

Research Summary on **HOVERCRAN** *Hovering Pulse Trawl for a Selective Crangon Fishery*



Authors: Bart Verschueren, Hans Polet



**Institute for Agricultural and Fisheries
Research**
Unit: Animal Sciences, Fisheries

Ankerstraat 1
B-8400 Ostend, Belgium
Tel.: +32 59 34 22 50
Fax: +32 59 33 06 29
www.ilvo.vlaanderen.be

Section Technical Fisheries Research

Fernand Delanghe (Technology)
fernand.delanghe@ilvo.vlaanderen.be

Jochen Depestele (Ecology)
jochen.depestele@ilvo.vlaanderen.be

Hans Polet (Coordinator)
hans.polet@ilvo.vlaanderen.be

Hendrik Stouten (Economics)
hendrik.stouten@ilvo.vlaanderen.be

Kris Van Craeynest (Technology)
kris.vancraeynest@ilvo.vlaanderen.be

Els Vanderperren (Technology)
els.vanderperren@ilvo.vlaanderen.be

Johny Vanhee (Technology)
johny.vanhee@ilvo.vlaanderen.be

Dirk Verhaeghe (Technology)
dirk.verhaeghe@ilvo.vlaanderen.be

Bart Verschueren (Technology)
bart.verschueren@ilvo.vlaanderen.be

Technicians

Eddy Buyvoets
eddy.buyvoets@ilvo.vlaanderen.be

Norbert Van Craeynest
norbert.vancraeynest@ilvo.vlaanderen.be

Christian Vanden Berghe
christian.vandenbergh@ilvo.vlaanderen.be

Kevin Vanhalst
kevin.vanhalst@ilvo.vlaanderen.be



Research Summary on HOVERCRAN

'Hovering Pulse Trawl for a selective Crangon Fishery'

Authors: Bart Verschueren, Hans Polet

Partners: VVW / Marelec NV / Ghent University

'Research Summary on HOVERCRAN, Hovering Pulse Trawl for a Selective Crangon Fishery' is a brief summary on the ongoing research on electric fishing for brown shrimp. This research focuses on the development and evaluation of a new type of shrimp beam trawl that reduces discards and environmental impact in the brown shrimp fishery.

This document is meant as a condensed overview on the goals, methods, current status and preliminary results of the research.

An annex comprises a fact sheet on the WWF International Smart Gear Competition, 2009. The HOVERCRAN research team succeeded in winning the Runner-up price.

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Background

The brown shrimp (*Crangon crangon*) fishery is a widespread human activity in the coastal zones of the North Sea. The popularity of the brown shrimp as a delicacy makes this fishery and its related food processing industry of great commercial importance. The fishery itself is carried out by an international fishing fleet of approximately 600 vessels (figure 1), operating mainly off the coasts of Denmark, Germany, The Netherlands, Belgium and the east of England. Total landings can mount up to 35,000 tons a year.

The discarding practices associated with the brown shrimp fishery have been regarded as a problem for many years. The poor selectivity of the small meshed nets produces very high amounts of unwanted by-catch. The fact that the fishery itself is carried out in vulnerable areas like coastal zones and estuaries, often important nurseries for a wide range of marine species, intensifies this problem. Especially the by-catch of young flatfish, like sole and plaice has a significant influence on the commercial fish stocks. An additional problem facing the fishery is the bottom contact caused by the heavy bobbin rope (figure 1) used to startle the shrimp.



Figure 1: Left: Traditional brown shrimp beam trawler; Right: Traditional beam trawl with heavy bobbin rope

Current technical modifications for by-catch reduction in the *Crangon* fishery, like sieve nets, focus on catch separation or filtering after species have entered the trawl. Damage incurred by contact, or stress caused during the capture and escape process may lead to higher discard and escapee mortality. Sieve nets are satisfactory effective at reducing by-catch of relatively large fish of all species, but less so at reducing 0 group plaice and sole, which make up a large fraction of the by-catch. Because of these drawbacks alternative measures are needed.

Basic principle

The HOVERCRAN, a modified 8m shrimp beam trawl, aims at stricter selectivity and reduced seabed contact. The fundamental idea (figures 2 & 3) is to replace the heavy bobbin rope with 12 lightweight electrodes, in order to use electrical pulsation as a stimulation alternative. Prior research by ILVO showed that the use of a specific electric field close to the sea floor induces a startle response in shrimp, meanwhile not affecting

most of the other benthic species. The elevated footrope lets non-target species escape underneath the trawl and collects the shrimp that jump up into the water column. Herein lays the selective fishing potential of this alternative technique. In addition, exposure and survival experiments, carried out in cooperation with the Ghent University, have shown that the use of these pulses, low in frequency, voltage and pulse duration has no significant effects on fish and invertebrate species (see annex 1).

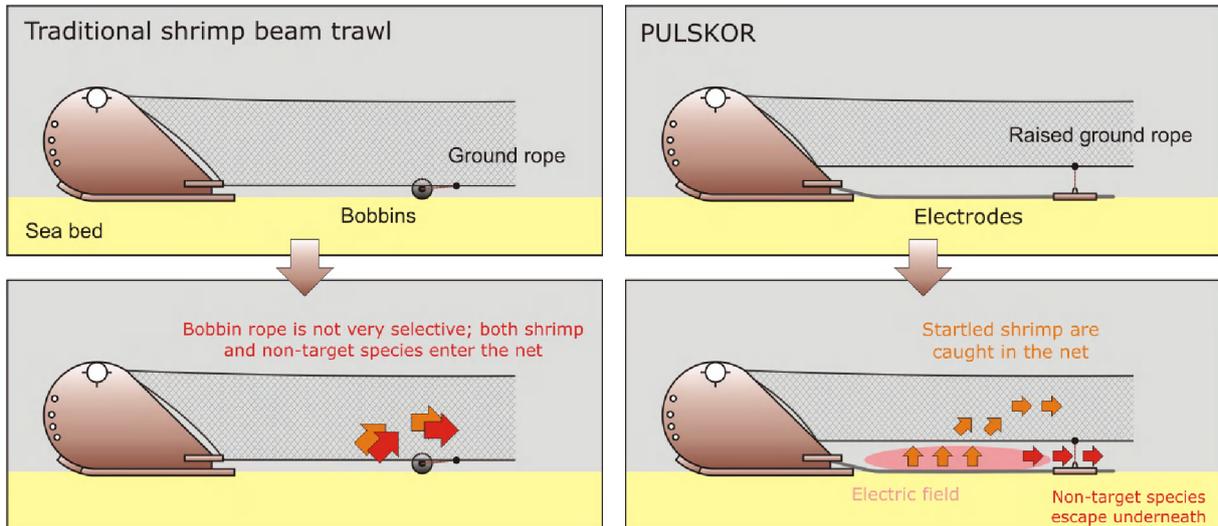


Figure 2: Schematic side view illustrating the basic principle of the HOVERCRAN (right) in comparison with the traditional catching technique (left); the bobbin rope has been replaced with electrodes, generating a specific electric field

