembly and is filled with clear water treated with an anti-fungal/algal agent. Although more expensive, this version of the SIACS enclosure has the following advantages over the unsealed enclosure.

Advantages of the sealed enclosure over the unsealed enclosure:

1. *The sealed enclosure operates in much shallower water.*
   This is because the mirror is always submerged in water whereas, in unsealed enclosures, the mirror comes out of the water when water levels drop below it.

2. *It operates equally well in a vertical or horizontal position (**Figure 10** and **Figure 11**).*
   A horizontal position may be preferable in a low fishway where water levels can be easily lowered for maintenance; a vertical position may be preferable in a counting fence where water levels cannot be controlled.

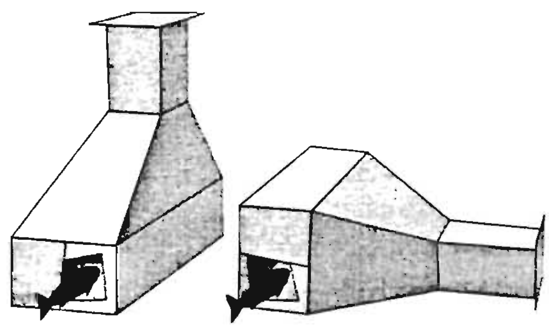


Figure 10. The possibility of either vertical or horizontal operation provides greater flexibility for the sealed enclosure.

3. *It operates in very dirty or turbid water.*
   The water between the camera and the tunnel is always clear because it cannot be contaminated by river water as is possible with the unsealed enclosure.

4. *Maintenance is possible in deeper water, even during flood conditions.*
   The camera hatch is accessible during relatively high water levels so that camera adjustments can be made and the interior of the enclosure can be cleaned if necessary.

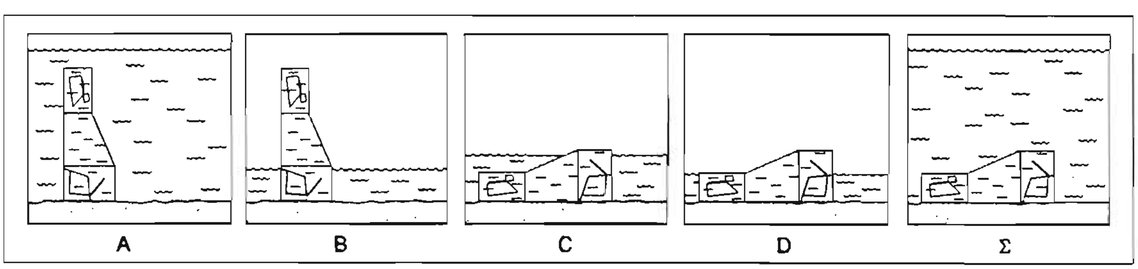


Figure 11. The sealed enclosure offers a wide variety of advantages over the unsealed enclosure.

5. *The sealed enclosure requires less energy to operate.*
   The constantly clean water between the light and the tunnel enables the system to operate using low light intensities (ie., low wattage).

6. *Requires considerably less effort to install* (two as opposed to six workers).
   Because the enclosure is waterproof, it is easily floated into the river and then sunk by filling it with water at the installation site. It is also lighter and more compact and therefore easier to transport.

7. *Almost all pre-operational set-up and calibration can be done in the laboratory* ***prior to field installation***.
   Calibration done in the laboratory tends to be more precise and easier than similar procedures performed under possibly adverse weather conditions in the field.

8. *It is more rugged and less prone to normal operational damage and vandalism.*
   Its general shape makes it less prone to being misshapen by blows to the corners and its sealed nature makes it far more difficult for vandals to break in to steal or damage the camera or lighting assembly. When filled with water, it is practically impossible to move.

9. *Requires less maintenance during use.*
   The water inside the enclosure is treated with an anti-algal and anti-fungal agent which prevents algae and fungi from growing on optical surfaces such as the outside tunnel walls, the camera's two-way mirror, and the lens covering the light.

REMOVABLE TUNNEL **(for use in the unsealed enclosure)**

A removable tunnel is required when using an unsealed enclosure. In operations where the water is deep it may be difficult to regularly clean optical surfaces such as the tunnel mirrors, and light and a design for such situations has been successfully tested. It consists of a tunnel-mirror assembly (**Figure 12**) fitted with a handle for easy lifting from the enclosure as in **Figure 8**. The triangle piece may be fitted with a hinge (**Figure 13**) to enable the camera case to be hoisted into shallow water without disturbing camera alignment.

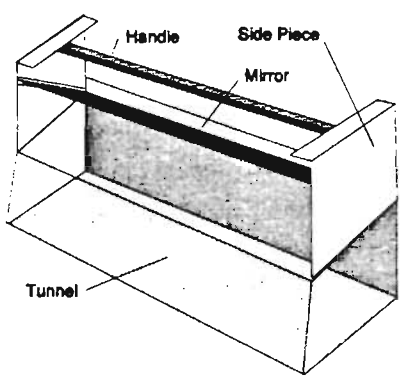


Figure 12. Removable tunnel-mirror assembly.

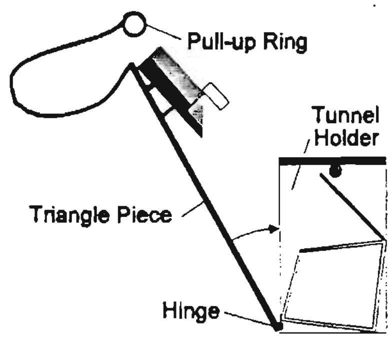


Figure 13. Hinged triangle piece for cleaning in deep water situations.

CAMERA ASSEMBLY

The Camera Assembly is shown in **Figure 14**. It consists of a specially designed waterproof case into which is mounted a standard security-type CCTV camera mounted with a deep red filter.

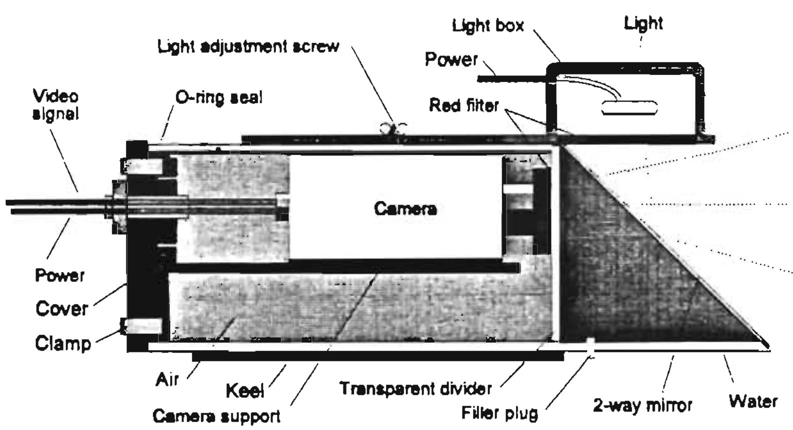


Figure 14. Camera Assembly.

The camera is mounted on a support attached to the cover and is placed close to the transparent divider at the front end of the camera chamber. The waterproof cover is held in place by four clamps and power and video signal lines pass through it. In front of the dividing lens is a water-filled chamber the front of which is mounted with a two-way mirror oriented at an angle of 45 degrees. On top of the case and overhanging the two-way mirror is a waterproof light also fitted with a matching red filter; a power supply cord passes into the light housing via a waterproof connector. At the bottom of the Camera Case is a longitudinal mounting keel which fits into grooves in the mounting bracket on the Triangle Piece.

To properly operate, the camera assembly must be oriented at a specific angle to the horizontal and be mounted at a specific distance from the rear wall of the tunnel. Detailed procedures to properly mount the camera and adjust the position of the light are described in the SIACS Technical Manual.

In a field situation, this assembly is placed inside the light-proof enclosure (sealed or unsealed) to minimize effects of changes in ambient lighting conditions.

FIELD INSTALLATION NOTES

SEALED ENCLOSURE

The following notes are based on the enclosure design tested at Biscay Bay River in 1995 (see Part V); details may differ somewhat for installation of later models.

1. Site preparation:- The site should be reasonably flat and devoid of large rocks which could cause the enclosure to be twisted out of shape (as could happen when the full weight of the water in the enclosure comes to bear on an uneven bottom during extremely low water levels). If an uneven bottom is unavoidable, consideration should be given to using a rigid, re-enforced steel cradle onto which the enclosure can be laid.

2. Algaecide preparation:- An Algaecide is required to prevent growth of algae which may cloud the water in the enclosure. *Double strength Clean & Clear Supreme* by Basic Chemicals Limited of Mississauga (see Technical Reference Manual for details) was tested and found to be effective for at least a four week period during the summer of 1995. The following procedure should be followed to produce the required concentration:

a. Thoroughly mix 100 mls of Clean & Clear in 900 mls of water (= Solution #1)
b. Thoroughly mix 100 mls of Solution #1 in 900 mls of water (= Solution #2)
c. Thoroughly mix 200 mls of Solution #2 in 900 mils of water (= Solution #3)
d. Add *all* of Solution #3 to the SIACS enclosure *after* the enclosure has been about half filled with water, as in Step 6 below.

3. Cleaning the Enclosure:- If not already done in the laboratory before being shipped to the field site, the enclosure should be thoroughly cleaned with a soft cloth and warm water with detergent. Include the inner surfaces of the tunnel and the mirror. After cleaning, the enclosure should be flushed with water which is clear and completely devoid of suspended solids. All tunnel surfaces which will be exposed to river water should also be thoroughly cleaned with warm water and detergent.

4. Preparation of water to fill enclosure:- Prepare enough clean water to fill the enclosure. This water should be free of suspended solids which might later precipitate onto the surfaces of the tunnel or mirror (and thereby deteriorate final image quality). If clear water is not available locally, it may be necessary to actively filter river water and hold it until ready to use. An alternative approach might be to make a settling basin and let the water remain there until all solids have precipitated; clean water can then be removed from the surface layers.

5. Installing the camera:- When using a horizontally oriented SIACS enclosure, it is especially important that the camera be installed *before* the enclosure is moved into the river. When using a vertically oriented system, the camera *may* be installed *after* the system has been placed in the river provided precautions are taken not to allow any river water to enter the enclosure during installation of the enclosure. The camera's base with the camera and lighting assembly attached should be slid securely all the way into the slot at the rear of the enclosure as in **Figure 9**, and the base then secured in place. The camera's power and signal wires are next fed through the waterproof connectors or, in the case of fixed connectors, plugged into the waterproof connectors on the inside of the camera hatch. The camera hatch is then fitted into place and secured with bolts and all filler holes capped tightly before floating the system into the river.

Caution:- When installing the camera, be careful not to loosen, adjust or otherwise change any of the camera alignment screws or brackets. If these settings are changed, realignment of the camera may be required.

6. Moving the enclosure into position in river:- Before moving the enclosure, make certain that all fill holes and hatches are tightened to prevent river water from entering. The enclosure is then floated by hand from the shore to a pre-selected site in the river. When in its correct position, it is oriented in *either a vertical or horizontal position*, depending on the project requirements. Next, the uppermost fill hole is uncapped and clean water, which has been previously filtered to remove all suspended solids is poured inside.

7. Adding the algaecide:- Half fill the enclosure with clean water to seat it firmly in place in the stream. Next, add all the concentrated Solution #3 of algaecide (from Step 3 above) and then add enough clean water to fill the enclosure. Replace and tighten the cap on the fill hole.

Do not attempt to move the enclosure after it has been filled with water. Such attempts will likely cause the camera to go out of alignment because of twisting of the structure.

***Note on minimum fill level:-** The enclosure should be filled to the top, regardless of whether a vertical or horizontal enclosure is being used. With a vertical enclosure, this means completely covering the camera case, and with a horizontal enclosure, it means that water should reach over the top of the mirror, preferably all the way up to the bottom of the fill hole.*

8. Securing the enclosure:- When the enclosure is completely filled, it should be secured with cables attached to a fixed upstream object such a steel pin secured in bedrock, or to a tree.

9. Fence construction:- Once the enclosure has been secured in place, the counting fence's steel A-frame posts should next be attached to both sides of the downstream end of the tunnel portion of the enclosure using angle brackets and U-bolts. Construction of the fence is then started from the tunnel to both shores, crossing the river at an angle to ensure that all migrating fish pass through the tunnel and are counted. As usual, the entire fence structure is rocked down and secured in place with cables to prevent washouts during flood conditions.

UNSEALED ENCLOSURE

1. Site preparation:- The site should be reasonably flat, with a stable bottom, and devoid of large rocks which could cause the enclosure to be twisted out of shape. If an uneven bottom is unavoidable, consideration should be given to either using a rigid, re-enforced steel cradle into which the enclosure can be set, or welding all joins in the enclosure to prevent twisting.

2. Cleaning the enclosure:- The enclosure and the tunnel assembly should be thoroughly cleaned with warm water and detergent. This cleaning should include the inner and outer surfaces of the tunnel and the mirror. After cleaning, it should be flushed with water. It is not necessary to use very clean water when cleaning the unsealed enclosure as when cleaning the sealed enclosure; river water is adequate for this purpose.

3. Positioning the enclosure:- Manoeuvring the enclosure from shore to the site in the river can normally done by hand with the plywood bottom, ends, and hinged covers already in place. This process may require four to six workers because the unit is heavy and will not float (as will the sealed enclosure), and river currents have a stronger effect on a fully submerged box.

4. Final assembly of enclosure:- Once positioned and secured, the top covers are opened and the removable plywood panels placed in the side channels (these panels, which, prevent small fish from entering the enclosure, are normally removed while cleaning). The steel triangular frame with the tunnel, mirror, camera and light attached are then lowered into place and clamped into position on the bottom of the enclosure. Power and signal cables are fed through a notch on the hinged edge of the top cover . The covers are normally locked to inhibit vandalism.

5. Securing the enclosure:- When the enclosure is completely filled, it should be secured with cables attached to a fixed upstream object such as a tree.

6. Fence construction:- Once the enclosure has been attached to a steel pin secured in bedrock, or to a tree, the counting fence's A-frame posts should be attached to both sides of the downstream end of the tunnel portion of the enclosure using angle brackets and U-bolts. Construction of the fence is then started from the tunnel to either shore, crossing the river at an angle to ensure that all migrating fish pass through the tunnel and are counted. As usual, the entire fence structure is secured in place with cables to prevent washouts during flood conditions.

ENVIRONMENTAL CONSIDERATIONS

ORIENTATION IN CURRENT

When used in a fishway, the enclosure should be placed in a location where the presence of bubbles will be minimized; also, it should be oriented so as not to impede the normal fish passage. The best location and orientation may have to be decided by trial and error.

When used in a stream, the enclosure should be placed above the counting fencein a position that provides the best possible water flow to attract fish. It should also be placed where changes in flow levels will not adversely affect the fish's ability to find or pass through the tunnel. Furthermore, the downstream entrance to the tunnel should lie snug against the opening in the fence. When used with a counting fence, it should be secured in place with supporting cables attached to the upstream side as shown in the **Figure 15**.

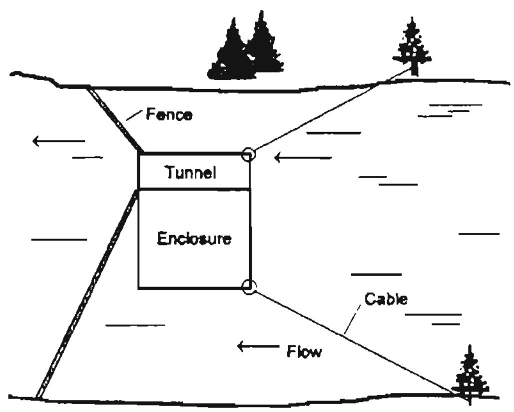


Figure 15. Installation of SIACS in fence at Biscay Bay River.

Regardless of where the enclosure is located, it should lie so that the tunnel is parallel to the current as shown in **Figure 16**.

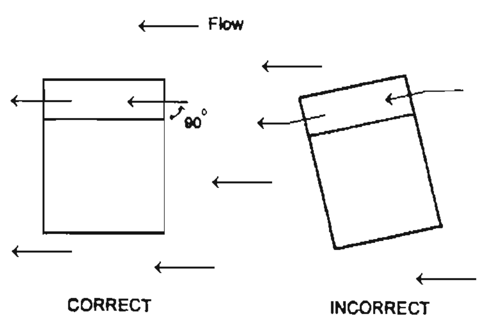


Figure 16. Orientation of tunnel to the current.

ORIENTATION TO THE HORIZONTAL

The enclosure should **NOT BE LEVEL** when placed in either a river or a fishway; it should be sloped so that the upstream end of the tunnel is about three centimetres *lower* than the downstream end as shown in **Figure 17**. This orientation eliminates a build-up of large bubbles in the tunnel which, in severe cases, can interfere with automated counting procedures.

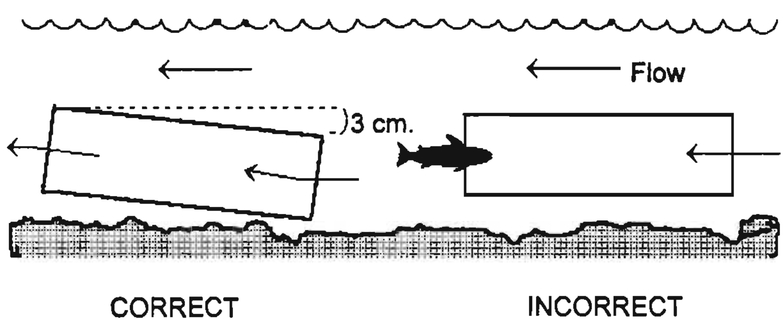


Figure 17. Bubbles are automatically cleared from tunnel when downstream end is higher than upstream end.

ORIENTATION TO THE SUN

Ideally, the tunnel should be oriented in a north-south direction. This orientation prevents direct light from entering the tunnel, especially shortly after dawn or before sunset. It is not always possible, however, to select a site which will enable ideal orientation of the system. If this is the case, an awning of suitable size should be placed immediately above each end of the tunnel to maximize the shading effect. Larger awnings are required if the tunnel is aimed directly toward the rising or setting sun and the system is not in the shadow of a hill; smaller ones may be used if the tunnel is oriented slightly off axis from the direction of the sun. The awnings can be directly attached to the enclosure above the tunnel openings as in **Figure 17**.

