Towed Bodies for Echo Sounding from Boats

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ABSTRACT

Enzenhofer, H.J. and G. Cronkite. 2003. Towed bodies for echo sounding from boats. Can. Tech. Rep. Fish. Aquat. Sci. 2467: 12p.

We have designed towed bodies that house acoustic transducers deployed from boats to survey fish abundance in rivers and large water bodies. This report describes the construction, dimensions and deployment of a single transducer towed body and a multiple instrument towed body that can be used during acoustic surveys. Both units have powder coated aluminium construction, are easily adjusted so that they track with stable pitch, roll and compass bearing and are towed alongside a boat at a depth of 0.5 – 1.0 meter below the water surface. The multiple-instrument towed body can house other water sampling instrumentation in addition to the transducer, for profiling water bodies. Attachment of an underwater position sensor displaying pitch, roll and compass bearing, confirmed that the multiple-instrument towed body produced a stable working platform for a split-beam transducer used on the Fraser River at Mission, British Columbia, Canada. Data produced by the position sensor indicated that the towed body became unstable when the boat made sharp turns but quickly recovered once the boat was on course. In addition, we also describe a winch and boom system that can be attached to the vessel for deploying both towed bodies.

RÉSUMÉ

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Nous avons conçu des poissons remorqués logeant des transducteurs qui peuvent être mouillés d'un bateau pour faire des relevés de l'abondance du poisson dans les rivières et les grands plans d'eau. Sont décrits dans le présent rapport la construction, les dimensions et le mouillage d'un poisson remorqué logeant un seul transducteur et un autre logeant plusieurs instruments, qui peuvent être utilisés pour faire des relevés acoustiques. Les deux unités, faites en aluminium enduit de poudres, sont faciles à ajuster de sorte à ce qu'ils peuvent suivre dans des conditions stables de tangage, de roulis et de cap lorsque remorquées le long du bord d'un bateau à une profondeur de 0,5 à 1,0 mètre. Le poisson à plusieurs instruments peut aussi loger d'autres instruments d'échantillonnage de l'eau en vue d'établir des profils de plan d'eau. Un capteur de position indiquant le tangage, le roulis et le cap fixé au poisson à instruments multiples a permis de confirmer que celui-ci constitue une plate-forme de travail stable pour un transducteur à faisceau partagé utilisé sur le fleuve Fraser à Mission, en Colombie-Britannique, au Canada. Les données fournies par le capteur de position ont révélé que le poisson remorqué est devenu instable lorsque le bateau a fait des virages serrés, mais qu'il a rapidement récupéré une fois le bateau sur la bonne trajectoire. Sont aussi décrits un treuil et une flèche qui peuvent être fixés au bateau pour mettre les deux engins à l'eau.

INTRODUCTION

Assessment of fish populations and the vertical and horizontal profiling of water bodies often require hydroacoustic systems or sampling instrumentation deployed from boats. Generally the instrument or acoustic transducer is towed alongside a moving vessel approximately 0.5 - 1.0 m below the water surface in a downward-looking configuration. Movement of the boat may impact the sampling instruments by introducing vibration noise or produce inaccurate measurements of depth or acoustic target strength when a transducer is not in a proper orientation. We designed two towed bodies to overcome these problems, one that houses a single transducer and a second that can house a multiple instrument package. The towed bodies are designed to track with stable pitch, roll and bearing, with minimal effect from the boat motion.

This report describes the construction, dimensions and method of deployment for each towed body. The Department of Fisheries and Oceans (DFO) is using the single transducer towed body for performing hydroacoustic estimates of juvenile sockeye salmon (*Oncorhynchus nerka*) in nursery lakes of the Fraser River system in British Columbia, Canada. The multiple instrument-towed body is presently used on the Fraser River at Mission, under a joint program between the Pacific Salmon Commission (PSC) and DFO to assess upstream migrating adult salmon. We also include a suggested boom and winch system for deploying the towed body that can be attached to the vessel. Both towed bodies include a protective fairing for the attached instrumentation, which does not hinder instrument function or accuracy.

In addition, we include a section that evaluates the performance of the multiple instrument towed body by using an underwater instrumentation package which tracks the pitch, roll and compass bearing of the sensor and downloads the data to a computer in real time. We felt that it was important to assess the unit in adverse conditions such as heavy current flow or rough water as these conditions exist in the Fraser River. Manufacturers of commercial towed bodies state that their products are stable, but do not present measurements of performance in their sales literature.

