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BIOMASS SURVEY MANUAL: A PROPOSED STANDARD GUIDE FOR CONDUCTING ANNUAL MONKFISH BIOMASS SURVEY IN NAMIBIAN WATERS

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ABSTRACT

To keep consistency in data collection and comparability of data time series in fisheries research, gear and sampling methods should be standardized. A full standard trawl system and sampling procedures have not been documented for the annual monkfish biomass survey in Namibia. Furthermore, the old research vessel (RV) *Welwitchia* was replaced with RV *Mirabilis* in 2014. Different trawl doors were used on RV *Mirabilis* resulting in poor catches of monkfish on the new vessel during a series of parallel trawling surveys. The purpose of this study is to standardize the trawl system and sampling procedures based on the methods used during the most recent biomass survey of November 2016. Blueprints for the trawl doors, sweep lines, trawl net and ground gear were developed to provide standard details of the trawl system configuration. Standard operating procedures were also expounded.

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LIST OF ABREVIATIONS

- BCLME Benguela Current Large Marine Ecosystem
- EEZ Exclusive Economic Zone
- FAO Food and Agricultural Organization for the United Nations
- GDP Gross Domestic Products
- MFMR Ministry of Fisheries and Marine Resources, Namibia
- MRAC Marine Resource Advisory Council
- MRI Marine Research Institute, Iceland
- NMFS National Marine Fisheries Service, U.S.
- NSA Namibia Statistics Agencies
- RV Research Vessel
- TAC Total Allowable Catch

1 INTRODUCTION

The Namibian fishery sector is one of the primary contributors to the country's economy. The sector employed about 25000 people in 2012 (Chiripanhura & Teweldemedhin, 2016). Most of the employment opportunities come directly from the marine commercial fisheries. The fishery sector (fishing and fish processing on board) contributes about 2.9% to the country's GDP (Namibia Statistics Agency, 2015). The marine fishery consists of key demersal and pelagic species which are regulated through TACs (Total Allowable Catches) and quota allocation system. The demersal species that are managed through the TACs are; hake (*Merluccius capensis* and *M. paradoxus*), monkfish (*Lophius vomerinus* and *L. vaillanti*), deep sea red crab (*Chaceon maritae*), rock lobster (*Jasus lalandii*) and orange roughy (*Hoplostethus cadenati*). Other TAC regulated species are pelagic; Cape horse mackerel (*Trachurus capensis*), pilchard (*Sardinops sagax*) and the Cape fur seal (*Arctocephalus pusillus*). The TACs are recommended based on stock assessment models that requires biomass indices to be obtained from surveys conducted each year.

Since 2000, the Ministry of Fisheries and Marine Resources has conducted annual biomass survey for the monkfish in Namibia. This document focuses on procedures and trawl equipment used to conduct the survey. Even though the current survey follows traditional methods used over the years, there has not been documentation of a full standard trawl system. As a result, the trawl used is not inspected over time, therefore any modification done might have not been recorded. In 2014, after a new research vessel (RV *Mirabilis*) was acquired for the MFMR, the trawl doors used on RV *Mirabilis* were different from those used during the past surveys. This has resulted in underperformance of the trawl on the RV *Mirabilis* as compared to the former RV *Welwitchia* (Nangolo *et al*., 2016a).

In this study, a standard manual for the annual monkfish biomass survey was developed in order to sustain the trawl performance and ensure that data for biomass estimates is continuously collected in a consistent way. The manual allows inspection of the trawl components to make sure that they conform to the set standards. The information used for standardization of the trawl was collected from the MFMR and the *Walvis Bay Trawl* (net-loft that repair the survey trawls) in Namibia. The sampling procedures were adapted from the traditional sampling methods of the past biomass surveys. Therefore, this manual does not intend to introduce new methods, but to document the whole trawl system and sampling methods to ensure consistent collection of data with standard measuring tools and methods.

2 BACKGROUND

2.1 Role of the Ministry of Fisheries and Marine Resources (MFMR) in the management of fisheries

The Namibian Ministry of Fisheries and Marine Resources (MFMR) is responsible for sustainable management of the living aquatic resources and promotion of aquaculture sector to maximize socioeconomic opportunities and benefits for all its people. Guided by the *Marine Act of 2000*, Namibia is considered to have one of the best fisheries management policies in the world, winning the Food Security Leadership Award in 2000 and Silver Future Award in 2012 (Paterson *et al*., 2013). As stipulated in the *Marine Act of 2000 (Act no 27 article 38)*, the Minister sets TACs based on the best scientific evidence. A Directorate of Resource Management works under the MFMR and is responsible for:

1. Providing advice on the state of commercially important marine fish stocks and recommendations on their appropriate yields.
2. Appropriate management measures in relationship to species and fish size limitations, closed seasons, closed areas and limitations on the type of gear and effect of fishing gear.
3. Research on fresh water fish resources in the interior of Namibia and provides advice on the conservation and management of those resources.

Scientists from MFMR conduct biomass surveys for the key commercial marine species every year. The surveys are conducted to estimate biomass indices which are one of the inputs in the stock assessment models. The results from the stock assessment models are then used to recommend TACs to the Marine Resource Advisory Council (MRAC). Apart from the biomass indices derived from the annual surveys, scientists also collect other important information such as species length distribution and other biological data, as well as environmental information. This information aids further studies on species such as diet composition, environmental effect on fish stock, geographical distribution of fish and overall monitoring of state of the fish stocks.

