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by

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APPLICATION OF ENERGY-SAVING CONCEPTS IN DUTCH FISHING CUTTER DESIGN AND OPERATION

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ABSTRACT

A review of energy-savings achieved on numerous vessels built after the world oil crisis of the mid 1970's is given and compared with applications in Dutch fishing vessel design and operation, in particular for flatfish beam trawlers, a highly overpowered small to medium sized vessel.
With reference to the main features and design requirements of this specific type of fishing boat the already applied energy-saving concepts will be discussed, like matching of engine, propeller and hull characteristics.
A brief comparison (dimensions, coefficients) between two representative beam trawlers, built in the seventies and eighties, confirms the fuel saving potentials.
The rapidly changing circumstances in Dutch beam trawling stress the need for a further reduction of the exploitation costs, for which design guidelines are included.

CONTENTS

1. INTRODUCTION

Since the two world oil crisis in the mid 1970's various energy-saving concepts have been developed for new building and existing vessels. Firstly the concepts were tested for and applied on the larger merchant vessels in deepsea trading and navy ships followed by the more specialised vessels in all areas of shipping and offshore industries, also including the smaller fishing vessels.

The scope of this paper is to investigate which energy-saving concepts have been applied (or still can be) on the Dutch fishing cutters, especially the major group of beam trawlers or so-called beamers. This vessel type has been developed, built and successfully operated in Holland in great numbers and with strongly increased main dimensions in the recent years.

Before discussing the applied concepts, it is necessary featuring this specific fishing vessel with her design requirements and to review the general accepted and mostly applied energy-saving possibilities for a fuel efficient ship.
By means of two representative cutters, of which one is built in the mid 1970's and the other one in the mid 1980's, a brief comparison is made with regard to the applied concepts.

Finally some concluding remarks and suggestions are given because of the present-day changing fisheries circumstances, such as the increased and future governmental regulations (quotas, licences, laying-up weeks, limited beam lenghts) and the more distant water alternative fishing grounds (travelling time).
Nowadays the necessity for a fuel efficient fishing cutter with reduced exploitation costs is more needed than ever before.

2. THE DUTCH FISHING CUTTERS

General

The Dutch fishing cutters can be featured as a smaller up-to medium sized fishing vessel suitable for beam trawling and/or bottom trawling and/or pair trawling, mainly fishing in near waters and for the North Sea species flatfish (plaice, sole), roundfish (cod), herring and shrimps.
About 80% of the present-day cutterfleet is a beam trawler, while the remaining 20% are almost all multi-purposed designed.
At the moment the Dutch cutterfleet consists of about 500 vessels, usually divided in an installed horse power range (Table 1).
Last year some newbuildings with 2200 kW (3000 hp) and even 3200 kW (4400 hp) installed horse power joined the Dutch cutterfleet.
The last twenty years the beam trawlers have commercially become the most important sector of the Dutch North Sea fisheries (in number: 500, employment: 3000 and landed fish: Dfl. 800.000.000,-). Besides an other Dutch commercial successfully built and operated fishing vessel type is the larger deepfreeze stern trawler with ship lenghts up-to 100 metres and installed

horse powers of 4400 kW (6000 hp). A totally different fishing vessel type from the cutters, mainly fishing for roundfish (herring, mackerel) in the North Sea and distant waters.
Because these vessels are quite similar to the larger merchant vessels, all kind of successfully applied energy-saving concepts have already been incorporated in the design and operation and will therefore not be included in this paper.

Layout/installations/equipment

As the major part of the Dutch cutterfleet consits of beam trawlers, the cutters will be featured on the basis of the two representative beam trawlers (Table 2).
In annex 1 (General Arrangement) and annex 2 (Beam trawling) it can be seen that the applied fishing method dictates the general arrangement to a great extent. All existing flatfish beam trawlers are towing two trawl nets by means of booms (outriggers) perpendicular to the shipsides and supported by a heavy gantry mast on the foreship.
The characteristic construction is a single deck hull with design trim and extended forecastle and aftward the superstructure with the crew's accommodation, wheelhouse and winchroom. The accommodation comprises cabins, washroom, shower, toilet, galley and messroom for a complement of 4 - 7 persons. Below the maindeck the hull is often subdivided in:

- forepeak (chainlocker, bowthruster)
- auxiliary engine-room (harbourset, oil- and freshwater bunkers, netstore)
- fish hold (insulated, crush ice machine, ice and fish box storage, oil bunker below)
- net store (oil bunkers below)
- main engine-room (medium speed diesel engines, reverse/reduction gear, generators, refrigerating plant)
- aftpeak (steering gear, nozzled propeller below)

As usual the forecastle runs well aft to form a large sprayhood protecting the fishermen working on the maindeck.
Below this sprayhood are the stainless steel fish sorting, stripping and washing machinery, to which the fish is transported by means of a conveyer belt, out of the fish dumping pound in the forward main deck.
Over the shipsides the catch is dumped into this pound. To which extent the above mentioned fish processing equipment is fitted depends on the skipper-owner and stability requirements (Dutch Shipping Inspectorate).
The midship section of the maindeck is a large teakwood covered deck area for fish gear handling and storage after fishing.
The trawl winch is installed in the winch room in the forward part of the superstructure and with fishing line openings in the front bulkhead.
The number of openings is depending on the winch type, mostly with 6 or 8 drums. Sometimes also a netdrum is fitted on the aft maindeck for pair trawling.

The wheelhouse is characteristic for this type of fishing vessel: spacious with good visibility on the working deck and horizon, sophisticated navigational aids, electronic fish finding systems and communication equipment. The engines, generators and trawl winch are bridge-controlled in front- and side panels, between which the skipper has a central position.