SINGLE TRANSDUCER TOWED BODY

CONSTRUCTION

The single transducer towed body is glider shaped with three stabilising fins and is constructed of aluminium, which is powder coated to provide corrosion protection (Fig. 1). The unit has a lead balance weight encased in the front section that can be accessed by removing the bolt which secures the polyethylene nose cap. A cable attachment bracket is welded to the top of the towed body and has an adjustable connecting eye with a 16mm hole for attaching a cable and thimble (Fig. 2) at various balance point positions. The towed body has an overall length of 105 cm and a dry weight of 14kg without a transducer.

The main body is constructed of two lengths of 75 x 75 x 6mm thick square tubing welded to a central chamber that houses the transducer. Shown in Fig. 1 is a transducer mounting plate (165 x 165 x 6mm) that bolts to the inner ventral surface of the central chamber.

Access holes, one in the main body (7.7 x 6.0 cm) and one on either side of the housing chamber (6.0 cm diameter) are provided for routing cables to either a single beam, dual beam, or split beam transducer. The stabilising fins (6mm-thick aluminium plate) are welded to the top rear section of the main body for a total wingspan of 48.3 cm. Two skid plates (6mm thick) are welded to the bottom of the housing chamber and angled outwards 20°. The skid plates protect the face of the transducer when the towed body is not in use and assist in maintaining a straight course during operation.

DEPLOYMENT

The towed body is towed alongside the boat 0.5 to 1.0m below the water surface and orients the downward looking transducer so that the axis of the acoustic beam is perpendicular to the water's surface. Adjustment to correct a nose up or nose down attitude is made by selecting the appropriate tow-cable position on the cable adjustment bracket. For example, if the towed body appears to dive nose down, the cable can be attached to a bolt-hole closer to the nose section until a flat trajectory is attained.

The transducer is passed up through the bottom opening of the towed body and bolted to the top of the housing chamber with stainless steel bolts. The design shown in Fig. 1 is for transducers that have the transducer cable connected to the side of the transducer case. Transducers having cable connections on the top require an access hole (large enough for the transducer cable end) to be drilled in the centre of the transducer mounting plate and the corresponding section of the cable attachment bracket removed to allow space to route the cable. This type of modification is similar to the design of the multiple-instrument towed body (Fig. 3), which also has a section removed for connecting a transducer cable to a top mounting transducer.

PERFORMANCE

Currently DFO uses two single transducer towed bodies from a survey vessel to collect acoustic data to estimate juvenile sockeye salmon densities in nursery lakes of the Fraser River watershed (Burczynski and Johnson 1986). One towed body houses a 420 kHz dual beam transducer driven by a Biosonics Model 105 sounder (Biosonics 1985) and the second towed body, mounted on the opposite side of the boat, houses a Biosonics 200 kHz split-beam transducer. Both acoustic systems collect 20LogR echo integration data and 40LogR target strength data of surveyed fish (Maclennan and Simmonds 1992). Parallel data sets are collected for comparative purposes, as the older dual beam system will eventually be phased out.

The towed bodies are deployed from booms similar to that shown in Fig. 4 with tow speeds in the range of 0.6-1.5 $msec^{-1}$. The slower tow speed occurs when operating a closing trawl system (Enzenhofer and Hume 1989) to obtain biological samples of the surveyed fish. The operators gauge the trawl duration to avoid excessive catch of fish by observing the echogram produced by the acoustic system. Since lakes generally have clear visibility, especially within a meter from the surface, the performance of the towed body can be assessed visually. Visual observations showed that the towed body remains stable while under tow even during the slower net sampling speed. The only difference observed between the slower and faster tow speeds is that the towed body planes slightly deeper in the water at slower speed.

Drastic changes in pitch and roll occurred when the boat made sharp turns and these changes meant that the acoustic data were unreliable during the turns at the ends of the transects. The towed body quickly recovers once the boat is on a steady course.

MULTIPLE INSTRUMENT TOWED BODY

CONSTRUCTION

The multiple instrument towed body is torpedo shaped with four stabilising fins and is constructed of powder coated aluminium (Fig. 5). Similar to the single transducer towed body, there is a lead weight encased in the nose section (Fig. 3) and a multiple-position tow cable attachment bracket. The overall length is 130.5 cm and its weight in air is 24 kg without instruments.

The main body is constructed of two pieces of 100 x 100 x 6mm thick square tubing welded to a central chamber. The central chamber has an instrument-mounting bracket that consists of two half round brackets cut from 11.4 cm diameter pipe welded to a mounting plate. Cylindrical instruments can be secured to this mounting plate with stainless steel hose clamps. A channel bracket (Fig. 5) with inside dimension of 11x 12.6 cm is illustrated and can be used for mounting instruments that have their own base plates.