Fishing operations for commercial purposes are restricted to fishing right holders to control the number of entry and fishing (MFMR, 2009). The Minister allocates fishing quotas to right holders depending on the amount of TAC set for each species per year. Fishermen are compelled to operate under the "*regulations relating to the exploitation of marine resources*" (MFMR, 2001). These regulations include control measures on minimum restricted mesh sizes for different fisheries.

2.2 Biology and distribution of monkfish

In Namibia, monkfish is a term used for two species (*Lophius vomerinus* and *Lophius vaillanti*) belonging to the Lophiidae family. The distribution of monkfish off the coast of Namibia is between depths of 130-800 m from 17° to 30°S, according to monkfish biomass survey data between 2000 and 2015. *L. vaillanti* is distributed northward from around 23°S while *L. vomerinus* is distributed along the entire coastline. *L. vomerinus* makes up to 99% of the total monkfish landings (Iiyambo, 2006) and can reach an asymptotic length of 110 cm (Nangolo *et al*. 2016b). According to Nangolo *et al*. (2016b), the largest monkfish measured on an annual monkfish biomass survey from 2000-2015 was 102 cm and the species may live in excess of 10 years.

2.3 Monkfish biomass survey

The early estimates of the monkfish abundance were derived from hake targeted biomass surveys on board *Dr Fridtjof Nansen* (Schneider & Johnsen, 2000). Both monkfish and hake are demersal species, however the behaviour and distribution of the two species are different. Hake lives off the seafloor while monkfish can inhabit the muddy bottom. The trawl used for hake surveys have a rock-hopper footrope that lift the fishing line about 25 cm off the seafloor (Schneider & Johnsen 2000). The distance between the fishing line and the seafloor was suspected to have increased escapement of juvenile monkfish (Schneider & Johnsen, 2000). As the landings and economical values of monkfish increased, it was imperative to start conducting monkfish targeted survey with a different trawl that would be more efficient in catching monkfish (Schneider & Johnsen, 2000). The first monkfish targeted survey was conducted in November 1999 on board the Namibian research vessel *Welwitchia*.

In 2012, the MFMR bought a bigger research vessel *"Mirabilis"* to replace the former research vessel "*Welwitchia"* (see Table 1. for the description of the vessels). In November 2014, during the annual monkfish biomass survey, a parallel trawls experiment was conducted between the two research vessels aimed to calibrate catches of the new vessel. The median catch rates for RV Mirabilis in 2014 was 19.2 kg/h whereas RV Welwitchia landed 30.9 kg/h. Lower catch rates were further observed on RV Mirabilis during the parallel trawls conducted in 2015 and 2016 between the two vessels (Table 2).

Table 1: Description of research vessels used for monkfish biomass survey

	RV *Mirabilis* (2014-present)	**RV *Welwitchia* (2000-2015)**
Length over all (L_{oa})	63.80 m	47.28 m
Width	14.30 m	8.30 m
Draft	4.5 m	4.0 m
Total Engine power	3200 Kw/4348 HP	1323.36 Kw/1774.66 HP

Table 2: Descriptive statistics of the catch rates for RV Mirabilis and RV Welwitchia during the inter-calibration experiments (2014-2016).

		RV *Mirabilis* catch rates (kg/h)		**RV *Welwitchia* catch rates (kg/h)**	
Year	Median	Median	Median	Median	Min/Max
2014	19.2	30.9	30.9	19.2	0/88.8
2015	8.67	17.75	17.75	8.67	0/96.77
2016	31.02	63.6	63.6	31.02	0/113.77

N = number of parallel tows conducted.

The inter-calibration experiments were done in the manner that the two research vessels trawled side by side with one vessel approximately 0.4 nm ahead of the other to avoid interferences in trawl sensors (Nangolo *et al.*, 2016a). The parallel position of the vessels (i.e. port or starboard and before and after) during the experiment where alternated on a tow-by-tow basis. The towing speed was kept at 3.0 knots for a targeted duration of 30 minutes for both vessels at each station.

During the inter-calibration experiments, trawls on both vessels were identical, but the trawl doors used were different giving different openings. RV *Welwitchia* used *Poly-Ice* (Area = 4.2 m^2; weight = 950 kg) trawl doors (Appendix C), while *Thyboron* (Area = 7.93 m^2; weight = 1936 kg) (Appendix B) were used on RV *Mirabilis.* Lower catch rates on RV *Mirabilis* were attributed to erratic behaviour of the door spread and the vertical net opening (see Table 3 for descriptive statistics). The door spread on RV *Mirabilis* was generally higher and unstable as compared to RV *Welwitchia.* The above was solved in September 2016 during a research cruise aimed to find alternative trawl doors that would give a comparable opening to the *Poly-Ice*. The *Steinshamn* (Area = 7.1 m^2; weight = 1800 kg) (Appendix A) trawl doors were found to give a similar opening to the old *Poly-Ice* and were used during the November 2016 monkfish biomass survey.