In the engine-room a main propulsion diesel engine (medium speed) is installed, which drives coupled to a reverse and reduction gear a fixed pitch nozzled propeller.
The electrical installation of beam trawlers consists of two ship's mains, a continious current (110 V/dc.) and three-phase current (220V/380V/ac), with a 24 V/dc emergency installation. The d.c.-main supplies electricity to the fish winch and bow-thruster, while the a.c.-main is indispensable for the auxiliary machineries of the propulsion plant and for the ship's safety. Both mains are generated independently, either diesel auxiliary engine driven (high speed) and/or diesel main engine driven (power take offs).
Because of the applied fishing method (week fishery of about 100 hours with about every 2 hours hauling) the diesel engines are running continuously with varying loads (range: 10-100%).
Depending on the choice of fuel operation (gas oil - heavy fuels), more or less oil treatment equipment is installed.

The refrigerating equipment is for maintaining a fishhold temperature of $-2^{o}C$ and making crush or flake ice for storing the flatfish in the fish boxes.

Design process and requirements

The starting points for a fuel-efficient cutter design are

> "minimum installed horse power for the applied fishing method(s), fishing grounds and catch capacity with an optimum electrical installation".

More than twenty years of flatfish beam trawling have been resulted in a very effective fishing method, but still enormously energy-absorbing; the resistance of the bottom trawled fishing gear is here decisive while the hull resistance is neglectable at the fishing speed (< 5-10% the total resistance, see also Annex 3).
Because the fishing grounds are usually not far offshore, the service speed is up to now of minor importance as design requirement for this type of vessel, even the Froude-numbers (speed/ length coefficient) are showing a heavily overpowered ship at the service speed.

As in the Dutch beam trawling sector a fishing company with more than 3 cutters is an exception, a company-orientated design approach is absent. Every skipper/-owner prefers and trusts his own shipyard and designer, to which extensive building specifications are hardly made.

Besides many yards are Engineering Works with all kind of subcontractors for the steel hull up to complete installations and are also shiprepair yards with 24 hours services.
Once a good cutter design is built, many newbuildings followed with skippers/-owners required adjustments and with often increased main dimensions.
So the design process, requirements and building are unique for this type of fishing vessel.

When the skipper with his own fishing ground preferences has an idea about the required ship's main dimensions, he and/or the designer can laid down the ultimate beam trawl dimensions and total weight. Often the skipper has also his expectations of the needed shaft horse power.
With these owners requirements the designer starts the further design taking into account the rules and regulations of the Netherlands Shipping Inspectorate for sea going fishing cutters and to-day also the governmental (operational) restrictions.
In Table 3 the above mentioned design requirements are summarized.

3. ENERGY-SAVING CONCEPTS

After the two oil-crisis in the mid 1970's, the designing of a fuel efficient ship was the ever recurring theme of Conferences and numberless publications. When studying these, one can extract the following common main points:

> "Achieving of fuel economy in ship design starts with the choice of the best economic design speed and continues with the minimising of resistance by good design of the lines, achievement of optimum propeller efficiency, the choice of a main engine with low specific fuel consumption, using cheap fuel oils and the best possible utilisation of waste heat and generating/distribuation of electricity".

Except an optimum ship design, a fuel efficient ship's operation is also indispensable for the long term fuel economy of the vessel.
This means: best choice of routing, ship's draft and trim, a rational maintenance and condition-/ fuel monitoring of the machineries, regular surveys and overhauls by a well trained crew.
Also regular dry docking is necessary preventing excessive hull fouling and a timely repairing of hull and propeller damages.

Without further discussion, the general accepted and applied energy-saving concepts in ship design, newbuilding and operation are summarized in Table 4.

Naturally the Dutch fishing industry was very alived to incorporate the promising concepts in their vessels, on the one hand by themselves and/or on the other hand in co-operation with the Netherlands Institute for Fishery Investigations - Technical Research Department (NIFI-TD or in Dutch: RIVO-TO). For this the

NIFI-TD made several energy-saving studies which are summarized in Table 5.

4. APPLIED ENERGY-SAVING CONCEPTS

For a specialised vessel like the Dutch fishing cutter, particularly the beam trawlers, the design speed and ship's lines are of minor importance for achieving a fuel efficient ship, because the fishing grounds are nearby and the applied fishing method is such energy-absorbing, that the hull resistance at the fishing speed is totally neglectable. So in the past decade, the designers, skippers/-owners, requirements and NIFI-TD focussed on a good North Sea fishing platform with minimum installed horse power for the chosen fishing gear (dimensions, weight) and catch capacity (ship's dimensions).
In this manner the application of the energy-saving concepts have been concentrated on reducing the fuel consumption at the fishing speed.
Up to now it was still possible to compensate the extra fuel costs (higher bunker prices, larger installed horse powers) by means of a higher productivity, but this elasticity will come to an end owing to the restricted catch possibilities.
In short the Dutch circumstances (designing, owners requirements) to reduce the fuel consumption was either a matter of shipyard competition or individual interests of the skipper-owner.
Still it is worthwhile to discuss the already applied energy-saving concepts in the Dutch fishing cutter design and operation, especially in view of the present-day changing fisheries circumstances, in which a fuel-efficient cutter is much more needed.
This will be done on the basis of the general energy-saving possibilities in Table 4, in which the applied concepts also will be given. At the end of this chapter a brief comparison is made of the two representative cutters trying to confirm these applications (Table 2).

1) VESSEL DESIGN

Hull resistance

Naturally every designer is continuously trying to improve the underwater hull form, especially the hydrodynamical unfavourable lines in case of the Dutch fishing cutters (small lenght-beam ratio (< 4.5) with a high installed h.p.), but with maintaining of the same stability.
Owing to this the afterbody needs always special attention. A bad designed and built afterbody results in a loss of propeller efficiency and adverse vibrations. Incidentally a bulbous bow was introduced and fitted in new designs.