DEPLOYMENT

Adjustment of the operating orientation of the multiple instrument-towed body is identical to that detailed in deployment section for the single transducer towed body. The multiple instrument unit is somewhat larger and heavier, making it cumbersome to launch or retrieve and the use of a winch and boom system should be considered (Fig. 4).

PERFORMANCE

We measured the performance of the multiple instrument-towed body on the Fraser River at Mission, B.C. The Pacific Salmon Commission uses this site to enumerate adult Pacific salmon returning to spawn. The river is approximately 400 m wide at this location and requires the use of a moving vessel performing cross-river transects to conduct the acoustic survey. The river current speed is approximately 0.6 to 1.0 $msec^{-1}$ and fluctuates depending on water levels and tidal stage.

Acoustic data were collected using an HTI Model 243 digital split-beam system (HTI 1998) with a towed body mounted 200kHz transducer towed alongside a boat travelling 1.4 $msec^{-1}$. The split-beam system measures the three-dimensional position of a target in the acoustic beam as a function of time (Traynor and Ehrenberg 1990) thus allowing an estimate of fish movement and flux (Ehrenberg and Torkelson 1996). When deployed on a moving platform, the echo co-ordinates must be corrected for the relative motion of the transducer in order to determine the true trajectory of a fish. The true fish trajectory is used in conjunction with a flux model to estimate the total abundance moving past the transect site (Xie 2000). The transducer motion data are recorded by an underwater position sensor (Jasco 1995) mounted in the central chamber of the towed body (Fig. 5). This sensor records the pitch, roll and compass bearing, which it sends via an electronic interface to a host system at a data flow rate of up to twice per second.

The orientation of the towed body during acoustic data collection periods is shown in Fig. 6. In each plot the X-axis displays the acoustic ping number, which is equivalent to time, collected at a pulse repetition rate of 30 pings per second. The Y-axis displays data output from the position sensor at a rate of once per second, time synched and recorded to the same computer collecting the acoustic data. At Mission, acoustic data are collected continuously, with one-way transects taking approximately 5 minutes. A two minute section of one crossing shown in Fig. 6(a, b, and d) displays the pitch, roll, and compass bearing respectively. The pitch shown in Fig. 6(a) is the up/down aspect of the towed body's nose relative to the water surface. In this case the towed body shows gradual undulations from 0° to –1° except for the beginning of the transect when the recorded pitch exceeded –2°. The larger pitch reading behaviour resulted when the vessel made a sharp turn at the end of a transect or when avoiding debris during a crossing. This is also shown in Fig. 6(c) for the compass bearing during three crossings of the river. The first crossing occurred at a course of approximately 320° ending approximately at ping number 7000. We noted that the bearing also reflects the actual course of the vessel as the towed body travels parallel to the boat. At the end of the transect a drastic change in bearing is observed during the vessel's turn, but quickly recovers once the vessel is on course for the next crossing in the opposite direction. A sudden change in compass bearing is seen during the third crossing approximately at ping number 20,000. This sudden bearing change could occur if the boat veered of course to avoid debris. The variation in compass bearing would also be affected by the boat operator's skill in maintaining a fixed-bearing during the crossing. Variation in motion was detected in the towed body but overall it was slow and predictable, allowing for corrections to be made so that targets can be tracked. Fig. 6(b) displays the roll, which is the side-to-side orientation of the towed body relative to the water's surface and Fig. 6(d) displays the compass bearing relative to magnetic north.

DEPLOYMENT BOOM AND WINCH

Shown in Fig. 4 is a suggested combination winch and boom mounted to a boat for deploying a towed body. We also illustrate a fin holster to store the towed body with the attached instruments. The holster is simply a rectangular frame with inside dimensions to fit the outside dimensions of the central chamber of either towed body (Fig. 1 & 5). Square notches are cut from either end of the holster to cradle the nose and tail sections of the towed body. The opening size for the notches are 100 x 100mm for the multiple instrument towed body and 75 x 75mm for the single transducer towed body.

The boom is constructed of two lengths of 3 inch diameter aluminium pipe (Schedule 80) welded at right angles to each other. The water end of the horizontal pipe is flattened to allow a 3-inch pulley to be mounted. This type of installation allows the winch cable to operate freely as well as keeping the cable from flipping off the pulley. The vertical section of the boom has an 8-inch standard flange welded to the bottom and is used as a turntable and locking mechanism. The entire boom and winch assembly is installed by sliding it over the top of an upright stanchion that has a base plate with bolt holes that correspond to the 8-inch flange that is attached to the boat gunnel. The boom can be pivoted on the base plate and stanchion and then locked into position with the lock pin.

A two-way trailer winch is mounted to the boom and provides a controlled launch or retrieval of the towed body even if the boat is moving. We used a mechanical gear driven winch because they are relatively inexpensive and easy to operate. This winch could be replaced with a remote controlled electric winch to automate the deployment, however this would require access to a 12V-battery system.