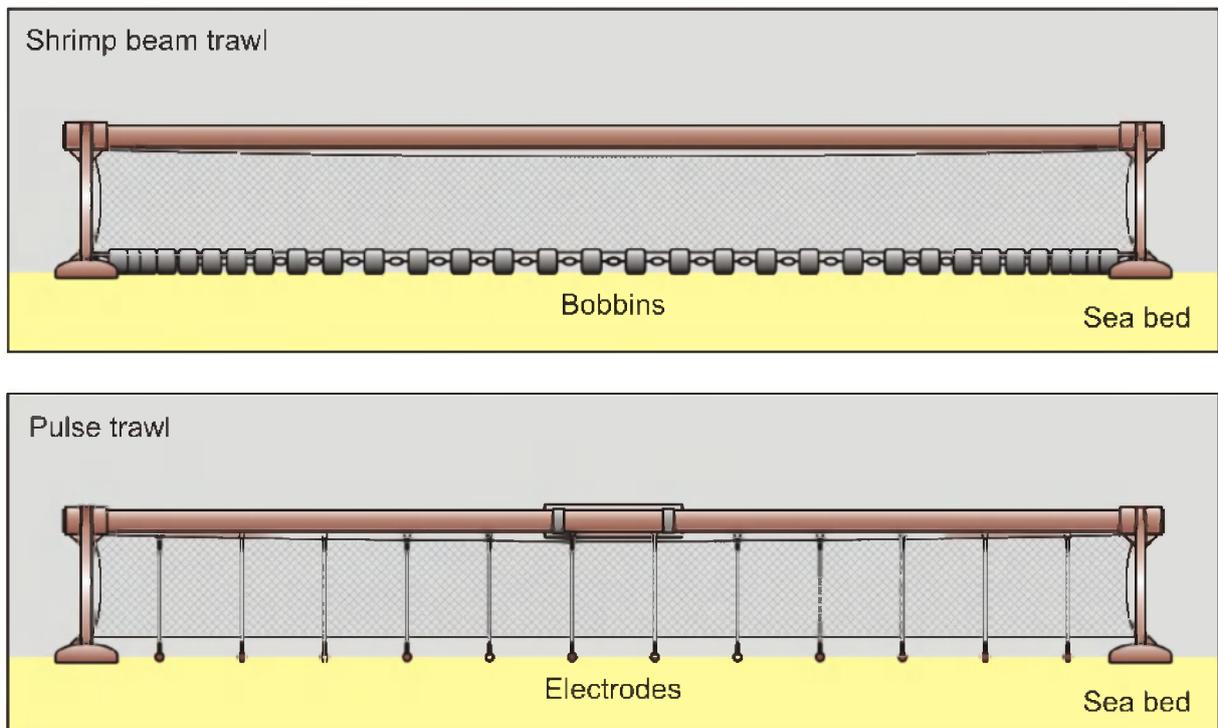


Figure 3: Schematic front views of the traditional shrimp trawl (above) with its bobbin rope touching the sea bed intensively and the HOVERCRAN (below), with only 12 lightweight electrodes touching the seafloor

Innovation

Experiments with electricity in fisheries have been carried out in the past in many areas in the world. Research on the application of electric fields in shrimp trawling already started in the late 1960s. In that period, electro trawls for brown shrimp were tested in Belgium, Germany, the Netherlands and the United Kingdom and most of the work pointed at good prospects for this type of fishery. Research continued into the 1980s but then stopped almost simultaneously in all North Sea countries. This was mainly caused by a Dutch ban on electric fishing driven by the fear of overfishing. In other parts of the world, however, interest in the fishing method persisted. The main objective of the experimental work usually was to reduce fuel consumption and to increase the commercial catches with no attention to selectivity.

The innovative idea to use electric pulses as a means to develop a species selective electro trawl for the brown shrimp fishery was first suggested at ILVO, back in the late 1990's. The basic idea is to invoke selectively a startle response for shrimp with electric ticklers and to allow non-reacting species to escape underneath a raised ground rope. The ILVO Fishing Gear Technology Section aimed at the construction of a new type of shrimp trawl that:

- improves species and length selection,
- reduces discards,
- reduces the impact of shrimp trawling on the environment and
- improves the quality of the commercial catches.

The challenge of this research was to define a specific electro pulse that induces a maximum startle response in brown shrimp, leaving other benthic organisms unaffected at the seafloor. Thorough analysis of the brown shrimp tail flip movement (figure 5) in different electric fields ultimately led to defining the ideal pulse parameters. A half-sine square pulse with a frequency of 4.5Hz and a pulse duration of 0.25ms, inducing an electric field strength of approximately 30V/m between thread-shaped electrodes (placed at 60cm from each other) gives the best result to startle brown shrimps (figure 4). Despite of the high conductivity of seawater ($> 50.000 \mu\text{S}/\text{cm}$), the low frequency and very short pulse duration make a very low energy input (1kWh for a single trawl) possible.