Nevertheless no tank tests were performed in the past decade for a systematic approach of the above mentioned hull form problems, comprehensible in view of the design requirements (Table 3).
Because of the individual character of the cutter fisheries and

the many commercial competitive smaller shipyards, a common data-base with the cutter main features never arose in Holland or it should be the NIFI-TD studies and reports "Optimising fishing cutter design" (Table 5).

In spite of the small resistance improving effects of the hull appendages and a sophisticated hull paint system, even neglectable in view of the beam trawling resistance (Annex 3), the shipyards paid still attention to these energy-saving concepts. At the other hand decreasing of the superstructure air resistance is a concept so far from the common fishing practice, that no one seems to have been involved with this possibility up to now.

Matching of engine, propeller and hull; waste heat recovery

The in a few years strongly increased dimensions and complexity of the Dutch fishing cutter installations and machineries require more pre- and computer aided designing with calculations, particularly for the technical problem of correct matching.
Based on the assumption of a given hull form and required speed, the factors affecting the efficient matching are:

- engine characteristics (torque, rpm, fuel consumption);
- propeller (type, accommodating)
- gear ratio (reverse, reduction, pto)

- Engine

  After the two oil crisis, the marine engine manufactures did a lot of research and developments to decrease the specific fuel consumption of their diesel engines and with success (savings up to 25%), but also to cut the initial price and the operating/ maintenance costs.
  Many of these newly developed engines (medium speed) were installed on board the fishing cutters, or even further developed because of the continously varying load at the applied fishing methods. The latter was also done with the introduction of the medium speed heavy fuel engines for the lower output ranges (1000-2500 kW, 700-3400 hp), to which the fishing world actually forces the engine manufacturers to produce these marine engines. With the heavy fuel engines nett-savings of about 10% can be reached and at the same time the skipper has more choice in burning different fuel oils (prices).
  In this the Dutch government played an important part by raising funds, through which the NIFI-TD was enable to make technical and cost-effect studies. The first study was already done in 1974 with blend oils on board a commercial deepfreeze trawler, but this had no follow up then. Only after the second oil crisis (1978) there was an urgent need for heavy fuels and the NIFI-studies were continued with blend oils, heavy oils (up to 180 cSt) on board six fishing cutters and in the past two years 6 fishing cutters have been accompanied with different medium speed heavy fuel engines. The results were published in NIFI-TD progress reports (Table 5) while the final report will be

published this year. Anticipating this report, the results will also be discussed in a separate paper on this ICES Working Group meeting in Hull (May 1986).
At this moment 4-5% of the Dutch fishing cutterfleet is burning heavy oils (30-180 cSt). There is still a reluctance on the part of many skippers to move away from gasoils because of the potential problems associated with heavy fuel operation (maintenance, extended oil treatment plant). The present-day falling oil prices does not stimulate the skippers to make use of this already proven energy-saving concept.

- propeller:

  Up to now the fishing cutter propeller was exclusively designed for a maximum efficiency at the fishing speed. This means that almost all Dutch fishing cutters have (rightly) been equipped with a four bladed nozzled propeller (fixed pitch) with the maximum diameter which can be accommodated in the afterbody. Only a few cutters have controllable pitch propellers and/or without a nozzle (=owners requirement).

- gear ratio:

  Because of the installed medium or high speed diesel engines a reverse and reduction gear is inevitable, mostly 3.5:1 up to 6:1 depending on the choice of engine and propeller. The higher installed horse power of the past years led to increasing vibration problems with the reverse/reduction gears, through which the power losses increased too (up to 5%).

- waste heat recovery:

  From the waste heat recovery possibilities of a marine diesel engine, only one concept has incidentally been applied in the Dutch fishing cutter design, viz installing a waste heat boiler in the exhaust system of the auxiliary engine. The produced steam is then used for:

  1. tankheating purpose;
  2. fuel pre-heating.

  To a limited scale some shrimpcutters are making use of the cooling water energy for shrimp cooking.

Electrical power generation

The auxiliary power installation (110 V d.c. and 380V/220 V a.c.) differs substantially for almost every fishing cutter. Skipper/owners experiences and requirements are underlying here. Often no energy-balance analysis was made or sometimes after the new building.

Because the Dutch Shipping Inspectorate (S.I.) requires two independently driven three phase current generators mostly two

identical diesel driven generators have been installed with a d.c. -generator coupled to each of the auxiliary diesel engines, often resulting in a overpowered situation.
However since 1982 more power take offs are used again on board the fishing cutters, either a gear box p.t.o (d.c) or engine front end driven generator by means of a frequency converter to generate electricity at varying r.p.m. Then one auxiliary diesel driven generator set can be used as emergency set to meet the S.I.-requirements.

Some NIFI-TD studies and reports (Table 5) were made concerning these matters, to which the cheapest lay-out (investment, fuel-efficiency) appeared to be:

- one p.t.o for the trawl winch generator (d.c.), coupled to the reduction gear box and main engine driven;
- one auxiliary diesel engine driven three phase current generator;
- one auxiliary diesel engine driven three phase current and direct current generator with 50% trawl winch power.

2) VESSEL OPERATION

Matching fishing gear/installed h.p.:

-fishing method(s):

As can be seen in Table 3 "Design requirements", the skipper's choice of the fishing gear mainly dictates the installed horse power and with this the expected fuel bill. Since the beam trawling method has been developed in the best catch effective one, alternatives are hardly applied. The disadvantage of this high energy-absorbing method has been accepted; the increased horse powers of the past years and the rising oil-prices were up to now compensated with larger fishing platforms and higher productivity, however with the same crew.