Table 3: Descriptive statistics for the recorded door spread and trawl net height during the inter-calibration between RV *Mirabilis* and RV *Welwitchia* (2014-2016).

		RV *Mirabilis*				RV *Welwitchia*			
		Door spread (m)		Trawl net height (m)		Door spread (m)		Trawl net height (m)	
Year	*N*	Median	Min/Max	Median	Min/Max	Median	Min/Max	Median	Min/Max
2014	40	151	116/204	1.1	0.8/3.3	96	57/100	1.1	0.9/1.7
2015	88	146.5	14.2/294	1.1	0.8/2.1	92	54/101	1	1/1.2
2016	21	134	19.62/270	1.1	1/1.5	96	83/101	1.1	1/1.2

N = number of parallel tows conducted. The experiment in 2016 was not conducted during the November biomass survey.

The general CPUE trend of commercial vessels shows stability from the year 2000 to 2008 shadowed by a sharp increase from 2008 (Figure 1). The upsurge in CPUE from 2008 is believed to be a result of the adoption of double-belly trawl nets that has improved catchability. The monkfish survey biomass series is characterized by rapid fluctuation in the abundance estimates (Figure 1). The biomass indices trend depicts a sharp fall from the beginning of the time series (2000-2003) and stabilizes between 2003 and 2005. There was no survey conducted in 2006. The biomass index indicates an abrupt growth between 2008 and 2009, followed by a negative nonlinear growth until 2015 and a rise in 2016. While the survey biomass indices are intended to capture changes in stock biomass, the variation in the biomass series can be influenced by many factors such as environmental attributes, unstable trawl system, trawl modifications and non-uniform fishing and sampling methods.

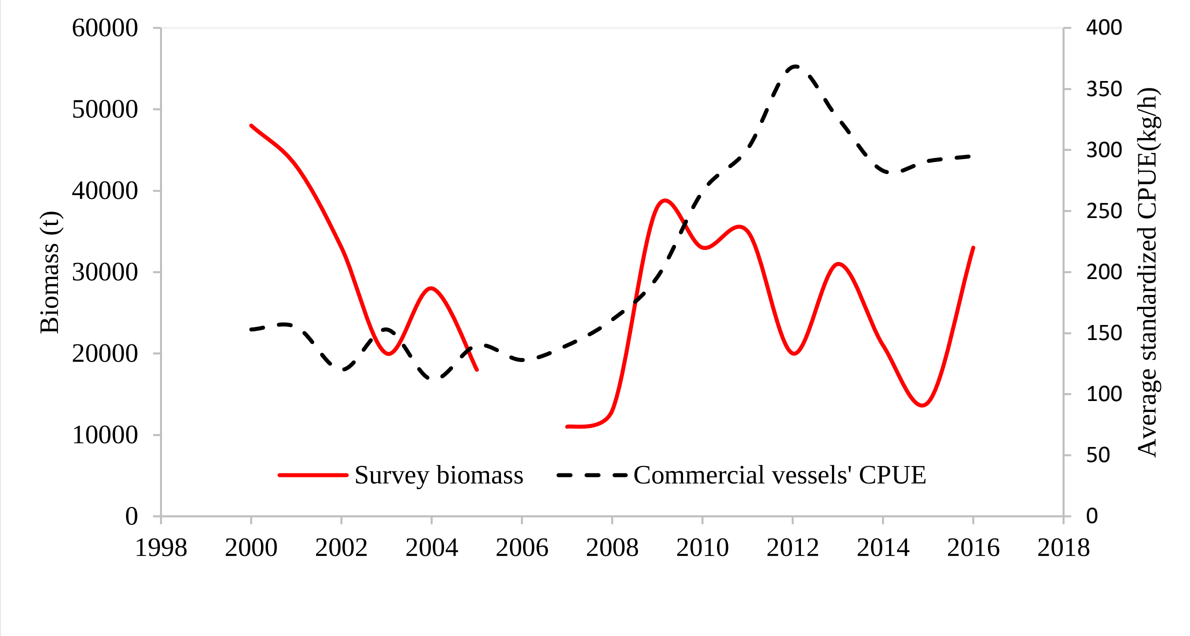


Figure 1: Monkfish biomass survey indices, together with relative CPUE of commercial vessels from 2000 to 2016. Biomass indices from 2000 to 2013 are from surveys conducted on RV *Welwitchia* using *Poly-ice* trawl doors, 2014 to 2015 from RV *Mirabilis* using *Thyboron* trawl doors and for 2016 RV *Mirabilis* with *Steinshamn* trawl doors were used.

3 STANDARDIZATION OF FISHERIES RESEARCH GEAR AND SAMPLING PROCEDURES

In fisheries research, standardization aims at establishing standards for fishing gear (as a measuring tool), and data collection protocols to allow; quality assurance of data, consistency in data collection and comparability of data time series. The concept of standardization of fisheries research gear is widely accepted as the best tool to reduce variation in trawl catchability of target species (Stauffer, 2004; Walsh *et al.,* 2009; Bagley *et al.,* 2015).