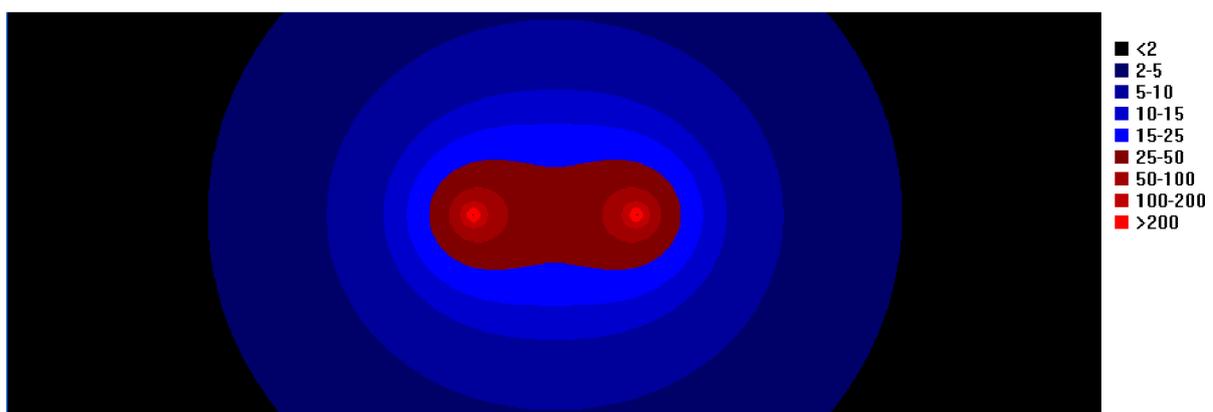


Figure 4: Simulation of the electric field strength around a pair of electrodes at a distance of 60cm from each other. The electric field strength is approximately 30V/m between the two thread-shaped electrodes

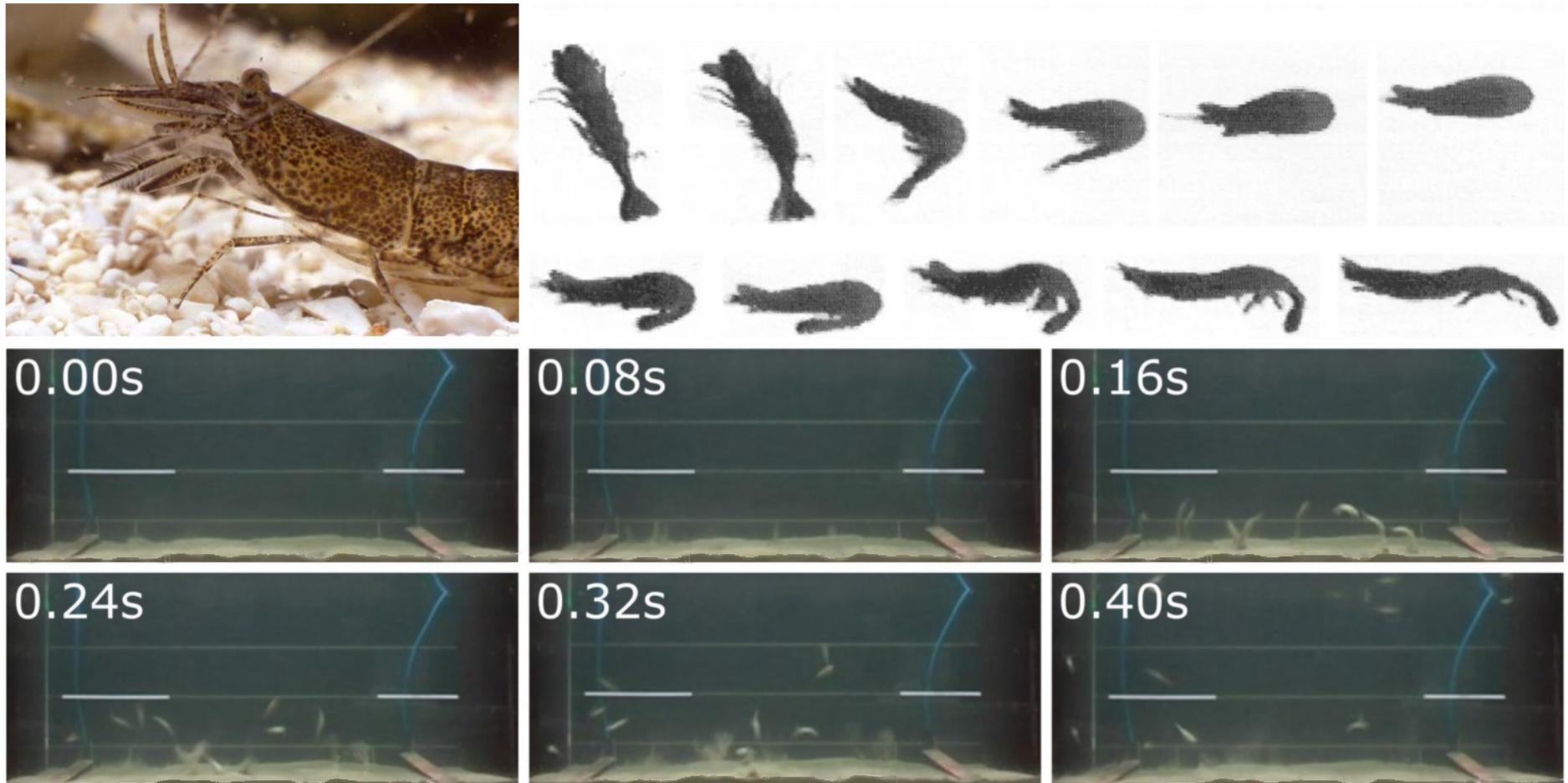


Figure 5: Top left: Detail of brown shrimp (*Crangon crangon*); Top right: Typical tail flip movement of brown shrimp; Below: Exposing brown shrimps to an electric field in the laboratory, the electric field is switched on after 0.08s, startling the shrimp en forcing them to jump out of the sand

Once these pulse characteristics were determined, they could be implemented in the construction of a suitable pulse generator effective for catching brown shrimp in the North Sea. Unfortunately, due to lack of funding it took several years before ILVO could actually start with the construction of the highly specialized equipment. In 2008 a HOVERCRAN prototype was finally developed and installed on a commercial shrimp cutter, on which extensive testing in commercial conditions now takes place.

Equipment and installation

Generating, implementing and handling the appropriate electric field in sea water requires custom equipment. A single HOVERCRAN system consists of three main components (figure 9 and 10): A pulse generator with 12 electrodes, a winch for hauling and lowering of the supply cable and a control unit to check operation.