-(beam) trawl net resistance:

Pair-trawling means a considerable fuel-saving (up to 25%) for the two cutters, to which the NIFI-TD is continuously studying and experimenting to reduce the net resistance.
To a lesser extent this was done for the beam trawl nets, for which effective energy-saving seems to be possible but not simple. For keeping the gear (beam, beam shoes, net, tickler chains) aground, the relation dimensions/weight/fishing ground/catch is a very important one and decreasing of the gear resistance should be carefully considered.
On this matters NIFI-TD is experimenting for years (Table 5), resulting in a successful alternative for the flatfish stimulation. Instead of the heavy tickler chains, about 30% of the total gear weight, an array of electrodes stimulates the fish to jump upward. Fuel savings of 20% at the same catches have been attained. In 1985 and this year this electrical stimulation

project enters into negotiations with commercial Dutch firms to produce the system. Various skippers have already asked for quotations and government/EEC grants.

-monitoring:

The newbuilding cutters of the recent years have been increasingly equipped with all kind of electronical monitoring instruments, especially the continuously displaying of the fuel consumption rate and performance of the propulsion and auxiliary machinery. Although reluctantly in the beginning, many skippers have already experienced that these instruments are means to operate the vessel more economically.
With a simple fuel flowmeter, of which various are on the market, savings up to 15% have already been made, particularly in case of speed reduction and a controllable pitch propeller (free running or round fishing).

-maintenance plan:

A single fishing cutter has been equipped with a condition monitoring computer, including a maintenance plan and some skippers have a maintenance contract with the diesel engine manufacturer.
With the increased complexity of the engine room lay-out and deck equipment a rational maintenance plan have become indispensable, on the one hand having a reliable fishing platform and on the other hand reducing the maintenance costs.
The NIFI-TD gives continuously information on the necessity of proper maintenance (Table 5) and many skippers know it for themselves.

3) VARIOUS

Sail assistance

A review of the applied energy-saving concepts in the Dutch fishing cutters would not be complete without some remarks to sail power. Sail propulsion studies and full scale projects of the past years have been resulted in 20-50% fuel savings for small fishing craft, which however were specially designed for sail propulsion and only suitable for certain fishing methods, such as long lining, pot and trap fishing, gill netting and seining. Fishing methods which are not energy-absorbing and require less working deck area with a favourable ratio between travelling time to the fishing grounds and the intensity/duration of the fishing operations. The fishing cutter design requirements (Table 2) are completely contrary to these factors and the potential fuel savings did not pass the study phase up to now.

Crew training

With the increased complexity of the propulsion-, electrical installations and fishing equipment, the necessity of a well trained crew is inevitable for economical fishing operations. Besides the high investments nowadays a reliable and safe fishing working platform is required with acceptable exploitation costs. In the past years the Dutch fishery training courses have increasingly tuned to these matters, particularly to the subject of "Energy-saving in the fisheries", to which regularly European study group meetings are being held for the training staffs (CEASM= Centre d'Etude et d'Action).

Comparison basic cutters

On the basis of only limited technical data, as given in Tabel 2, two beam trawlers will be finally compared with regard to the above mentioned applied energy-saving concepts. Both basic cutters are representative for their period with a ship's length and installed horse power of respectively 37 m./1100 kW (1500 hp) and 40 m/1600 kW. For the data acknowledgement is made to Visser shipyard (Den Helder, Holland)

Hull resistance:

The parameters which are affecting the underwater resistance of both round bilge hulls are confirming the impression of the small ship lines improvements. In spite of the increased beam (1m.), the 3.2 m. longer waterline lenght slightly improves the prismatic coefficient (-0.01) and the half angle of waterline entrance (-2^{o}) at almost a same blockcoefficient, respectively 0,55 and 0,58. The greater speed/length ratio of the second cutter (+0.06) can be interpreted as having a somewhat better wave pattern at the free running speed, although tank test data or performance measuring aboard should give here the decisive answer. The latter also concerns the longitudinal centres of buoyancy, which are slightly aft of midships, respectively -0.8% and -0.5%

Looking at the actual blockcoefficients and theoretical optimum ones (boundary speed) for the free running speed, it can be analysed that both beam trawlers are strongly overpowered. Vessels of 34-37 metres length and with a speed of 12.3-13.4 knots should have a block of about 0.45 instead of 0.55 or 0.58. Besides for increasing the free running speed with 8%, a 46% higher installed horse power and a larger diameter propeller (+0.4m) is to be needed.

The second cutter has a more sophisticated paintsystem than the first one; nowadays the frequency of drydocking 1-1½ year in stead of 2 years.

engine:

Both medium speed diesel engines are running gasoils with a 15% lower rate of specific fuel consumption for the"new" fishing cutter with a modern, more economical, diesel engine.

propeller:

The propellers have been designed for trawling and are of the fixed type, turning in a nozzle.

matching fishing gear/installed hp:

The extra installed horse power has been led to heavier beam trawls (+1.5 tons) and longer beams (+3.5 m) resulting in an increased trawling speed of + 0.8 knots for the second cutter and a higher fishing effort for the new cutter.

5. CONCLUSIONS

Although the main features of the Dutch fishing cutters are the same, hardly two cutters can be found with identical installations and equipment. The main reason for this is the skipper-owner individualism and the absence of a company orientated cutter design approach.
Naturally the competitive designers and shipyards have been improved the cutter design on many details.

Up to now the energy-saving concepts were only applied if the expected fuel savings did not interfere to much with the existing fishing operations.
Besides the rising fuel oil prices could still be compensated with larger fishing platforms and the same crew, through which the beam trawlers became more independently of the weather and sea conditions. Naturally the skippers are also making extra hauls per fishing week and/or more fishing hours.
However, in the foreseeable future this catch-elasticity will probably be over owing to the overfishing (TAC, quotas), more stringent governmental regulations (licences, limited beam length obligatory laying-up weeks), a more efficient inspection and higher fines.

As can be seen in Table 2, the accent of the energy-savings in the Dutch fishing cutter design and operation was mainly related to the technical aspects of fuel-saving, viz.