3.1 Fish capture process

The fish capture process with bottom trawls depends on the fish behavioural response to the fishing vessel and different components of the trawl fishing system (trawl doors to codend). The vessel, trawl doors and sweep lines act as fish herding devices towards the mouth of the trawl (Walsh, 1996). The fish capture process can be split into three zones (Figure 2):

1. *Zone 1*: fish within the vicinity of *zone 1* encounter the noise emitted by the vessel, warps, trawl doors and trawl net. A proportion of the fish in this zone is herded towards the trawl doors.
2. *Zone 2*: fish can either be herded towards the centre of the trawl path by the sweep lines and the sand clouds created by the trawl doors or escape below or above the sweeps. At the trawl mouth, fish respond to the visual cues of the net and ground gear. The usual behaviour of fish at the trawl mouth is swimming in the direction of the tow until they are exhausted to turn and enter the net or escape below the fishing line or above the headline.

3. *Zone 3*: inside the net, fish is herded towards the codend by the net panels, however some may still escape through mesh (Walsh, 1996; He, 2010).

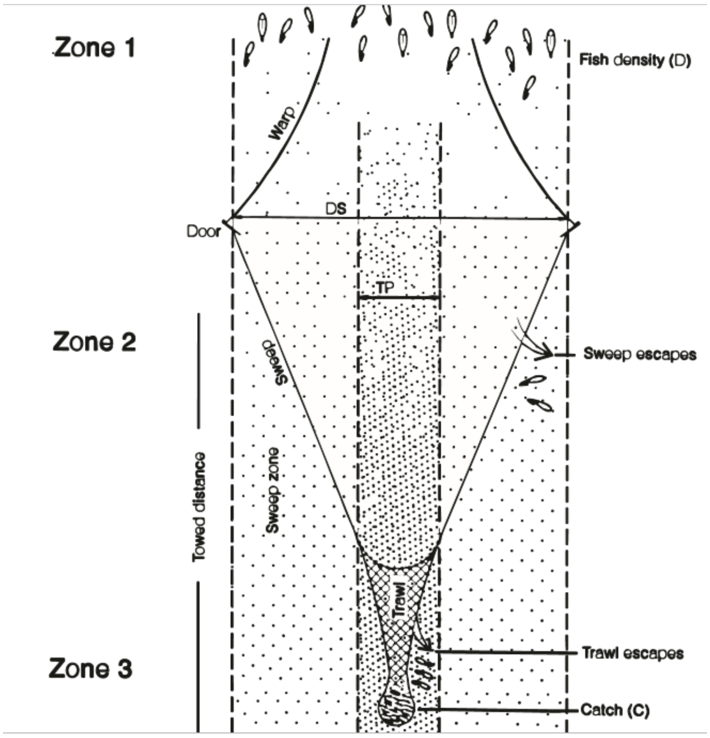


Figure 2: Three zones of the trawl system that influence the fish capture process (Walsh, 1996).

The extent to which different components of the trawl system influence fish behaviour towards the gear is different between species. For example, benthic species such as sole, monkfish and skates respond more to the trawl components after direct or near contact with the trawl components (He, 2010). The behaviour of fish in the trawl path is largely affected by the different components of the trawl system, so any modification can consequently affect the trawl performance and catchability of target species.

3.2 Consequences of gear modifications

Modification of research gear and sampling procedures has been reported to have affected time series of species abundance estimates (Jakobsen *et al.*, 1997; Zimmermann *et al.*, 2003; Axelsen & Johnsen, 2015). Zimmermann *et al.*, (2003) suggested that the adoption of the improved trawl performance monitoring system (such as monitoring of bottom contact) by the National Marine Fisheries Services (NMFS), U.S., has more influence on the increase in biomass estimates as opposed to increase in species abundance.

In the Benguela Current Large Marine Ecosystem (BCLME), the comparability of biomass indices time series for Angola (from 1985 to 2013), Namibia (1990-1999) and South Africa (2000-2001, 2008) is affected by changes made on the trawl systems. Such modifications include; change of vessels, tow duration and trawl doors, modification of footrope. Other modifications that can affect comparability of data include introduction of; tickler chains, constraining rope and trawl sensors (Axelsen & Johnsen, 2015). These surveys were conducted on board *Dr. Fridtjof Nansen* research vessels. Similar changes were reported in the Barents Sea between 1981 and 1996 (Jakobsen *et al.*, 1997). In both cases the time series have to be compared with caution, taking into account the severity of the effect of each change made. In cases of Barents Sea and Namibia (1999 only), parallel trawls with the aim of calibrating time series were conducted. Even though the time series of biomass indices were calibrated for Barents Sea and there were no significance differences in the catch rates between vessels in Namibia, changes made have affected the length distribution series (Axelsen & Johnsen, 2015; Jakobsen *et al.*, 1997).