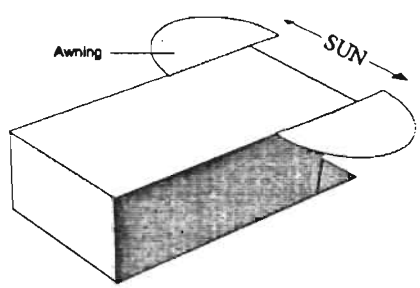


Figure 18. Awnings are used to reduce adverse effects of direct sunlight.

OPERATING IN DIFFERENT WATER DEPTHS

Sealed vs. unsealed enclosures

As indicated above, the sealed enclosure version of SIACS may be installed in either a horizontal or vertical orientation and can operate at a wider range of depths than systems using the unsealed enclosure. The unsealed enclosure can be operated only in the horizontal position and requires approximately twice the water depth of the sealed enclosure because its mirror must be covered with river water.

Single vs. stereo imaging

Single imaging only is possible with unsealed enclosures operating at water levels too low to cover the mirror. Stereo imaging is possible with the sealed enclosure, however, any time the tunnel is completely filled with river water. Since stereo imaging is required for reliable length estimates, the sealed enclosure is preferred in studies where lengths are important and where water levels are likely to drop below the top of the tunnel.

Effects of tunnel size

Larger and higher tunnels require greater water depths than smaller, lower ones, especially if fish measurements are being recorded using an unsealed enclosure. Given tunnels of equal size, the sealed enclosure enables stereo imaging in less water than unsealed enclosures.

FISH BEHAVIOUR

Crowding Below Fence

A major concern of anglers about the use of counting fences on river systems is that they might impede fish migration, sometimes for unacceptably long periods. It is argued that crowding of fish below counting fences enables increased exploitation so that fewer fish are available to upstream anglers, or that the fish only migrate past the fences during certain water conditions, such as high water or immediately after rain. During three summers of operating counting facilities with tunnels in Biscay Bay River and other locations in Newfoundland, however, there have been no reports of salmon holding up below a fence.

The impact of varying tunnel size has been evaluated and it has been observed that trout, salmon, and eels readily pass through a tunnel only slightly wider than their body widths. Thus, the tunnel need only be a little wider than the width of the body of the largest fish expected. Nevertheless, anglers have expressed the desire for tunnels of much greater width to be used, especially in areas not previously studied using the SIACS. Tunnels much wider than the standard 25 centimetre width are possible in this system.

Holding up in the tunnel

While salmon do not appear to hold up below the fence during daylight hours, delay has been observed during the night when some were observed staying in the tunnel for some time before moving upstream. While this problem is not serious when semi-automatic counting is being used, it is a serious problem during automatic counting with a computer; automatic counting works best when the fish pass through the tunnel in single file because more than one fish in the tunnel at the same time can result in inaccurate counts and measurements. The reason for night-time delays at the tunnel appears to be hesitation of fish to move from the lighted tunnel into the upstream darkness. Two approaches were developed to reduce this problem: (1) SIACS uses a *low intensity* red light produced by two seven watt bulbs which minimizes the effect of the tunnel lighting on salmonid behaviour, and (2) a white light 10 to 20 meters upstream of the tunnel illuminated the river bottom above the tunnel (**Figure 19**) so that salmon passed with equal ease during light and dark periods.

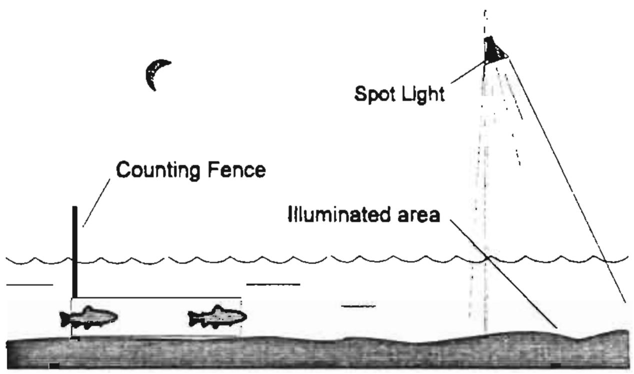


Figure 19. Use of upstream light to attract fish upstream through tunnel at night.

CLEANING REQUIREMENTS

Periodic cleaning is required for all optical surfaces exposed to river water and image quality should be evaluated at least once a week to determine if cleaning is necessary. Time between cleanings may vary among different locations and environmental conditions. During times of high water temperature, which accelerates growth of algae, and during periods high turbidity, cleaning may be required every second day or so. Main problem areas are growth of algae or build-up of detritus on the surfaces of the tunnel exposed to river water in the sealed enclosure while unsealed enclosures require periodic cleaning of each of the outside of the tunnel, the mirror, light, and the sloping mirror mounted in front of the camera.

Cleaning the tunnel

The tunnel can be cleaned with a large sponge mop mounted on the end of a handle long enough to reach the length of the tunnel. Tunnel surfaces should be cleaned by wiping vigorously with a soft sponge. Wooden or metal parts of the mop can damage surfaces so care should be taken not to scrape the surfaces of the tunnel or the retroreflective material; even minor scrapes on this material will show up as dark lines on the image and these may interfere with monitoring operations, especially in computer assisted monitoring.

Never use a dirty or gritty cloth which may scrape the surfaces!

Unsealed enclosures:- Build-up of detritus or algae on both the inside and outside walls of the tunnel can be easily detected by either inspecting the tunnel directly or by viewing the image on a monitor (preferably the latter method - as it is more sensitive). Undesirable material will show up on the monitor as clearly defined, dark black material against the illuminated background of the tunnel. At times, algae may have long streamers flowing downstream from points of attachment.

Sealed enclosures:- Only those walls of the tunnel which are exposed to river water need be cleaned in this type of enclosure and the procedure is the same as that described in the previous paragraph. Users should be aware, however, that deterioration of image quality may also result form a buildup of algae *inside* the enclosure as a result of a leak which enables contaminated river water to enter the enclosure.

Cleaning the overhead mirror

This is normally only required for unsealed enclosures in which the river water comes in direct contact with the mirror. Build-up of detritus or algae on the mirror can be easily detected by either inspecting the mirror directly or by viewing the quality of the image of the overhead view of the tunnel on a monitor (preferably with a monitor - as this technique is more sensitive). Undesirable material will show up on the monitor as clearly defined, dark black material against the illuminated background of the tunnel. At times, algae may have long streamers flowing downstream from points of attachment. The mirror should be cleaned by hand with a sponge or soft cloth. Note that even minor scrapes will show up as dark lines on the image and these may interfere with automatic monitoring.

If the mirror of a sealed enclosure requires cleaning, the camera hatch and camera must first be removed and a large sponge on the end of a stick used for cleaning. Buildup of dirt on the mirror should not occur, however, if the system is properly set up. See the section on setting up the sealed enclosure.

Cleaning the Camera Assembly:- The system should be periodically examined for dirt on the angled mirror at the front of the camera case. Cleaning is indicated when bright circular spots are seen in the field of view, especially in the darker areas of the image above and below the tunnel. These are caused by dirt on the angled front-surface mirror on the camera case. The mirror should be cleaned with either a smooth sponge, a gloved (woollen) hand, or simply by wiping it clean with bare fingers. Care should be taken not to bump or dislocate the lighting assembly while cleaning. Buildup of dirt on the camera should not occur, however, with sealed enclosures if it is properly set up. See the section on setting up sealed enclosures for details.

Cleaning the Enclosure:- The inside of the unsealed enclosure should be cleaned about once a week during high water temperatures or periods of dirty water. Close the tunnel to prevent passage of fish during this operation and raise the side panels of the enclosure to enable a free flow of water in the enclosure between the camera and the tunnel to carry away detritus. Use a stiff bristled brush to clean the inner top, bottom, and sides of the enclosure, being careful not to jar the lighting and camera assembly. After cleaning, replace the panels and open the tunnel.

IMPORTANT: ***Be sure to check for the presence of small fish which may have entered the chamber during the cleaning process. Small fish such as fry or sticklebacks in the chamber will cause false and completely unreliable counts when using automatic counting.***

CAMERA ALIGNMENT

Align Camera before aligning light!

Note:- Camera alignment is critical if fish are to be measured or if a computer is to be used for monitoring. When semi-automatic counting with video recorders is engaged, and fish are not being measured, camera alignment is not critical and is more a case of individual preference than technical necessity.

To avoid the adverse effects of working in less than ideal conditions, alignments ideally should be made in a water bath in the laboratory (see **Figure 20**) prior to installation in the field . Camera alignment for use in sealed enclosures requires a much deeper tank than that required for unsealed enclosures.

Regardless of where the alignment is conducted, however, alignment should be re-checked in the field before actual operation of the system and corrections should be made if required.

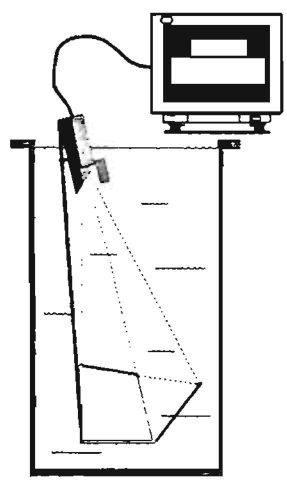


Figure 20. Camera alignment is best done in a tank in the laboratory.

To align the camera:

1. Check to see that the Camera is pointing straight ahead so that the image of the Tunnel and Mirror is in the centre of the monitor's screen. If it is not, loosen the clamps on the back of the Camera Case, pull out the Back, and turn the Camera so that it is pointing straight ahead. Replace the back, recheck camera alignment and reseat the clamps.

2. Loosen the clamps which hold the camera case in place on the cradle, or in the case of some models, the camera tightening screw as shown in **Figure 21**.

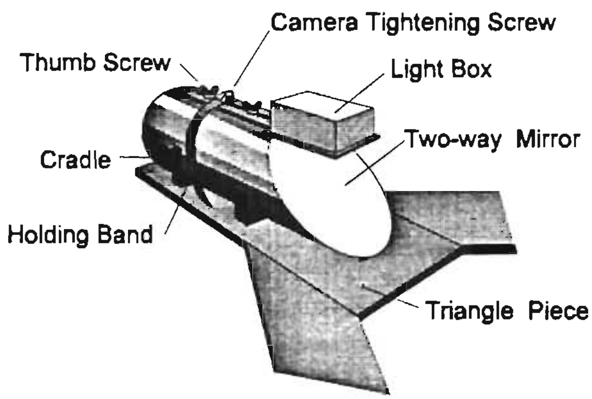


Figure 21. The camera can moved forward or backwards in the cradle.

3. While viewing the image on the monitor, move the Camera Case forward or backwards in its cradle until only the lower, facing edge of the bottom of the tunnel is visible as shown on the left hand side of **Figure 22**; it should impossible to see the top, or roof, of the tunnel as shown on the right hand side of **Figure 22**. If unable to obtain the correct image using this technique, see the SIACS Technical Manual for detailed information on camera alignment.

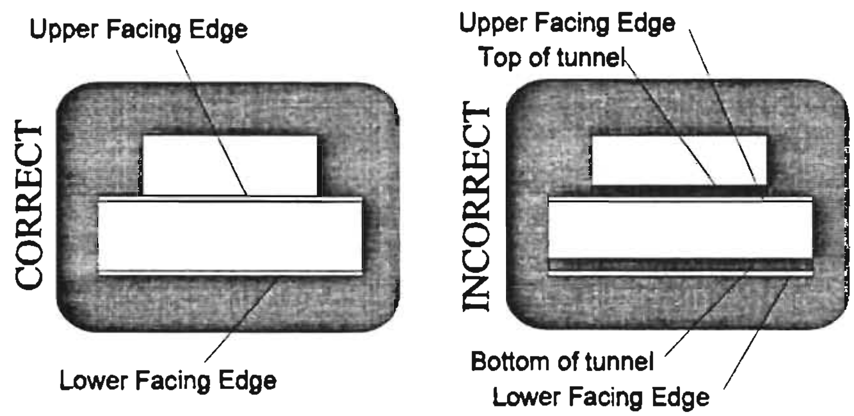


Figure 22. The top of the roof of the tunnel and the bottom of the tunnel should not be visible in the image.

4. Loosen the clamps on the back of the camera case and rotate the back while viewing the image on the monitor. The image of the tunnel should be horizontal as in the left hand side of **Figure 23**; the most accurate way to obtain this position is to align one of the horizontal edges of the tunnel with the horizontal raster lines on the monitor's screen. Failure to properly align the tunnel in this manner will interfere with computerized fish monitoring and may result in a reduction of accuracy in estimates of fish counts and lengths.

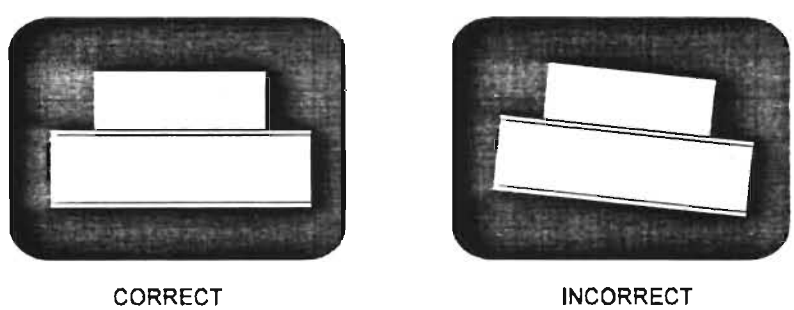


Figure 23. Image of tunnel should be horizontal and edges should be parallel with the monitor's raster lines.

LIGHT ALIGNMENT

The objective of this exercise is to align the light (i.e. the light box) so that the light being reflected from the rear and bottom wall of the tunnel are of even brightness. This process is completed as follows:

> **ATTENTION**
> **Be sure *camera* is aligned before aligning light!**
> (see instructions above)

1. Be certain that the light box is submerged and then turn on the light (failure to submerge the light box may cause the bulbs to overheat and distort or destroy the red filter in the box.

2. Loosen the two wing nuts on top of the Camera Case (see and **Figure 24** and **Figure 25**.

3. While viewing the image of the tunnel on the monitor, move the light box forward or backwards until the brightness of the reflection of the light in the upper (mirror) image has the same intensity as the reflection from the rear wall of the tunnel.

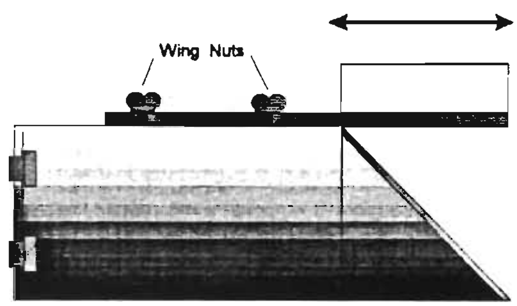


Figure 24. Set screws used to adjust light.

4. Tighten the *rear* wing nut very slightly while leaving the forward nut loose.

5. Move the light box from side to side as in **Figure 25** until the intensity of the reflected light is evenly distributed from the left to the right side of the mirror and tunnel views. This right-left movement is made possible by the oversized width of the groove in the base of the light box holder. The amount of movement required may be very slight.

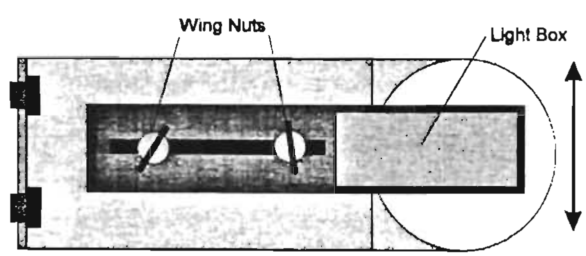


Figure 25. Side to side adjustment of light is made after loosening Wing Nuts on Camera Case.

6. The ideal lighting arrangement is obtained by ensuring the following:

a. both the tunnel and the image of the tunnel in the mirror are evenly illuminated throughout their lengths.

b. intensity of the light is as bright as possible. The ideal intensity is that which will allows a threshold setting of about 75 threshold units to be used with Canpolar's Salmon Tracking software (see relevant section under the Salmon Tracking Software for details).

7. Tighten both wing nuts to complete adjustment.

ELECTRICAL HOOKUPS

The main electrical layout required to operate the imaging system are shown in **6**. Care should be taken, of course, to ensure that the correct voltages are applied to the particular setup being used. For example, the standard setup used at Biscay Bay River employed a camera and lighting system which required 24 volts AC. Other cameras and lighting arrangements may require different voltages.

Make a final test of all electrical and video connections inside the camera case before the case is closed. Before submerging the case, ensure that lead-in connectors are properly tightened and the O-ring seal properly seated and lubricated to prevent leakage.

To prevent overheating and possible melting of the red filter on the light box, do not turn on the camera light until the light box is fully submerged.

CAUTION: - When 110 volts is used as the primary power supply, it should be converted to 24 volts (preferably 12 volts), before being fed to the counting site on the river. Use of high voltage at the counting site can be hazardous and requires special precautions. See provincial regulations in the Technical Reference Manual for detailed requirements.

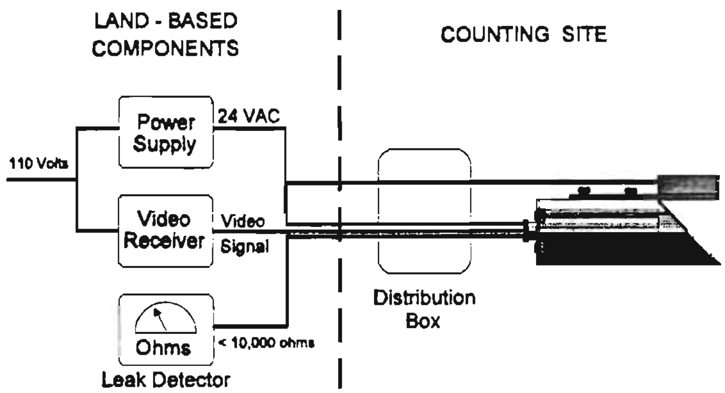


Figure 26. Electrical hookups for basic SIAC system equipped with a leak detector.