1. choice of diesel main and auxiliary engines (initial price, lowest possible fuel costs, low and easy maintenance);
2. cheaper heavy fuel oils;
3. generating of electricity with power take offs and/or independently driven generators;
4. matching of engine/propeller/hull.

In the present day started and future changing Dutch fisheries circumstances, reducing of the strongly risen exploitation costs, is more needed than ever before. Besides more energy-losses can be expected due to poorer fuel oil qualities and vibration problems in gear boxes.
Except the above mentioned concepts also the remaining energy-saving possibilities (Table 2) should be reconsidered carefully, starting with a new concept in hull design to which tank tests are absolutely inevitable.
According to the author's opinion the following energy-saving concepts are important to realise the potential 15-25% fuel savings as already experienced with similar vessels:

1. systematic hull form model tank tests (bulbous bow, afterbody, lengthening existing cutters with a midship section);
2. improving underwater hull finishings (appendages, paintsystem);
3. matching engine/propeller/hull (poor quality fuel oils, propeller alternatives, gear ratio, propeller accommodating, efficiency measurements);

4. electrical power generation (energy-balance, power take offs, diesel auxiliary engines);
5. matching fishing gear/installed horse power (electrical or alternative flatfish stimulation);
6. condition- and fuel monitoring (maintenance plan).

However, the 15-25% saving potentials can become even higher by application of heavy fuel engines (+ 10%) and electrical flatfish stimulation (+ 20%) on board the Dutch fishing cutters.

Of course a technic-economical cutter design approach is then inevitable with regard to the above mentioned savings/extra investments and increased operational requirements, particularly the governmental restrictions (fishing effort).

TABLES 1-5

Table 1 HP-RANGE

CLASS	INSTALLED HORSEPOWER RANGE		NUMBER (about)
1	140<	<220 kW (300 hp)	150
2	220<	<740 kW (1000 hp)	150
3	740<	<1440 kW (2000 hp)	150
4	1440<	<2200 kW (3000 hp)	40
5	2200<	<3000 kW (4000 hp)	10
6	3000<		1

TABLE 2 - MAIN FEATURES

MAIN FEATURES DUTCH FISHING CUTTER BEAM TRAWLERS, BUILT IN:		I mid 1970's	II mid 1980's
Length o.a. (loa)	m	37.05	40.15
Length p.p. (Lpp)	m	32.90	36.00
Length waterline (Lwl)	m	33.80	37.00
Beam moulded (Bm)	m	7.50	8.50
Depth moulded (Dm)	m	4.10	4.78
Design draft (Tm)/TV/TA	m	3.20/-/-	4.00/3.15/4.90
Displacement (Δ)	ton	460	640
Weight ship + machinery (Wsm)	ton	-	-
Fish hold capacity (H)	m^3	185	270
Speed free running/fishing (V)	kn	12.3/6.1	13.4/6.9
Propeller (type, diameter)		Nozzle 2500	Nozzle 2900
Side thruster		-	yes
Block coefficient C(b)		0.55	0.58
Prismatic coefficient C(p)		0.66	0.65
Longitudinal centre of buoancy (LCB)		-0.8%	-0.5%
Lwl/Bm		4.50	4.35
Bm/Tm		2.34	2.13
Speed-length ratio ($V/\sqrt{L}$)		1.16	1.22
Displacement-length ratio ($\Delta/(0{,}01L)^3$		337	358
Half angle of waterline entrance ($\frac{1}{2}\alpha$)		34°	32°
After body (stern, accommodating)		TRANSOM	TRANSOM
Fore body (bulbous bow)		NO	NO
Diesel main engine (kW/hp/rpm)		1100/1500/800	1600/2200/900
Diesel auxiliary engine (hp)		2x75	2x230
Generators (kVA)		2x50	2x95
Harbour set/emergency set (kVA)		-	60
Refrigerating plant		yes	yes
Trawl winch (drums)		6	8
Beam length	m	10.5	14.0
Beam trawl weight	ton	2x4.5	2x6.0

TABLE 2—MAIN FEATURES, CONT.

MAIN FEATURES DUTCH FISHING CUTTER BEAM TRAWLERS, BUILT IN:	I mid 1970's	II mid 1980's
Apendages		
- rudder fairings	-	-
- external (keel) coolers	-	-
- thruster opening fairing	-	yes, 850
- water intakes/discharge	-	-
- hull zincs (form, number)	60	70
- lifting pads (rudder/prop)	-	-
- shell pipe/tube fenders	semi-circle	semi-circle
- other protuberances	-	-
Paintsystems		
- system (conv./one/two comp)	conv	2 comp.
- repainting, incl. grit blasting	-	yes
- prop. cleaning/repairing	-	-
- surface detoriation	-	-
- frequency drydocking (years)	1-2	1-1½
Energy balance	-	-

TABLE 3 - FISHING CUTTER DESIGN REQUIRMENTS

Owners requirements

- shiplength and lay-out
- fishing method(s)/grounds
- fishing gear dimensions and weight
- fishing speed
- trawl winch
- fish finding equipment
- navigational equipment
- communication equipment
- fish processing plant

Technical requirements

- trawlnet resistance
- installed horse power
- main dimensions/hull form
- stability requirements
- (de)-rating main engines
- ballast/bunkers
- propulsion machineries (unmanned, varying load)
- electrical installation (energy-balance)
- refrigerating plant
- oil-treatment equipment

Operational requirements

- requirements Dutch Shipping Inspectorate (construction, safety, stability)
- quotas
- licence's installed horse power
- laying-up weeks (10)
- reduced gear beam length*
- reduced installed horse power*

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* not in force (summer 1986 (?)).