3.3 Gear standardization

Developing research gear standards (through documentation) is crucial before starting survey time series (Bagley *et al*., 2015). However, in the absence of standards or due to several modifications on research gear done over the years, it is imperative to establish standards of the gear in use to establish a baseline for reference in calibrating any future modifications. Standardization allows inspection of gear over time to ensure that it does not deviate from the set standards. Several countries such as Canada, Iceland, New Zealand and United States have established manuals of standardized research gear and sampling procedures (Stauffer, 2004; Walsh *et al.*, 2009; MRI, 2010; Bagley *et al.*, 2015) and a series of international surveys (ICES, 2012, 2015). Components of standardized research gear and sampling procedures include;

1. Warps
2. Trawl doors (type and rigging)
3. Back strops, sweep lines and bridles
4. Ground gear and floating line
5. Trawl net (design, material and meshes)
6. Fishing protocols (i.e. towing speed and duration and gear performance monitoring)
7. Survey design
8. Sampling procedures
9. Data handling

In cases where multiple vessels are used to conduct surveys, calibration must to be conducted first before starting biomass indices time series. Moreover, when modifications to the standardized gear are necessary, the modified gear need to be calibrated before adopted (Bagley *et al.*, 2015). Calibration is conducted between two or more vessels towing the same gear at the same time and speed to test if gear perform the same. Calibration factors are established in cases were catch rates and/or size distribution of the target species is found to be different between vessels. Vessel and gear monitoring systems are also part of a standardized research gear system. When a vessel is being replaced and calibration with the old vessel is not possible, it is recommended that the new vessel should be similar to the former in terms of size and fishing power (Bagley *et al.*, 2015).

4 STANDARD TRAWL SYSTEM FOR THE NAMIBIAN MONKFISH BIOMASS SURVEY

The trawl system described in this chapter is derived from the setup of the most recent monkfish biomass survey conducted in November 2016. The 2016 setup is recommended to be kept as the standard for the monkfish annual biomass survey. The trawl should therefore be inspected continually to ensure that it conforms to the standard described in this chapter.
The replacement of ground gear auxiliaries (e.g. rubber discs, footrope chains, tickler chains) should comply with the standard weights. The reduced hydrostatic lift force (buoyancy) by additional sensors and other sampling equipment mounted on the trawl net should be compensated for with floats of which buoyancy is equivalent to the applied sinking force. It is recommended that all trawl nets used for the survey are marked for identification purpose.

4.1 Trawl net

The standard *Albatross* trawl net (Figure 3 & 4) has a stretched net circumference of 81.6 m measured around the fishing line bosom and the top panel. The headline is 50.3 m long while the length of the fishing line is 63.9 m. The float line has a total buoyancy force of 74.1 kgf out of 30 floats (200 mm diameter).

The top wings have 75 meshes down to 6 meshes of 200 mm length. The depth of the top wing is 43 meshes (8.6 m long). The lower wings have 54 meshes down to 6 meshes of 200 mm length. The depth of the lower wings is 31 meshes (6.2 m long). The square panel length is 6.3 m long with 212 meshes down to 174 meshes (mesh size = 200 mm). The belly is 29.7 m long and at the rear end is a codend of 13.2 m. The belly has meshes from 174 to 73 m with 120 and 200 mm mesh size at different sections of the belly. The codend has an outer net of 133 mm mesh size and an inner blinder of 10 mm to prevent escapement of small fish. The *Albatross* trawl net is designed to have an elongated side panel wings of 11.7 m. The total length of the trawl is 69.5 m.

The recorded headline height from the 2016 biomass survey had a symmetrical distribution ranging from 1 to 1.6 m (M = 1.1 m) (see Appendix D for the full survey station information).