CONCLUSION

We believe that both the single transducer towed body and the multiple instrument towed body provide a stable working platform to deploy acoustic transducers and sampling instrumentation from boats. When operating in clear water bodies the single transducer towed body provides a simple and relatively inexpensive method to collect acoustic data. When visibility is a concern the multiple instrument towed body can be used as it provides room to house other instrumentation. For example, an underwater position sensor capable of displaying the orientation of the towed body will give the operator a measure of the towed body's operation and stability. Whichever unit is selected, both are simple in design and easy to adjust in field.

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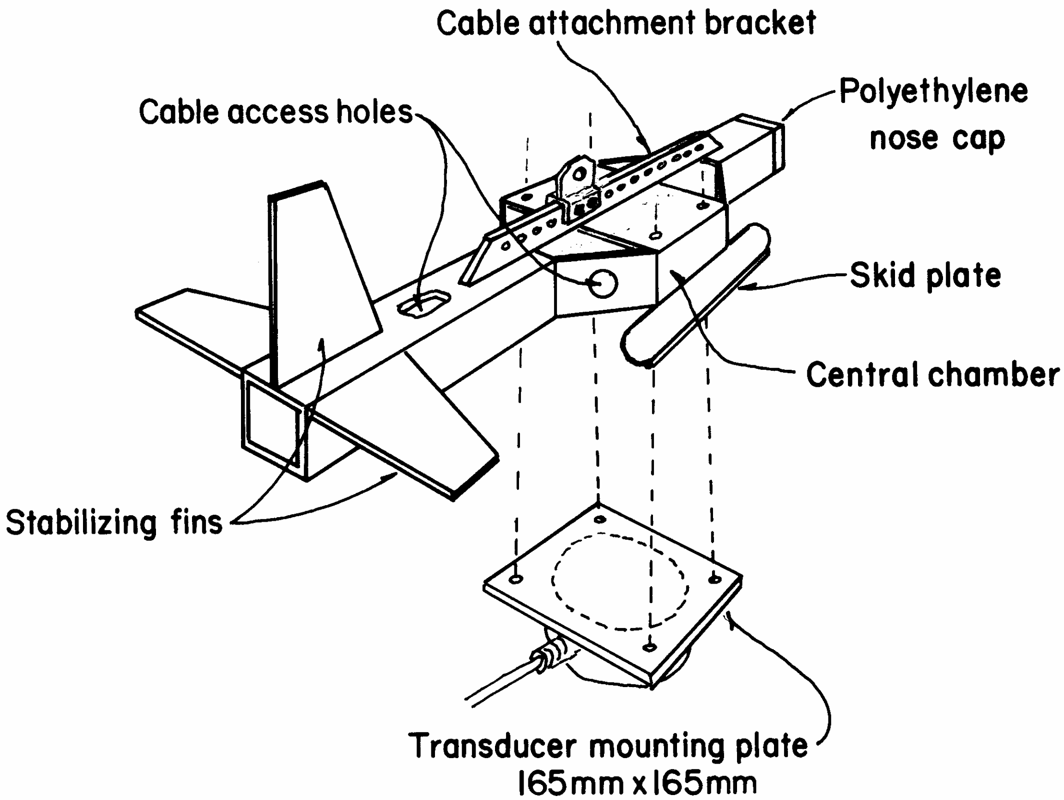

Fig.1. Three-dimensional view of the single transducer towed body, showing a transducer mounting plate that bolts up into the central chamber.