TABLE 4 - ENERGY-SAVING CONCEPTS

GENERAL ENERGY-SAVING CONCEPTS IN SHIP DESIGN AND OPERATION	DUTCH FISHING CUTTER (applied)	(future studies)
1. VESSEL DESIGN		
- hull resistance		
- tank tests (data base)		X
- hull form parameters/coefficients	X	X
- fore body (bulbous bow)		X
- after body (propeller efficiency)		X
- trim, draft, speed		X
- appendages		X
- bilge keels		X
- external/flush coolers		X
- hull mounted equipment		X
- thruster opening fairing		X
- rudder fairing		X
- shell protection rubbers		X
- paint system		X
- air resistance		
- shape superstructure/masts		
- wind area		
- speed (vessel/wind)		
- matching engine/propeller/hull	X	X
- engine (torque-rpm/fuel consumption)	X	X
- distillate/heavy fuels	X	X
- oil treatment	X	X
- gear ratio	X	X
- waste heat recovery	X	X
- propeller (type, diameter, rpm)	X	X
- accommodating propeller	X	X
- electrical power generation	X	X
- energy-balance (load shedding)		X
- power take offs	X	X
- diesel auxiliary engines	X	X
2. VESSEL OPERATION		
- matching fishing gear /installed hp	X	X
- fishing method(s)	X	X
- trawl net resistance		X
- derating engines/reduced speed	X	X
- routing (wind/tides/steering)		
- condition monitoring	X	X
- fuel monitoring	X	X
- maintenance plan	X	X
- machinery/equipment		X
- hull fouling (drydocking)		X
- repairing damages, leakages		X
3. VARIOUS		
- sail assistance		
- crews training		X

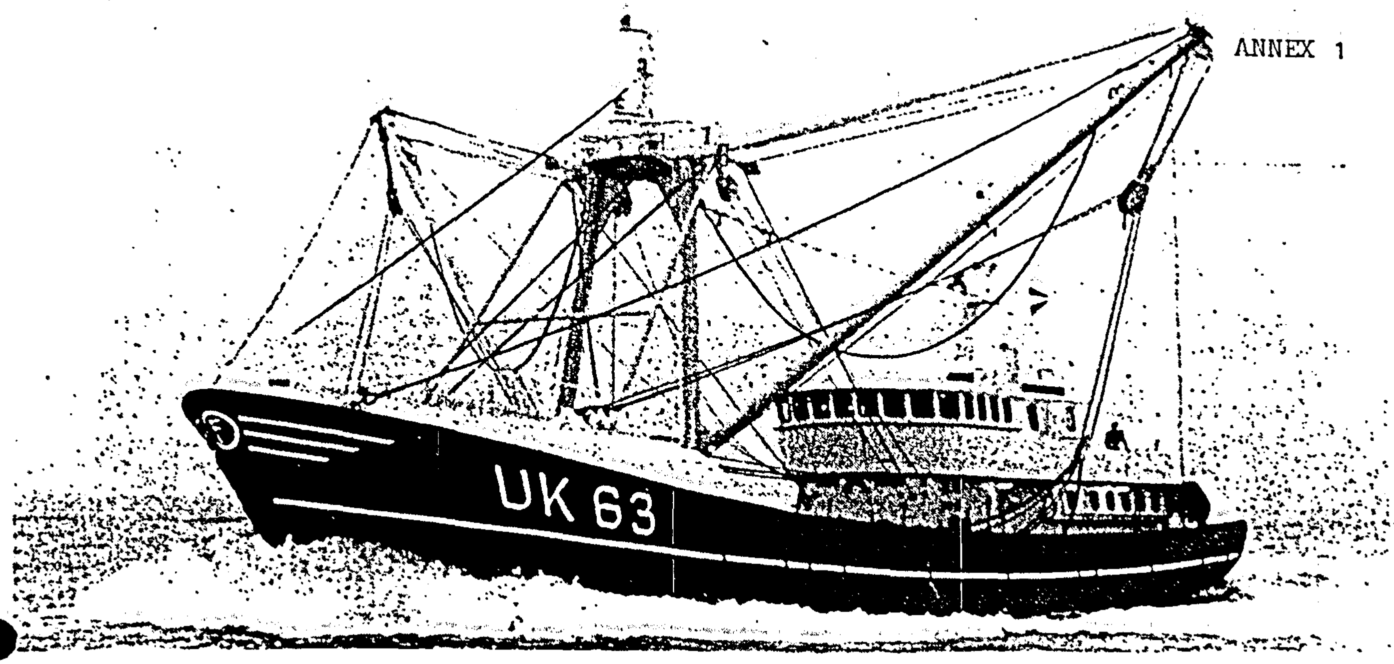
TABLE 5 - ENERGY SAVING REPORTS NIFI (RIVO-TO)

RIVO-TO REPORTS (in Dutch)	TITLE
TO 74-09	Reducing energy-costs by efficient maintenance of propulsion machinery in fishing vessels
TO 77-03	Idem, II
TO 79-02	Optimising fishing cutter design - I
TO 80-05	Idem, II
TO 80-06	Pair trawling in Dutch fisheries
TO 80-08	Electric beam trawling on plaice/sole
TO 81-03	Idem, II
TO 82-03	Beam trawl resistance/weight fishing gear/installed horse power
TO 83-03	Usage of heavy fuels in the fisheries
TO 84-04	Auxiliary engines onboard a 1300 kW (1760 hp) fishing cutter
TO 84-05	Power generating and electrical usages onboard fishing cutters
TO 85-05	Protocol efficiency measurements propulsion plant onboard a 2000 kW (2700 hp) fishing cutter