The main element of the system is the pulse generator (figure 6) which converts common alternating current (AC; 50Hz and 230V) into low-frequency pulsed direct current (PDC; 4,5Hz; 0,25ms) and transmits it to 12 electrodes in the net. This generator is fed with 230VAC through a supply cable coming from the ship. Power requirement is approximately 1kWh for a single generator. The generator, constructed in pickled high-quality stainless steel, is screwed at a small bracket welded on the beam of the beam trawl. It is sealed and filled with oil to make it pressure resistant and to protect its internal components. It has no moving parts.

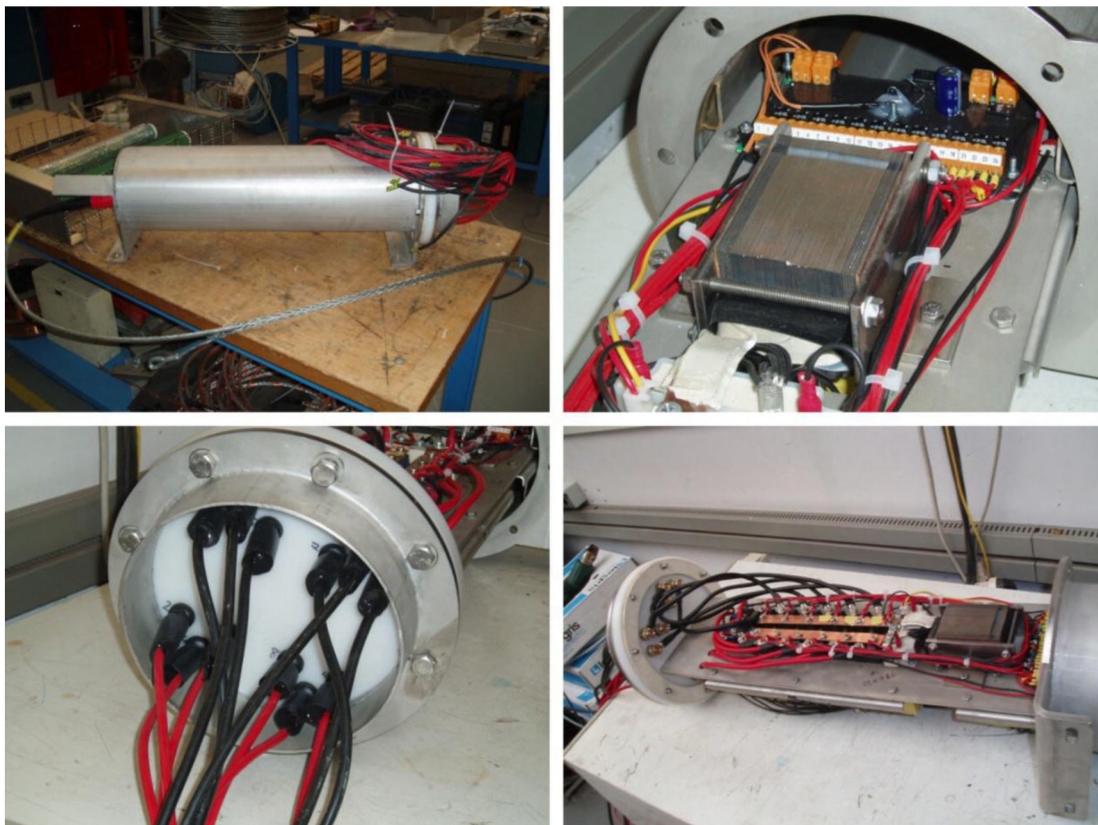


Figure 6: Detailed photographs of the pulse generator showing the stainless steel housing and the internal electronic parts

An electrode set exists of 12 stainless steel cables ($\varnothing 12\text{mm}$, 3m length) with one strand removed and replaced by a 10 mm² copper conductor (figure 10). The 12 electrodes (6 cathodes + 6 anodes) form 11 electrode pairs that are alternately driven by the pulse generator in order to save electrical energy (figure 7). One cycle is completed in 222ms.

