TUGOS UTILIZATION AND SELECTIVE GEAR DEVELOPMENT

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Duration: January 1, 1988 to March 31, 1990

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I. EXECUTIVE SUMMARY:

This report describes the work accomplished by the Center for Fisheries Engineering Research in an S-K sponsored project to complete the development of TUGOS into an operational system and utilize it through cooperative selective gear development efforts within the northeast region. Some background for the project is included and the specific objectives of the project are described. The approach used to meet the project objectives are presented along with the specific project accomplishments towards those objectives.

The description the final TUGOS system is included as well as a description of the gear observation experience to date and its use in regional selective gear development projects.

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II. PURPOSE OF PROJECT:

II. A. Description of Problem:

By the end of 1987 a project funded by the Saltonstall-Kennedy Fisheries Development Program was completed. Entitled "A Regional Towed Gear Observation System," it resulted in the development of a compact system for the in-situ observation of fishing gear and the study of fish behavior as it relates to the selectivity of gear. It is described in full in references 1 and 2.

Called the Towed Underwater Gear Observation System (TUGOS), the system combined proven underwater components. The hydrodynamic enclosure was based on an ENDECO V-fin that was reconfigured during its molding process to accomodate the TUGOS pressure housing. Controllable trim tabs were added to the trailing edge of the V-fin to provide pitch and roll control. A fixed, buoyant rudder provides directional stability.

The main pressure housing for TUGOS in an elongated version of a MiniROVER housing and is rated and tested to 1000 feet. The cylindrical portion is 25" long and is fitted with mounting tabs, anode mounts, cable penetrations, and a recess in the underside to accomodate a Mesotech transducer.

Within the main pressure housing the two fore and aft camera pan and tilt units are separated by the vehicle power supply/control system bay, the multiplexer/sensor bay, and the transducer/cabling bay. These electronic sub-assemblies slide in both ends of the housing.

Below the V-fin and pressure housing is a skid assembly. The skid performs several functions including protection of the viewing domes, holding lead ballast, and supporting fore and aft domed flood lights for illuminated viewing. The TUGOS vehicle is shown in Figure 1.

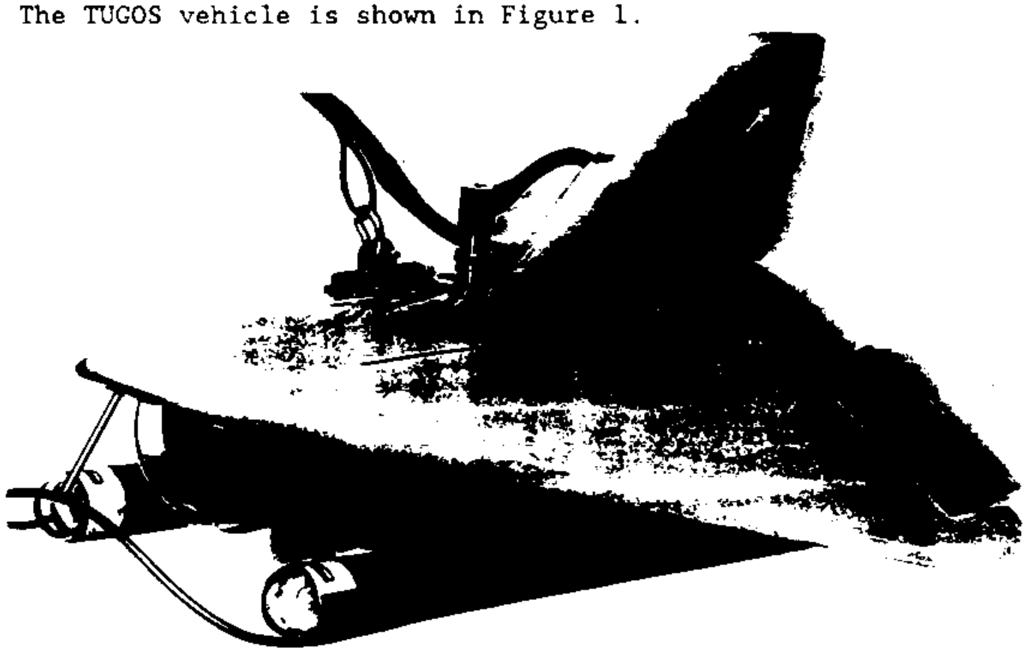

Figure 1. The TUGOS vehicle.

The TUGOS control console operates off 120V A.C. from a portable generator or ship's power, if available. The console provides power to the vehicle through the tow cable. It takes operator signals from the hand box, encodes them in a data stream, and sends them to the vehicle. The console also receives multiplexed sensor information from the vehicle, decodes it, and through a video graphics overlay, displays them to the operator. Power monitoring and leak detection equipment are located in the console. Switches on the front of the console control the vehicle lights, graphics overlay, depth reset, and main power. The vehicle, the control console, and the operator's handbox are pictured in Figure 2.

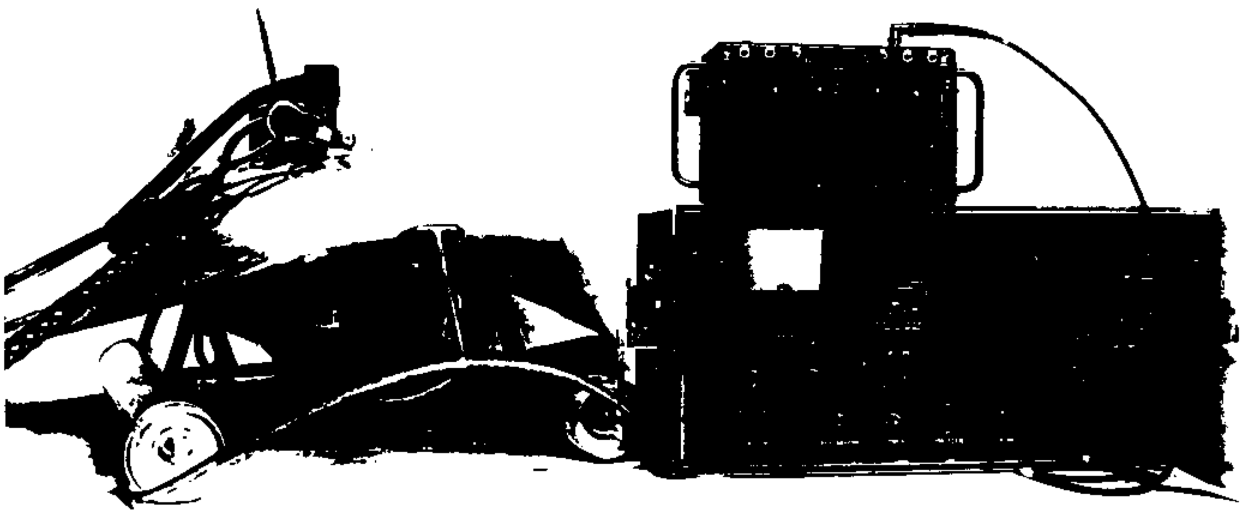

Figure 2. A front view of the TUGOS vehicle with console and handbox.

The power block is connected directly to a heavy-duty storage battery. Rotation of the sheave is controlled by the polarity of the two leads. A system of automotive solenoids located in the battery carying case is used to effect the high-amperage switching using a remote single-pole-double-throw toggle switch. The portable generator has a 12V charging connection to keep the battery topped off during a deployment.

This cable handling system proved to be very effective and relatively effortless. The block was found to have plenty of power for vehicle retrieval. By properly flaking the cable on deck, cable pay-out could be unattended. During haul-in of more than 10 feet, the incoming cable must be arranged on deck to prevent tangles.

The TUGOS monitor is an 8" portable unit that can be operated from its own internal batteries. The VCR can also be operated without external power. Both units, however, are normally run off 120V A.C. The TUGOS generator is a 1600 watt gasoline powered unit that has proven easy starting and dependable. There is ample capacity to power additional components as they are added later. The entire TUGOS system is diagramed in Figure 3.

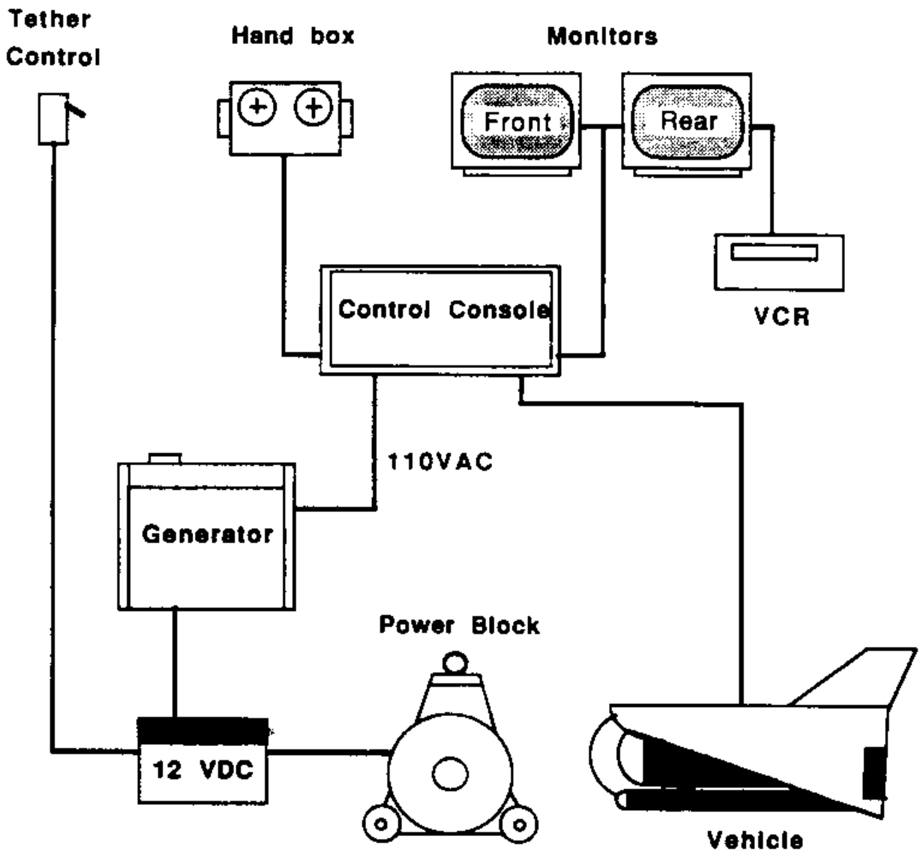

Figure 3. Major components of the TUGOS system.