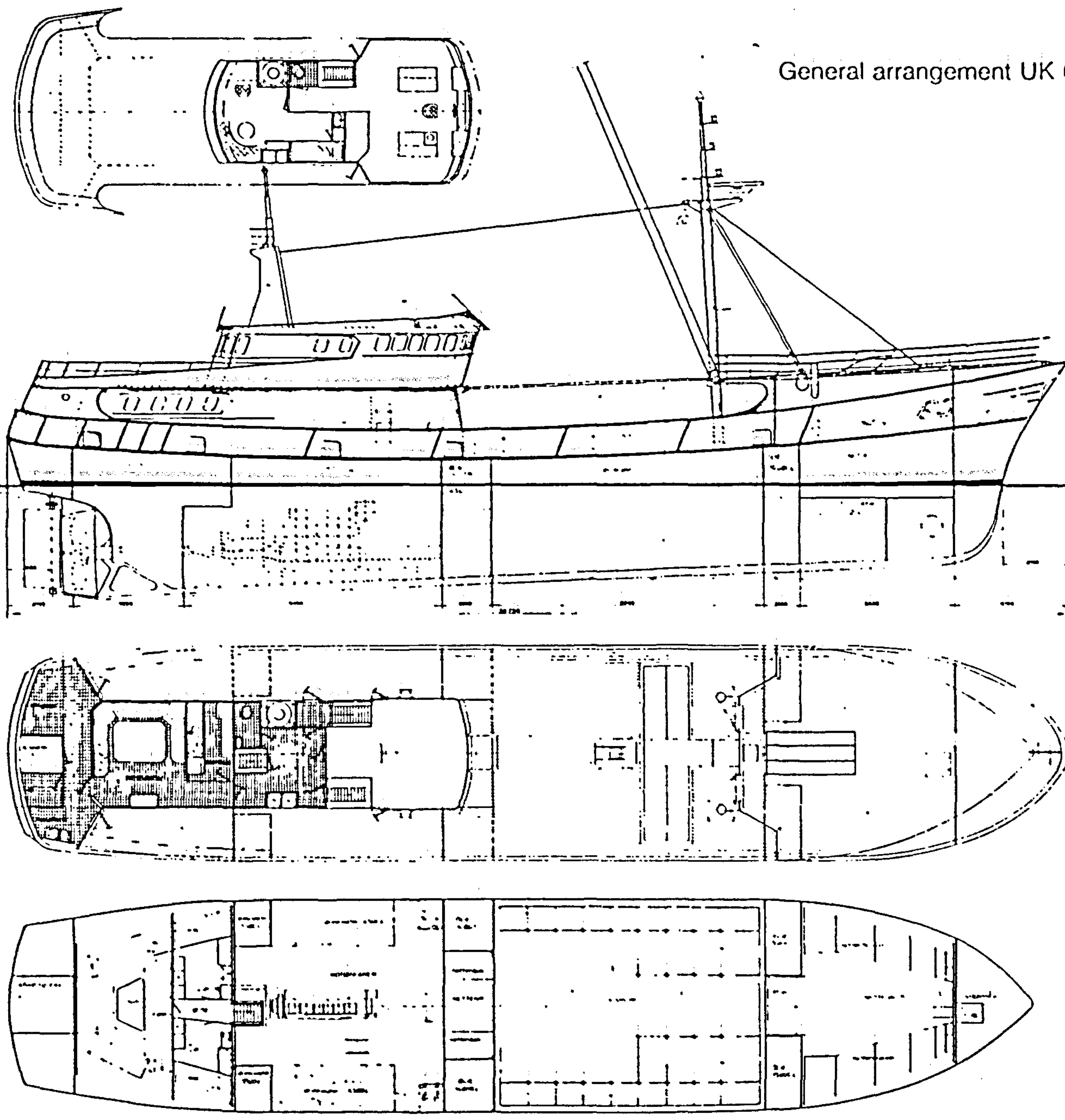
<u>ANNEX 1-3</u>

1	- GENERAL ARRANGEMENT
2	- BEAM TRAWLING
3	- DIAGRAM THRUST/RESISTANCE/FISHING SPEED

ANNEX 1

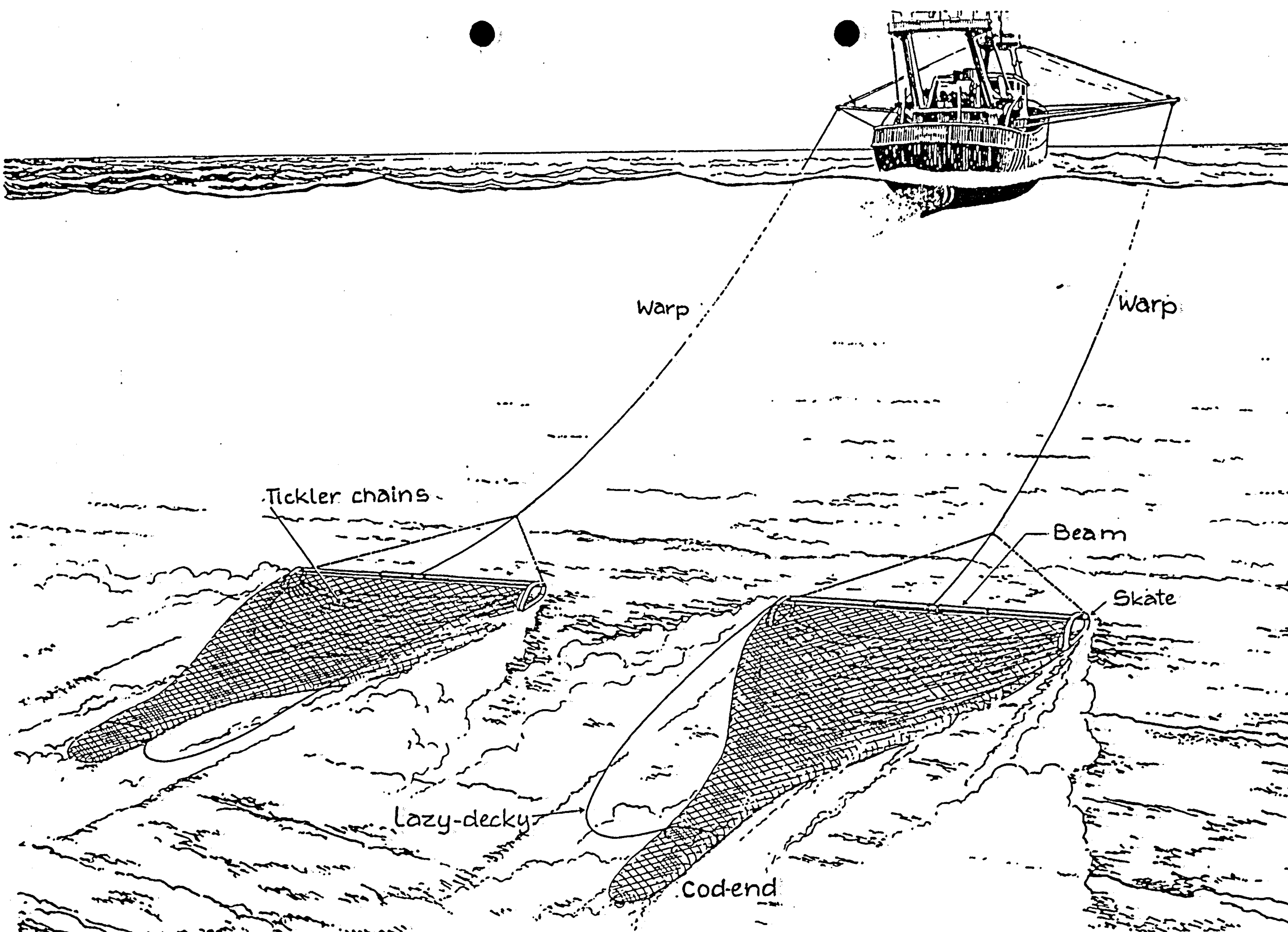