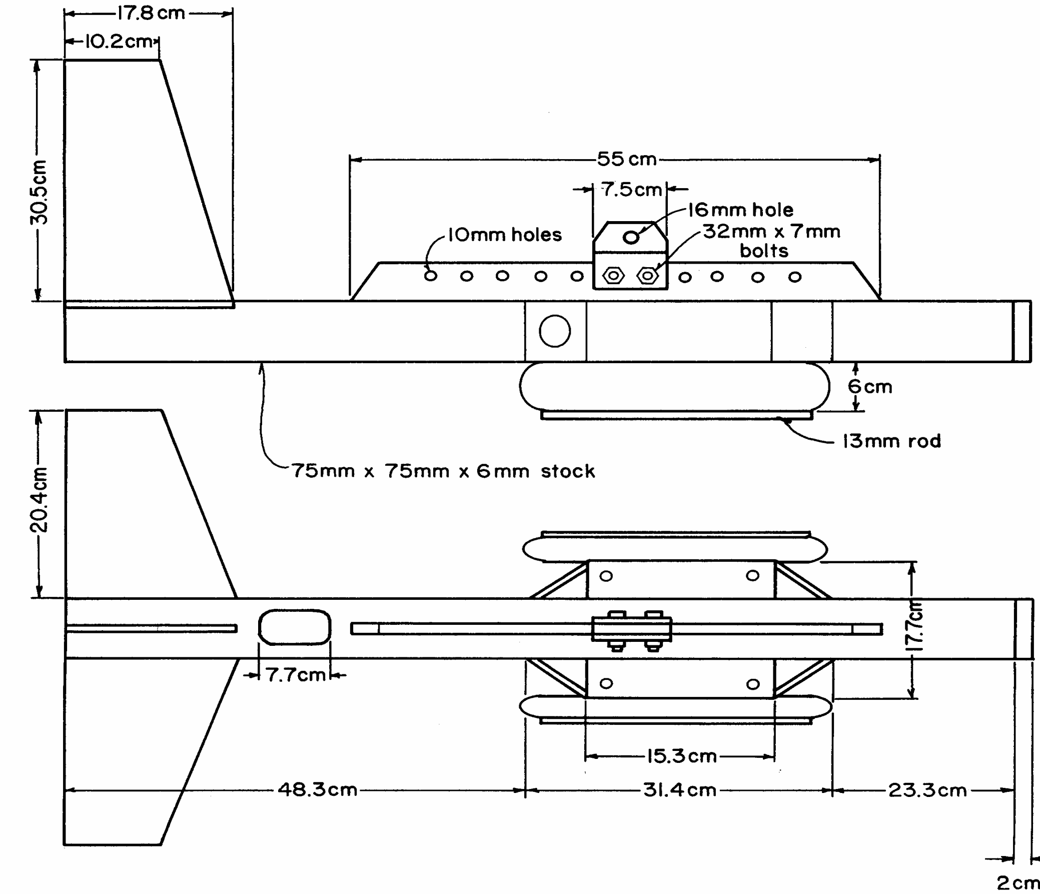

Fig. 2. Schematic of the single transducer towed body showing dimensions. The top diagram is a side view with the adjustable cable attachment bracket and adjustable connecting eye for attaching a cable thimble. The bottom diagram is a top view of the towed body.