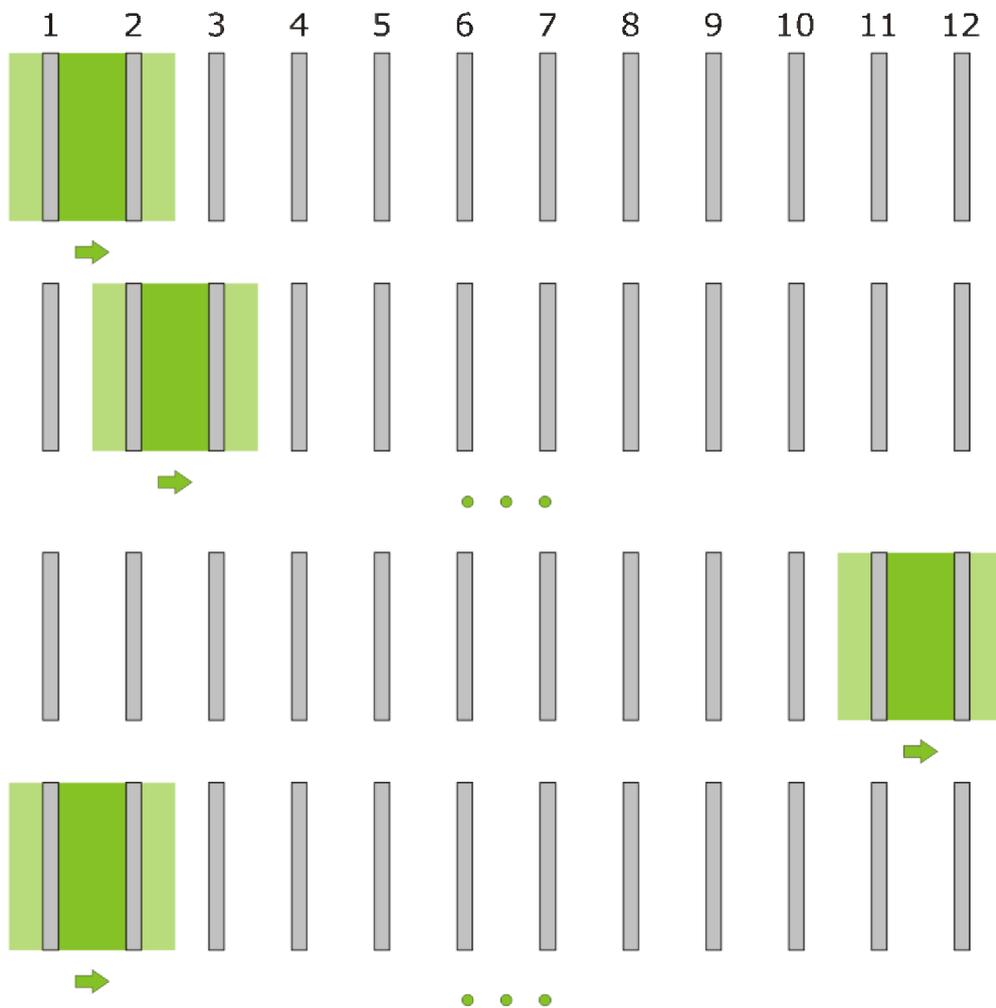


Figure 7: Schematic illustration of the 'chase principle': The 12 electrodes (6 cathodes + 6 anodes) form 11 electrode pairs that are alternately driven by the pulse generator (electric field in green); a cycle is completed in 222ms

Lowering and hauling of the 100 m long supply cable (along with the fishing gear cable) demands a specific winch (figure 8) . This electric winch is mounted at the basis of the outrigger in order to save space. Only one additional conducting pulley block at the top of the outrigger is needed. The winch maintains a constant traction force on the supply cable to prevent it from breaking or wrinkling. The moving parts inside the winch are self-lubricating and come with a lifelong guarantee. The armed SUBCONN® supply cable is especially designed for harsh environments and has a very high tension strength.

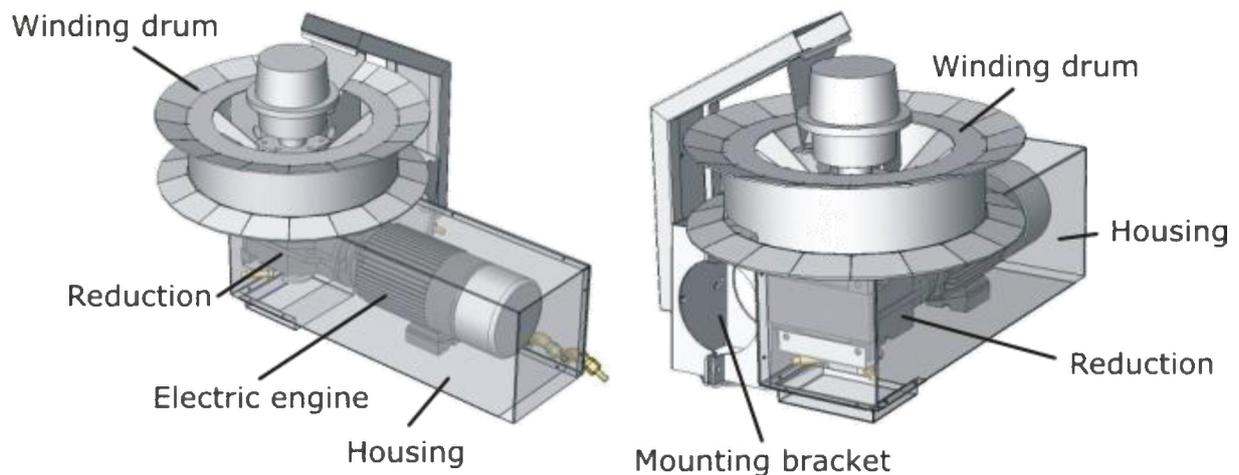


Figure 8: Illustration of the electric cable winch used for hauling and lowering of the supply cable

All equipment was custom built by Marelec NV, a company specialized in marine devices. Electronic schemes were designed in cooperation with Ghent University. All parts are highly seawater resistant and need no maintenance. Only the electrode set needs to be replaced three times a year due to corrosion and wear. A set can be easily made by the fisherman himself and would only cost 200€.

At the moment total production costs are relatively high, given the experimental stage. If the system would be implemented in commercial fisheries, cost price would automatically drop. At the moment modifying an existing beam trawl shrimper with a double (port and starboard gear) prototype system including:

- 2 Pulse generators with 100m supply cable each
- 2 Electric winches
- 1 Control cabinet
- Installation and start-up

would cost approximately 45.000€. It is important to consider that the existing beam trawl serves as a basis for the electrical gear. Netting and beam trawl are identical. Bobbin ropes are no longer needed and deliver a profit of approximately 6000€.