During the initial trials the lateral controlability of the vehicle was judged insufficient. The sideways movement of the vehicle was intended to be accomplished by the differential actuation of the two ailerons. The resulting roll would then direct the depressing force of the V-fin outwards, and cause the vehicle to move to that side. Unfortunately, this control response was ambiguous, depending on the location and depth of the vehicle.

Another drawback of the initial system was the type of control used on the actuators. This system was a direct adaptation of the rate-control architecture used on the MiniROVER. The actuators move with a speed proportional to the position of the control joystick. This is inconvienient as it does not provide a sense of the angle of the control surfaces, making piloting difficult.

Another problem was the difficulty of piloting the vehicle when the rear camera was selected. The original tether had only one video coax and the operator had to choose between either the fore or aft camera. When viewing through the rear camera piloting was difficult. It was similar to driving a car in reverse, but without a rear-view mirror. The pilot needs the view from the front camera for control and safety purposes, even if the scene of interest is to the rear of the vehicle.

In spite of few unresolved problems, the initial project established a regional capability for at-sea observation of fishing gear. Previously, the Northeast region has had no effective means of observing harvesting gear in commercial use, consequently there had been little serious research on gear development. With TUGOS a variety of industry and management inspired efforts were now possible.

The need to improve the TUGOS system coupled with the importance of supporting the deployment of the system within the region prompted the initiation of a follow-on project. With the support the Saltonstall-Kennedy Fisheries Development Program a project to correct the deficiencies of the initial system was begun. In addition, mechanisms for the logistic support of TUGOS were developed.

II. B. Objectives of the project:

The goal of this project, as stated in reference 2, was to provide a regional gear observation capability to assist the fishing industry research and development interests of the Northeast region and insure full and efficient utilization of the system once in place.

These goals were to be reached through the coordinated pursuit of the following individual objectives:

1. Improve the performance of TUGOS to a fully operational status through modifications to the control system and tether.

2. Development of a shore-side logistic support base for TUGOS.

3. Enhancement of TUGOS through the development of capabilities for deployment from larger trawlers and the ability to observe in ambient light of deeper trawling depths.

4. Provision of TUGOS in support of regional gear research projects.

5. Establishment of a long term program of gear research among cooperating regional organizations to address the industry's needs.

6. Establishment of a gear testing and observation service for commercial fishermen using TUGOS.

7. Development of sources of continued funding to insure the long-term availability of TUGOS to the region's fishing industry.

III. APPROACH:

III. A. Description of the work that was performed:

III. A. 1. Improve the performance of TUGOS to a fully operational status through modifications to the control system and tether.

III. A. 1. a. Addition of a controlable rudder.

In order to improve the controlability of the vehicle laterally a controlable rudder was installed to allow positive yaw control, independent of roll or pitch. In anticipation of such a need, a third control circuit had been incorporated in the original TUGOS design. This added system is much like the aileron systems, with an emphasis on robustness and immunity from becoming fouled in fishing gear.

The new rudder was designed to be slightly bigger in total area than the original fixed rudder. The rear portion of the rudder is 4" x 10" and is movable. This is the same dimension as the each of the two ailerons and therefore they will all be interchangeable.

The actuator for the rudder flap is housed within the fixed portion of the rudder. They are connected by a short external linkage. Also within the fixed rudder and directly in front of the actuator is its feedback pot. Both units are connected by a short linkage within the rudder. Again, for simplicity, the rudder actuator and feedback pot are identical to those used for both ailerons, facilitating ease of manufacture and minimizing the required spare-parts inventory.

Both the actuator and the pot housings are fitted with watertight connectors at their top ends. Cables from these units run from within the rudder into the V-fin, and finally plug into the main pressure housing on the underside of the vehicle.

The control for the rudder is independent of the primary maneuvering joy stick. A separate knob on the face of the hand box is used to bias the rudder as needed.

Figure 4 shows the general layout of the new rudder. It is fabricated from high-density PVC foam and covered in two to four layers of resin impregnated glass cloth. Weldments for bolting the rudder to the top of the vehicle are fabricated in stainless steel and are screwed and bonded to the PVC and fiberglass. These weldments are then bolted to the body of the V-fin as was the original rudder.

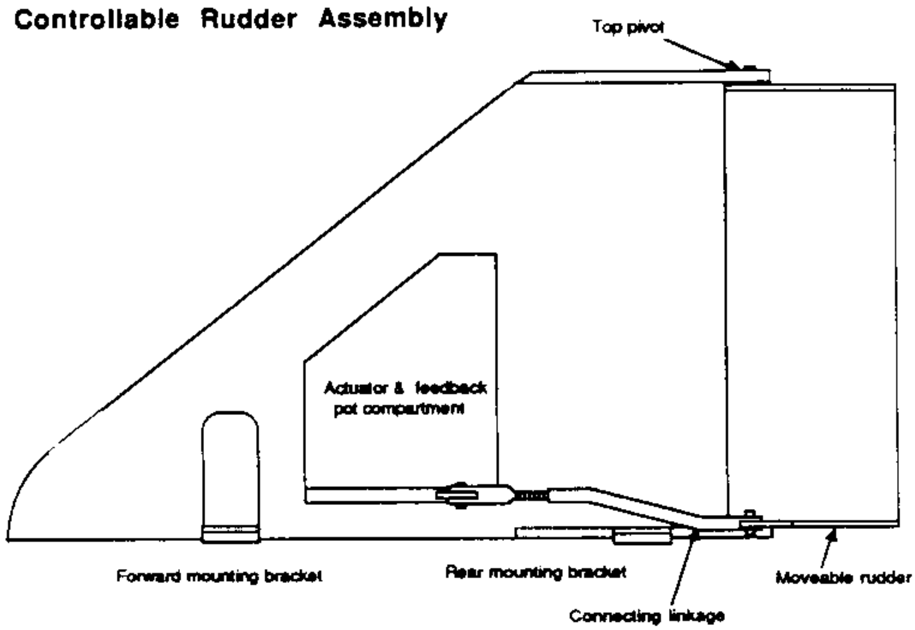

Figure 4. New rudder assembly

III. A. 1. b. Addition of a feedback control system.

To improve the ease of piloting TUGOS the original rate-control architecture adapted from MiniROVER was changed in favor of servo control. With this system the position of the control surface follows directly the position of the joystick lever. This change required modifications to the control circuitry, the addition of proportional servo control amplifiers, the incorporation of feedback potientiometers, and the design and fabrication of the mechanical linkages for between the actuators and feedback potientiometers.

The original control technique was borrowed directly from the MiniROVER thruster control circuitry. Moving the joy stick in one direction or the other caused the actuator to operate at a rate proportional to the stick movement. Control surfaces were "nudged" into their desired position. Once the actuators reached the limit of their travel, their slip clutches would allow the motor to operate without damage.

This technique was sufficient to demonstrate the TUGOS concept but inadequate for a fully operational vehicle. The control requirements of the TUGOS are somewhat unique. Servo feedback on ailerons that operate both together and differentially required an unusual mixing circuit that was not currently available. This special board was developed for Benthos by Vantech, Inc. of California. As with the rudder feedback system, each pot was located beside the actuator, within the cavity of the V-fin. Voids had been cast previously in anticipation of this modification. The general arrangement of the actuators, pots, and ailerons is revealed in Figure 5.

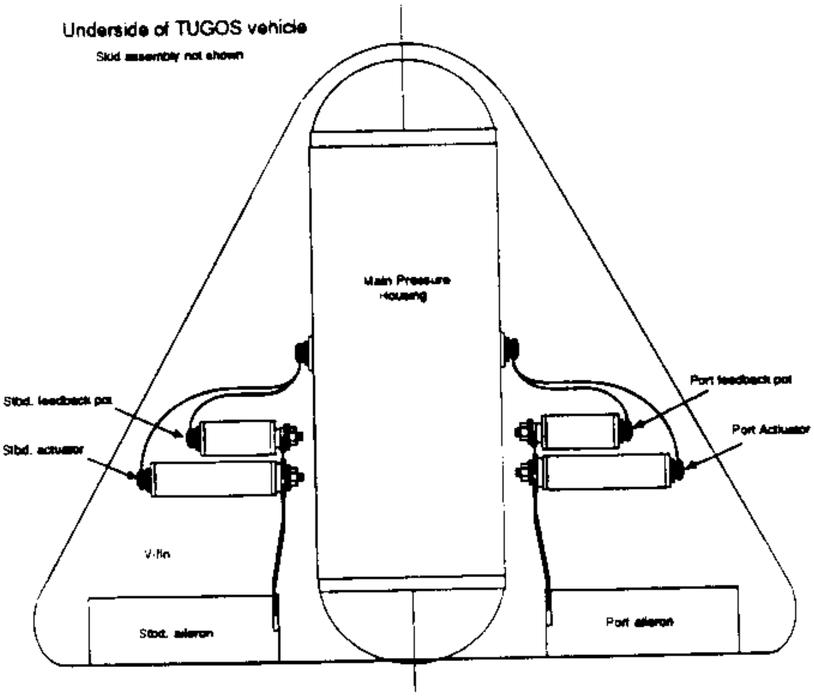

Figure 5. Arrangement of the servo-feedback aileron system.

III. A. 1. c. Development of a new tether configuration.

The present system of toggling from the front camera to the rear camera has some serious drawbacks. Most serious is the difficulty in piloting when the rear camera is in use. This is of minor consequence when the vehicle is well clear of the bottom and the process of driving backwards is simply a piloting challenge to be met with operator experience. However, when near the bottom, pilot error or an unseen obstacle could cause a loss of the vehicle.

Various techniques of sending both video signals to the surface simultaneously were considered; FM modulation, frequency or temporal multiplexing, split screen, etc. None had the advantages or economy of simply using two separate coaxial pairs, one for each camera. Any other technique would have either degraded picture quality, added considerably to the electronics cost and volume, or added to the tow cable diameter. The coax size required for raw video, over the lengths of interest, is approximately 0.13". Because of the arrangement of the conductors in the cable bundle, the addition of a second coax added little to the overall bundle diameter. This second coax also adds to the servicability of the tow cable by providing some redundancy should one of the coaxs fail.

The cable configuration which was specified includes the two coaxs and one bundle of eight 22 ga. conductors in a spiral with one 18 ga. conductor placed in each of the gaps around the overall overall bundle. South Bay Cable produced the cable and they provided an outer wrapping of two layers of mylar tape. The application of kevlar braiding and a polyester abrasion jacket was done by Yale Cordage of Yarmouth, ME. A breaking strength of 5000 pounds was provided.