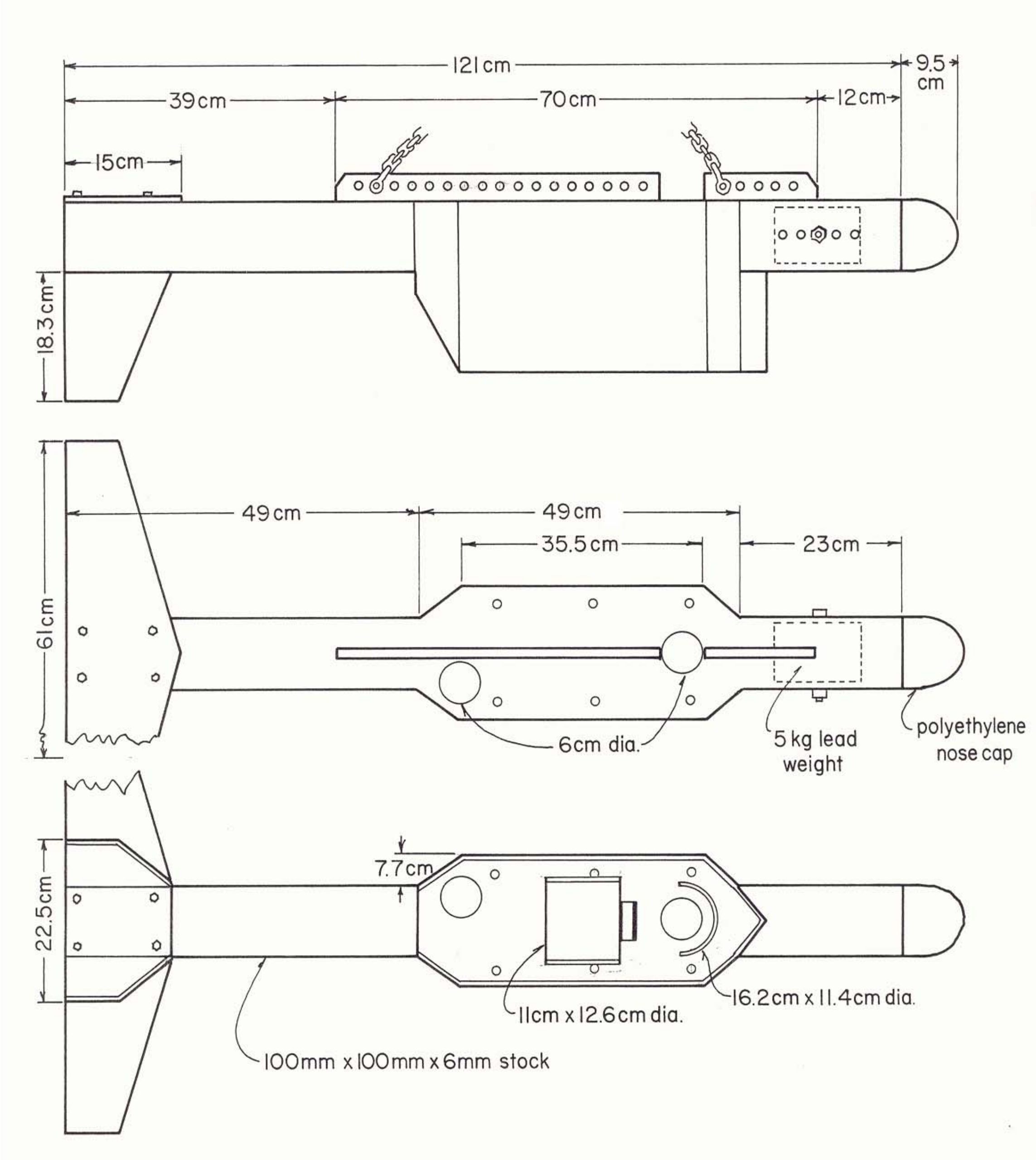

Fig. 3. Schematic of the multiple-instrument towed body showing dimensions for construction. The top figure is a side view showing the adjustable cable points. The middle figure is a top view with cable access holes and location of the lead weights encased in the front section visible. The lower figure is the bottom view with an attached instrument-mounting bracket visible. Note that the cable attachment bracket has a section removed to allow access for connecting a transducer cable to the transducer.