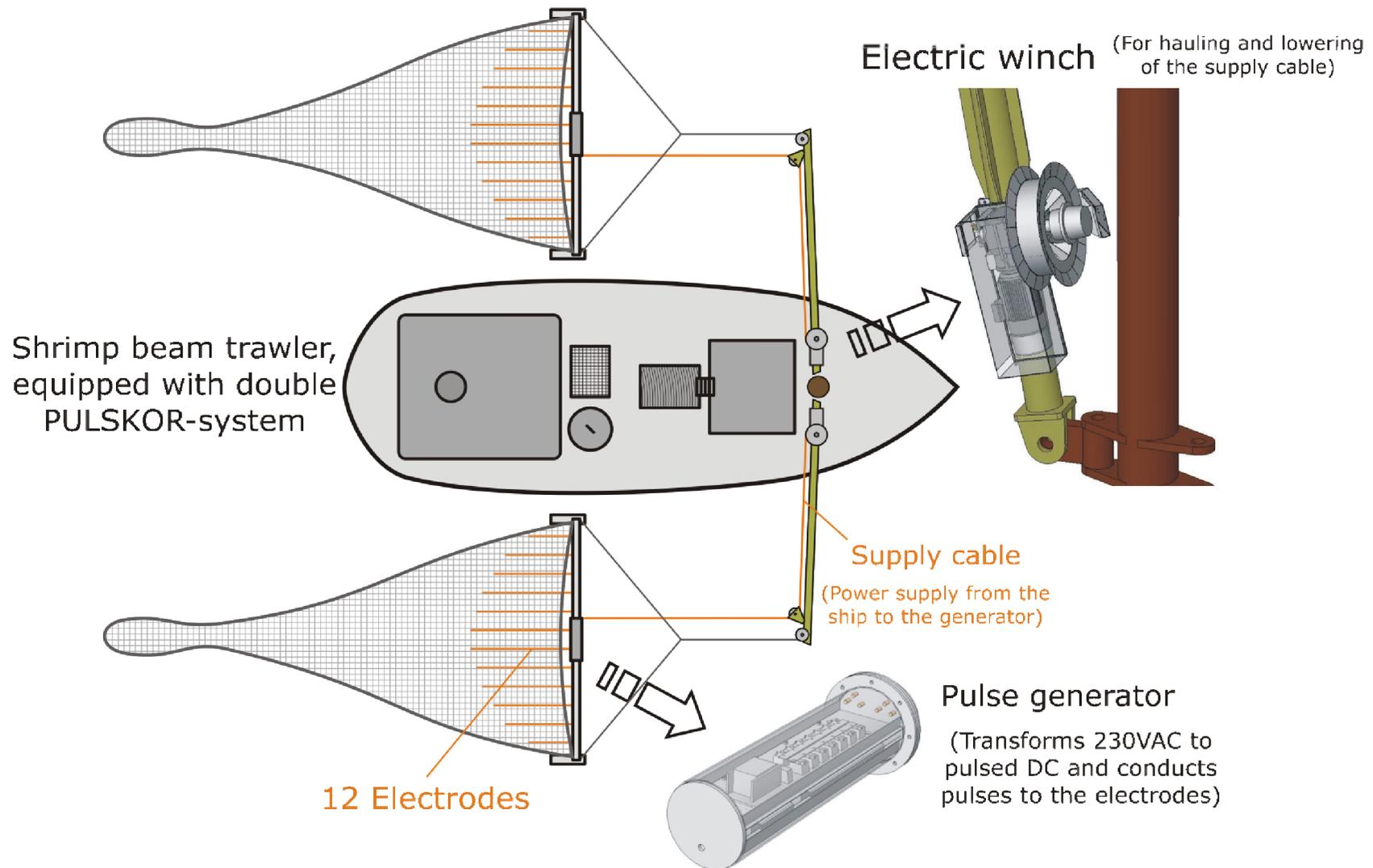


Figure 9: Schematic illustration of a shrimp beam trawler equipped with a complete (double) HOVERCRAN system; the main components are: The pulse generator (mounted on the beam); the electric winch with the supply cable (mounted on the base of the outrigger) and the electrodes in the lengthwise direction of the net



Figure 10: Detailed photographs of the installed HOVERCRAN system. Top left: Electric winch; top middle: Deck infrastructure; top right: Additional pulley block guiding the supply cable; Below left: control cabinet; Below middle: the adapted shrimp beam trawl; below right: Electrodes

Test results

Preservation of the commercial catches and the reduction of discards and seabed contact are the decisive criteria in the evaluation of the HOVERCRAN. Extensive testing of the prototype on a commercial shrimp cutter, by direct catch comparison with a standard shrimp trawl, revealed important and hopeful results (figure 11). First and foremost could be shown that at least as much shrimp can be caught with the new technique in comparison with the traditional gear. An important remark hereby is that the catch efficiency of the HOVERCRAN seems less influenced by the fishing conditions. Different hauls during daytime, night time, in clear or turbid water, in good and bad weather conditions produced relatively constant catches, while the traditional gear showed rather diverse catch results.

On top of that, an average by-catch reduction of 35% in volume is a major step forward in the discard issue of the brown shrimp fishery. The results show that the raised ground rope plays an essential role in separating shrimp from unwanted by-catch. The higher the footrope is placed, the more by-catch is reduced. As a consequence also more shrimp tend to escape beneath the ground rope. Therefore the ideal footrope height should be a trade-off between acceptable shrimp catches and sufficient by-catch reduction.