III. A. 1. d. Determination of optimal cable fairing.

Due to the desire for maximum performance envelope of TUGOS, the possible benefits of cable fairing was investigated. Yale Cordage offers a variety of woven-in "fuzz fairings" which have proven advantageous in many applications. Unfortunately, there is little specific data on these fairing to give the insight needed to specify its construction.

Due to our mutual interests in these issues, a series of experiments were conducted cooperatively among MIT, Benthos, and Yale Cordage. Using the David Taylor Research Center circulating water channel, full-scale measurements of the hydrodynamic forces on sample sections of TUGOS cable were made. The apparatus used is shown in Figure 6 and the arrangement in the CWC is shown in Figure 7. A complete description of these experiments and the results can be found in reference 4.

A description of the experimental cables is presented in Table 1. The test procedure was to first pretension a suitable length of each cable between the two load cells to approximately 60 pounds. This was to minimize sag and to encourage realistic vibration modes. Zero-speed data was recorded and due to the accuracy of the three-component load cells being used, the summed forces on the cable were always close to zero. The actual zero-speed values were used to correct the subsequent results for that cable and angle.

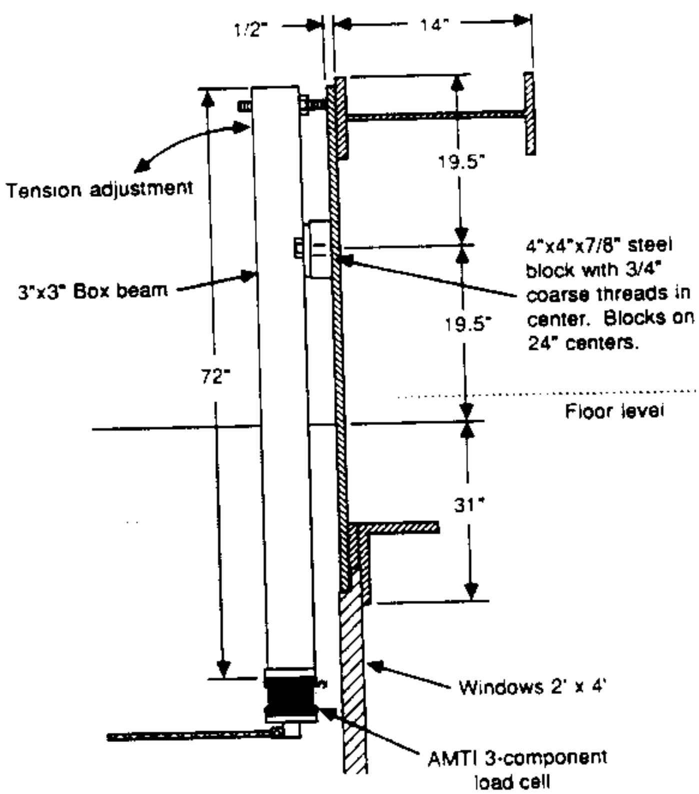

Figure 5 The apparatus used for the cable tests.

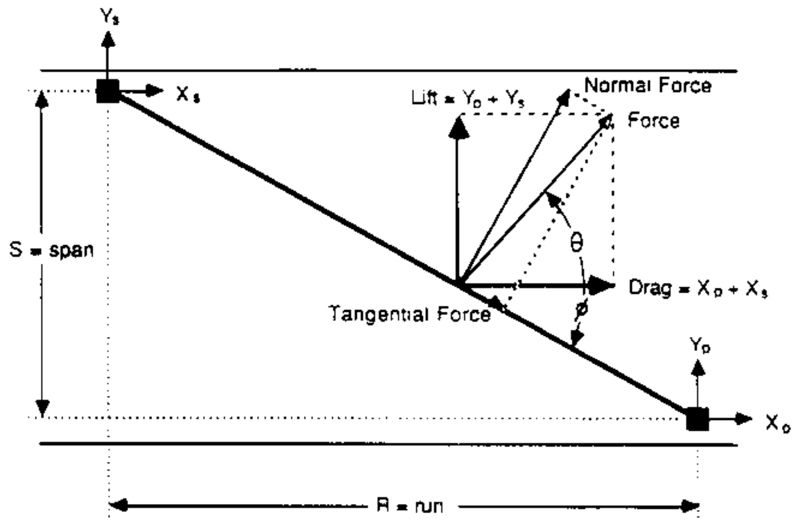

Figure 6. The test arrangement in the CWC and the analysis geometry.

Cable No.	Diameter	Description
1.	.430 in.	Bare cable, no jacket, no fairing
2.	.520 in.	Braided jacket, no fairing
3.	.520 in.	Braided jacket, soft fairing, short length
4.	.520 in.	Braided jacket, soft fairing, medium length
5.	.520 in.	Braided jacket, soft fairing, long length
6.	.520 in.	Braided jacket, med. fairing, short length
7.	.520 in.	Braided jacket, med. fairing, medium length
8.	.520 in.	Braided jacket, med. fairing, long length
9.	.520 in.	Braided jacket, stiff fairing, short length
10.	.520 in.	Braided jacket, stiff fairing, medium length
11.	.520 in.	Braided jacket, stiff fairing, long length

Table 1. TUGOS test cables supplied by Yale Cordage.

A summary of the experimental results are presented in Table 2. Here, data has been converted into coefficient form, both in terms of lift and drag components and then in terms of normal and tangential components.

These results indicate that some of the fairings do reduce the normal forces on the cables. In all cases, the tangential forces on the faired cables are greater due to increased wetted surface. These results would suggest some advantage to TUGOS performance if the lower portions of the cable were faired and the upper portions were jacketed only.

Two new 2,500-foot spools of cable were received from South Bay Cable. A 700-foot length was prepared for application of the Kevlar and jacketing by Yale Cordage. This shallow-water tether was made without fairing as it was needed before the hydrodynamic test data could be fully analyzed. Jacketing and fairing of the remainder of the two spools was completed early in January of 1990. Both lengths (2,500' and 1,800') were jacketed with the kevlar braid, polyester overbraid, and medium length medium stiffness fairing on the lower 500 feet of each.

Span =	21.5	Phi = ATAN(span/run)	Cn = F*sin(theta+phi)/sin^2(phi)
Run23 =	50	Theta = ATAN(Cl/Cd)	Ct = F*cos(theta+phi)/(pi*cos^2(phi
Run44 =	22	F = D*cos(theta)	

Cable	Speed	23 degrees		44 degrees		90 deg	23 degrees		44 degrees		90 deg
#	(kts)	Cd	Cl	Cd	Cl	Cd	Cn	Ct	Cn	Ct	Cn
1	1	0.3	0.154	0.827	0.933	2.691	1.666	0.081	2.549	-0.038	2.691
	2	0.122	0.346	0.748	0.803	2.383	2.346	-0.009	2.246	-0.016	2.383
	3	0.159	0.301	0.806	0.786	2.206	2.175	0.010	2.304	0.017	2.206
	4	0.19	0.302	0.814	0.677		2.259	0.021	2.156	0.068	
	5	0.177	0.296	0.753	0.698		2.191	0.017	2.099	0.032	
2	1	0.306	-0.131	0.712	1.184	3.006	0.003	0.126	2.752	-0.198	3.006
	2	0.201	0.18	0.704	0.713	2.182	1.569	0.043	2.051	0.003	2.182
	3	0.182	0.193	0.713	0.678	1.964	1.597	0.034	2.013	0.022	1.964
	4	0.168	0.218	0.656	0.601	1.866	1.709	0.026	1.818	0.031	1.866
	5			0.582	0.579	1.647			1.680	0.007	1.647
3	1	0.242	0.136				1.413	0.064			
	2	0.222	0.176				1.598	0.051			
	3	0.226	0.148				1.443	0.056			
4	1	0.252	0.307	0.895	0.228	2.393	2.445	0.042	1.614	0.299	2.393
	2	0.267	0.215	0.796	0.199	1.85	1.942	0.060	1.430	0.268	1.850
	3	0.248	0.18	0.755	0.199	1.64	1.687	0.059	1.372	0.249	1.640
	4	0.266	0.168	0.713	0.189	1.647	1.662	0.067	1.297	0.235	1.647
	5			0.643	0.298	1.545			1.356	0.157	1.545
5	1	0.544	0.017				1.477	0.186			
	2	0.334	0.155				1.758	0.093			
	3	0.311	0.172				1.800	0.082			
	4	0.281	0.158				1.642	0.074			
	5	0.279	0.15				1.589	0.074			
6	1	0.607	0.286	1.026	0.618	2.417	3.220	0.168	2.373	0.188	2.417
	2	0.421	0.311	0.842	0.478		2.897	0.100	1.904	0.167	
	3	0.364	0.266	0.725	0.412	1.549	2.487	0.086	1.640	0.143	1.549
	4	0.347	0.221	0.671	0.363		2.179	0.087	1.491	0.141	
	5	0.32	0.215	0.653	0.37	1.355	2.076	0.079	1.476	0.130	1.355
7	1	0.704	0.324				3.690	0.196			
	2	0.379	0.188				2.066	0.103			
	3	0.309	0.193				1.918	0.078			
	4	0.266	0.199				1.845	0.063			
	5	0.267	0.176				1.712	0.066			
8	1	0.506	0.434				3.836	0.111			
	2	0.403	0.318				2.892	0.092			
	3	0.402	0.234				2.395	0.104			
	4	0.357	0.221				2.205	0.091			
	5	0.351	0.194				2.031	0.093			
9	1	1.718	1.007				10.277	0.445			
	2	1.596	0.857				9.085	0.425			
	3	2.751	0.464				9.696	0.884			
	4	0.999	0.406				4.919	0.286			
10	1	1.846	0.775				9.236	0.524			
	2	1.372	0.543				6.670	0.394			
	3	1.065	0.413				5.127	0.307			
	4	0.874	0.366				4.367	0.248			
	5	0.748	0.316				3.754	0.212			
11	1	1.735	0.84	3.312	1.274		9.337	0.476	6.604	0.920	
	2	1.153	0.496	1.877	0.794		5.839	0.326	3.848	0.490	
	3	0.857	0.419	1.43	0.639		4.636	0.235	2.981	0.359	
	4	0.722	0.381	1.259	0.551		4.071	0.193	2.608	0.321	
	5	0.633	0.325	1.12	0.488		3.516	0.171	2.317	0.286	

Table 2. Summary data for all cables in Cl, Cd, Cn, and Ct form.

III. A. 1. e. Development of reliable splicing techniques.

During the initial deployments of TUGOS with the new tether problems were experienced with electrical short circuits. Soon after launch, the voltage leakage alarm would begin to sound. Each time the problem was associated with the an electrical short between the main vehicle power lead and one of the data multiplex lines.