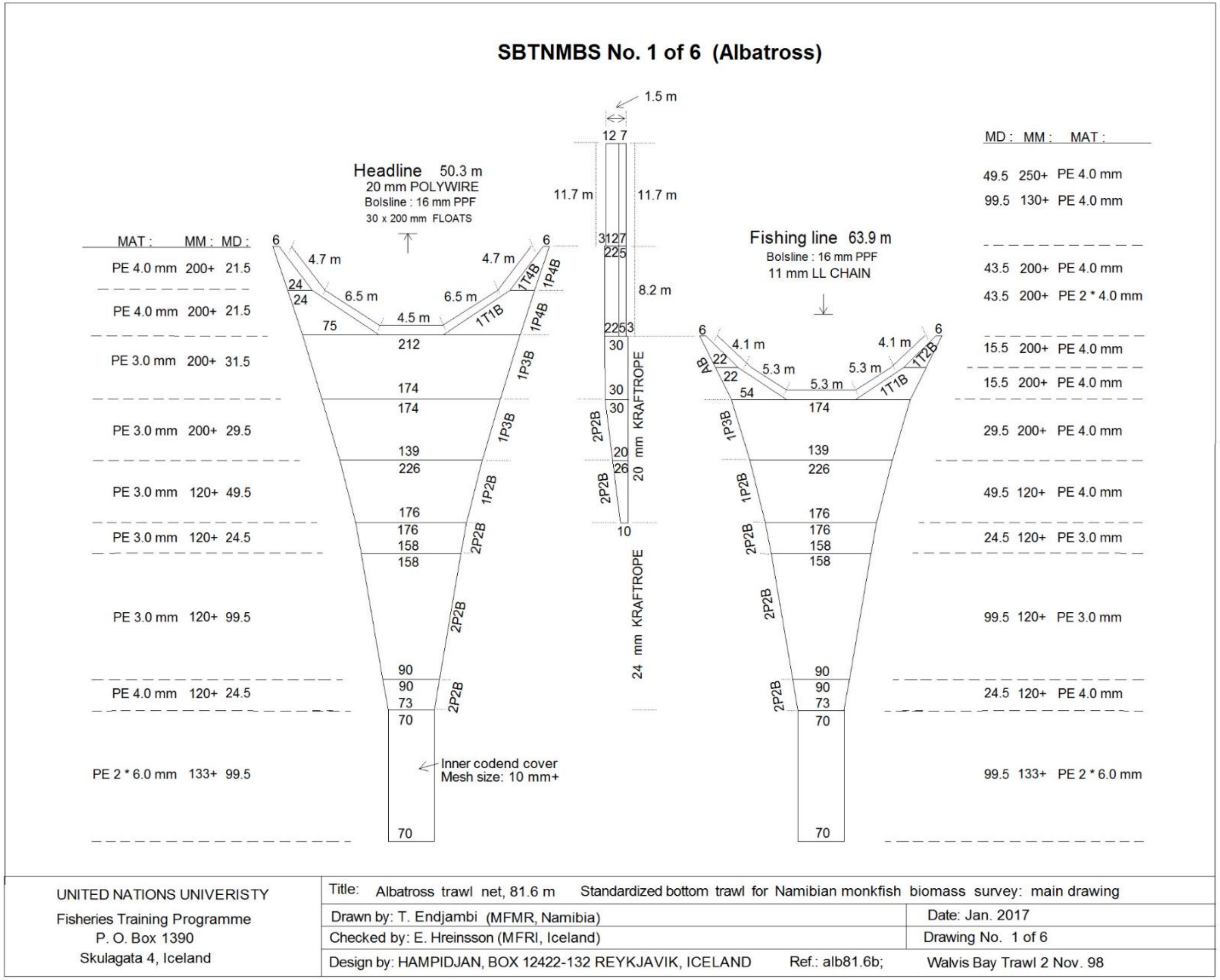


Figure 3: Standardized bottom trawl net for the Namibian monkfish biomass survey. Main drawing.