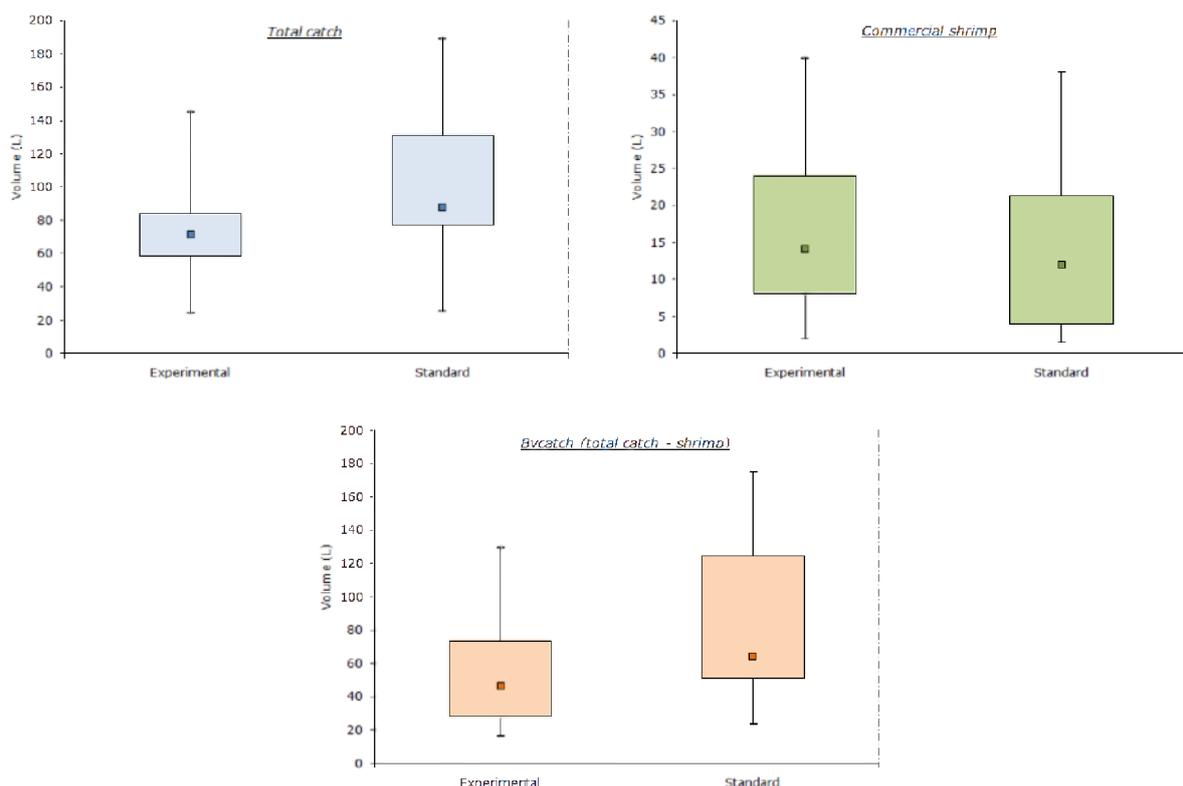


Figure 11: Box plots comparing catch volumes of pulse trawl (experimental) and standard shrimp trawl; substantial reduction of by-catch (below) leads to smaller total experimental catches (left), while experimental commercial shrimp catches slightly exceed the standard catches (right)

It should, however, be borne in mind that the sea trials only covered a relatively short time range of 6 months in summer and autumn and only took place in Belgian waters.

For this reason, it is recommended to elaborate the research. An extensive range of sea trials on commercial vessels in different conditions and fishing grounds should precede commercial application.

Reduction of bottom contact by 75% (figure 12) is a radical change in the environmental impact issue. Opinions on the effects of the bottom contact on the seafloor and its associated organisms differ a lot. Avoiding bottom contact in the brown shrimp fishery makes the discussion redundant.

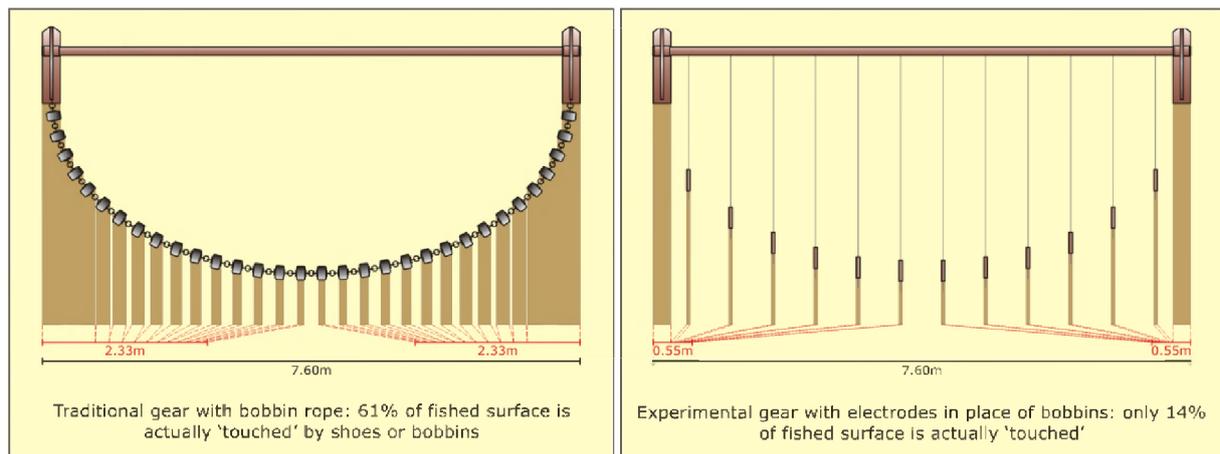


Figure 12: Schematic top view of a traditional shrimp beam trawl (left) and HOVERCRAN (right) (netting is not drawn), illustrating the reduction of seafloor contact with 75%

Profitable fishing

The basic principles of HOVERCRAN are: simplicity, robustness en cheap design. It is an important advantage that the existing shrimp fishing gear can serve as a basis for the construction of the HOVERCRAN. The additional system components can be placed upon the available gear without making radical changes to the existing infrastructure.

Implication of the HOVERCRAN does not influence the current way of fishing in a practical way. The basic operations that are already run by the shrimp fishermen remain unchanged. The treatment time also stays the same. Preparing of the gear is done in a similar way as it is today with traditional gear. Before every haul a superficial visual inspection of the electrode system is recommended. Fishing itself happens in exactly the same way: the towing speed, tow duration and choice of location remain the same. A control cabinet in the wheelhouse allows for checking whether the system is functioning properly on the seabed during fishing. The system operates fully automatically. It switches on when the gear is under water and at a safe distance from the ship. Conversely, the system automatically switches off during hauling when the gear reaches a certain distance from the ship. This automatic control prevents human errors to occur, which guarantees safety of the crew. The crew cannot come into contact with electrically charged components. At the end of the haul, the cod end is retrieved and emptied in the same manner.

Due to the by-catch reduction, total catch volume in the cod end is smaller with the electrical gear. As a result commercial catches are pure (figure 13) and lead to a shortened sieving process. This improves catch quality and relieves the workload of the crew significantly.



Figure 13: Photograph of an almost pure brown shrimp HOVERCRAN catch

An additional advantage is that the technique varies little with the moment of fishing. Traditionally Brown shrimp are fished upon during the night or in daylight when the water is turbid. Apparently shrimp hide deeper in the sediment when visible to predators. The deeper shrimp burrow in the sediment the more difficult it becomes to catch them with the traditional bobbin rope. Experimental testing has shown that the electrical gear is far less dependent on the behaviour of the shrimp. Whether the shrimp are foraging on the sea bed or hiding deeper in the sediment, catch volumes stay relatively constant comparing to the traditional gear. This could offer more flexibility to the shrimp fishermen in choosing fishing time and fishing grounds. This may also reduce workload for the crew and contribute to better social conditions.

Recently the brown shrimp fishery got confronted with MSC certification. More and more retailers turn exclusively to the sale of fish from certified fisheries. To obtain such a certificate a fishery has to prove its sustainability and has to meet certain environmental standards. At the moment the issues mentioned above make it difficult for the brown shrimp fishery to request for an ecological label. A label however could improve the competitive position and the image of this important fishery, and therefore could preserve the existence of several involved companies. Consequently the implementation of adequate selectivity enhancing and bottom impact reducing measures could result in both ecological and commercial improvements. It is hard to predict if an ecological label leads to higher prices. But what is certain is that such a label will certainly ensure adequate market outlet. Implementing the HOVERCRAN-system could without any doubt expand the chances of acquiring such a label for the brown shrimp fishery.