LIGHTNING PRECAUTIONS

The probability of a lightning strike is increased when power and video lines extend over land and water. In such cases, electronic equipment in the SIAC system is especially prone to damage from lightning strikes. Equipment at Biscay Bay River has been struck by lightning several times and major damage was done during the first strike before precautions were taken. Expensive electronic equipment, such as cameras, VTR's, monitors, computers, etc., should therefore be protected by a lightning protection system involving installation of lightning rods at strategic points in the system.

A typical lightning protection system is illustrated in **Figure 27**. Guidelines and additional reference material are provided in the SIACS Technical Manual and should be seriously considered. When used in fishways where entire systems may be installed underwater along with electrical generating and data recording equipment, the risk of damage from lightning is greatly reduced.

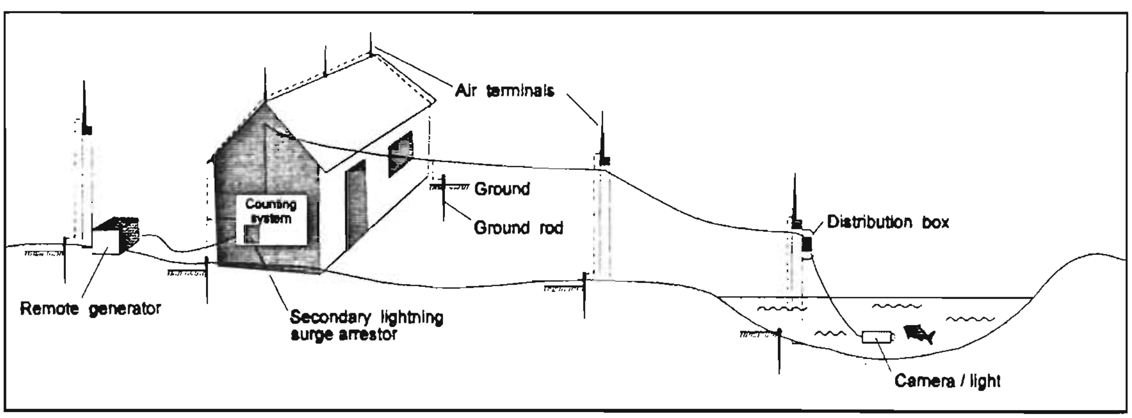


Figure 27. Lightning protection system used with SIACS at Biscay Bay River..

PART III - SEMI-AUTOMATIC MONITORING

INTRODUCTION

Semi-automatic counting of migrating salmonids involves the use of an electronic motion detector to detect the presence of a fish as it enters the tunnel and activate a video tape recorder to record the fish's passage. The high contrast images produced by the SIACS are ideal for this application because its lighting arrangement is relatively insensitive to momentary changes in ambient light such as shafts of glittering sunlight shimmering into the tunnel. This lower sensitivity results from the relatively high intensity of light reflected from the retroreflective background in the tunnel in comparison with the lesser intensity ambient light. Brightly lit bubbles passing through the tunnel are rendered black against the background tunnel wall, thus rendering them much less detectable.

The primary purpose of the semi-automatic type of recording system is to have the recorder activated only during times that fish are actually passing through the tunnel; at other times, when there are no fish present the recorder remains in a standby mode (see **Figure 28**). The great advantage of this arrangement is in time saved by the operator who must manually review the entire tape to count (and measure, if desired) the fish as they pass; the amount of recording time when no fish are present in the tunnel is kept to a minimum and the operator is able to focus attention on migrating fish rather than many hours of blank tape per day.

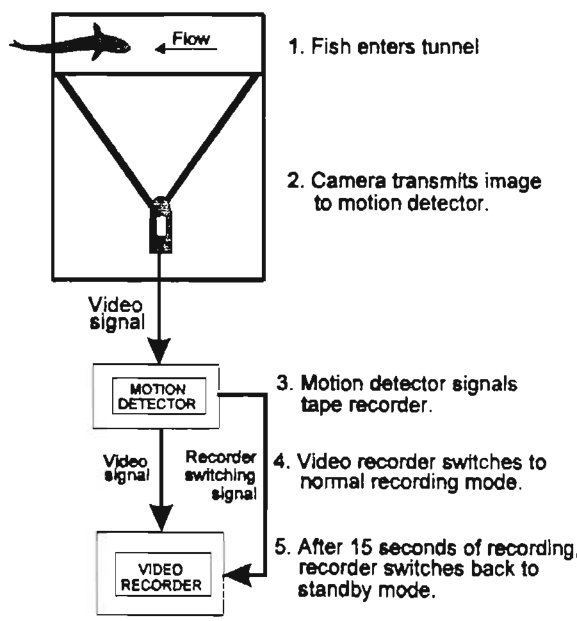


Figure 28. Sequence of events during semi-automatic recording of fish migrations.

RECORDING SETUP

Arrangement of equipment and the sequence of events in automatic detection and recording is shown in **Figure 28**. Upon movement of a fish into the image field, the motion detector signals the video recorder which then switches from a slow 120 hour (standby) recording mode to a standard two hour recording mode. It remains in the standard mode for a preset number of seconds to enable the passage of the fish to be recorded.

Electrical connections should be made as shown in **Figure 29**. The following procedure is based on use of the Panasonic AG-6010s time lapse recorder. If necessary, see the Technical Reference Manual for wiring details.

1.. Connect the **video signal** cable from the camera to the video input connector of the **motion detector.**

2. Connect the **monitor** to the video output connector.

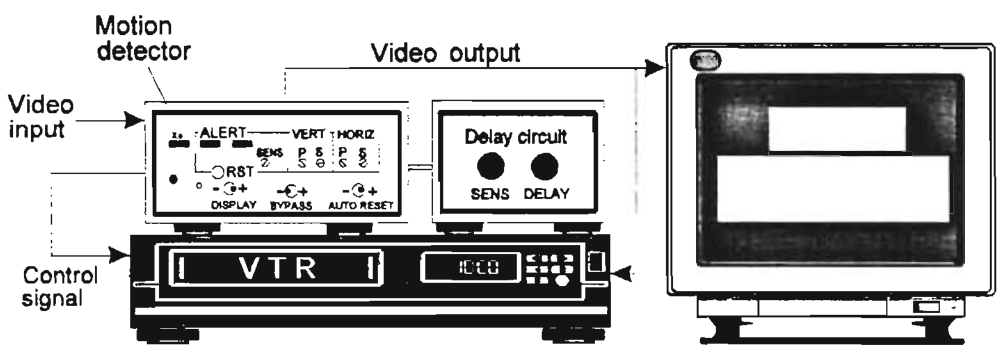


Figure 29. Hookup for automatic recording.

3. Connect the **Motion Detector** plug to the socket leading to the **Alarm Terminal Connections** of the **recorder** as shown in the figure on page 17 of the Panasonic AG-6010 manual. (Note that connection procedures of other models or brands may differ so check for differences with relevant literature if different types of equipment are being used.)

4. Turn on power to all equipment in the system.

5. Turn on the time-date display on the recorder and follow directions in the recorder's manual to place the time-date display in an unoccupied area of the monitor's screen, such as the lower right hand corner.

6. Set correct time and date of the time-date display according to instructions in the recorder's manual.

7. Switch recorder to 120 hour recording mode.

NOTE: Some recorders have a slow reaction time to the signal from the motion detector when they are set to record in the 120 hour mode and in this case one to several frames may be lost before recording starts. If this is a problem, try a lower setting such as a 72 hour mode.

8. Set the Delay knob to enable about 15 seconds of recording time (for each fish which enters the tunnel).

8. Ensure that the Motion Detector is properly set up according to procedures in the following section and press appropriate buttons to **begin recording**.

NOTE: Tapes made with this method are ***not** normally suitable for later review* by an automated image analysis system because of momentary electrical interference in the picture which accompanies the switch-over from the 120 hour recording to the standard two hour recording mode. In future, however, improved switching electronics and recording mechanisms may enable automated image analysis with these tapes.

MOTION DETECTOR SETUP

The motion detector used is standard equipment in security systems and has been modified to reduce both its sensitivity to movement in the image field (so it will not be triggered by small pieces of debris which float through the tunnel), and the time which it remains active during a given trigger cycle. Proceed as follows to set up and operate the system to automatically record fish as they enter the tunnel[1].

1. Activate the Display on the motion detector by pressing the DISPLAY switch to +. This will display the Sensitive Area which is boarded by the two vertical sensitivity bars (see **Figure 30**)

[1] This detector used is a modified (see Technical Reference Manual) American Dynamics 1461 Single-Channel Motion Detector. Procedures for other types may be different.

2. Adjust the position and size of Sensitive Area (small screw driver required) by changing the VERT and HORIZ settings so that it covers the downstream end of the tunnel (see **Figure 30**A). In this location, the motion detector will sense the entrance of each fish as soon as its nose enters the tunnel. The tape recorder will then be activated.

> **Note:-** The Sensitive Area may be broadened to include the entire length of the tunnel as in **Figure 30B** if it is important to record images of downstream migrating fish for measurements. (This is necessary if measurements are to be taken when the fish is in the centre of the tunnel rather than at either end; having the sensitive area only at the downstream end of the tunnel would result in pictures of downstream swimming fish being taken just as they leave through the downstream entrance.)

3. Adjust sensitivity of the detector by turning SENS (small screw driver required) on either the Motion Detector or the Delay circuit box (see **Figure 29**) so that the detector responds to the presence of fish in the Sensitive Area, but not to the presence of small pieces of debris which might be floating downstream through the tunnel, or to minor variations in ambient light near the

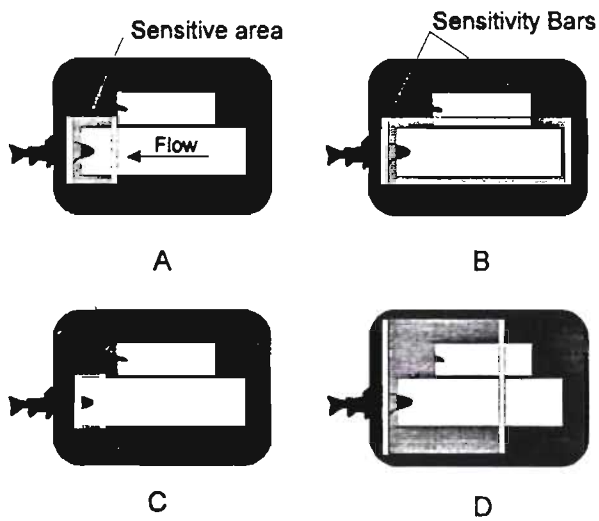


Figure 3. Adjustment of the Sensitive Area of the Motion Detector.

end of the tunnel. This adjustment is best made through trial and error and a reasonably good starting point is to set the sensitivity as high as possible without activating the recorder in the absence of a fish; this setting will likely respond positively to the smallest fish entering the tunnel. *Sensitivity may have to be adjusted when the size of the Sensitive Area is changed.*

Note:-

- **If the highest sensitivity setting is too low**, decrease the size of the sensitive area as shown in **Figure 30C**.

- **If the lowest sensitivity setting proves to be too high,** increase the size of the sensitivity area as shown in **Figure 30D**.

4. Set the period of time which the recorder will operate at normal recording speed. This is done by adjusting the Delay Knob as shown **in Figure 29**; a 15 second recording time is usually about right. At the end of this time the recorder automatically switches the recorder back to the slower 120 hour standby mode.

Momentary switching from standby mode to normal recording speed whenever a fish passes through the tunnel enables 24 hours or more of recording on a single C120 video recording tape and greatly speeds up review of the tape and manual counting of migrating fish by an observer.

Detailed information on one possible arrangement of equipment to achieve automatic recording is given in Part V.

Before beginning a recording session, be certain that the correct time, day, month, and year are set on the VCR and are displayed on the screen. *See previous section for details on setting up the recorder.*

COUNTING FISH

Two separate video tape recorder and monitor combinations are normally used to monitor tapes of migrating fish; the first is used to record fish as they pass through the tunnel while the second is for play-back counting and measuring. While both systems need not be the same, it is wise to use identical recorders for both purposes so that the play-back machine can be used as a backup recorder in the event of a malfunction of the recorder.

When a tape is played back, the recording rapidly skips over time periods when no fish were present in the tunnel and automatically slows down to normal speed when one or more fish are present. This enables accurate counting, especially when there are more than one fish in the tunnel at the same time, or when one or more fish may linger in the tunnel for some time.

COUNTING PROTOCOL

The following protocol should be used when recording fish counts:

1. A fish is counted as having passed upstream only when its tail has completely disappeared from the upstream end of the tunnel. The time recorded for the passage should be that displayed on the screen just before the fish disappears upstream.

2. A fish is counted as having passed downstream only when its body has completely disappeared from the downstream end of the tunnel; the time recorded for the passage should be that displayed on the screen just before the fish disappears downstream.

3. The following procedure should be followed at times when there are more than one fish in the tunnel at a time.

> **a.** As above, the time recorded for the passage should be that displayed on the screen just before the fish disappears upstream or downstream.
>
> **b.** If the fish are all travelling in the same direction (i.e., all up or all down) the reviewer need pay attention to only those fish which leave the tunnel, moving either upstream or downstream.
>
> **c.** If some fish are moving upstream while others are moving downstream, particular attention should be made to keep track of the movements of individual fish.

COUNT ACCURACY

The accuracy of this method to count fish depends to a large extent on the quality of the video recording. More specifically, the faster the recorder can switch from the 120 hour time lapse mode to the standard 2 hour mode, the better. A loss of 2 to 4 frames before 2-hour recording begins is possible with some units. While such delay is not normally a problem, it becomes relevant if a fish dashes, or swims very rapidly, from one end of the tunnel to the other; at such times a migrating salmon may register itself on only one or two frames as it swims past. For this reason, the person reviewing the tape must be alert at all times for rapidly swimming fish passing through the tunnel. Fortunately, such rapidly swimming fish are rare and, in most situations, will have no significant impact on overall accuracy of the counts.

Accuracy of counts using this technique thus approaches 100%; errors may occur when rapidly swimming fish are encountered and missed by the person reviewing the recordings.

MEASURING FISH

The geometric design of the tunnel and the precise position of the camera in the SIAC system enables reasonably accurate estimates of the length of the fish as they pass through the tunnel. This is accomplished by simply measuring the apparent length of a fish on a properly calibrated monitor and then converting this measurement to the fish's true length.

Note on measuring speed:- *An experienced person can measure about 20 fish per hour while and inexperienced person may measure about 10 per hour.*

IMPORTANT
CAMERA MUST BE CORRECTLY ALIGNED
FOR MOST AURATE MEASUREMENTS
(see section on Camera Alignment above)

SCREEN CALIBRATION

Proper calibration of the monitor's screen is necessary for accurate length estimates. It should be therefore checked before the start of each measuring session. Checking the monitor's screen calibration is especially important **IF** the size or position of the picture on the screen changes even slightly when adjustments, such as picture contrast or brightness, are made. For this reason, it is wise to check to see if the monitor being used is subject to this behaviour and, if so, ensure that either the controls are deactivated or that routine calibration checks are maintained just in case monitor settings are inadvertently changed. **If they have changed**, make appropriate adjustments *to the monitor* to return the size and position of the image to its original size and position, i.e., so that the original size and arrangement of the image of the tunnel is duplicated; failing this, the screen should be recalibrated using the technique outlined below.

Calibration procedure

1. Measure and record on paper the elevation in millimetres of the upper, mirror view, M, of the tunnel as shown in **Figure 31** . This is the distance between the upper edge of the bottom of the mirror image (i.e., the top edge of the roof of the tunnel) and the lower edge of the mirror image of the tunnel.

Record this value in the space labelled *Mirror Elevation* near the top right hand corner of a blank SIACS Worksheet.

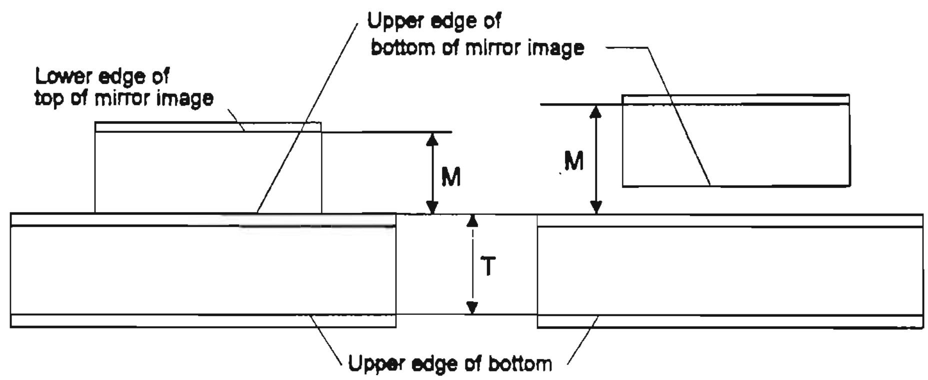


Figure 4. On-screen measurements (in mm.) required for calibration of monitor. The right hand side diagram is for use with systems with mirrors located some distance above the roof of the tunnel.

2. Measure the elevation in millimetres of the view of the tunnel as shown in T of **Figure 31**. This is the distance between the upper edge of the bottom of the tunnel and the upper edge of the bottom of the mirror image.

Record this value in the space labelled *Tunnel Elevation* near the top right hand corner of the SIACS Worksheet.

3. Determine the Screen Conversion Factor as follows:

A. Prepare a straight cylindrical rod with holes near either end and tie a length of thin monofilament fishing line through each of the two holes as shown in **Figure 32**; the length of this *calibration rod* should be equal to the *average* body length one might expect to encounter in the fish stock being studied; the rod's diameter should be about the same as that of a common broom handle (about 25 mm).

B. *With the fully aligned camera and tunnel assembly submerged,* dangle the calibration rod in the middle of the tunnel so that it is parallel to the top, bottom and sides of the tunnel.

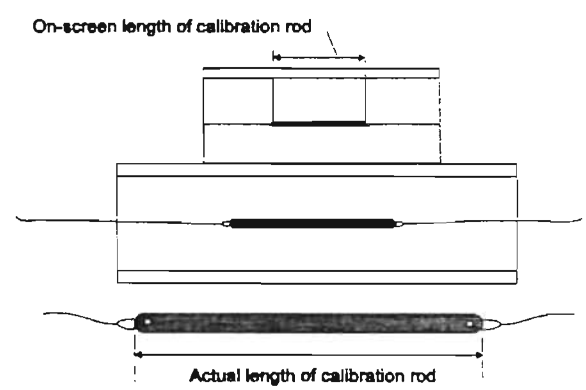


Figure 5.Measurements required for calibration of monitor's screen.