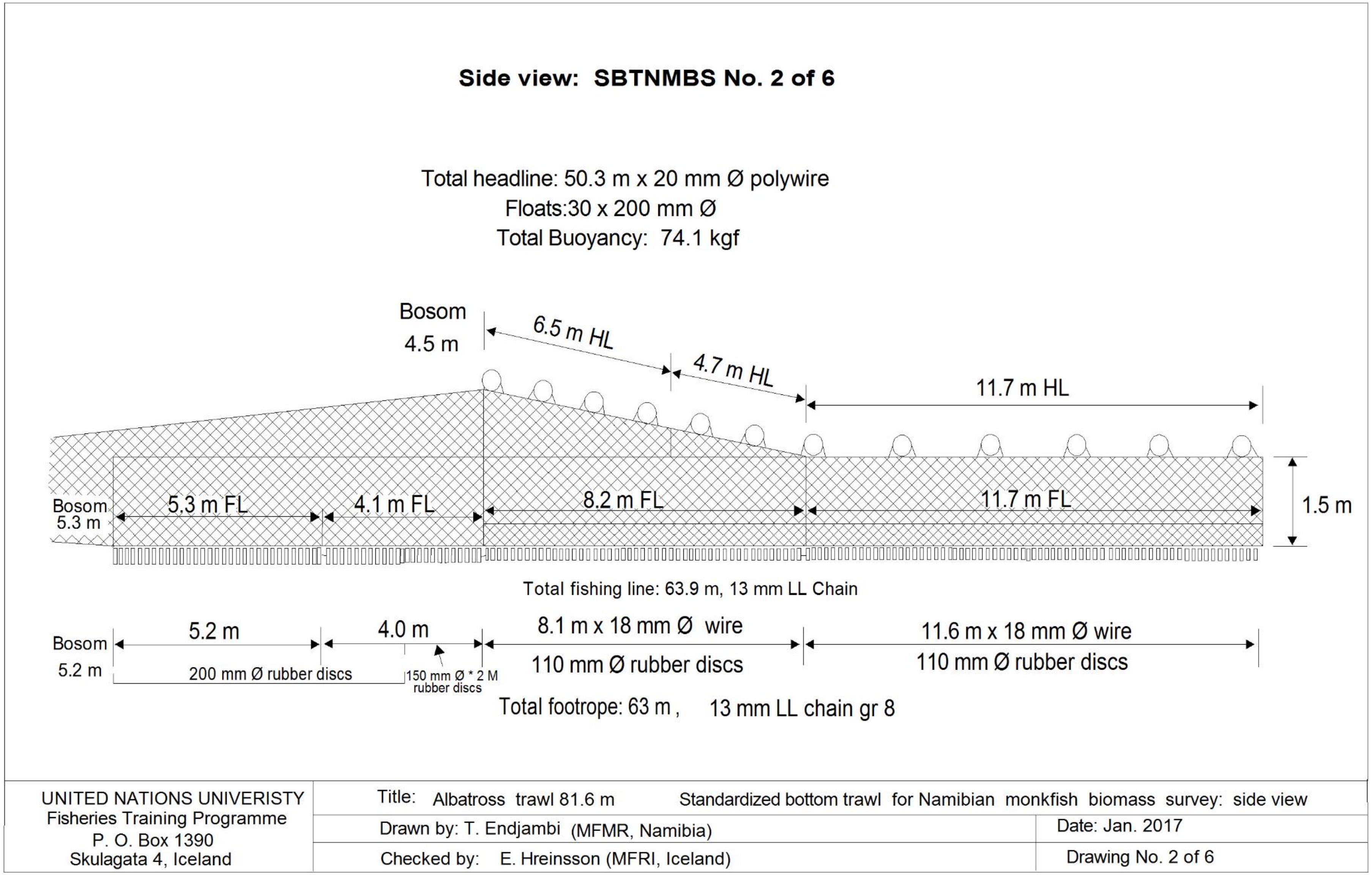


Figure 4: Standardized bottom trawl net for the Namibian monkfish biomass survey. Side view from the square to the side wing.

4.2 Ground gear

The weight of the ground gear keeps the net on the bottom and used in tandem with the float line to keep the mouth of the trawl net open. The *Albatross* trawl has tickler chains that helps to disturb fish from the seabed.

The standard *Albatross* trawl net comes with a rubber disc footrope (Figure 5). The rubber discs are made out of tires and have a diameter of 200 mm with a 50 mm centre hole in the centre section of the footrope. The centre of the footrope has extended rubber discs of 150 mm (diameter) with a 50 mm centre hole at the front end. At the wings of the footrope are rubber discs of 110 mm (30 mm centre hole). The total weight of rubber discs on the footrope is 700 kg in air. The footrope is attached to the fishing line with two links (chain). The total length of the centre of the footrope is 23.6 m and one wing length is 19.7 m.

The rubber discs are threaded together with a 13 mm LL gr 8 chain in the centre of the footrope (weight = 68.4 kg in air) and an 18 mm (diameter) wire at the wing sections weighing 47.3 kg. The fishing line is made out of 11.2 mm LL chain weighing 43.8 kg (in air) at the wing sections and 13 mm LL chains weighing 69.9 kg (in air) at the centre of fishing line (Figure 6). Tickler chains are made out of 10 mm (diameter) ML chains weighing 132.8 kg (in air) in total (see Figure 7 for arrangement).

The total weight of the ground gear (footrope chains + wire, tickler chains, fishing line and rubber discs) is 1106 kg in air.