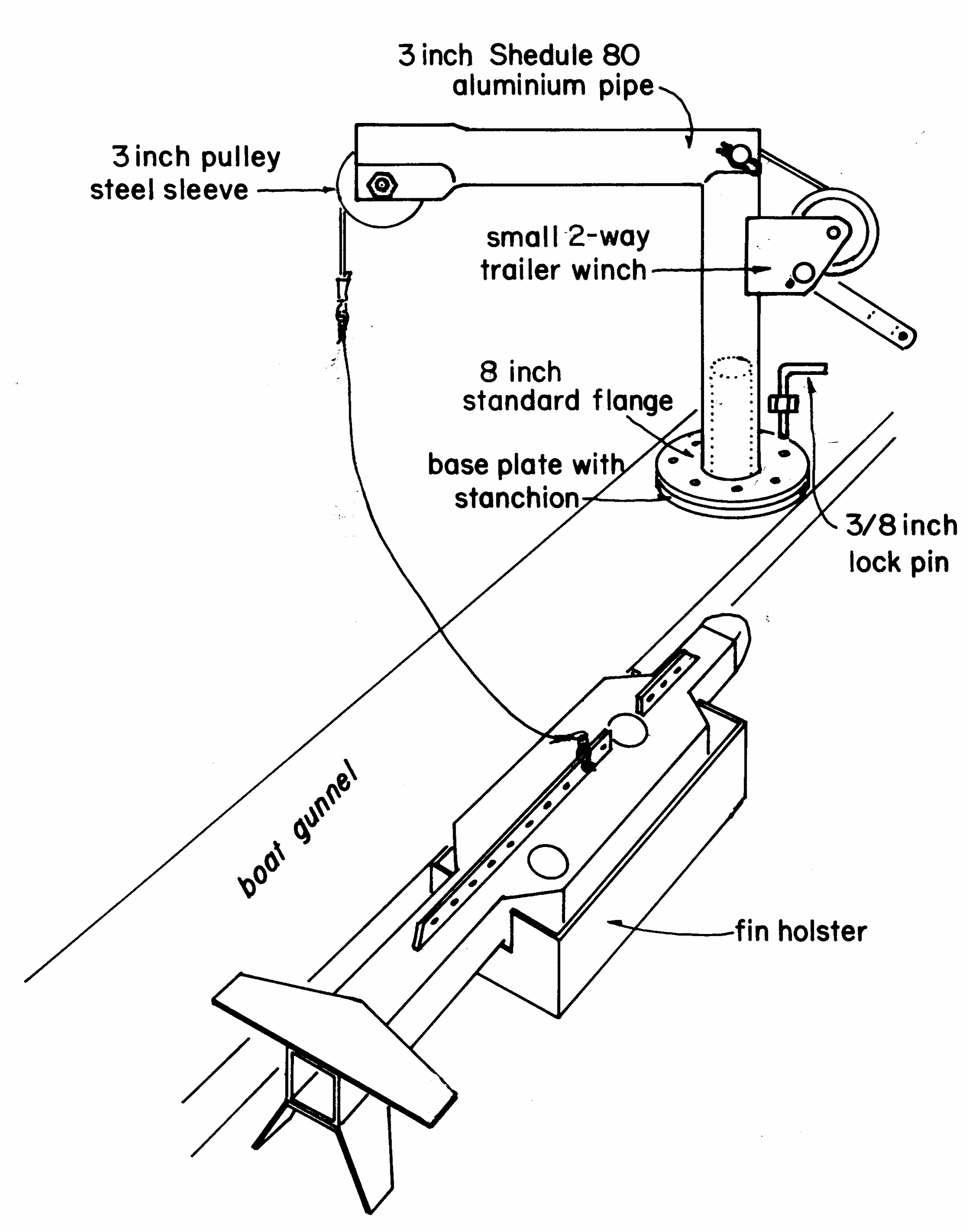

Fig. 4. Three-dimensional view of a boom and winch system for deploying a towed body from the side of a boat. A fin holster is illustrated for storing the towed body when not in use.