Annex

Factsheet:

***International WWF Smart Gear
Competition 2009***

***Runner-up price winner:
The HOVERCRAN***



2009 Runner-up: The HOVERCRAN

Institute for Agricultural and Fisheries Research Wins \$10,000 with Innovative Fishing Method

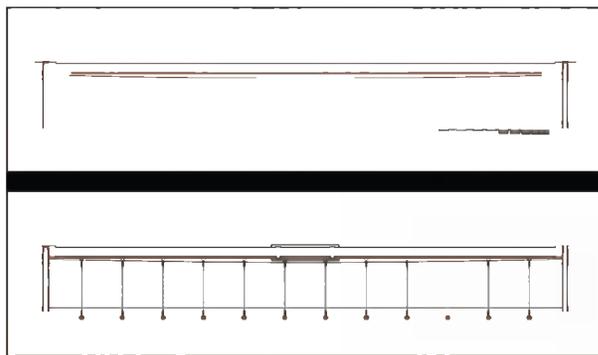
The 2009 International Smart Gear Competition awarded one of only two runner-up prizes to a team at the Institute for Agricultural and Fisheries Research (ILVO) in Belgium. The team took the \$10,000 prize for their innovation of the HOVERCRAN, a fishing device that improves commercial catch quality and lessens seabed damage in the brown shrimp fishery.

The brown shrimp (*Crangon crangon*) fishery is widespread in the coastal zones of the North Sea. Inherent in the equipment used are two major problems:

(1) the small meshed nets have poor selectivity, resulting in large amounts of bycatch, and (2) the heavy bobbin rope used to startle the shrimp into the net wreaks havoc on the seabed.

The winning team built the HOVERCRAN (HOVERing pulse trawl for selective CRANgon fishery) with these basic principles in mind: simplicity, robustness,

durability and cheap design. The device is a modified 8-meter shrimp beam trawl, in which the heavy bobbin rope has been replaced with 12 lightweight electrodes. A harmless, low-intensity electric field close to the seafloor selectively provokes a startle response in brown shrimp. The



Schematic front views of the traditional shrimp trawl (top) with its bobbin rope touching the sea bed, and of the HOVERCRAN (pulse trawl) with only its 12 lightweight electrodes touching the sea bed.

elevated footrope lets nontarget species escape underneath the hovering trawl and collects the shrimp that jump up into the water column. This technique reduces bycatch volume by 35 percent and decreases seafloor contact by 75 percent. It has implications for a large number of shrimp fisheries around the world where bycatch is the biggest issue the industry faces.

The challenge of this research was to design and integrate specific equipment capable of creating an electro-pulse that induces a maximum response in the shrimp only. Equipment needed included a pulse generator, a winch for hauling and lowering the supply cable, and a control unit to check operation.

That the existing shrimp fishing gear can serve as the basis for the construction of the HOVERCRAN is an important advantage. The additional system components can be placed on the available gear without making radical changes to the existing infrastructure. This means that HOVERCRAN does not negatively influence the current way of fishing. The towing speed, tow duration and choice of location remain the same. But with HOVERCRAN's automatic controls in place to prevent human errors, the crews are safer and work time between hauls is shorter due to less bycatch.



An almost-pure brown shrimp catch made with the HOVERCRAN.

“Current technical modifications for bycatch reduction in the *Crangon* fishery focus on catch separation or filtering after species have entered the trawl. Damage incurred by contact, or stress caused during the capture and escape process, may lead to higher mortality of bycatch. HOVERCRAN can play an essential role in reducing these discards through an alternative startling method that succeeds in catching bottom-dwelling shrimp without touching the seafloor.”

Hans Polet
HOVERCRAN lead researcher
ILVO Fishing Gear Technology Section

“More and more retailers turn exclusively to the sale of fish from certified fisheries that are sustainable and meet certain environmental standards. At the moment, discard and bottom-contact issues make it difficult for the brown shrimp fishery to request an ecological label. A label, however, could improve the competitive position and the image of this important fishery, and therefore could preserve the existence of several involved companies. HOVERCRAN can play an essential role in acquiring such a label.”

Bart Verschuere,
HOVERCRAN research coordinator
ILVO Fishing Gear Technology Section



Components of the HOVERCRAN system include (l to r) the electric winch, the adapted beam trawl, and the control cabinet.

Benefits to Fishermen and Oceans

- Catches at least as much shrimp as traditional gear does
- Improves species selectivity of brown shrimp fishery
- Reduces bycatch discards by 35 percent in volume
- Reduces seabed contact by 75 percent
- Improves commercial catch quality
- Delivers relatively constant catch efficiency under varying fishing conditions
- Creates prospect of obtaining a sustainability label
- Offers basic features of simplicity, robustness, durability and cheap design

The ILVO - Fishing Gear Technology Section: 2009 Runner-up

The Institute for Agricultural and Fisheries Research (ILVO) - Fishing Gear Technology Section is a dynamic group of 13 motivated people with different backgrounds and skills. The primary objective of the group is the development of sustainable fisheries from a technical perspective, and particularly via applied fishing methods.

The HOVERCRAN team consists of

- Hans Polet, engineer. Leader of the Fishing Gear Technology Section and initiator of the HOVERCRAN research, Polet launched the innovative idea to use electric pulses as a means to develop a species-selective electro-trawl for the brown shrimp fishery.
- Bart Verschueren, biologist with technical experience. Coordinator of the HOVERCRAN research.
- Fernand Delanghe, electrical engineer. More than 35 years of experience in fisheries research.
- Norbert Van Craeynest, technician. Ex-fisherman with lifelong experience in all kinds of fisheries.
- Eddy Buyvoets, technician. Expert knowledge of net construction.
- Manfred Van Elslande, ex-shrimp fisherman. With his lifelong experience in the Belgian coast *Crangon* fishery, he was skipper on the HOVERCRAN testing vessel.

Mike Osmond
WWF California Marine Office
171 Forest Avenue
Palo Alto, CA 94301

smartgear.org
smartgear@smartgear.org

650-323-3506