Unlike the original TUGOS tether and the other cables used by most Benthos ROVs, the new TUGOS tether is unjacketed. The cable bundle is water blocked and wrapped in two layers of mylar tape. The typical urethane outer jacket was ommitted for overall diameter considerations.

In the design of such cables, the watertight integrity of such an outer jacket is not assumed; it is more for abrasion resistance. In the case of most ROVs, this urethane jacket is engineered to provide buoyancy to counter the weight of the copper conductors. Our problems were being caused not by the absence of the outer plastic jacket, but instead by the fact that the individual conductor insulation is of polypropylene. Evidence of corrosion at the soldered wire joints where the lower end of the tether is spliced to the connector pigtail indicated that water was migrating between the conductor insulation and the potting material.

Using the present splicing technique, this was unavoidable. It became evident that a new splicing technique was called for. Subsequent discussions with South Bay Cable indicated no solution other than accepting the diameter penalty and installing a plastic jacket. However, Tom Yale, of Yale Cordage, reported success in other cases when each conductor was fitted with one or several tight-fitting O-rings over the polypropylene insulation. With each conductor so fitted, the splice could then be made with a cavity mold and the water migration would be prevented without the use of a plastic jacket. This new splice technique was performed and the problem has been resolved.

III. A. 2. Development of a shore-side logistic support base for TUGOS.

As TUGOS has developed, the equipment associated with the complete outfit has grown. This increase in weight and volume has presented problems with respect to transportation to deployment sites and storage while not in use. Each use required movement from the 3rd floor storage location within the Sea Grant offices to a vehicle and the reverse process upon return. With a dedicated vehicle, the storage problem would be eliminated and TUGOS would be much more portable and ready for deployments.

A small utility trailer was purchased which will provide secure storage of the system and a convienient means of transporting to a deployment site. The trailer provides an 8'x5'x4' capacity, adequate for all present TUGOS components and some room to grow. In addition, large shipping crates were purchased to allow the safe shipment of the system when there would be a cost advantage over driving with the TUGOS trailer. These crates were used during a recent deployment in Georgia when Amtrak proved to be the best mode of shipment.

III. A. 3. Enhancement of TUGOS.

III. A. 3. a. Establishment of low-light viewing capabilities.

Significant advances have been made in the miniaturization and performance of intensified video cameras over the last few years. As a result, a small, highly sensitive, high-resolution camera was identified that would fit the existing pan & tilt units of TUGOS. This camera, a Xybion ISS-255, provides the ability to view gear in the low to non-existent light of typical trawling depths.

After a demonstration of the Xybion at MIT to check for size compatibility and performance, the unit was ordered. In addition to the basic unit, an option was ordered which de-powers the intensifier at light levels which might harm the internal components.

The Xybion camera has been received and and a special mount will be made to allow easy interchange with the conventional cameras presently used by TUGOS. Due to its cost ($9,500) the use of this camera will be confined to deployments that would see clear benefits from its low-light capabilities. The specifications of the Xybion ISS-255 can be found in Appendix I.

III. A. 3. b. Establishment capabilities for deployment from larger trawlers.

New connectors to make up the 1800-foot tether for deep deployments have been ordered with a mid-July 1990 delivery indicated. The tether will be made up for use either hand-tended over the power TUGOS block or in conjunction with a storage reel. The reel eliminates the need for constant hand tending as is done with the shorter, shallow-water tethers. It has been ordered but not yet received.

This longer tether, the take-up reel, and the low-light camera provides the basic enhancements needed for use of the system on larger trawlers to fishing depths of 100 fathoms.

The eight-inch Sony portable monitor has provided excellent service throughout all TUGOS deployments. Since the modification of the system to provide simultaneous views from the front and back cameras, a second identical monitor was purchased.

III. A. 4. Provision of TUGOS in support of regional gear research projects.

Both during its developoment as well as after it became operational, the TUGOS system has been utilized in a variety of regional gear research projects. As shown in the table below, deployments occured during the previous S-K supported development project and throughout the course of the present two-year enhancement and utilization project. An up-to-date schedule follows.

Date	Vessel	Activity
Dec. 1987	R/V Wilbour	Bottom observations
Mar. 1988	R/V Wilbour	Bottom and dredge observations
Sept. 1988	R/V Paul Derocher	Trawl observations
Nov. 1988	R/V Wilbour	Bottom observations
Jan. 1989	R/V Paul Derocher	Trawl observations
Apr. 1989	R/V Edgerton	Bottom observations
Aug. 1989	R/V Gloria Michelle	Sampling trawl observations
Feb. 1990	F/V Special K	Shrimp trawl observations
Apr. 1990	R/V Gloria Michelle	Sampling trawl observations
June 1990	R/V Georgia Bulldog	Finfish separators Obs.

Table 3. Deployment schedule for TUGOS.

The first two deployments made use of the Massachusetts Division of Marine Fisheries research vessel the R/V Wilbour. Both these occasions were for the testing of the vehicle. On the first trip only the vehicle was launched, and no gear. The stability of the vehicle was tested as well as the ability to adjust depth using the trim tabs.

During the secong trip, a small dredge was deployed to evaluate the lateral maneuverability of the vehicle. Both trips were done in shallow water (20 to 40 feet) over bottom that offered no obstructions.

The third trip was done both to test the vehicle in deeper water and to observe a shrimp separator net that had been developed by the Maine Division of Marine Resources (DMR) Fisheries Technology Service (FTS). The DMR has found the recordings of value in their separator trawl development efforts. The extensive views of the codend separator portion of the net provided an excellent opportunity to fine-tune its geometry. The deployment arrangement for the TUGOS observation of a trawl is diagramed in Figure 7.

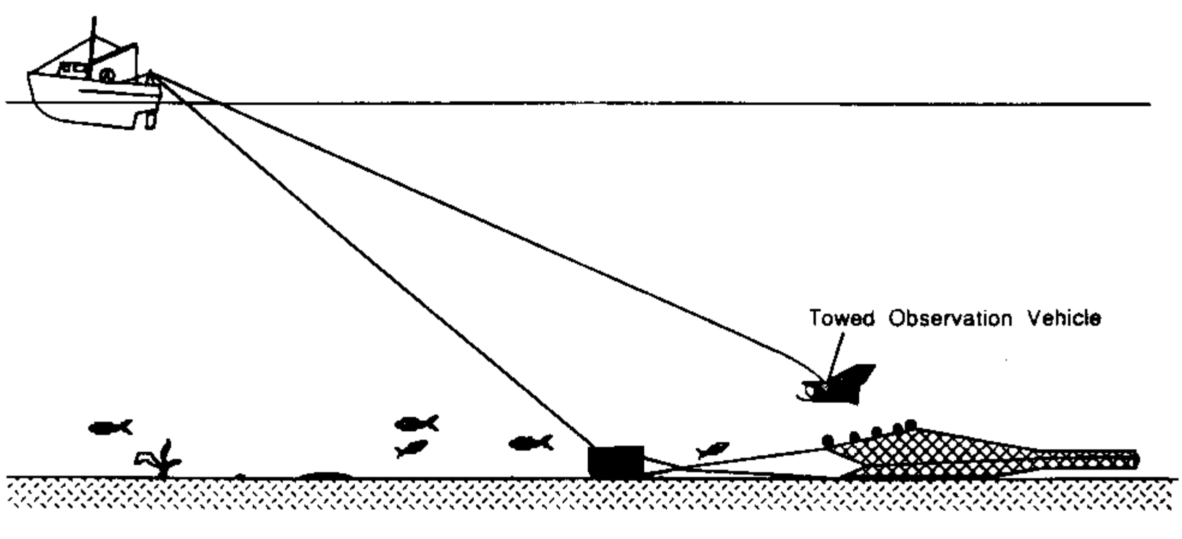

Figure 7. Arrangement of the vessel, trawl, and TUGOS.

A demonstration of the TUGOS system was held on April 7 during the regional gear meeting held by the Massachusetts DMF in Sandwich. In addition to a verbal presentation of our progress to date, a short demonstration cruise aboard the MMA research vessel Edgerton was included. The vessel departed from the Sandwich bulkhead and the deployment of the system took place off Sandwich Beach. The system worked well though turbididity levels in the water provided a disappointing opportunity for viewing or demonstrating the vehicle's capabilities.

The participants at the meeting were informed of the operational status of TUGOS and that opportunities for its use were being invited. Representatives from several organizations indicated upcomming projects in which TUGOS would be of value though no specific dates were identified.

In August 1989 TUGOS was used to make observations of a sampling net aboard the R/V Gloria Michelle. In this deployment, the system was loaded aboard the vessel at Davisville, R.I. for use on a northward leg of a sampling cruise. Several deployments were made in a 60'-80' area south of Gay Head, Martha's Vineyard, near Nomans Island.

Video recordings of the net were made, though poor underwater visibility limited the range of view and occasionaly made finding or avoiding the trawl difficult. Ben Allen from Benthos was aboard for this deployment and the occasion was used to de-bug some lingering problems with the videographics overlay board. Upon completion of the deployment, the Gloria Michelle continued her passage north and off-loaded TUGOS and TUGOS-personnel at Woods Hole.

During February 1990, the system was used aboard the commercial fishing vessel Special K out of Rockport, Massachusetts. While fishing off the mouth of the Ainisquam River, observations of its shrimp separator net were made including details of the chain sweep and tickler chain. Views of the rear of the net included the diamond flapper opening for finfish escapement.

Visibility during this trip was exceptional and well over half the length of the net could be viewed at once. The handling and performance of TUGOS on this 42' dragger was excellent.

In April 1990 three trips aboard the NOAA R/V Gloria Michelle were made to view several bottom trawls. Because of high winds, the first trip was made inside Narragansett Bay. Visibility was poor at the depth of interest and only limited footage was obtained. The net being observed was a shrimp net fitted with a large-mesh panel behind the footrope.

The second day, with improved weather, tows were made east of Pt. Judith where somewhat better visibility provided viewing of the net used on the previous trip. The combination of depth and tether length yielded a less than ideal control situation that, in retrospect, could have been improved by adding flotation to the tether. In spite of this, good footage was obtained of most portions of the net.

On the third day, with continued moderate underwater visibility, observations of the Massachusetts DMF trowser trawl was made. Good observations were made of the vertical separator panel, the crotch, and the two codends.