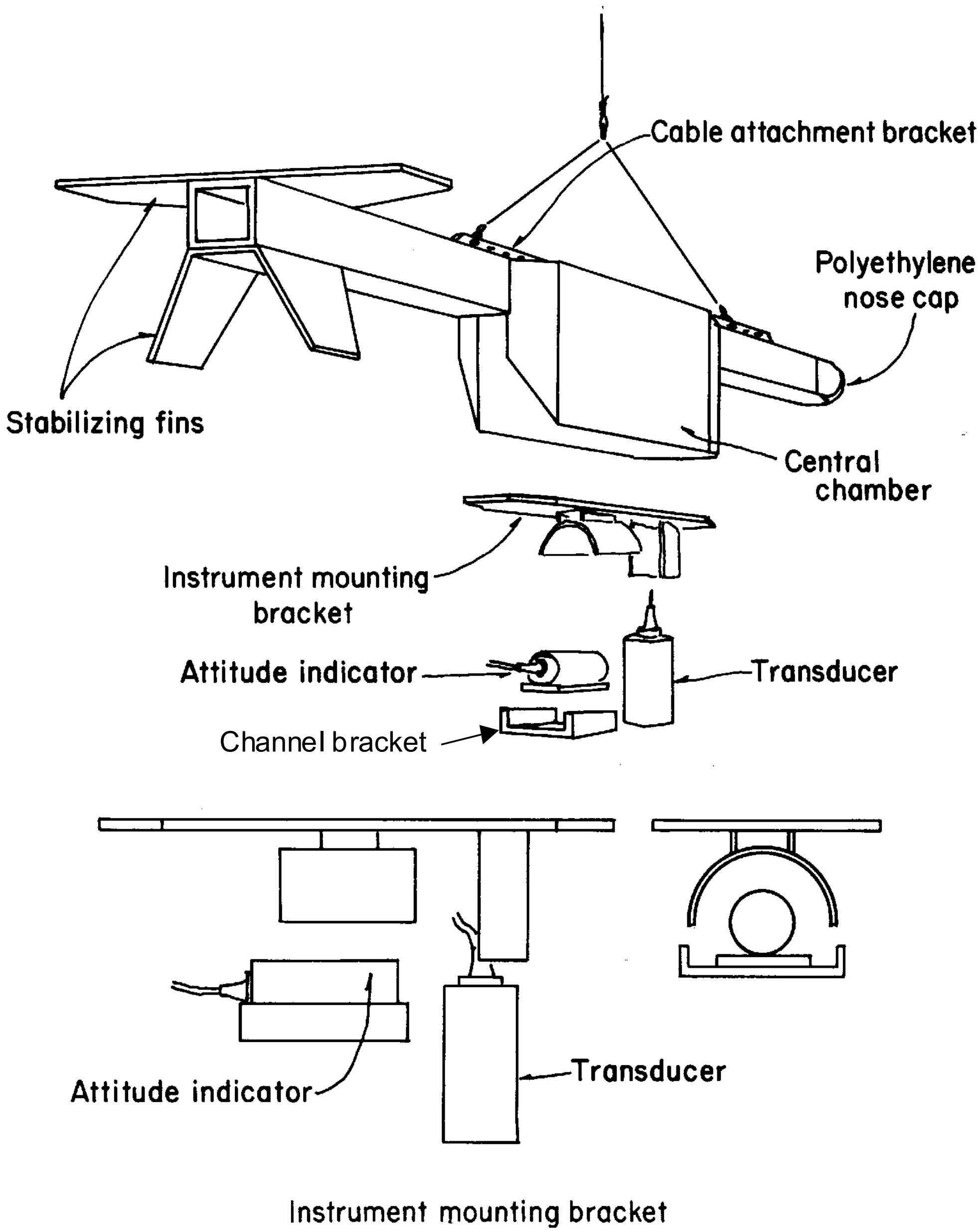

Fig. 5. The upper diagram is a three-dimensional view of the multiple-instrument towed body suspended by a cable to the cable attachment bracket. An attitude indicator and transducer that mounts to the instrument mounting bracket are shown. Underneath the attitude indicator a channel bracket is shown for mounting instrumentation that comes with base plates. The bottom figure is an expanded view of the instrument-mounting bracket. All instrumentation is held in place with stainless steel hose clamps (not shown).

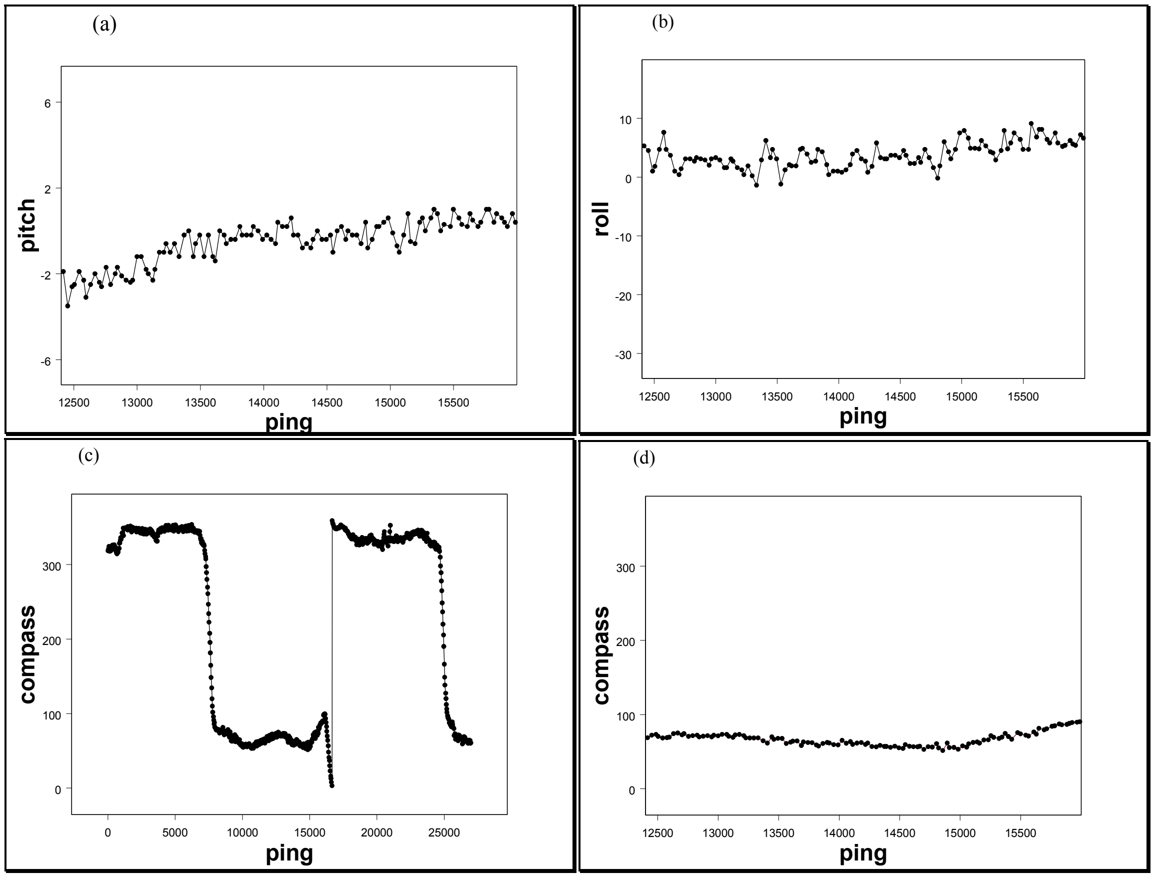

Fig. 6. Orientation of the multiple-instrument towed body as displayed by an underwater position sensor during cross-river acoustic data collection on the Fraser River. In each plot the X-axis displays the acoustic ping number and the Y-axis displays orientation of the sensor in degrees. (a), (b) and (d) display pitch, roll and compass bearing respectively for a two-minute section of the same river transect. The compass bearing for three cross-river transects is shown in (c).