C. ***Make a video tape recording of this sequence*** *and use it to obtain the values required in the subsequent steps. Keep this tape for reference throughout the field season.*

D. Determine a *first estimate of the true length* of the Calibration Rod as follows:

a. Measure the *apparent length* (in millimetres) and upper and lower position of the calibration rod on the monitor's screen using the technique described in the Measuring Procedure on pages 34 to 37. (Do not bother to measure the Body Angle now because the calibration rod is parallel to the bottom of the tunnel and its value is therefore zero degrees).

b. Record the *apparent length* in the appropriate column on the SIACS Worksheet.

c. Start the ***Convert*** program and **make a note of the Screen Conversion Factor** being used.

d. Determine a *first estimate of the corrected length* of the calibration rod using the technique described on page 34 for measuring fish.

e. EXIT the ***Convert*** Program.

E. Calculate the final Screen Conversion Factor using the following equation:

$$\text{Final Screen Conversion Factor} = \frac{\text{True length of the Calibration Rod} \times \text{Old Screen Conversion Factor}}{\textit{First estimate of the true length of calibration rod}}$$

F. Restart the Convert Program and

a. ENTER a "2" for Setup

b. Press the ENTER key twice to skip data entry for screen measurements.

c. ENTER the password to change the current Screen Conversion Factor.

e. ENTER the final Screen Conversion Factor.

f. The ***Convert*** Program is now ready for routine length determinations

g. Be certain the image of the tunnel on the screen has not moved; if it has moved, do either of the following:

i. readjust the image controls on the monitor (contrast, etc) to restore the image to its original position

ii. re-calibrate the monitor's screen conversion factor

iii. check to see if the camera itself has been moved since the last calibration, and if so, either

- re-align camera in its cradle (When in a field situation, this requires a fair degree of effort. Therefore, **every effort should be made not to jar or otherwise disturb the position of the camera in the cradle after it has been set**)
- re-calibrate the monitor's screen conversion factor

4. Record the new Screen Calibration Factor in the appropriate place on the top of the SIACS Worksheet.

MEASURING TOOLS

Fish are measured from the monitor's screen. The screen should have a diagonal measurement of from 14 to 23 inches, preferably the larger, and if possible, the screen should be flat. A distortion-free, flat-screen 23 inch television set with a monitor setting is ideal.

Construction of the Ruler Plate

In preparation for measuring, a *Ruler Plate* with *two* one-millimetre scales should be prepared and attached to the screen as shown in **Figure 33** using the following procedure:

1. Attach a narrow strip of tracing paper (of the type used for drafting) vertically on the screen so that its right edge is perpendicular and in the *exact centre* of the screen.

2. Mark the point on the right side of the strip which intersects with *upper edge of the bottom of the tunnel.* (See **Figure 31** for identification of the various edges of the tunnel view.)

3. Mark the point on the right side of the strip which intersects with *upper edge of the bottom of the mirror image.*

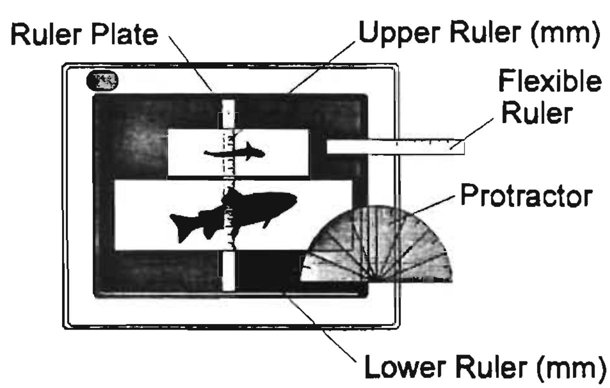


Figure 33. Equipment required for measuring on-screen image of a fish.

4. Mark the point on the right edge which intersects with *lower edge of the top of the mirror image.*

5. Remove the strip of paper and add *two* one-millimetre scales to it as follows:

> **Upper Ruler:** Put the zero mark on the paper strip at the intersection with the *upper edge of the bottom of the mirror image* and extend a millimetre scale from there *up* to the *lower edge of the top of the mirror image.* This is called the *Upper Ruler.*
>
> **Lower Ruler:** Put the zero mark on the paper strip at the intersection with the *upper edge of the bottom of the tunnel* and extend a millimetre scale from there *up* to the *upper edge of the bottom of the mirror image.* This is called the *Lower Ruler.*

6. Re-attach the Ruler Plate to its original position on the screen.

7. The screen is now ready of measuring fish. (Use of the protractor in measuring fish will be described in the next section).

MEASURING PROCEDURE

To measure fish, the *apparent length* of the fish on the screen is measured first. Next, the *position* of the fish in the tunnel is measured in both the tunnel and mirror views. Then the *angle of the body* of the fish to the horizontal is determined. Finally, the data collected are fed to a computer program and the *corrected length* of the fish is calculated. The following steps should be followed in detail to determine the fork length of a fish:

1. Advance the tape frame by fame, either forward or backwards, until the fish lies in the centre of the screen, i.e., until the mid-point of the length of the fish coincides with centre line of the screen as shown in **Figure 33**.

> *Note that it may be impossible at times to find a frame in which the fish lies exactly in the centre of the tunnel. In such cases, the accuracy of the measurement will less then ideal. Check with the project leader to determine if measurements on such fish should be recorded or if they should be omitted.*

2. Place a flexible millimetre ruler against the screen and measure the length of the *curved distance* between the tip of the snout to the fork of the tail as shown in the **Figure 34**. This is the *apparent length* of the fish.

Figure 34. Method of measuring apparent length of fish.

3. Record the *apparent length* of the fish in Column D of a SIACS Worksheet.

4. Determine the mid-point of the body (✚) which is vertically half way between the upper and lower edges of the fish and measure its height above the bottom of the mirror on the upper ruler as shown in **A** of **Figure 35**. This is the *mirror height of the fish.*

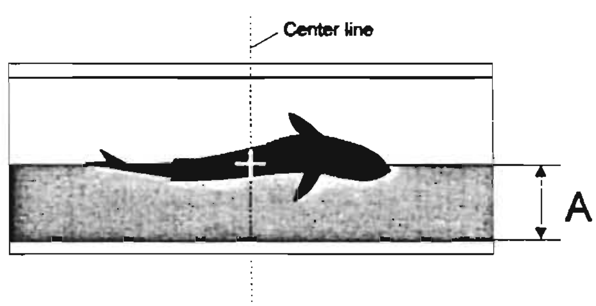


Figure 35. Measuring the mirror distance of the fish.

5. Record the *mirror height of the fish* in Column A of the SIACS Worksheet.

6. Determine the mid-point of the body (✚) which is vertically half way between the upper and lower edges of the *body* of the fish; measure its height above the bottom of the tunnel on the lower ruler as shown in **B** of **Figure 36**. This is the *tunnel height of the fish.*

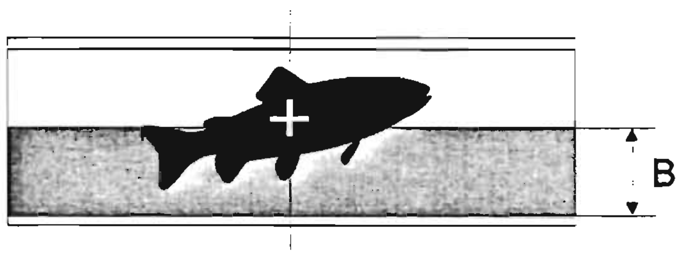


Figure 36. Measuring the tunnel distance of the fish.

7. Record the *tunnel height of the fish* in Column B of the SIACS Worksheet.

8. Use a short piece of string with sticky tape attached to both ends to construct a line through the fork of the tail and the tip of the snout as shown in **Figure 37**.

9. Find the monitor's *raster line* which crosses both the string and the fork of the tail (or tip of the nose). Use the protractor to measure the angle between this raster line and the string. This is the *body angle* of the fish.

10. Record the *body angle of the fish* in Column C of the SIACS Worksheet. This is the last step in measuring the fish's image on the screen.

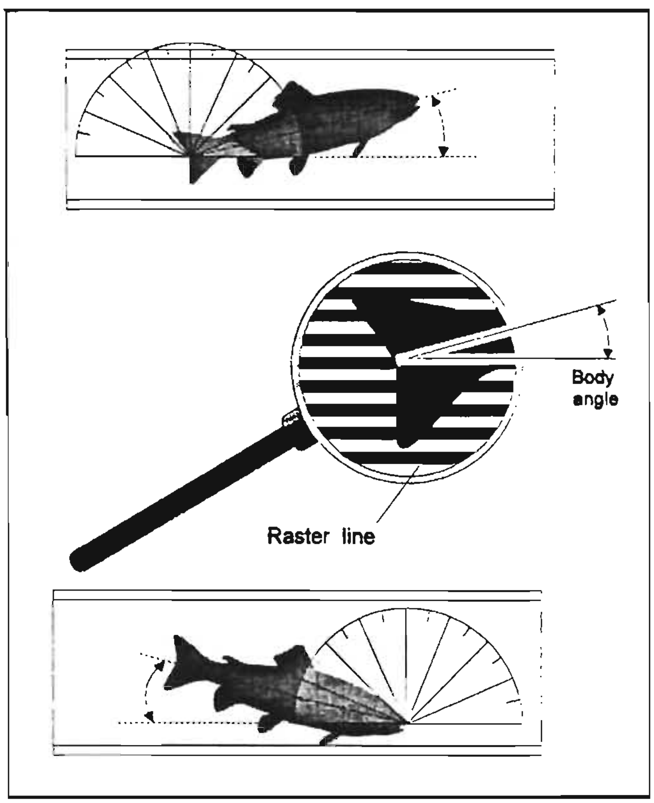
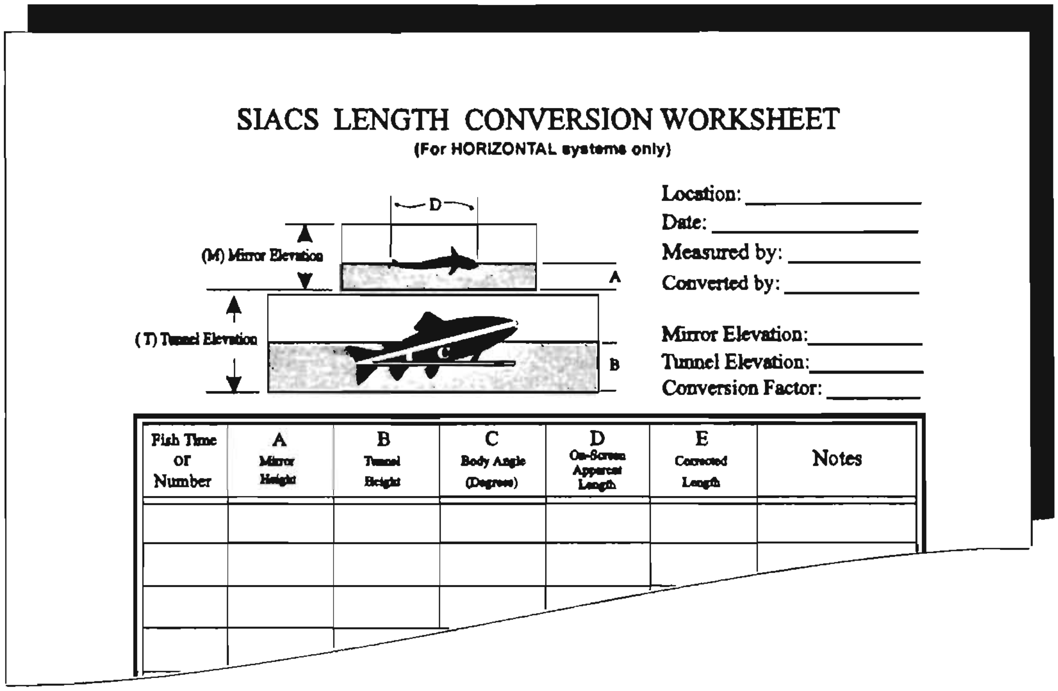


Figure 37. Measuring body angle.



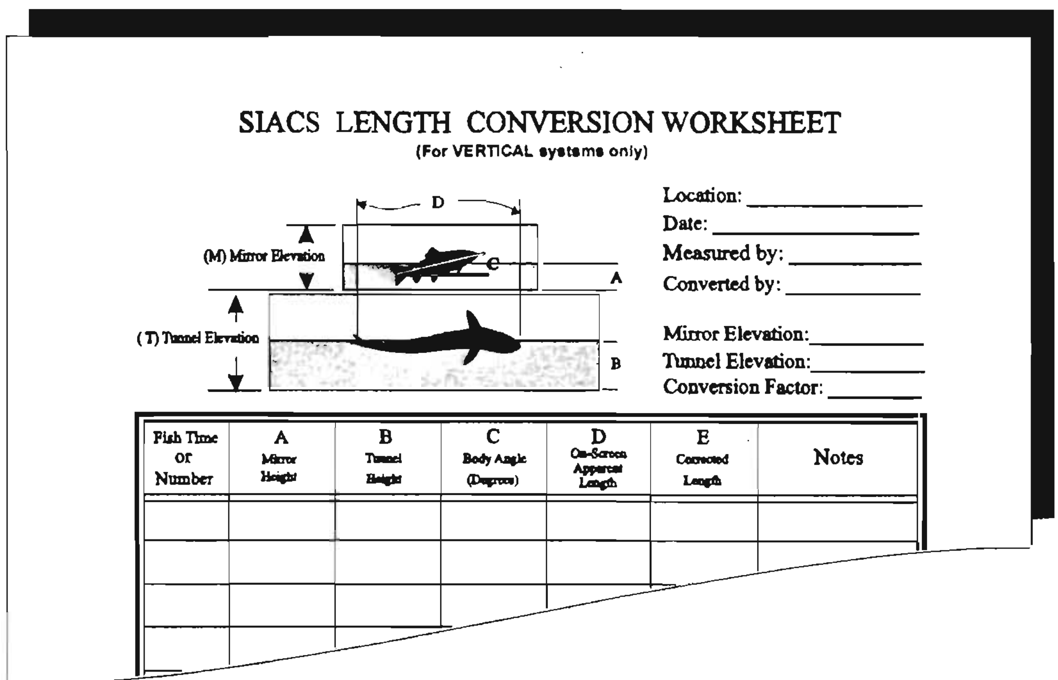
SIACS LENGTH CONVERSION WORKSHEET

(For HORIZONTAL systems only)

Location: ______________
Date: ______________
Measured by: ______________
Converted by: ______________

Mirror Elevation: ________
Tunnel Elevation: ________
Conversion Factor: ________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes



SIACS LENGTH CONVERSION WORKSHEET

(For VERTICAL systems only)

Location: ______________
Date: ______________
Measured by: ______________
Converted by: ______________

Mirror Elevation: ________
Tunnel Elevation: ________
Conversion Factor: ________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes

(convert2.cdr)

Field Worksheets for Horizontal and Vertical SIACS.
(*Full-size* worksheets suitable for copying are included as an Appendix.)

Note on body angle data:- When the fish's body angle is small, it accounts for a very small portion of the final estimate of the length of the fish and may, *at the discretion of the project leader*, be omitted. See the Technical Reference Manual for details on the effects of this measurement on the estimates of body length.

11. Convert the apparent length of the fish as recorded in Column D of the SIACS Worksheet into the corrected length as described in the next section, **Length Conversion**.

LENGTH CONVERSION

This section deals with converting the apparent lengths, as measured from the screen, into corrected, or true lengths. To do this, use the computer program entitled CONVERT.EXE; (a data file called CONVERT.DAT is required to run this program and should be in the same working directory). Instructions for using this program follow.

1. At the DOS prompt, type CONVERT and press the ENTER key.

2. ENTER a "**1**" to go to the Data Conversion menu.

5. Mirror Height: - ENTER the value from **Column A** of the SIACS Worksheet.

3. Tunnel Height:- ENTER the value from **Column B** of the SIACS Worksheet.

4. Body Angle:- ENTER the value from **Column C** of the SIACS Worksheet.

6. Apparent Length:- ENTER the value from **Column D** of the SIACS Worksheet.

7. Corrected length:- The corrected length of the fish is automatically calculated and printed on the screen. Write this value in **Column E** of the SIACS Worksheet.

8a. Another fish:- Press ENTER to clear the screen for determination of the corrected length of another fish, or,
or
8b. Exit program:- Type a negative number (such as "-9") and press ENTER to exit the CONVERT program.

LENGTH ACCURACY

In theory, a very high degree of accuracy is possible with the geometric configuration of SIACS. Nevertheless, in practice, a variety of factors serve to degrade the accuracy of the estimate. Contributing factors include (1) the amount of distortion in the image produced by the camera's lens and electronics, (2) distortion produced by the monitor's picture tube (and its associated electronics), (3) inability to use a frame in which the fish is centred (from left to right) on the screen, (4) degree of crowding in the tunnel (it may be difficult or impossible to determine all the critical measuring points on each fish when silhouettes of several different fish overlap in the image), and (5) variations among staff workers.

Assuming ideal images, **the most important factors which affect accuracy are:**

a. Accuracy of *all* measurements used to determine the **screen's Conversion Factor**, including the length of the calibration rod, the heights of the rod above the bottom of the mirror and tunnel, and the apparent length of the rod on the screen.

b. Accuracy of *all* measurements made from the screen, including the height of the fish above the bottom of the mirror and the tunnel and the curved fork length of the fish. *Total lengths are less accurate than fork lengths* because they are based on either the top or bottom tip of the tail which is usually either closer or further away from the camera than the body of the fish.

c. Accuracy of the placement on the monitor's screen of the two zero points on the Ruler Plate.

Figure 38 was prepared using 13 fish of known fork lengths (50 to 60 cm) and an additional 40 measurements of four rods of known lengths (ten length estimates at each of 40, 50, 60, and 70 centimetres. It demonstrates the level of accuracy one might expect with manually determined measurements using a SIACS. Causes for any reduction from this level of accuracy should be determined and corrected.