In June of 1990 a trip was made on the R/V Georgia Bulldog which was chartered by the University of North Carolina. The task was the observation of finfish separator devices in shrimp trawls. Three days were scheduled out of Brunswick Georgia however damage to the tether limited us to one. During that first day the operation of the vehicle required flotation on the tether to allow for the shallow scope (10 to 1). The vehicle performed well but repeated encounters with the buoyant lazylines from the dual rigs caused entanglements. Observations were being attempted during sampling tows and modifications could not be made to accommodate the needs of the vehicle. Limited footage was recorded. Another trip is planned in September with dedicated observation time on a single rig without lazylines.

In spite of the major engineering and operational modifications that have been done to TUGOS during this project, the only two deployment commitments which had to be cancelled due to TUGOS were aboard the Delaware II and Gloria Michelle to view minesweeping nets. Neither of these activities were at all related to fisheries development or gear selectivity issues of the region and were therefore unrelated to the primary mission of the TUGOS project.

One scheduled deployment period associated with commercial demonstrations of the Maine DMR shrimp separator trawl concepts did not occur. This was due to problems associated with the nets and limited patience of the commercial operators. The effort ceased before the TUGOS portion of the project could happen.

To keep a record of TUGOS deployments a log sheet was developed. This sheet is reproduced in Appendix III.

III. A. 5. Establishment of a long term program of gear research.

Progress on this objective of the project has been slow. This S-K project provided for the cooperative use of TUGOS, but the development of a long-term research effort requires funding yet to be identified. Gear research requires funds to support vessel time, the construction of experimental gear, and salary and logistic support for the project participants. Without such funding a long-term program of research is of little use.

To a limited extent, the ad-hoc meetings of regional gear researchers has seen to the coordination of the limited gear selectivity and gear development projects that occur in the northeast. This group meets approximately twice a year where project results and future plans are discussed.

III. A. 6. Establishment of a gear observation service for fishermen.

Most important in the full utilization of TUGOS is the use of commercial vessels. To this end, a substancial effort was made during 1988 Fish Expo to identify fishermen with ideas and needs associated with TUGOS.

Through conversations, questionaires, and follow-up phone calls opportunities covering the coast from Canada to Virginia were found. Applications range from seabed surveys for scallops, mussels, and bottom conditions to the study of roller gear and fish reactions in general. The more specific of these are listed in Table 1.

The availability of TUGOS for use aboard these vessels has been limited due to the down time associated with the work on the system. While the deployment on the F/V Special K could be placed in this catagory, the vessel's involvement in the shrimp separator project catagorized it as a cooperative project with the Mass. DMF.

Name	Port	Vessel	Gear or problem to be studied
Quesada	Gloucester	Golden Sea	Net and door performance
Conrad	Pt. Judith	Terry Lynn	Observation of nets and dredges
Mirachi	Scituate	Christopher Andrew	Fish reactions
O'Leary	Pt. Judith	Miss Judith	Gear tuning
Johnson	Orr's Island	Silver Dollar	Shrimp & groundfish observations
DeLeo	Gloucester	Santina D	Hand lining and bottom surveys
Murphy	Portsmouth	Dory I	Net observations
Kendall	New Bedford	Nordic Pride	Standard and modified dredges
Macara	Provincetown	Ruthy L	Gear tuning
Peemoeller	Va. Beach	Sea Hope	General observations of nets
Theroux	Woods Hole	Nobska	Roller gear on hard bottom
Stamopoulos	Boston	Mantoudi	Gear and fish observations
Amaru	Chatham	Joanne	Trawl and longline study
Higgins	Portsmouth	Prospector	Urchin surveys
Giacalone	Gloucester	Capt. Emorson	Groundfish observations
Furbush	Burlington	Melosira (U of V)	Lake Champlain fisheries
Warrington	Portsmouth	David Lee	Shrimp/Flounder observations

Table 1. Partial list of contacts made at 1988 Fish Expo

III. A. 7. Development of continued funding for TUGOS.

Important to the full utilization of TUGOS is the ability to keep the system operational and available at a minimum cost to priority research efforts. To this end, the identification of long-term sources of funding has been an important part of this project.

Fortunately, fulfilling the objectives of TUGOS is an important goal of the MIT Sea Grant College Program. It is seen as an effective way of addressing the needs of an important constituency, the fishing industry. The salary for the project P.I. has, for the most part, been provided by MIT. In addition, the lab space and other logistics for the system's support has also been provided at no cost. The continued support of TUGOS is planned for as long as it proves of value to the industry and contributes towards a better utilization of our regions living resources.

In addition, funding for specific projects is being sought. The S-K program continues to be an appropriate source of funding for projects of this nature. The authorizing legislation for the S-K funds requires that projects have an element of risk in achieving positive results and that the benefits be widely dispersed. Clearly, the development of TUGOS fits these criteria as does its use as an operational system.

A specific national priority area identified in the 1990 S-K program solicitation is the development of methods of evaluating and managing the inadvertent capture or destruction of juvenile fishes, non-targeted species and/or protected species. TUGOS is a one-of-a-kind system that can make a unique contribution to this important area of research. Its maintenance, utilization, and enhancement will allow important progress in this area.

The National Coastal Resources Research & Development Institute (NCRI) is also seen as a potential source of funds for work with and related to TUGOS. Its establishing legislation calls for research and demonstration projects to promote the efficient and responsible development of ocean and coastal resources.

The 1991 NCRI request for proposals has identified fisheries as a priority program area. Specifically, the evaluation of new and modified fishing gear aimed at increased efficiency and productivity. The development and testing of selective and resource sparing gear is well within the perview of this NCRI initiative.

Three project proposals are being developed to secure follow-on support for TUGOS.

1. The Development of an Improved Hydrodynamic Enclosure for TUGOS.

This project will utilize the experience gained in three years of operating TUGOS to design, fabricate, and install a new hydrodynamic enclosure to replace the original V-fin. This new enclosure will offer the following advantages:

a. Increased roll stability.
b. Reduced tendency to become tangled in cables and netting.
c. Better vertical control.
d. Greatly increased lateral control.
e. Lateral control that does not require vehicle roll.
f. More protection for the pressure housing and viewing domes.
g. Easier piloting.
h. Improved directional visibility forward and upward.

2. Methods to Reduce Juvenile and Non-target Fish Mortality in Trawl Nets.

This project will use a combination scale model hydrodynamic tests and in-situ gear observations using TUGOS. The goal will be the determination of flow contitions within the trawl net and the effect of flow control devices on flow directions and velocities. Methods for enhancing escapement opportunities for small or non-targeted fish will be developed and tested. The project results will be applicable to all fisheries, however, specific gear selectivity innovations for the northeast region will be used as demonstrations.

3. In-situ Observations of Commercial Trawls and Dredges.

This project seeks to supply the knowledge necessary to understand the resource implications of commercial fishing practices. Through the application of TUGOS and other cameras and remote sensing instruments on commercial vessels, the selectivity and resource impact of trawls and dredges will be investigated. Opportunities for the improvement of gear will be identified.

4. Marine Mammal Bycatch in the Mackerel Trawl Fishery.

This project will observe the mechanisms of marine mammal entanglement and drownings in the east coast mackerel fishery. Modifications of gear handling procedures will be developed to reduce adverse impacts.

III. A. 6. Publications.

A technical paper on the development of TUGOS was presented at the Oceans '87 conference in Halifax, Nova Scotia, in October 1987 (2). The presentation was well received and prompted a lot of interest from fisheries researchers in other parts of the world.

Several articles have been written for Commercial Fisheries News on TUGOS and its use in gear selectivity (5,6,7). An effort has been made to keep fishermen informed of the progress being made with TUGOS and their response has been very encouraging. Most fishermen express a keen desire to see their gear first hand. With the involvement of such interested industry members, the cost of boat time in later gear research can be kept to a minimum. Copies of these articles are included in Appendix IV of this report.

III. B. Project Management:

This project has been managed by Clifford A. Goudey, project director for the Center for Fisheries Engineering Research. He has been responsible for the completion of each project task, negotiations with project vendors, and liaison with potential users. Financial management and contract administration of this project has been by Tim Downes, administrative officer of the MIT Sea Grant College Program.

The largest expenditure of this project has been the cost of the improvements to TUGOS. The prime vendor for these modifications was Benthos, Inc. of Falmouth, Massachusetts. Their use as the principal subcontractor was based on their effective involvement in the original TUGOS development project and their ability to provide components for TUGOS through the use or modification of MiniRover parts. The acquisition of the low-light camera from Xybion was based on the unique size of the ISS-225 product.

IV. FINDINGS:

From the results of the deployments of TUGOS, it is clear that the system has met its design goals for size and ease of handling. Its portability is far superior to any other system with similar capabilities.

While achieving an operational status required more time than anticipated, the resulting system is a major advance in the research capabilities of the region. The system can now achieve depths and scope ratios compatible with those of most commercial trawling operations. The viewing capabilities of the vehicle, both dual camera and wide range of pan & tilt, are well suited to the observation of fishing gear and far better than other systems intended for similar applications.

The addition of the Xybion low-light camera provides a capability for the proper evaluation of fish behavior without the intrusion of artificial lights. The small size and quietness of TUGOS can further ensure realiable observations compared to the large, noisy rotor-type systems.

TUGOS is now providing views that have been unavailable to the regions gear researchers in the past. This does not mean that the system in perfect or that it is appropriate for all gear research needs. We have found the following:

1. The safe deployment of TUGOS requires favorable weather and sea conditions. Retrieval of the system in heavy weather presents hazards to the personnel involved and subjects the vehicle and tether to possible damage.

2. The typical underwater visibility in the northeast region can cause disappointing viewing. This manifests itself in two ways. First is the time involved in acquiring the trawl. Since the trawl is affected by cross tides when in contact with the bottom, it is not always directly behind the vessel. When long lengths of cable are out or when the direction of set is unclear, finding and orienting the vehicle to the net can be time consuming. Second, poor visibility also prevents the observation of overall net shape or the sighting of on-coming obstacles ahead of the vehicle.

3. The use of vehicle roll to achieve lateral movement of the vehicle complicates the task of piloting. In addition to introducing spatial disorientation, it couples the horizontal and vertical control.

4. The location of the tow point tends to invite the entanglment of the vehicle in any ropes or wires that the vehicle encounters. In addition, the delta-wing shape makes the vehicle prone to becoming impinged on the inside of the net since the widest part is aft.

5. The vertical separation of the center of buoyancy and the center of gravity is insufficient to provide roll stability at higher towing speeds.

6. ' 'e low position of the viewing domes with respect to the bottom of the ski presents undue hazards while in close proximity to the seabed.