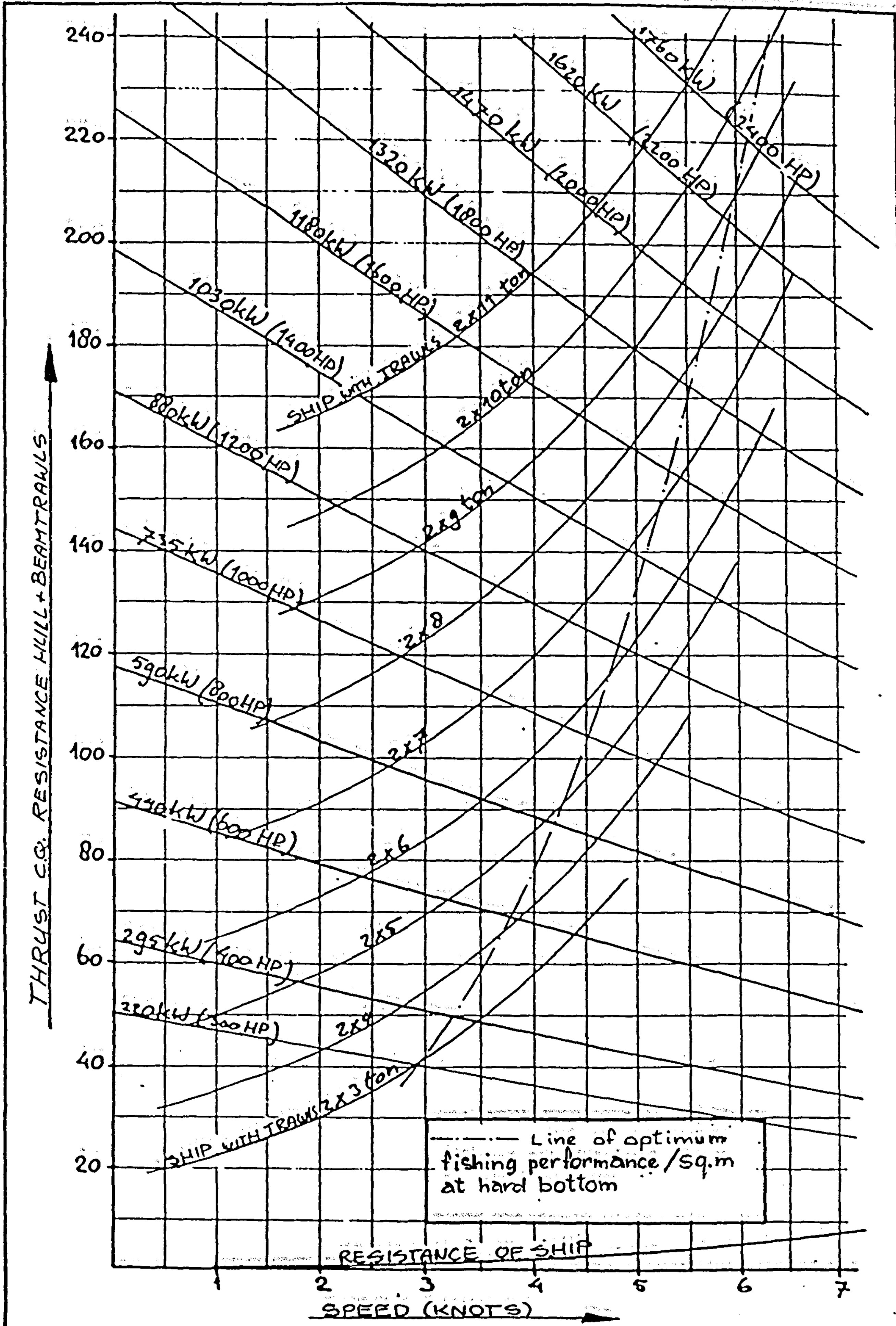
General arrangement UK 63



1965

ANNEX 2





POWER, THRUST AND RESISTANCE OF BEAMTRAWLERS

RIVO tech. research - HOLLAND