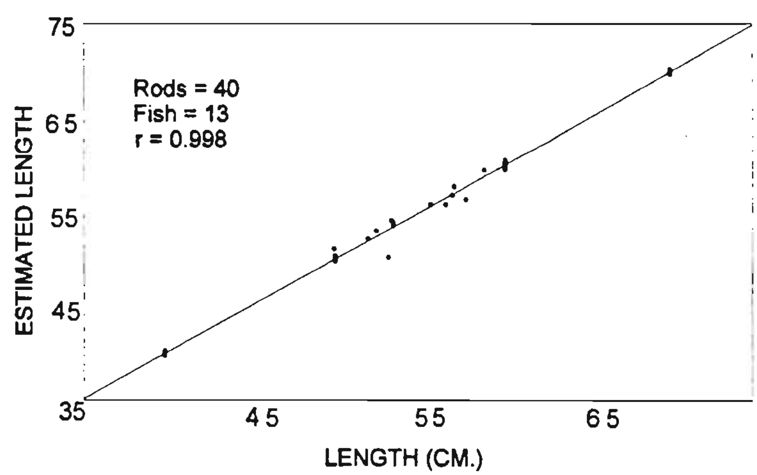


Figure 38. Accuracy of on-screen measurement determinations using calibration rods and fish of known length.

Attention should be paid to variations in accuracy of length determinations among different staff members. One method of evaluating this is to use a video tape of recordings of several fish of known lengths swimming in the tunnel. This tape can be used at the beginning of, and several times throughout each field season to test and correct measuring methodologies and accuracy. Consistency of measurements among different workers ensures the validity of comparisons of length frequency distributions (for example, **Figure 39**) of migrating fish from one time period to another.

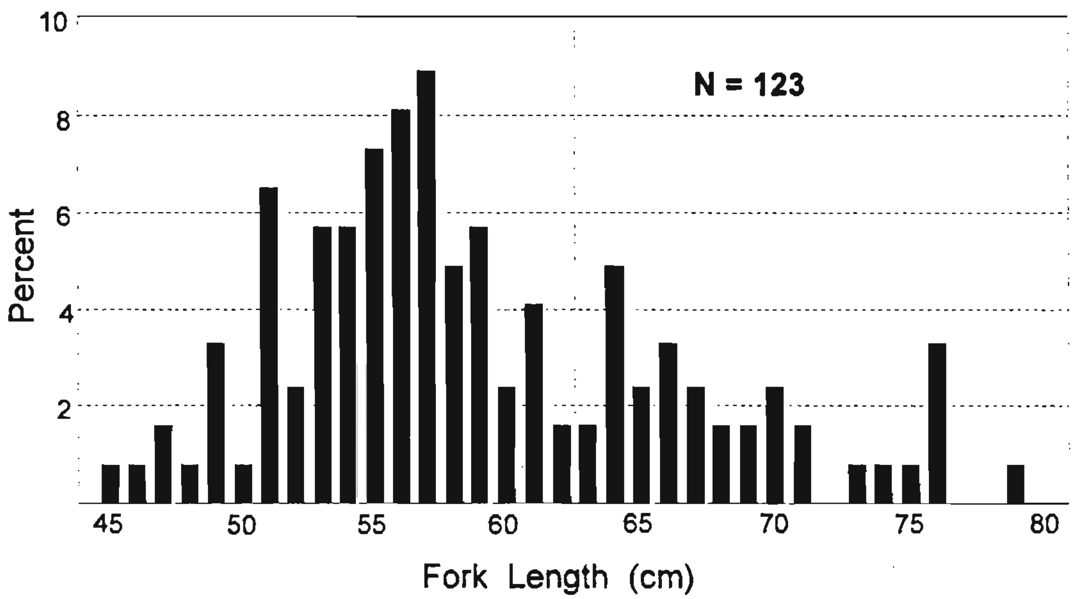


Figure 39. Length Distribution of salmon migrating upstream in Gander River on August 4, 1995. Data from semi-automated monitoring with SIACS.

PART IV - AUTOMATIC MONITORING

Full automation of counting and measuring fish as they pass through the tunnel can be achieved with specially designed image analysis software run on a personal computer equipped with image analysis capabilities. Basic system operations and layout are shown in **Figure 40**. While the tunnel and lighting assembly are capable of producing images ideal for this purpose, the accuracy of the fish counts is to a large degree dependant on the quality of the software used. Accuracy of measurements is dependent on the accuracy of the calibration, quality of the software, the accuracy of the construction of the tunnel, and alignments of component parts.

For automatic monitoring, high contrast silhouette images created by SIACS optics and lighting are converted into even higher contrast images by changing the light grey background of the original image to pure white and converting images of the fish to pure black. Thirty times per second, new images are examined by the computer to determine if a fish is passing a designated area of the image. If one is detected, its direction is determined and apparent size measured. The apparent size is then converted by the computer to a *first estimate* of the actual size by means of a conversion factor and this *first estimate* is saved on the computer's hard disk. A more accurate *final estimate* of the actual size of the fish is calculated later with a separate computer program using positional information on the fish's precise location which was stored on the computer's hard disk along with the *first estimate*.

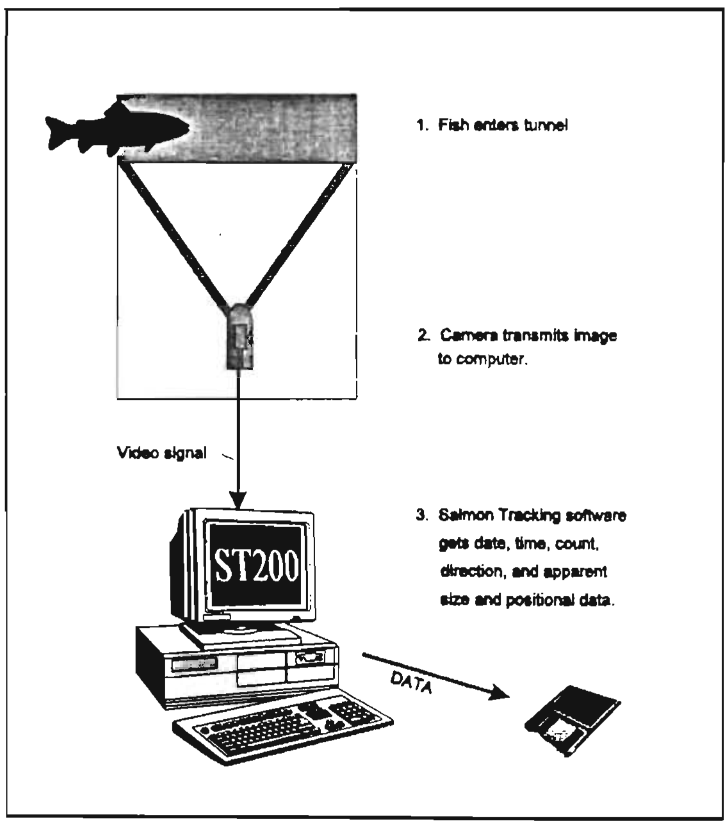


Figure 40. Basics of operation of automatic fish monitoring with SIACS.

SPECIAL DESIGN REQUIREMENTS

Tunnel design

In the standard tunnel and lighting design which is based on SIACS units with *short camera to tunnel distances*, there is a distinct reduction of light intensity near the upstream and downstream ends of the tunnel, and to some extent in the mirror image as well. This standard tunnel design is excellent for semi-automatic monitoring but is *not* adequate for automatic monitoring with the ST200 Salmon Tracker program. The ST200 program requires even distribution of background light from side to side and top to bottom in the image. A modified version of the tunnel is therefore necessary for automated monitoring when SIACS with short camera to tunnel distances are employed. Modification consists of a tinted front panel and installation of retroreflective wedges at either end of the back of tunnel as shown in **Figure 41**. Use of the retroreflective wedges is not required, however, for units designed with a suitably long distance between the camera and tunnel.

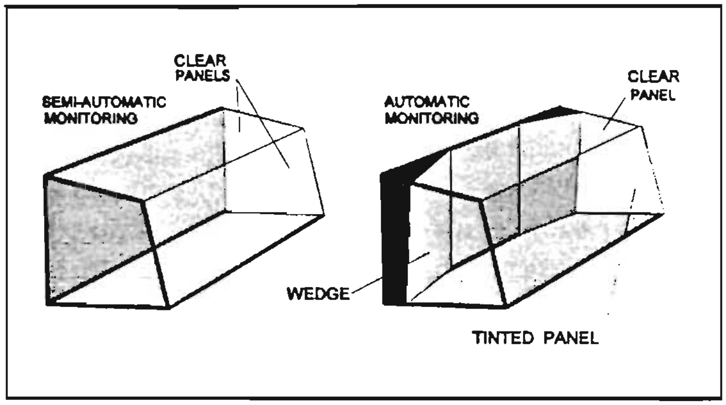
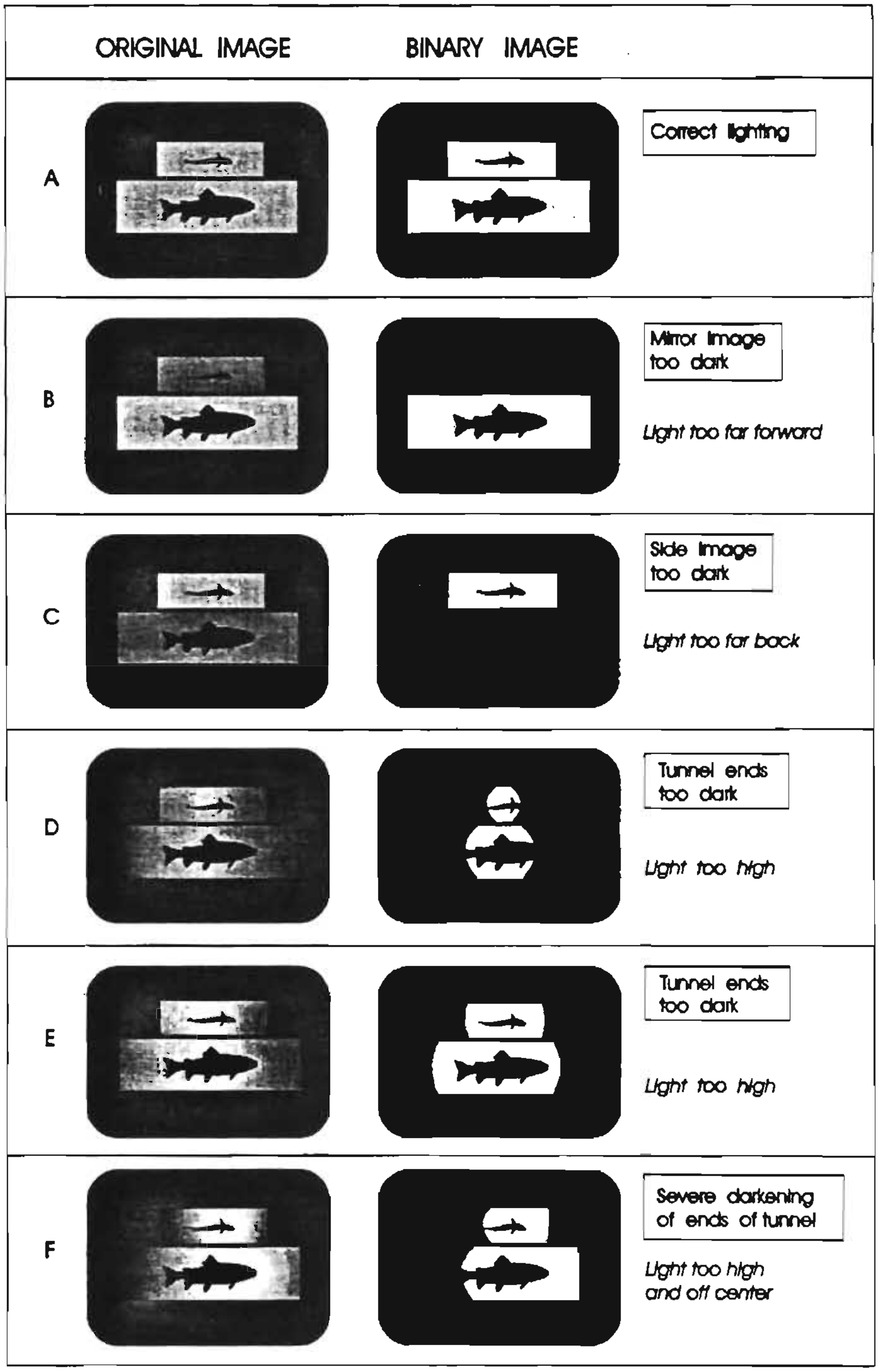


Figure 41. Difference between tunnels used for semi-automatic monitoring and automatic monitoring with the ST200 Salmon Tracker software.

Distribution of light

It is imperative that lighting be set up properly when using the ST200 Salmon Tracker program (see **Figure 42**). Retroreflective material on the rear and bottom of **the tunnel should be *evenly illuminated* from side to side and corner to corner**; furthermore, the upper, mirror view should have about the same brightness as that of the lower, side view of the tunnel.

Even illumination across the entire length of the tunnel ensures that the same threshold level will be applicable in all parts of the image. If light should decrease near the ends of the tunnel, or if there should be much less light in the mirror image than in the side view, a threshold which is just right for the side view may cause the ends of the tunnel in the mirror image, or the entire mirror image to be "blacked out", as in **Figure 42B**, and the ST200 software will not operate properly.



(threshld.cdr)

Figure 42. Effects of various arrangements of lighting on the binary image produced in SIACS, giving reasons for uneven lighting.

Intensity of illumination

Experience has shown that, although the exposure control circuitry of the camera adjusts automatically to changes in light intensity it is not sensitive enough for routine usage in SIACS. Very small changes in the brightness of the bulbs can cause significant changes in the optimal level of the threshold so that periodic checking and adjustment of the Threshold is necessary to maintain optimal operating conditions. Changes in light output can be caused by normal deterioration of the bulbs, or by variations in the voltage applied to them. For these reasons, the following procedures should be followed.

1. Install a new set of bulbs in the light box at the beginning of each season.

2. Periodically check and adjust the threshold as required.

3. When the system is used in a un-staffed field situation where it is not possible to closely monitor the threshold level, a voltage regulator should be installed *inside the light box* which will maintain the voltage *at the bulbs* within one tenth of a volt (see Technical Reference Manual for details).

ELECTRICAL HOOK-UPS

While the basic components of the automated system are shown in **Figure 40** and **Figure 42**, two optional monitors with a video distribution amplifier may be used in situations where the computer is set up in a field cabin rather than in a small shed or a stand-alone submerged system. The advantage of this set-up is that it allows continuous viewing of the original image from the camera along with the binarized image from the computer.

Details of a fully evaluated electrical setup are included in Part V. These show coupling both semi-automatic and automatic monitoring systems for critical assessments with SIACS.

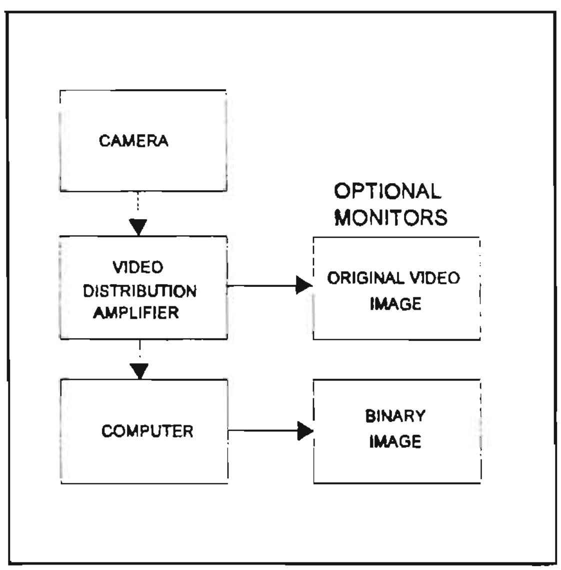


Figure 43. Optional monitor hook-up where field conditions allow.

THE *ST200 SALMON TRACKER* PROGRAM

The Salmon Tracker Software used with SIACS was designed by Canpolar East Inc. of St. John's Newfoundland; the following instructions are based on the ST200 version for MS-DOS. This version enables the collection of the date and time of passage, a *first estimate* of total body length, and the direction of movement of each fish passing through the tunnel. It operates best with a computer equipped with an Intell 486 or faster processor (with math co-processor). An Occulus 300 image board is also required. User Documentation for the software is found in the SIACS Technical Manual. The computer should be set up to automatically start this software when it is turned on. See Figure 1 on page 5 of the User Documentation for a picture of the start-up screen.

Starting the Salmon Tracker Program

To start automatic counting and measuring, use the cursor keys to highlight the desired Tracking option (single window, double window, or water-level tracking) on the menu and press the **Enter** button on the keyboard.

Quitting the Salmon Tracker Program

To end automatic counting and return to the main menu screen, press the **Esc** key, highlight the **Quit** option on the menu, and press **Enter**.

Selecting Set-up options

The Set-up option should be selected and run prior to the first routine operation at a particular field site. All settings are subsequently stored on the hard disk and will not normally require changes for the remainder of the field season. The operator is referred to Canpolar's User Documentation for the software which gives basic information on the various options available for running the ST200 program. The following paragraphs provides useful additional information, based on DFO's field experience, for setting up and running the program.

THRESHOLD

Definition of *Threshold*

Background: Normal black and white photographs are composed of a full range of image brightnesses from pure white to pure black; these are called *half-tone images*. When a computer analyzes such photographs, it assigns a number to the degree of brightness in each small part (called a pixel) of the picture so that the number zero represents pure white (or extremely light grey) and the number 255 represents pure black (or extremely dark grey). Numbers between zero and 255 all represent different shades of grey, from very light grey for the number one to very dark grey (almost completely black) for the number 256. The ST200 Salmon Tracker program has a built-in function which converts to zero brightness levels below and above a user-defined threshold level; in other words, if a user sets the threshold value equal to 125, then the computer converts all brightness values below 125 to zero and all values of 125 and higher to 255. The image is thereby converted from a low contrast *half-tone image* with 256 (0-255) levels of grey to an extremely high-contrast *binary image* with only two "shades of grey" - "pure" black and "pure" white.