7. In spite of the increased maneuverability offered by the controlable rudder, the range of lateral motion remains inadequate for reliable viewing of all parts of the trawl. Also, the response to lateral commands can be ambiguous at certain scope ratios.

8. The main pressure housing and actuator and potientiometer housings have performed perfectly with no evidence of leaking during any of the deployments.

9. The control console, hand box, vehicle power and electronics subsystems, and cameras have performed well and seem able to withstand the level of abuse associated with use aboard commercial vessels.

10. The videographics display is a great aid in the piloting of the vehicle but occasional problems remain that require de-powering its P.C. board to regain proper operation.

11. The compact power block has proven to be an excellent means of tether handling. It is easy to install on vessels and is kind to the tether.

12. The 8" Sony monitors have given good service and provide excellent picture quality.

V. EVALUATION:

This project has established and utilized a regional capability for at-sea observation of fishing gear. Previously, the Northeast region had no effective means of observing harvesting gear in commercial use. Consequently, there had been little serious research on gear development. In the last two years TUGOS has obtained important footage of both the configuration and dynamic performance of fishing gear, the reactions of fish to the approach of the gear, and the escape of fish from the gear. The knowledge gained from those observations have been applied toward the modification of gear for improved selectivity.

The modifications that were required to get TUGOS operational were not fully known at the submission of the proposal for this project. The original project was on-going and sea trials opportunities has not allowed the full evaluation of the system. For this reason less time and project resources were available for utilization compared to the proposed level.

Due to the effort involved, a fifteen month no-cost extension to the project was requested and granted. Also, modifications to the project budget were allowed. Much of the salary for the principal investigator was therefore covered by the MIT Sea Grant College Program as matching support for the project allowing for project funds to pay for the modifications.

With respect to meeting the project objectives the following can be said:

1. TUGOS is fully operational.

2. A shore-side logistic support base for TUGOS has been established.

3. TUGOS has been enhanced through the development of a longer tether and the addition of a low-light camera.

4. TUGOS has been used in support of four regional gear research projects.

5. A long-term, well coordinated program of gear research has not been established.

6. A gear testing and observation service for commercial fishermen using the TUGOS is in place.

7. Sources of continued funding to insure the long-term availability of the TUGOS to the region's fishing industry are being sought through applications for follow-on funding from appropriate sources.

VI. CONCLUSION:

Based on the findings of this project the following conclusions can be made:

1. The small size and ease of handling of the TUGOS system makes it operable from small vessels using hand deployment.

3. TUGOS has proven to be a robust and capable system for the observation of fishing gear and other towed applications.

4. Video observations of the performance of fishing gears and the reactions of fish to the gear is an effective and often unique way of answering questions regarding gear selectivity.

5. The use of a V-fin depressor as the hydrodynamic enclosure for a towed system provides good vertical control but is not ideal for a system requiring lateral excursions. TUGOS could be improved significantly through the redesign of its enclosure.

6. The use of the TUGOS system in regional gear research has not occured to the extent anticipated. Due to inadequate levels of funding, its use is typically confined to observations of gear developed through conventional trial-and-error techniques for purposes of project documentation. As such, planned TUGOS usage is often confined to the end of projects and is quickly axed when boat time or good weather runs out. Only when TUGOS is incorporated into the early stages of a project, when the problem is being defined and as solutions are being evaluated, will its full value be realized.

7. Based on operational experience, several ways of improving TUGOS have been identified and need to be implemented.

VII. REFERENCES.

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5. Goudey, C.A. 1986. Underwater Eyes Provide View of Trawl. Commercial Fisheries News, Oct.

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VIII. APPENDICES

Appendix I	Specifications of the Xybion ISS-255
Appendix II	TUGOS deployment log sheet
Appendix III	Articles in Commercial Fisheries News

2. CAMERA SPECIFICATIONS

All of the LSI's, discrete components, and other circuitry for the ISS-255 camera are contained on printed circuit boards housed in the body of the camera.

2.1. Feature List

The following list outlines the features which make the ISS-255 a unique product.

- Small size
- Light weight
- Rugged construction — extruded aluminum housing
- Single power source: 11-15 VDC at approximately 5 watts, or 117 AC 50/60 Hz with optional power supply module
- Frame scan or field scan (factory select)
- Choice of RS-170 or CCIR output formats
- Sync lock or H & V lock control
- Automatic iris control (with -I option)
- Automatic (and optional manual) intensifier gain limit
- Extremely good anti-blooming performance
- Clock noise filtering
- Adjustable "C"-mount back focus
- Automatic or adjustable camera gain and adjustable video black level (on optional power supply)

2.2. Technical Summary

The following specifications represent typical ISS-255 camera performance. Xybion Electronic Systems reserves the right to make changes in design which affect specified performance without notification.

SPECIFICATIONS:

Electrical:

Input voltage Range:	11 to 15 VDC	
Input Power:	Less than 5 watts.	
Scan Rates:	<u>Vertical</u>	<u>Horizontal</u>
RS-170	60Hz	15.750kHz
CCIR	50Hz	15.625kHz
Imager Type:	Interline Transfer CCD	
Imager Resolution:		
RS-170	768H x 493V	

CCIR	756H x 581V
Camera Image Plane:	12.7 mm x 9.525 mm
Camera Image Format:	1-inch
Grey Scale Rendition:	10 shades of grey, minimum (EIA grey scale chart).
Geometry:	Unaffected by input voltage or ambient temperature.
Intensifier Type:	18-mm, Gen-II single micro-channel plate
Spectral Response:	400 nm to 900 nm, typical
Sensitivity:	Better than 1 x 10^{-6} FC faceplate illumination.

Mechanical:

Camera Size:	7.00" long (less lens) 2.00" wide 4.00" high
Camera Weight:	2.75 lbs.
Lens Mount:	Standard "C," for 1-inch format lens
Camera Mounting:	¼-20 holes 1-inch on center, bottom (3)
Mating Connectors:	I/O — Hirose HR10A-10P-12S (12-pin) Video — UG 1094/U (BNC) Lens — Hirose HR10A-7R-4P (4-pin)

Environmental:

Temperature:	0°C to 50°C (operational)
Relative Humidity:	0-95% non-condensing

Appendix II

Center for Fisheries Engineering Research MIT Sea Grant College Program

TUGOS Deployment Log Sheet

Date: ______________________ Vessel: ______________________

Project: ____

P.I.: ______________________ Others aboard: ______________

Departure port: ______________ ______________________

Comments: ____

____

____

Launch 1

Time: _____ Location: __________________________________

Pilot: ______________________ Assistant: ______________

Activity: ____

Depth: _____ Speed: _____ Video footage: ______________

TUGOS performance: ____________________________________

Comments: ____

____

____

Launch 2

Time: _____ Location: __________________________________

Pilot: ______________________ Assistant: ______________

Activity: ____

Depth: _____ Speed: _____ Video footage: ______________

TUGOS performance: ____________________________________

Comments: ____

____

Appendix III

October 1986
COMMERCIAL FISHERIES NEWS
Special Supplement

Using gear observation vehicles

Underwater eyes provide view of trawl

Fishermen work under a unique handicap - they are unable to see the tools of their trade in use. Once the gear goes overboard, they must resort to detective skills and a little imagination to figure what their gear is up to. When the catch is off, is the gear out of tune or are the fish just not there?

The feel of the wires, the shine on the doors and chain, a little weed here, some gilled fish there, and of course the size of the bag - these are the clues. Their proper interpretation is learned through years of experience, supplemented by guidance from net makers, technical reports, and more recently, the study of model nets in a test tank.

ON-DECK

BY CLIFF GOUDEY

The use of test tanks is a convenient and efficient way to learn how trawls respond to rigging changes. The popularity of the MIT (Massachusetts Institute of Technology) Sea Grant trawl courses is evidence that fishermen are interested in improving their diagnostic skills and understanding of trawl performance.

The study of the shape and drag of model nets and the effects of speed, spread, and rig adjustments will always be useful. However, test tanks fall short of the real thing in two respects. First, some fishing conditions are difficult or impossible to duplicate in a tank. Varied bottoms, cross tides, and obstructions are examples.

The second problem is the importance of the interaction of fish with the trawl. Fish are not simply filtered out of the water; their behavior during the approach and passage of a trawl is crucial to its effectiveness. Therefore, the observation of gear and fish behavior under commercial conditions is needed if issues such as the selectivity of gear, the herding effect of large mesh, or the impact of gear on the bottom are to be resolved.

Many of us have seen underwater video tapes from the Department of Agriculture and Fisheries for Scotland (DAFS) Marine Laboratory in Aberdeen, Scotland. The observation of fish during capture has been an active area of research for the Scots for over a decade. Unfortunately, the application of their observations and results to US fisheries should be done with caution due to obvious differences in gear design, species, and habitat. Regardless, their techniques are sound, and the success of the Aberdeen lab causes one to ask why such work isn't being done in this country.

Back in the 50s, the old Bureau of Commercial Fisheries (BCF) had an active program in the area of trawl performance. BCF researchers in Woods Hole may have been the first to use television to study the behavior of fish in a trawl.

Research priorities changed, however. It was not until the late 70s, when the problem of Gulf of Mexico turtle bycatch in shrimp trawls surfaced, did researchers (now NMFS) return to the business of recording the performance of nets with film and video. This work at the Pascagoula, MS lab began much like the Aberdeen studies, first with free-swimming scuba divers, then with divers on a towed sled.

Recently, both organizations have developed diverless capabilities using remotely-piloted towed observation vehicles, greatly increasing their range of safe operation.

This task of observing commercial trawls presents a unique set of requirements for a towed vehicle. In addition to maneuverability along the length of the trawl, the vehicle must be able to cover the full width, from door to door. Important viewing directions are downward, ahead, astern, and to either side.

There are two systems designed to meet these requirements which are being marketed for fisheries research. One is the commercialized version of the Aberdeen laboratory device and the other is the Canadian Manta II system.

Two Scottish companies are producing the Aberdeen system. One is Norland R.C.V. Systems, Ltd. of Orkney, and the other is Seametrix Ltd. of Aberdeen. Both systems are similar in appearance and shown in Fig. 1.

Most noticeable about the units are the four rotors used for maneuvering. When spinning they produce a side-force much like a spinning baseball. The rotors are driven either electrically or hydraulically in pairs, forcing the vehicle downward and to either side. A camera and pan and tilt unit are located at the rear of the vehicle. In addition to the original DAFS vehicle, several systems have been sold to other fisheries research organizations in Europe.

The Manta II system is from Sea-I Research Canada Ltd. of Sidney, British Columbia. The Manta II vehicle is pictured in Fig. 2 on page 30.