Definition: The *Threshold* is the user defined value between zero and 255 which determines the particular level of grey which will is used in the image analysis procedure as a dividing point between pure white and pure black. In some circumstances a low threshold setting is required for proper operation while in others a different setting is required.

Setting the threshold

Selecting the ideal threshold level is dependant on the quality of the original, grey-scale image and requires some understanding and experience. The ideal threshold level for use in the SIACS is that which does not allow the pure white background in the binary image to encroach on the pure black outline of the fish, while at the same time enabling one to clearly see the tips of fish's tail at all times.

The threshold is set using an optional monitor as shown in **Figure 43**. With an live, active image coming from the camera to the input connector of the OC300 Image Board on the back of the computer, a standard (RS-170) monitor is connected to the output of the Image Board. The computer is turned on and the **Threshold** option selected from the **Setup menu**; press **Enter** to begin and use the **Up** and **Down** arrow keys to increase or decrease the threshold value.

For best results*, the threshold should be set during a period of bright sunlight with an actively swimming fish trapped in the tunnel and, in the case of an unsealed enclosure, with the cover of the enclosure shut.*

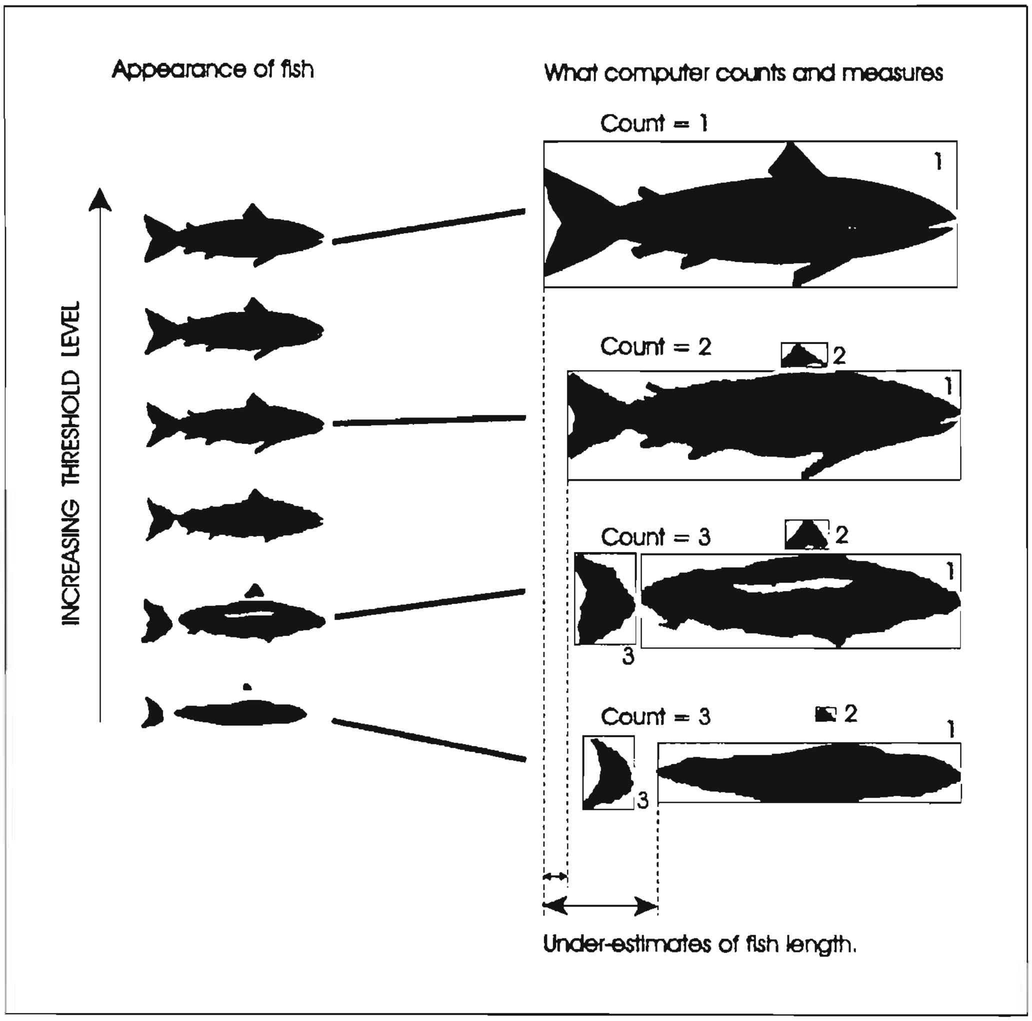
Effects of threshold level

The effects of changing the threshold level are shown in **Figure 44**. Lowering the threshold below optimal levels will cause the fish to appear shorter and thinner than it really is as shown on the left hand side. For this same reason, and especially when the background is unevenly illuminated, those parts of the fish's image with unusually bright background nearby may break up. An improperly set threshold on the image of a fish can thus result in an **underestimate of the length** of a fish, and a single fish can be **miscounted** as being two or even three fish.

Optimal threshold level

Although the threshold level can be set anywhere between zero and 255, optimum values may vary with specific field circumstances as described in the next section. The best operational level is somewhere around 100 and higher while levels below 60 being borderline, and 75 being close to the norm. Proper setting of the threshold requires experimentation and experience.

IMPORTANT
Proper setting of the threshold level is *critical* to optimal functioning of the ST200 Salmon Tracker Software.



(fishthsh.cdr)

Figure 44. Effects of varying threshold values on how the computer counts and measures fish.

If the optimal threshold value drops below 75 determine the cause and correct the problem (see the following paragraphs). If values approaching 255 are required to obtain an ideal picture, a good quality video signal attenuator should be installed to enable the level to be manually adjusted downwards.

Factors affecting threshold level:

a. Weak video signal strength caused by very long cables cause dim images which in turn demand a lower threshold level, sometimes approaching zero (which is unacceptable).

b. Strong video signal strength may cause unusually bright, low contrast pictures which demand higher threshold levels, sometimes approaching 255. Such a high level, depending on the quality of the image leaving the camera, may or may not be unacceptable.

c. Low image contrast results in a very narrow range of acceptable threshold levels so that there is too little latitude for normal variations. Variations in image contrast can be caused by either of the following:

- burned out light bulb (there are two bulbs in the light box)
- drop in voltage to bulb
- drop in light output due to aging bulb (replace each season)
- a build-up of silt in the river (normal during or after a heavy rainfall)
- excessive build-up of algae or other materials on the tunnel surfaces
- inadvertent bumping and misalignment of the lighting
- dirty water in water-filled chamber of camera case

d. Dark picture may also be caused by the same factors as listed in the previous paragraph.

THE TRACKING WINDOW

The **tracking window** defines the area of the picture which is analyzed by the computer; parts of the picture outside this window are disregarded. A fish must be at least partially inside this window to be detected by the computer and must pass completely through the window to be counted and measured. Parts of the tracking widow are identified in the figure on the next page. *The tracking window is actively tracking fish when it is flickering (**Figure 45**) - it*

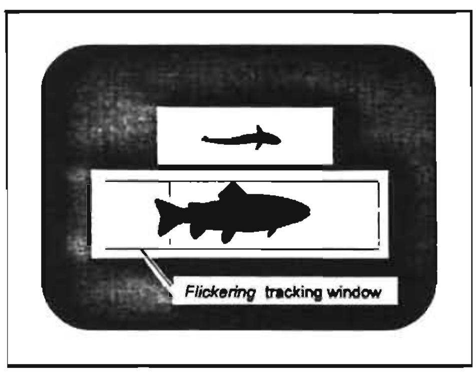


Figure 45. The flickering tracking window indicates that the program is properly tracking fish.

does not flicker when the system is not in tracking mode.

The advantage of seeing the binarized image is that it shows a flickering rectangular box superimposed on a *binary image* of the tunnel (see **Figure 45**) when the Salmon Tracker program is in Tracking Mode. This box is called a *tracking window*. Details of the tracking box are also given in **Figure 45**.

Moving the Tracking Window

To adjust the position of the window, go to the **Window Setup** from the **Main Menu** and select **Top View Settings**. Select **Window Position** and use the arrow keys to move the window into position in the centre of the top view (mirror image) of the tunnel. Press the **Enter** key to return to the **Top View Settings** box.

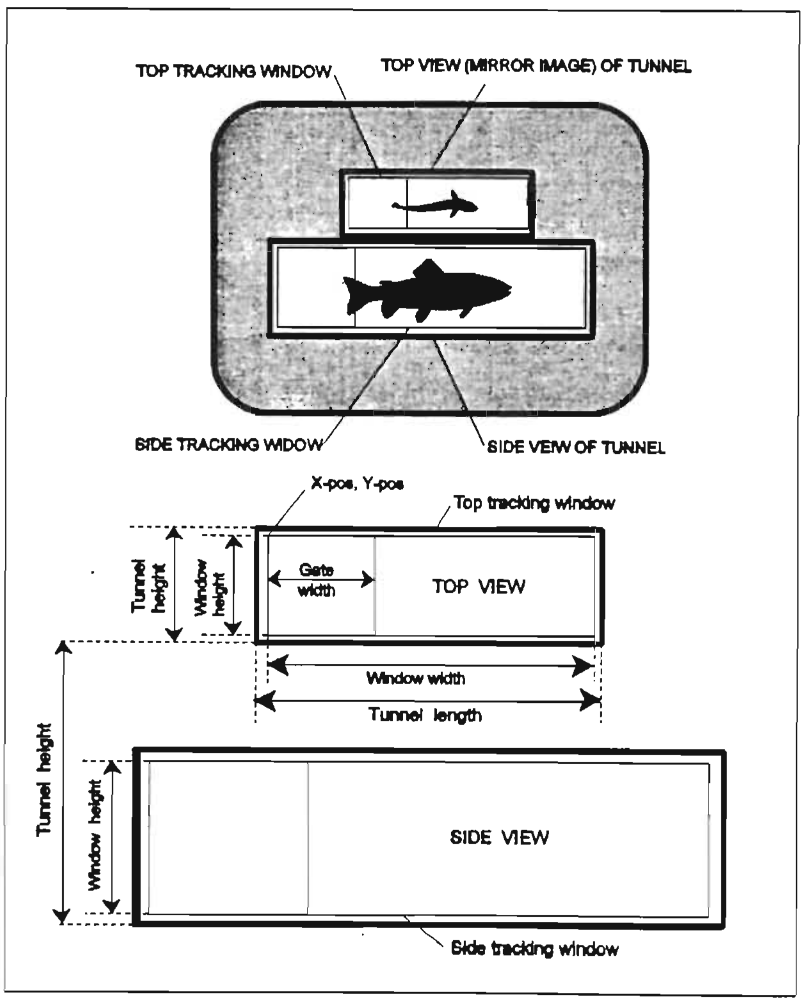


Figure 46. Parts of the Top and Side View Tracking Windows.

Changing Window Dimensions

The tracking window should be sized so that its edges are as close as possible to the edges of the tunnel without touching any dark areas associated with the tunnels edge. **Window Height** and **Window Width** are selected from the **Top View Settings** box and adjusted with the arrow keys. It may also be necessary to adjust the window's position (as in the previous paragraph) to align all sides of the Tracking Window with the sides of the tunnel.

Setting the Gate Width

The **Gate** is that part of the **Tracking Window** which is involved in determining swimming direction of the fish. It consists of two vertical lines, one of which also serves as one end of the **Tracking Window**, while the other is a movable vertical line inside the Tracking Window. A fish passing the left line first and the right line next is designated as having passed from left to right through the tunnel.

The optimal width of the **Gate** is dependant upon a number of factors such as anticipated size of targeted fish, swimming speed, and the most common swimming direction. Normally, the width is set at about 25-30% of the length of the tunnel; *it should be set, however, so that the remainder of the **Tracking Window** is large enough to accommodate the largest anticipated fish.*

THE CUT-OFF AREA

Definition:- The **cut-off area** is the area of a fish in a tracking box to which the ST200 software is sensitive as shown in **Figure 47**. It is used to set the area of that part of a fish which must be inside the **Tracking Window** before automatic tracking of the fish begins. It may also be used to set the size (area) of objects which will be disregarded during tracking. When set to a very low level, such as 5 to 25, fish tracking will begin as soon as a very small part of the body (for example, the nose) becomes visible inside the Window. When set to a large area such as 200 or 300, a much greater part of the nose of the fish must enter the Window before tracking begins.

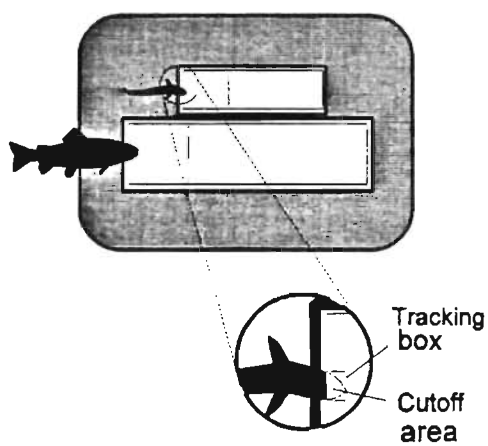


Figure 47. The cutoff area controls the area of a fish's image to which the ST200 software is sensitive.

The advantage of using a *low* cut-off area is that rapidly swimming fish will be detected as early as possible and will therefore be less likely to be missed. The **disadvantage of a low setting** is that if the image of a fish should break up because of a poor threshold setting (see Setting the Threshold), a small part of the *fish* such as a part of the tail or a fin, may be interpreted as being a small fish; this can cause miscounts of fish if more than one fish is present in the tunnel at the same time. A second disadvantage is that ordinarily non-problematic, small dark areas of the background (caused by too high a threshold setting) in the tracking Window can confuse the software and cause errors.

The advantage of a *high* cut-off area is that very *small fish and pieces of debris floating in the water will be disregarded* by the computer. The **disadvantage of a *high* cut-off area** is that the system is less sensitive to rapidly swimming fish and such fish may be missed.

The **ideal cut-off area** will represent a compromise between the advantages and disadvantages and may vary from one situation to another. A cut-off area of about 200 worked well at Biscay Bay in 1994 and 1995 and may be used as a starting point for any particular field situation. Experimenting with video tapes of migrating fish is the surest way of determining the best cut-off area.

CALIBRATION OF LENGTH MEASUREMENTS

The ST200 software enables control over the minimum size of fish which will be detected and measured. This is of particular interest in situations where monitoring of the movements of smaller fish is neither required nor desired; the function can also be used as a means of disregarding pieces of debris shorter than the minimum fish length.

1. Before calibrating, select **Top View Settings** from the **Window Setup** menu and select **Scale Factor**. Enter a "1" for the SCALE mm/PIXEL factor; this value will result in the length of a fish being expressed in pixel units.

2. Prepare a calibration rod of known length similar or the same as that used when calibrating the monitor screen (see **Screen Calibration**).

3. Switch the program to tracking mode. With one person holding the downstream end of the line while another holds the upstream end, pull the rod through the centre of the tunnel so that it is remains parallel to the sides of the tunnel at all times. Note the *measured length* of the rod as recorded by the computer; this is the length of the rod in pixel units.

4. Divide the *measured length* of the rod into the rod's true Length; this is the required calibration factor in millimetres per pixel.

5. Repeat the above procedure several times to satisfy oneself of the accuracy of the factor.

6. Enter the new calibration factor as the new SCALE mm/PIXEL value as in Step #1.

Example:

1. Enter a "1" as the Scale Factor.
2. Record True Length of calibration rod on paper (eg. 630mm).
3. Run ST200 and obtain *estimated length* of rod as it passes through tunnel, eg. = 350
4. Compute new Scale Factor = true length / *estimated length* = 630/350=1.80
5. Enter *1.80* mm. per pixel as the new Scale Factor.

Accuracy of length measurements

Fish length measurements recorded by the Salmon Tracker program do not take into account the distance of the fish from the camera. For this reason, lengths of fish which swim through the half of the tunnel which is closer to the camera will be overestimated while the lengths of those which swim in the far side of the tunnel will be underestimated. Another source of length error is that the ST200 program assumes that the body of each fish is straight instead of being bent as is normal for a swimming fish. Furthermore, the angle of the fish to the horizontal will also affect accuracy of length measurements. For improved estimates of the length, the data file should be edited using the EDITDATA.EXE program in the ST200 directory; this program takes some of these factors into account and improves the estimated lengths in the data file. See Reducing Data Files on page 55)

ALTERNATIVE TRACKING MODES

There are three different tracking modes available:

1. Double Tracking

This is the normal tracking mode for the Salmon Tracker. It is used when water levels are constantly above the top of the mirror. It tracks the movement of fish and measures them in the Top View Tracking Window. The position of the fish in the tunnel is then determined in both the Top View and Side View Tracking Windows.

2. Single Tracking

This mode monitors fish in either the Side View or the Top View Tracking window, but not both as in Double Tracking. Since there is no stereoscopic image of the fish as it passes, the distance between the camera and the fish cannot be calculated so that length estimates are not as accurate. This mode is not normally used in routine monitoring and is available for research purposes when required. *Use Side View Tracking only when the water level does not cover the mirror or when conditions are such that the Threshold Level cannot be properly set for both the Top and Side Views combined.*

3. Water Level Tracking

This is the normal tracking mode for the Salmon Tracker when water levels may drop below the top of the mirror. It monitors the water level in the mirror image and, should the level drops below the top of the mirror, it automatically switches to the Single Tracking Mode using only the Side View Tracking Window.

> **ATTENTION**
> The Water Level Tracking mode must be manually reset after the water level increases to cover the top of the mirror.

RUNNING THE ST200 SALMON TRACKER PROGRAM

Before starting the program, make sure all the proper electrical connections are made and that the monitor displaying the *binary image* is turned on.

1. At the DOS prompt, type **ST200** and press **Enter**.

2. Select **Window Setup** to change default settings, if necessary. (see above instructions for changing default settings).

3. Select either **Single**, **Double**, or **Water-level Tracking** mode and press **Enter**.

When Single is selected, choose between Top View and Side View Tracking and press Enter.

4. Check the binary image to ensure that the tracking window is *flickering* - this indicates that the system is correctly tracking fish. After checking, disconnect or turn off the monitor if desirable.