It uses control surfaces to maneuver and has onboard batteries for its power requirements. This feature allows an umbilical cable only 3/8" in diameter and a small winch size. A sophisticated onboard computer and control system provides stable or terrain-following operation.

Though smaller than the Scottish systems, and frequently operated from a 38' open-deck vessel, the vehicle's 8' length and 900-pound weight could be an awkward handful aboard a small trawler. This is the system purchased by NMFS Pascagoula and installed aboard the NOAA R/V *Chapman* for its research program.

The price of both types of units is substantial, with the DAFS-type systems costing from $110,000 to $140,000. The base price of the Manta system is around $190,000.

Their potential use in dealing with the many gear-related problems facing the New England fisheries has prompted a careful look at the pros and cons of acquiring a system for shared use within the region.

The Center for Fisheries Engineering Research at MIT, in cooperation with most of the groups in the Northeast with interests in gear research, submitted a proposal to NMFS for consideration in this year's Saltonstall-Kennedy (S-K) Fisheries Development Program.

What we proposed was the purchase of a Manta system for use throughout the region on a whole shopping list of trawl and dredge projects. The system would also be available for use by commercial

continued on page 30

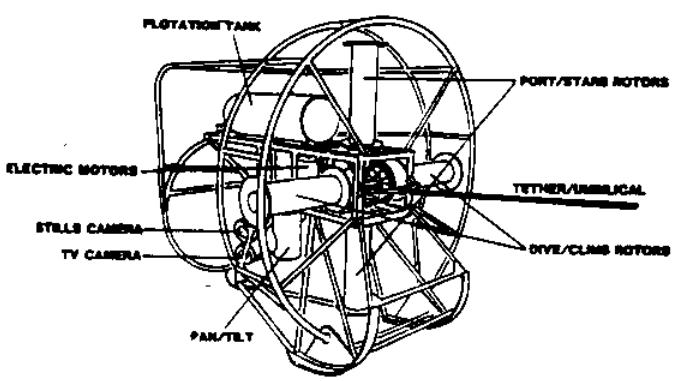

Fig. 1. The rotor-controlled trawl observation vehicle developed at the Aberdeen Fisheries Laboratory in Scotland.

Underwater eyes

continued from page 29

fishermen in studying their own gear. The two-year proposal included the training of operators, the lease of a truck to carry the system from port to port, and the establishment of long-term gear research programs to help in fisheries development and in the management of stocks.

I'm happy to report that in August we were notified that the project was approved for funding. However, due to limited S-K program funds, only one year of support is available and at a level of half of what is needed to buy the Manta system.

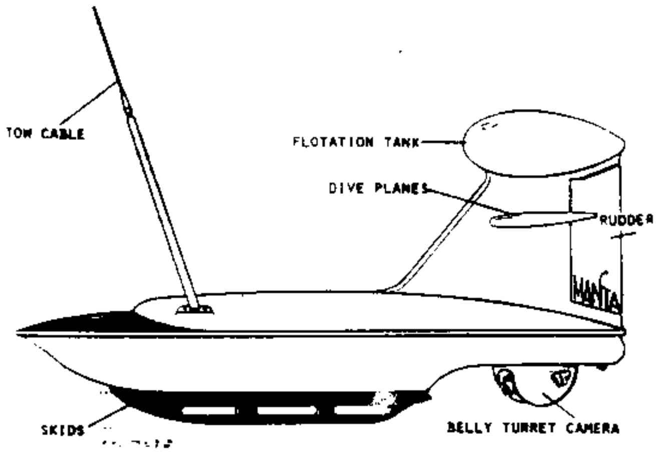

Fig. 2. The Manta towed vehicle from British Columbia was recently purchased by the NMFS Pascagoula, MS lab for midwater trawl research.

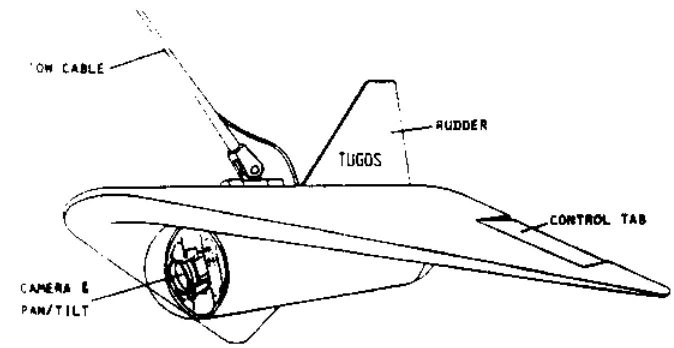

Fig. 3. The Towed Underwater Gear Observation System planned by MIT for gear research in the Northeast region.

We have considered renting the Manta to accomplish a couple of the most important gear projects, but that would leave nothing to allow the continuation of gear research after the first year. Instead, we are planning the assembly of a low-cost system from proven components typically sold for underwater inspection, surveying, and oceanographic work. The concept planned is the Towed Underwater Gear Observation System, or TUGOS, and it is pictured in Fig. 3.

TUGOS, as planned, is the combination of a V-FIN towed depressor with the guts of a Minirover remotely operated vehicle (see *Commercial Fisheries News*, Sept. 1986, page 10). We hope to keep the vehicle less than 3' long and under 200 pounds.

The V-FIN, made by ENDECO Inc. of Marion, MA, will be modified with control surfaces for maneuverability. The Minirover, from Deep Sea Systems International of Falmouth, MA, will be stripped of its propeller thrusters and snugged under the V-FIN with its domed, directable television camera facing forward or aft.

Will a system like this ever be in the price range of the commercial fisherman? I think so. Most of the hardware needed has been developed for, and at the expense of, the oil companies. The marketplace for these gadgets has become quite competitive. For example, the Minirover system sells for under $25,000. The value of a towed version for checking out the gear, identifying schools of fish, or surveying the bottom is easy to appreciate.

With crude oil prices down and things grim in the offshore oil fields, it seems these high-tech ocean equipment companies should see the fishing industry as a natural place to offer their expertise and sell their wares. They have the technology to extend our range of sight and sense right down to the seabed. Let's hope they can help us fish more effectively and selectively.

story and illustrations by
Cliff Goudey

Cliff Goudey is a fisheries engineer at the MIT Sea Grant Program and director of the Center for Fisheries Engineering Research.

A technique whose time has come

Gear selectivity: Catch only what you want

Gear selectivity - being able to catch only what you want while leaving undersized and non-targeted stocks on bottom - is a fishing technique whose time has come in New England.

More than 60 people attended an Oct. 14-15 conference on gear selectivity entitled "Gear Selectivity as a Management Tool." The Massachusetts Institute of Technology (MIT) Sea Grant Program and the New England Fisheries Development Foundation sponsored the conference. Held on the MIT campus in Cambridge, MA, the meeting was an opportunity for gear researchers and fishermen to share ideas on how trawls and dredges might be designed to be more selective.

The first day began with a summary of gear selectivity research reported at a recent European conference. This was given by Al Blott of the National Marine Fisheries Service (NMFS) Fisheries Engineering Group in Narragansett, RI. The Europeans, he reported, are active in the development of selective gear. Due to the differences in fisheries, however, their techniques don't necessarily apply to our problems in the Northeast. Blott described the use of horizontal separator panels in shrimp trawls. Clean catches of shrimp and finfish were retained in two separate cod ends.

ON-DECK

BY CLIFF GOUDEY

After this first general topic, the presentations were grouped into four separate topics: groundfish, northern shrimp, scallops, and pelagic stocks. The groundfish session began with Arnie Carr of the Massachusetts Division of Marine Fisheries (DMF) who reported the results of some fishing trials the DMF recently conducted comparing square-mesh cod ends with conventional diamond mesh.

Gear and selectivity issues in the Northwest and Alaska groundfisheries were then described by Bill West of NorEastern Trawl Systems. Of particular interest was the recent turmoil over crab bycatch in the yellowfin sole fishery and a NMFS effort to study the problem. West showed some video footage of underwater observations using the Manta system in which flats were seen avoiding a sweep which had well-spaced large-diameter rubber disks. The flats could have easily passed between the disks but seemed to keep clear due to the mud cloud being kicked up.

Next Richard McLellan, captain of the *Irene's Way* of Boothbay Harbor, ME, described his efforts to develop techniques for bottom pair trawling. Capt. McLellan described the gear that he has evolved and how the six-inch minimum size mesh size has nearly eliminated undersized bycatch. He believes the technique has unique potential on certain grounds that are presently uneconomical to fish.

Frank Mirarchi captain of the *Christopher Andrew* of Scituate, MA, then spoke about the two years of experience he has had with a square-mesh cod end. Using knotless 5½-inch webbing hung on the square, he has been able to reduce discards as well as the amount of trash retained.

The shrimp session began with a presentation by Phil Averill of the Maine Department of Marine Resources (DMR). Averill described work being done by the DMR Fisheries Technology Service to develop and introduce shrimp separator trawls. Using standard shrimp nets, angled, square-mesh separator panels have been fitted which deflect finfish up, out of the trawl, and into a second, larger-mesh cod end. Excellent separation rates have been reported with no apparent loss of marketable finfish. (See DMR News, page 10.)

The conference segment on scallops was begun by Ron Smolowitz of NMFS in Gloucester. He reported on past and present work on determining the selectivity of New Bedford dredges and how ring size, shell size, and meat count affects the overall productivity of the grounds.

Concerns over dredge inefficiency and the mortality of uncaught scallops were discussed.

The popular but controversial use of trawls on scallops was then described by Phil Cahill of the Virginia Institute of Marine Science Sea Grant Program. He presented a video tape of an on-deck fishing operation which revealed the alarming potential of the gear. The tape showed haul after haul, each one filling the deck. The uniformly small size of the scallops and their rough treatment on deck provoked some debate.

Phil Averill then briefly described DMR studies on the Maine scallop drags. Their concern has been primarily with the effects of the drags on the bottom. He reported on some techniques to reduce impacts on the seabed while maintaining scallop productivity.

Midwater fisheries were the last to be covered. Guy Marchesseault of the New England Fishery Management Council described some of the current controversies over the region's pelagic stocks and their management. He also expressed his concern over ensuring the off-bottom performance of trawl gear. The gear regulations imposed on foreign midwater trawlers to minimize groundfish bycatch are considered by many to be inadequate. If those same rules are applied to domestic fisheries the council might have to impose area closures to protect certain non-pelagic stocks.