5. Press the **Esc** button to stop tracking and return to the Main Menu when necessary.

***Note:-** The ST200 program will run with a video signal from either a camera or a video recorder. The video recording, however, should free of interference resulting from stoping and starting the recorder during the recording process. Making copies of video tapes omitting such interference, or omitting long periods of blank tape between fish, as might be required for research or public demonstrations, requires a special dubbing procedure. See Appendix I for instructions to prepare such tapes.*

DATA STORAGE AND RETRIEVAL

Immediately after detecting, measuring, and determining direction of movement of a fish, this data, along with the time and date and positional data, are stored in the ST200 directory on the hard disk. *The name of the file in which it is stored corresponds to the date on which the tracking program was last started* and has the following format: **mmddyyyy.STD.** For example, if the tracking program was started on June 15, 1995 and allowed to run for more than 24 hours without resetting it, records of fish passing through the tunnel on June 16th or later would be stored in the same file.

Copying Data Files

At the DOS prompt(C:>), place a formatted floppy disk in Drive A and type in the following:

COPY mmddyyyy.STD A:\ where mm = month, dd = day, and yy = year

For example to copy the data file started on June 15, 1995, type **COPY JN151995.STD A:** and press **Enter**. To return to the ST200 program, type **ST200** at the DOS prompt and press **Enter**.

> **ATTENTION**
> ***Fish may pass through the tunnel undetected while data files are being copied. Therefore, the operator may wish to close the tunnel during copying.***

Transmitting data files

Data files may be transmitted by telephone to another computer with the use of a modem and communications software. Instructions for doing this depend on the software used. The data files are stored in the Directory called ST200 unless they have been moved to another Directory.

ST200 Data Summary

Combined data from a series of data files can be printed or viewed by selecting **Statistics** from the **Main Menu**. Proceed as follows.

To obtain an on-screen data summary:

a. Turn printer off, using either the program selection method or by simply turning off printer.

b. Select **Statistics** from the **Main Menu**. A data entry screen will appear.

c. Enter the Directory in which the data are being stored. Normally, this would is **C:\ST200**.

d. Enter starting date in the format provided above.

e. Enter starting time where using a 24 hour clock. For example, 1 PM is entered as 13. **Note that midnight is entered as a ZERO, not as 24.**

f. **Enter** the date and time of the end of the desired data series.

g. A summary of all data on fish counted between the starting and ending will be displayed on the screen.

To print a data summary:

a. Be sure printer is turned on and use the Main Menu to enable printing.

b. Follow steps (b) through (f) above as for the "On-screen summary of data".

c. Data collected on all fish between the starting and ending dates and times are printed.

NOTE:- These data summaries are based on the *raw data* collected by ST200 and as such gives only a rough estimate of fish numbers. It does not take into account fish which linger in the tunnel or fish which exit from the same end of the tunnel as they entered. *For a more accurate summary of salmonid movements, see section on Reducing Data Files (page 55).*

REDUCING DATA FILES

Data files recorded by the ST200 Salmon Tracker include data on current settings of the program in addition to data on time, date, direction, size, and position in the tunnel, as well as times when there were no fish in the tunnel. Furthermore, they include information on each fish passing the Tracking Gate, even if it simply entered the tunnel at one end, lingered for a while in the tunnel, and finally exited by the same end of the tunnel (such an event does not, of course, represent a fish which passed through the tunnel). The data become further complicated when several fish linger in the tunnel for a while before one or more passes on through, either upstream or downstream. Such problems can result in many pages of data on fish movements when in fact very few may have passed through.

In addition to the superfluous data problem indicated above, the information collected on the total lengths of the fish is not as accurate as it might be because the ST200 program does not calculate the effects on the size estimate of a fish's distance from the camera; the length provided by the Salmon Tracker Program may be either an overestimate or an underestimate, depending on the fish's distance.

Fish movement and positional data necessary to make the improvements on estimates of numbers of fish moving upstream and downstream, as well as on length estimates are available on the data file. The required calculations were not made because the computer processing time required to conduct them could result in missed fish counts, especially when fish were moving through the tunnel in rapid sequence. (This is an obvious area of improvement when faster computers become available.)

Less complicated data files are required for routine data analysis. A utility program entitled EDITDATA.EXE is therefore provided to edit the ST200 data files to remove useless fish movement data and to improve length estimates; it also simplifies the file be removing other superfluous data. Options to print the edited file and summaries provided.

Loading the EditData Program

At the DOS prompt, type **EDITDATA** and press the **Enter** key. The following menu appears:

MAIN MENU

1. Edit an ST200 Data File
2. Select Print-out Options
3. Change Default Settings
4. Exit Program

Changing Default Settings

All default settings should be checked and changed as necessary *after* the camera has been aligned and *before* the program is run. Also, if for any reason the camera has moved during the field season, those settings dealing with the position of the tunnel and mirror in the image should be rechecked and reset before the program is used. Optimal accuracy of length measurements is possible only when the settings relating to the position of the tunnel and mirror are properly set.

> ***Default settings should be checked in either of the following circumstances:***
>
> 1. When the system is first installed at the field site.
>
> 2. When the camera has been moved, either by design or by accident. Movement of the camera may be detected by marking the position of the centre of the bottom of the tunnel ***on the monitor's screen*** when the system is first set up and then periodically checking to see that the image of the tunnel has not moved from this spot. **If the image has moved, the default settings should be corrected immediately.**

To change the default settings, select the procedure from the **Main Menu** and respond to the questions presented. The following provides necessary background information for the setting of the more involved parameters:

1. Sensitivity to multiple fish counts

The problem of keeping track of individual fish at times when there are two or more fish in the tunnel at the same time is quite complex and has not been fully solved in the ST200 Salmon Tracker program. For this reason, the EditData program performs a series of analyses on the ST200 data to improve the accuracy of the counts when multiple fish are present in the tunnel. This program is by no means perfect and its precision in correcting the data is dependant to some extent on the number of fish in the tunnel at a given time as well as the speed at which they move through the tunnel, and even more importantly, the degree of lingering by individual fish in the tunnel. For this reason, a *sensitivity factor* has been incorporated into the EditData program; a value of about 1.25 worked reasonably well at Biscay Bay River in 1994 and should be used as an experimental starting point.

To evaluate the current sensitivity value, the user should make a video tape of some of the most common occurrences of multiple fish in the tunnel, visually evaluate the actual numbers of fish passing through the tunnel in each instance, and then run the ST200 program with the tape. The resulting data file is then edited using the EditData program with a variety of Sensitivity settings. The Sensitivity setting which provides the most accurate fish counts should be used.

The sensitivity setting does not impact on estimates of fish length because the EditData program discards all estimates where more than one fish is present in the tunnel at the time a length estimate is made by the ST200 program. *A zero length is recorded for each fish associated with a multiple fish condition in the tunnel.*

2. Pixel Calibration Factor

This forms part of the procedure to improve the length of fish estimated by the ST200 program. To set this factor, move a rod of known length up and down through the tunnel as described in the Screen Calibration in Part III, Semi-automatic Monitoring. Make a video tape of this procedure and run the video tape with the ST200 program, selecting only those image sequences during which the rod is in the centre of the tunnel and is parallel to the top and sides of the tunnel. Edit the resulting ST200 data file using the EditData program and note the estimated length of the rod. Next, change the Pixel Calibration Factor using the following procedure:

$$\text{New Pixel Calibration Factor} = \frac{\text{Correct Length of rod} \times \text{Current Pixel Calibration Factor}}{\text{Estimated length of rod}}$$

3. Tunnel Image Pixel Values

In this step, the ST200 program is used to determine the correct values of the remaining parameters required by the EditData program, the main objective being to determine the central, Y- Position values of the parts of the tunnel image as shown in in **Figure 48**.

To obtain these pixel values:

a. From the Main Menu of the ST200 program, select **Window Setup** and *record on paper* the values of the X-Position and the Y- position for both the Top View and the Side View. These values will be needed in Step (h).

b. Select **Top View Settings** from the menu.

c. Move the position of the *bottom* of the *Top Tracking Window* to the middle of the mirror as shown in the figure and record on paper the value of the Y-position displayed for the *Top View Settings* on the ST200 screen.

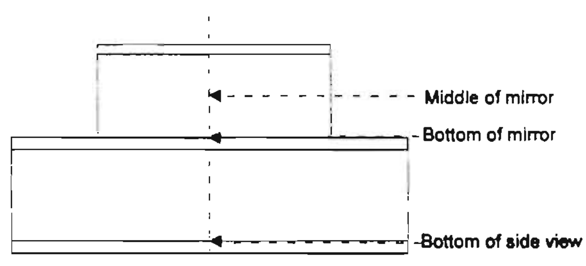


Figure 48. Locations of important pixels obtained from ST200 Program for use in the EditData Program.

d. Move the position of the *bottom* of the *Top Tracking Window* to the Bottom of the Mirror. Record on paper the value of the Y-position displayed for the *Top View Settings* on the ST200 screen.

e. Select **Side View Settings** from the menu.

f. Move the position of the *bottom* of the *Side Tracking Window* to the Bottom of the Mirror. Record on paper the value of the Y-position displayed for the *Side View Settings* on the ST200 screen.

g. Move the position of the *bottom* of the *Side Tracking Window* to the Bottom of the Side view of the tunnel. Record on paper the value of the Y-position displayed for the *Side View Settings* on the ST200 screen.

h. Reset the X- and Y-positions for both the Top and Side Views to the values recorded in Step (a).

IMPORTANT

The last step, (h) is critically important to obtain best possible estimates of fish lengths! Be certain to re-set these values.

i. After determining these values, exit the ST200 program and start up the EditData program and begin **Change Default Settings** procedure. Next, refer to the locations of the settings determined in the figure and enter them in response to the appropriate questions.

Data Reducing Procedure

1. Select 1 from the Main Menu.

2. Provide the first 8 (or 7 if day number is less than 10) characters of the name of the file to edit (without an extension), *filename*, and press Enter.

3. The following events occur automatically:

a. All ST200 setting data is stripped from the data file.
b. All records of times with no fish in the tunnel are stripped
c. All records of fish which did not pass completely through the tunnel are deleted.
d. All records of multiple fish in tunnel are analyzed and the net number which passed through the tunnel at a time is estimated.
e. All length estimates are improved using the positional data on each fish and the positional data are subsequently stripped.

f. Two new files are created in the ST200 directory. These are *filename*.SAL and *filename*.SAE where:

- *filename*.SAL is the modified file containing the record of salmonids only,
- *filename*.SAE is a modified file containing the records of both salmonids and eels.

g. A summary of the movement of all salmonids is displayed on the screen, for example:

DATA FILE SUMMARY

	TIME	DATE	
First Fish:	22:17:51	07/07/94	
Last Fish:	03:24:21	07/08/94	
	UP	DOWN	NET
Grilse:	35	2	33
Salmon:	1	0	1
Un-measured:	2	1	1
	38	3	35

Size limits used: Grilse: 43 to 63 cm.
Salmon: >63 cm.

h. A hard copy of the summary may be printed. See **Printing Reduced Data** below for printing options.

Printing Reduced Data

Be sure the printer is connected and turned on. Then,

1. From the **Main Menu** choose **Select Print-out Options**

2. Note which print option has already been selected and change, if necessary, by choosing from among the options displayed (all options return to the Main Menu).

PRINT OPTIONS

Current option selected: 2

1. Display only summary on screen
2. Display and print only summary data
3. Display summary and print summary + salmon data
4. Display summary and print summary + salmon data + eel data
5. Return to Main Menu

PART V - THE BISCAY BAY RIVER PROJECT

Developmental research done at Biscay Bay River from 1992 to 1995 included construction and testing of several different subsystems of the SIAC System. These included the development of both the unsealed and sealed enclosures as well as a stand-alone field unit which incorporated practically all the control features for a complete research unit which enabled *simultaneous* semi-automatic and automatic monitoring as well as special alarm functions. This field case also enabled remote capturing of fish using automatic and manually controlled electronic gate releases which simultaneously dropped metal gates at the upstream and downstream opening of the tunnel. Operational aspects of the Field Case are provided in the following pages while construction details of the enclosures are included in appendices, as follows:

Page 61, The Field Case developed and successfully tested at Biscay Bay River.

Page 62, Details of the power supply panel of the Field Cases.

Page 63, Wiring diagram for Field Cases based on a video signal from the camera via a fibre optic cable (for areas where excessive electrical interference causes degradation of video signal over long distances from the river enclosure to a shore monitoring site).

Construction plans of unsealed and sealed enclosures used are provided in Appendices II and III. It should be noted, however, that these diagrams are for those units already tested at Biscay Bay River and significant improvements have since been designed by DFO in St. John's for incorporation into future models.

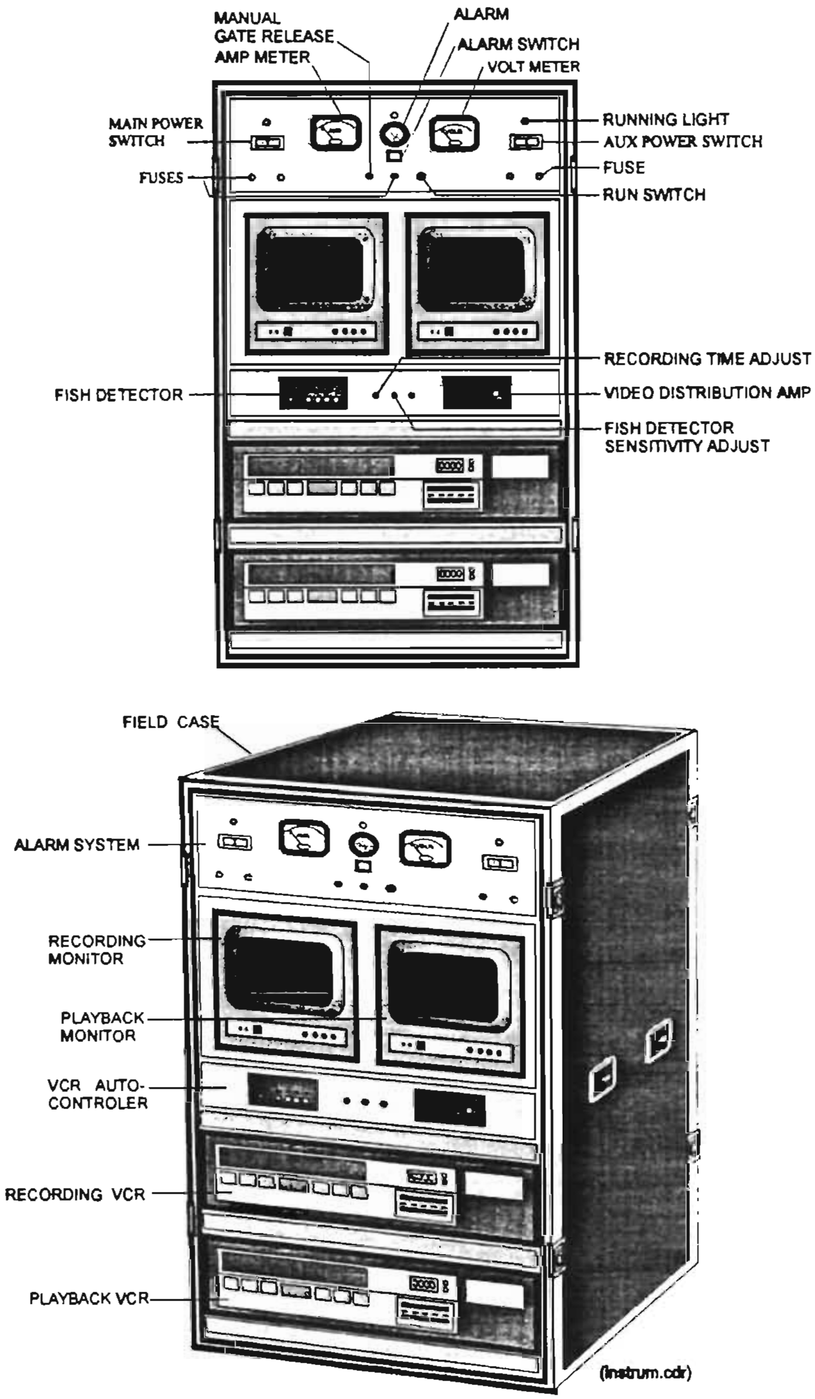


Figure 49. SIACS Field Case used at Biscay Bay River.

FIELD CASE CONTROL CONSOLE

(of Biscay Bay System)

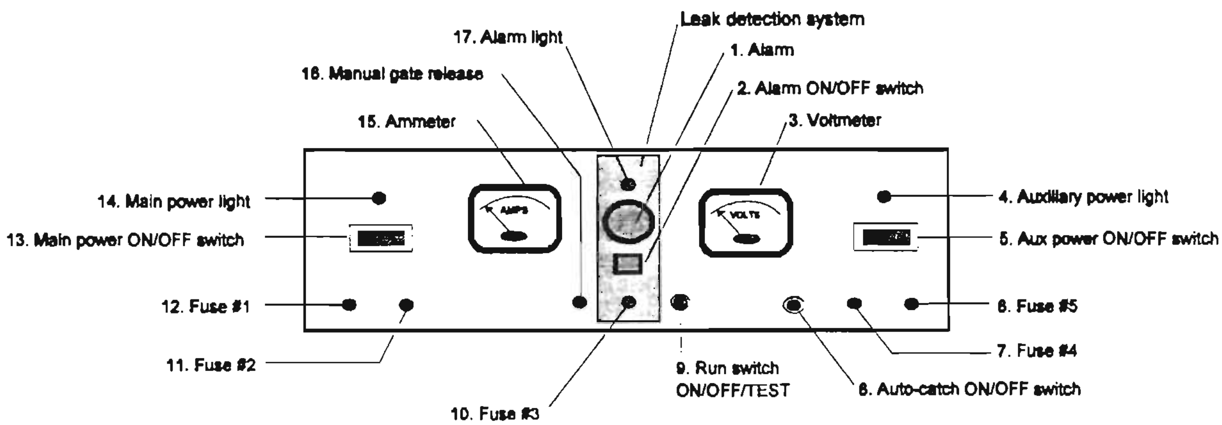


Figure 1. Details of the Control Console panel of the Field Case.