The group then watched a video tape provided by John Watson on the Pascagoula Lab's effort to develop gear suitable for the coastal pelagic resource in the Gulf of Mexico. Due to the high swimming speed of these fish, special trawling methods have been developed aboard their research vessel, *Chapman*.

The gear they have found to be the most successful is a 196 mesh x 32" Shuman trawl towed behind NorEastern Trawl Super-V doors. The use of the Manta II trawl observation system was shown together with some underwater scenes of the net and the behavior of fish within it.

The first day finished up with a presentation by me on MIT's Saltonstall/Kennedy (S/K) sponsored project to establish a regional system for the underwater observation of towed fishing gear. This project was described in *Commercial Fisheries News*, Oct. 1986, pages 28-31 of the Fishing Trends supplement. It will allow researchers and fishermen in the Northeast region to make real progress in developing selective gear.

The second day of the conference was structured to allow for more discussions and feedback from fishermen. An initial presentation by Guy Marchesseault on the techniques of stock management was followed by Ron Smolowitz on how the use of gear restrictions could be enforced. These two topics generated a lot of debate as many in the audience felt the poor record on enforcing mesh size did not inspire much confidence that other, possibly more complex, gear restrictions could be effectively enforced.

This discussion lead into a program segment called "limitations of practicality." Paul Shuman of Shuman Trawl in Hope Valley, RI, explained the netmakers' viewpoint on some of the gear ideas that had been suggested. He was somewhat doubtful about whether such things as separator panels or escape panels are yet to the stage of development where they can be expected to work under realistic fishing conditions.

Shuman wondered who would be accountable if a net built to some "regulation design" did not perform as anticipated. He also expressed concern over the tendency to develop a specialized net to solve a selectivity problem whereas most fishermen are looking for a combination net, suitable for a changeable fishery.

On the positive side, Shuman felt that the use of a towed video system to observe gear and fish reactions and the ability to show video tapes to fishermen will be important in generating their interest and willingness to try new gear ideas.

Speaking from his experience running a small dragger, Bentley Howard of Steuben, ME, described his use of square mesh and how reductions in the amount of on-deck sorting can be a real incentive to adopt selective gear. He agreed that underwater video tapes showing the problem and the cure would be convincing.

The remainder of the conference dealt with the plans of gear research organizations in New England for the coming year. Ken Coons of the New England Fisheries Development Foundation outlined the foundation's plans to help coordinate regional gear research and formulate long-term plans for conservation engineering within the region.

Also included on the agenda were presentations on Sea Grant's and the S/K program's role in gear research.

Victor Omelczenko of the National Sea Grant Office explained that fisheries research and gear selectivity are considered high-priority nationally. However, since individual Sea Grant programs develop their own areas of concentration, the national program cannot dictate projects. Ultimately, if fishermen want to see more effort in gear research, they should express their feeling to the Sea Grant director within their states.

Bruce Moorehead of the NMFS Saltonstall-Kennedy Fisheries Development Program then described the history of that program and how last year's and this year's funds have been allocated. Important to the group in attendance was the program's growing recognition of gear development and conservation engineering as an appropriate area for support.

Most of the fishermen, industry representatives, and gear researchers agreed that the trend needs to be continued since effective fishing techniques and stable management plans are essential to fisheries development.

Proceedings of the conference are available from MIT Sea Grant at a cost of $5.00 by writing to the following address: Center for Fisheries Engineering Research, MIT Bldg. E38-376, 292 Main St., Cambridge, MA 02139.

Cliff Goudey

Work to begin on selectivity

Underwater vehicle set for gear watching

Nearly a year ago, I reported on our plans to develop a system for looking at trawls and dredges during actual fishing time (see *Commercial Fisheries News*, Fishing Trends supplement, October 1986 issue, page 28). At that time, the Center for Fisheries Engineering Research had just received a Saltonstall-Kennedy grant to build such a system for use within the Northeast region on gear-development projects. We've come a long way since then and I hope the regular readers of this column share my excitement over future possibilities.

ON-DECK

BY CLIFF GOUDEY

In the Northeast region, we are at a critical time for our fisheries. We have the ability to fish traditional species to exhaustion. In addition, alternatives to groundfish, often requiring small mesh, can put extra pressure on traditional stocks due to bycatch.

Gear selectivity and bycatch reduction have become areas of great interest to those who manage our fisheries. Fishermen had better develop an interest as well.

The Towed Underwater Gear Observation System, or TUGOS, is nearly ready to go to work. The merit of the system lies in its simplicity and the fact that it has a single purpose: gear research. The key part of the system, the underwater vehicle, is finished and has completed most of its sea trials.

The system is a tool to be used cooperatively throughout the region. It will allow fishermen, gear researchers, and fisheries managers to work together towards establishing a better understanding of the fishing process and solve specific gear-related problems.

As shown in Figure 1, the cylindrical pressure housing of the TUGOS is nestled under the delta-shaped wings. Maneuvering is accomplished through trailing-edge ailerons; working together, they vary the vehicle's angle of attack and therefore its depth. Working differentially, the ailerons control vehicle roll which allows it to move across the width of the trawl or dredge.

Viewing is from two pan-and-tilt cameras facing fore and aft within hemispherical domes. To protect the pressure housing and camera domes, a skid assembly has been included which doubles as a location for lead ballast and lighting.

The compact size and non-snagging shape of the TUGOS vehicle is revealed in Figures 2 and 3. These diagrams also show the angles of view provided by the two cameras and the protective guards which run from the forward tip of each skid up to the nose.

Electrical power is provided to the vehicle through the 9/16" diameter tow cable which has one 75 ohm coax for the TV signal and fourteen #26 copper conductors. Most of the vehicle power requirements are attributable to lighting. Power for the onboard electronics, video cameras, pan and tilt motors, and the aileron actuators pass through the vehicle power chassis where operator control signals regulate the current distribution.

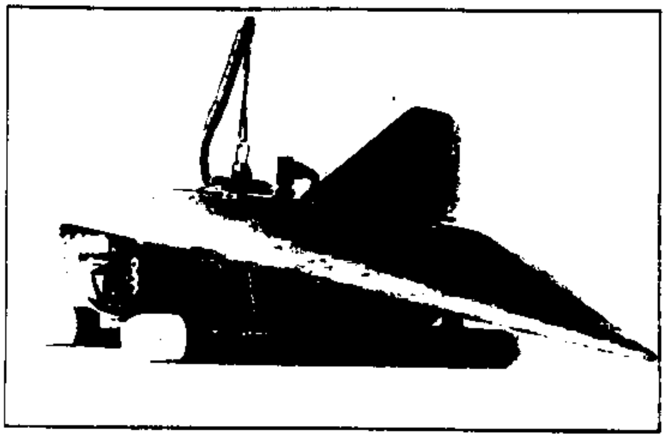

Figure 1. The TUGOS vehicle.

The vehicle is controlled by two joy-sticks, one to maneuver the vehicle and one to aim the video camera. A switch selects between the forward- or rear-looking camera. In addition to the video signal, data on the performance of the vehicle is also sent to the surface. Vehicle-mounted sensors include pitch, roll, magnetic heading, depth, altitude, and speed.

Many of the planned applications of TUGOS involve studying only the mechanical performance of gear. For this work, vehicle lighting can allow the use of conventional color cameras.

In the future, when research includes the observation of fish as they react to the approaching gear, no artificial lighting can be used without risk of effecting behavior. A low-light black & white camera is planned which will allow viewing in the near darkness of fishing depths.

The small size and ease of handling of the TUGOS vehicle allows it to be used from the smallest of commercial fishing vessels. With no ballast, its ondeck weight is around 120 pounds and its submerged weight is 30 pounds. For this reason, hand tending of the tether is an option, especially when the vehicle is rigged with minimum ballast and when the vessel can slow for retrival.

For deployments where powered tether handling is required, an electric-powered line hauler will provide for console-controlled tether adjustment. The power block will be an Electra-Dyne 12-volt unit,

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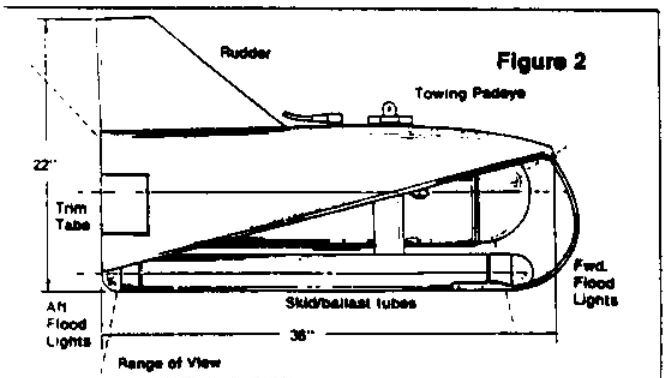

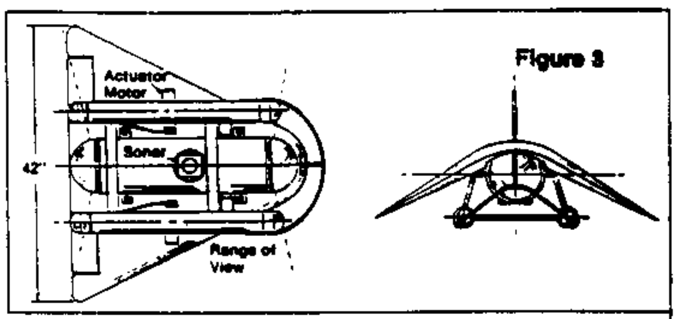

Figure 2. A side view with the forward crash frame installed.
Figure 3. Underside and front views of the TUGOS vehicle.

modified to handle the tether. In the future, a winch system is planned for use on vessels with sufficient deck space and for projects of longer duration.

Over the next year, there are important fisheries research and gear development efforts being planned in which the TUGOS will play a critical role. Some topics that have already been identified are shrimp separator trawls, selective whiting trawls, improved scallop dredges, and the study of the impact of trawls on lobsters.

None of these topics is without controversy. However, through direct observations of gear performance and fish behavior under true commercial conditions, we can resolve issues using fact rather than prejudiced speculation. Most importantly, we can have recorded visual evidence for all to see.

In addition to specific development projects, a more general program of trawl observations is planned. An essential part of all this work will be the participation of industry. Meaningful research requires observations under true commercial conditions. This means commercial boats, commercial gear, and fishermen cooperation. I am confident that for many fishermen the opportunity to see their own gear in operation will be sufficient incentive for this kind of cooperation.

The TUGOS will be operated and maintained by the Center for Fisheries Engineering Research. We hope to get financial support to make it available, without cost to deserving projects within the Northeast. We also hope to receive the funds necessary to upgrade the system.

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