1. Alarm - sounds on water leak in camera case. Automatically drops gate to shut tunnel when monitoring ceases
2. Alarm shutdown switch
3. Voltmeter - monitors voltage to camera, lighting system, and all controls
4. Auxiliary Power Light - indicates if auxiliary power is in use (for example, if site work lights are on)
5. Auxiliary Power ON/OFF switch
6. Fuse #5 - 4 amp. (see parts list for details)
7. Fuse #4 - 1 amp. (see parts list for details)
8. Auto-catch function ON/OFF switch - gate drops automatically when fish enter tunnel (this function not implemented at time of writing of this report)
9. Video Loss Alarm switch
Top = ON - normal operating mode - alarm armed
Middle = OFF - defeats video alarm for use during system setup
Bottom = TEST - test for proper operation of video loss relay circuit
10. Fuse #5 for Auxiliary Power Supply (see parts list for details)
11. Fuse #2 Line OUT (see parts list for details)
12. Fuse #3 Line IN (see parts list for details)
13. Main Power ON/OFF switch
14. Main power ON light
15. Ammeter - monitors amperage of current to camera, lighting system, and controls
16. Manual gate release socket - receives plug for manual release cord
17. Leak alarm tripped indicator light - leak condition exists when ON

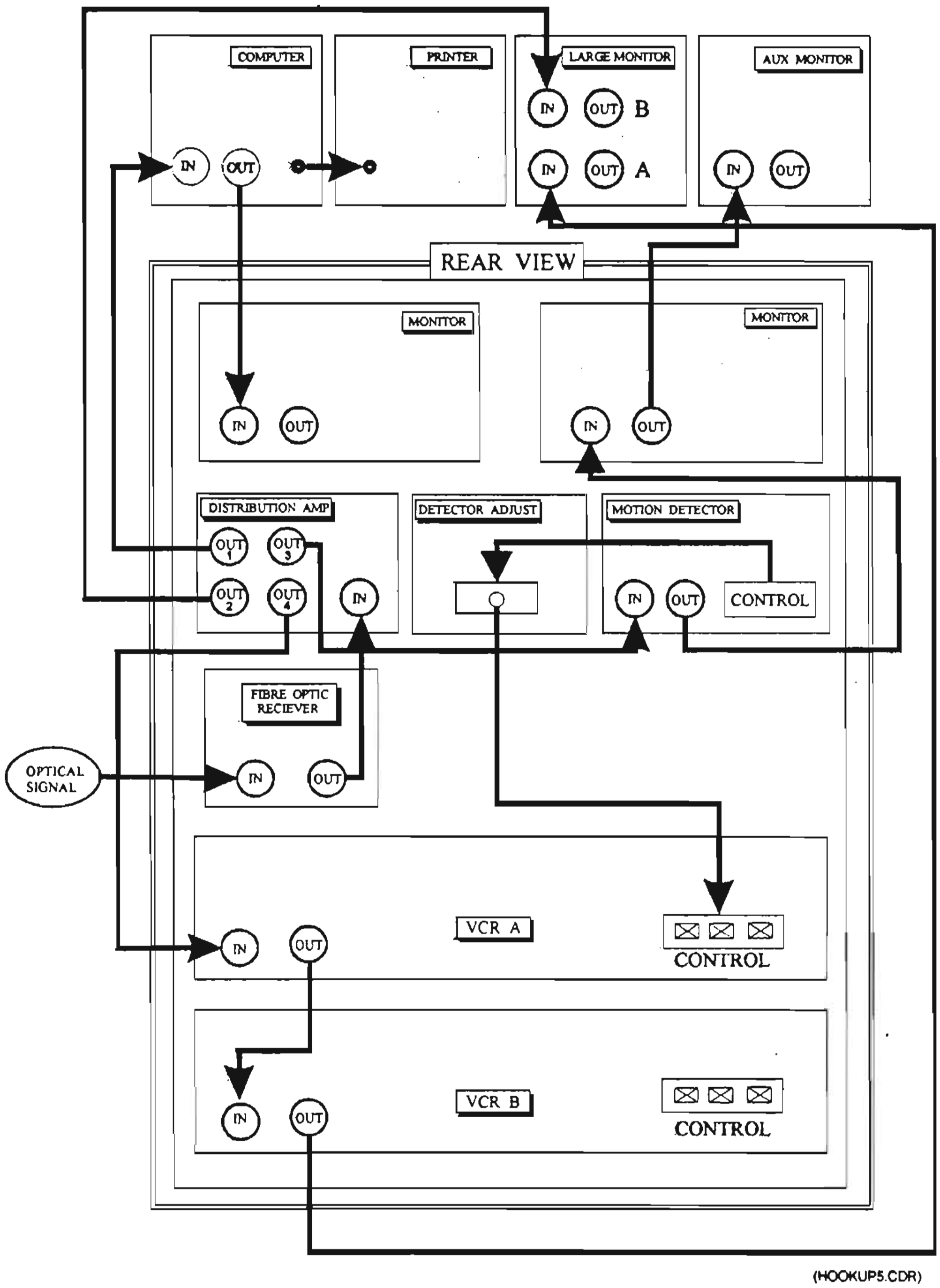


Figure 50. Electrical hookup with Fibre Optic video input signal for the SIACS used at Biscay Bay River where there was serious electrical interference from a nearby power line. In a normal setup, the fibre optic cable and receiver would not be used and the electronic video signal would feed directly into the distribution amplifier.

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APPENDIX 1

Transfering fish images from source to target video tapes

The following instructions will result in a tape with spacings of about 10 seconds between fish. It ensures that recording overlaps between fish occurs when there are no fish present in the tunnel. The resulting tape, which has a continuous stream of fish with 10 second intervals between them, is ideal for experimental work with Canpolar's ST200 Salmon Tracking Software.

1. SOURCE
   a. PLAY until fish enters tunnel.
   b. PLAY REVERSE 14 seconds before fish enters tunnel.
   c. PLAY

2. TARGET
   a. RECORD immediately SOURCE tape has played 5 seconds.
   b. RECORD for 14 seconds after fish leaves tunnel.
   c. STOP recording.

3. SOURCE
   a. STOP playback (PAUSE may also be used).

4. TARGET
   a. PLAY REVERSE until fish is in tunnel.
   b. PLAY until 3 seconds after the fish leaves the tunnel.
   c. STOP playback.

5. SOURCE
   Go to Step 1 and repeat procedure for next fish.

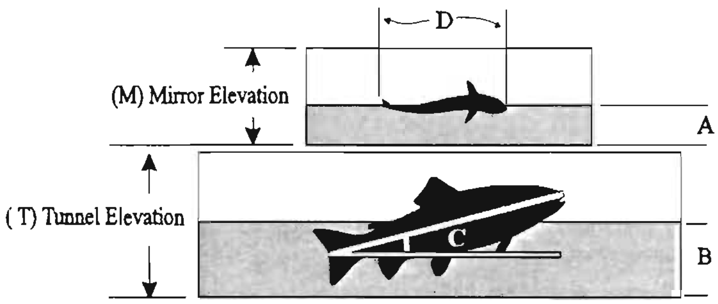
APPENDIX 11

SIACS Length Conversion Worksheets

This appendix consists of four blank SIACS Length Conversion Worksheets suitable to photocopy and use in semi-automatic monitoring and measuring of fish; two are for *Horizontal* Systems and two are for *Vertical* Systems.

SIACS LENGTH CONVERSION WORKSHEET

(For HORIZONTAL systems only)



Location: ________________

Date: ____________________

Measured by: ____________

Converted by: ____________

Mirror Elevation: __________

Tunnel Elevation: __________

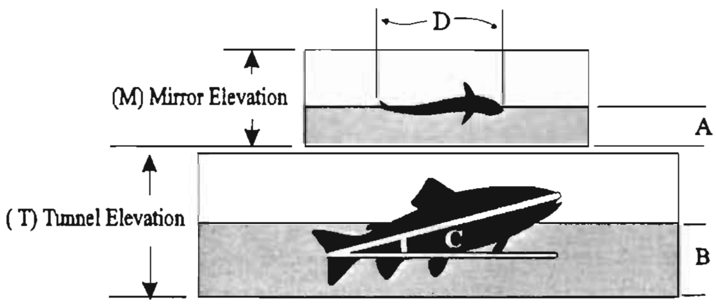
Conversion Factor: ________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes

(converth.cdr)

SIACS LENGTH CONVERSION WORKSHEET

(For HORIZONTAL systems only)



Location: ________________

Date: ________________

Measured by: ____________

Converted by: ____________

Mirror Elevation: __________

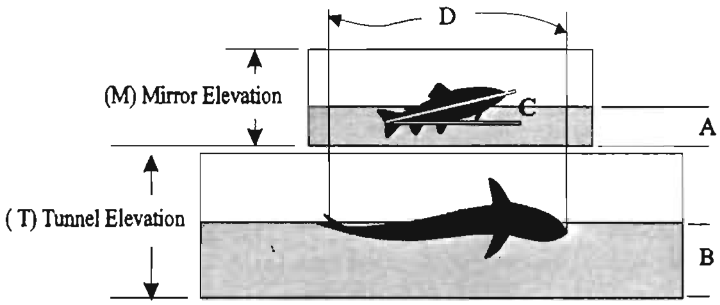
Tunnel Elevation: __________

Conversion Factor: _________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes

(converth.cdr)

SIACS LENGTH CONVERSION WORKSHEET
(For VERTICAL systems only)



Location: ______________

Date: ______________

Measured by: ______________

Converted by: ______________

Mirror Elevation: ______________

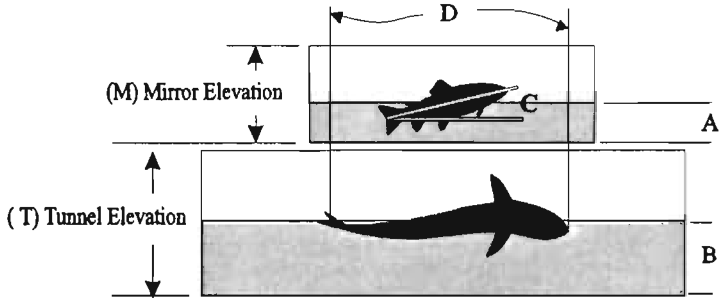
Tunnel Elevation: ______________

Conversion Factor: ______________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes

SIACS LENGTH CONVERSION WORKSHEET

(For VERTICAL systems only)



Location: ______________

Date: ______________

Measured by: ______________

Converted by: ______________

Mirror Elevation: __________

Tunnel Elevation: __________

Conversion Factor: __________

Fish Time or Number	A Mirror Height	B Tunnel Height	C Body Angle (Degrees)	D On-Screen Apparent Length	E Corrected Length	Notes

(convertv.cdr)

APPENDIX III

TROUBLE SHOOTING GUIDE

The following is a brief outline of some of the more common problems and their solutions. Once a potential solution has been identified, use the index of the Field Manual to find the appropriate reference to instructions on proper procedure.

MONITOR AND ELECTRICAL INTERFERENCE

1. Picture on monitor has "snow" in it.
    a. poor connections
    b. interference from external source, eg. generator,
2. Picture on monitor has herring bone pattern.
    a. interference from external radio signals
3. Picture on monitor has many of dark horizontal stripes.
    a. interference from external source such as Loran C transmitter
4. No picture on the monitor
    a. 110 V power not on
    b. BNC connector not connected or improperly connected
    c. check all fibre optic connectors
    d. electrical or fibre optic cable damaged
    e. check all connections in line between camera and monitor
    f. GFI (Ground Fault Interrupt) switch at distribution box needs to be reset
    g. Camera not transmitting video signal

BUBBLES IN TUNNEL

5. Many dark bubbles swirling in upstream half of tunnel
    a. water too shallow, ie. top of tunnel too close to surface for current flow
6. Large bubbles slowly moving along the top of the tunnel
    a. downstream end of tunnel is not sufficiently higher than upstream end
        Solution: Either reorient tunnel or drill a series of holes along top rear of tunnel to allow bubbles to escape.

MOISTURE OR WATER IN CAMERA CASE

7. Moisture alarm is ringing.
   a. immediately turn off all power to system
   b. block tunnel to prevent fish migration
   c. check camera housing for improper O-ring seal or broken lens
   d. check transparent divider in camera case
   e. water leaking through wiring insulation to camera case

   Note:- do not allow power cables to go into water as water may feed up into the ends of the cables and later find its way into the camera case.
8. Camera flooding
   a. remove camera and open case; place in sun to dry; send for check/repairs
   b. determine cause of flooding, fix, and replace camera with spare. Check for
      - defective o-ring
      - defective o-ring seal
      - defective wire connector
      - leaking "through case wire or fibre-optic connector" (tighten if necessary)

   Note:- do not allow power cables to go into water as water may feed up into the ends of the cables and later find its way into the camera case.
9. Foggy camera lens
   a. moisture has condensed on the camera lens
   b. check interior of camera case for condensation
   c. if too much moisture in camera replace or dry the desiccant (according to instructions)
10. Reset alarm system after problem is corrected
   a. add fresh, dry salt to moisture detector
   b. cut off exposed and corroded tips of wire, clean new tips,
   c. test detector by touching wire together (alarm should sound)
   d. insert wires into detector and reseat detector at bottom rear of case

DIRTY OPTICAL SURFACES

11. Build-up of algae in light path
   a. clean sloping mirror on camera case mirror and main mirror
   b. increase frequency of cleaning tunnel surfaces during warm water conditions
12. Dirty water in (un-sealed) enclosure, clean water outside
   a. remove side panels and scrub inner walls of enclosure
   b. flush out enclosure and replace side panels
13. In case of sealed enclosure, clean all surfaces and change water with antialgal agent

VERY POOR CONTRAST

14. Because of dirty water
   a. increase light output by increasing voltage to bulb(s)
   b. replace bulb(s) with double or quadruple the light output bulb(s)
   c. revert to VCR monitoring with manual counts (semi-automatic monitoring)
   d. close tunnel until turbidity reduces to acceptable level

e. if possible use a sealed enclosure for counting fish in rivers with frequent dirty water problems.

15.Because of dirty or poor quality retro-reflective material

a. replace retro-reflective material on the rear and bottom surfaces of tunnel

16. Because of build-up of algae in sealed enclosure

a. drain water from sealed enclosure (a pump may be necessary)

b. scrub and hose down all internal surfaces, being careful not to scratch optical surfaces on light boxes, mirrors or tunnels.

c. refill enclosure with water treated with algaecide

17. Because of build-up of algae or other material in the water filled chamber of the camera case

a. drain water from chamber by removing the two filler plugs

b. wash out chamber with warm soapy water

c. rinse out chamber with plenty of clean water

d. refill chamber with clean, chlorine treated water

(Note: System boyancy changes with these steps; secure system against movement in current.)

LIGHTING

18. Light too bright in centre of image

a. light box too high above the mirror

b. refocus light

19. Light too dark in upper and lower corners

a. refocus light

20. Mirrored image is too dark in comparison with tunnel

a. check and clean main mirror and inside and outside of top of tunnel

b. refocus light

c. revert to single window counting using the side view (bottom) of tunnel only

21. Sunlight getting into system

a. set up sun shades over tunnel opening causing problem

b. if sun is very low on horizon when problem occurs, place a piece or board or other opaque material some distance upstream (or downstream) of tunnel opening so that opening of tunnel is shaded from sun while at the same time fish migration is not impeded

COUNT ACCURACY IS UNACCEPTABLY POOR (ST200 Program)

22. Threshold

a. check that threshold level is 70 or more

b. if threshold less than 75, determine cause and correct problem

c. review section in field manual on "Factors affecting threshold level"

23. Check the gate width and adjust if necessary (it should equal to about 20-30% of the length of the tunnel.

24. Multiple fish passing through tunnel
    a. check to determine if more than three fish are passing through tunnel at a time
    b. check to determine if fish are following too close behind or side by side
    (if fish images touch each other, errors in measuring and counting may occur)
25. Apparent presence of many fish of very small size
    a. reduce detectable minimum fish size setting in the ST200 program.
26. Counts when no fish are present
    a. most likely related to computer loosing synchronization with camera
    (check and ensure see that the camera's sync button is set to internal synchronization)
    b. possible problem with OC300 image board; have board checked

INACCURATE MEASUREMENTS - *SEMI-AUTOMATIC* MONITORING

27. Estimated size is inaccurate
    a. check calibration of monitor
    b. camera may have been jarred closer or further away from the tunnel since the last time the system was calibrated; if so, recalibrate tunnel

INACCURATE MEASUREMENTS - *AUTOMATIC* MONITORING

28. Generally inaccurate length measurements
    a. over and underestimates can occur when the threshold is improperly set; see instructions on setting threshold
29. overestimates of length when multiple fish in tunnel
    a. decrease the millimetres per pixel scale factor in the ST200 program
    b. fish images touch each other as they pass through tunnel and ST200 software interprets several fish to be one. This is normal for ST200 software. Take field action to minimize occurrences of more than one fish in tunnel, for example:
        i. ensure good water flow through tunnel
        ii. place a white light upstream of tunnel during darkness
30. underestimates of length
    a. increase the millimetres per pixel scale factor in the ST200 program

INACCURATE RECORDER ACTIVATION - *SEMI-AUTOMATIC* MONITORING

31. Fish are not detected as they swim through tunnel
    a. increase sensitivity of motion detector, or
    b. change size of sensitive area scanned by motion detector
32. False positive activation of motion detector
    a. small fish present inside enclosure; remove fish
    b. check for a hole though which the fish might have entered

ST200 PROGRAM

Refer to the ST200 Users Guide for details on proper operation of this program. Some problems not covered in this Guide follow:

33. False positive counts
    a. resulting from loss of synchronization of camera with OC300 image board
        i. ensure synchronization switch on camera is set to *internal*
    b. see trouble shooting guide on *Count accuracy*
34. False negative counts
    a. see trouble shooting guide on *Count accuracy*
    b. replace image board with properly working board and have suspect board checked in the laboratory
    c. ensure that edges of tracking window do not overlap dark ends of tunnel image

PRINTING

35. Report will not print
    a. ensure that printer is plugged in, connected to computer, has paper, and is properly working
    b. check computer and printer manual for trouble shooting
36. Faded print
    a. check and replace ribbon or ink cartridge

COPYING FILES

37. Disk error is reported
    a. ensure use of a formatted disk
    b. check manual for DOS (disk operating system)

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