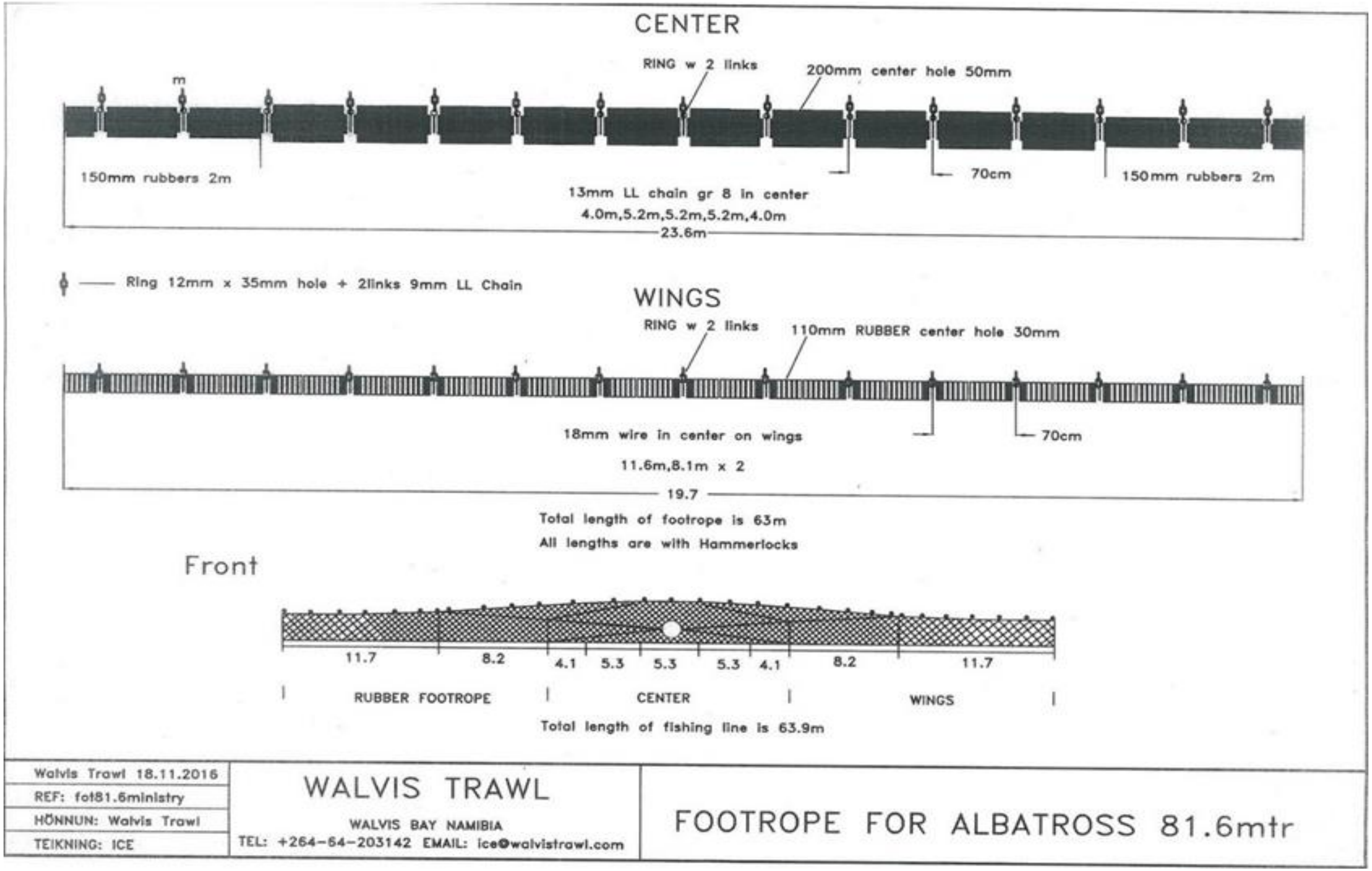


Figure 5: Standardized bottom trawl net for the Namibian monkfish biomass survey. Rigging of the footrope.

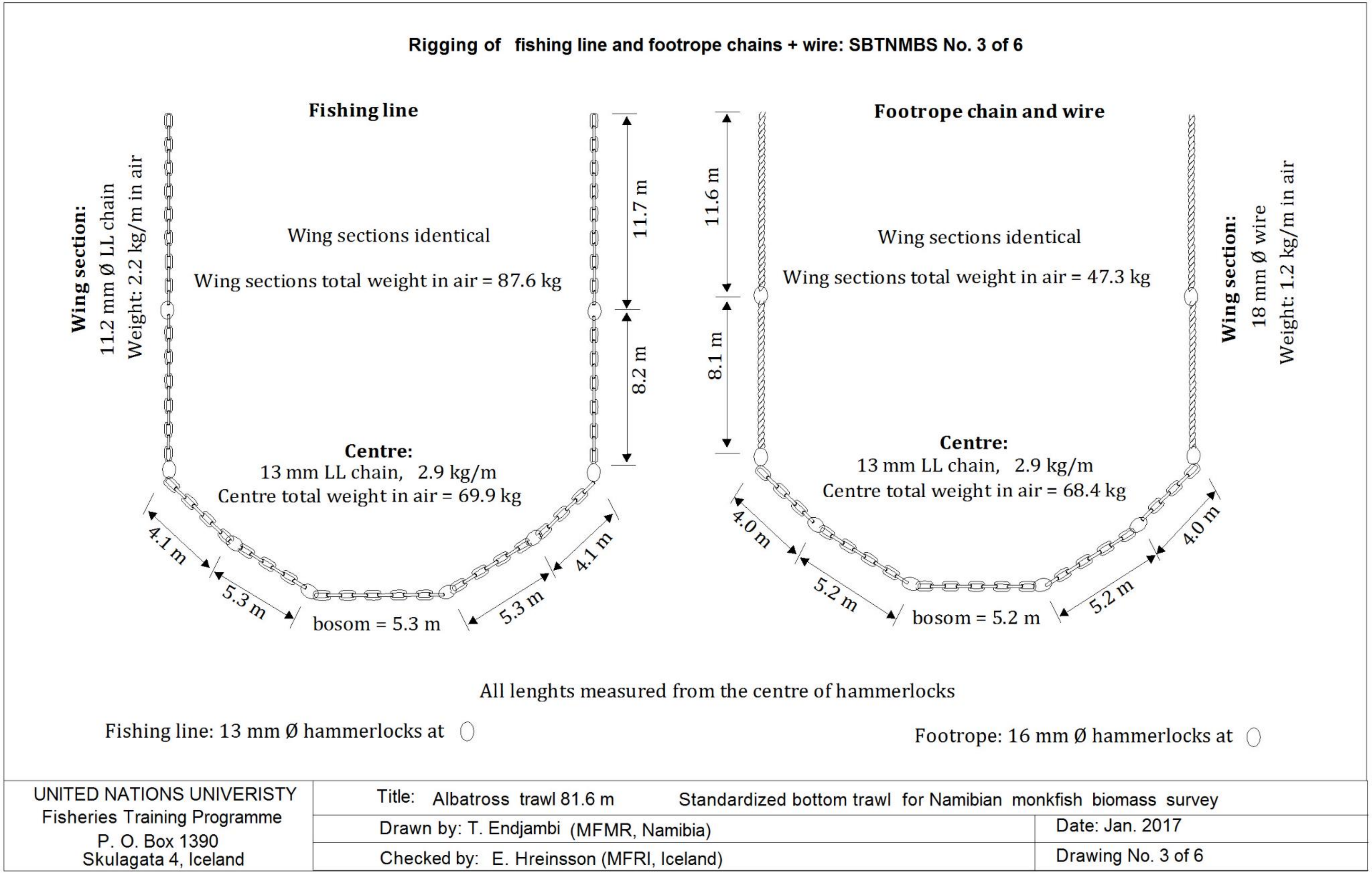


Figure 6: Standardized bottom trawl net for the Namibian monkfish biomass survey. Configuration of fishing line and footrope.

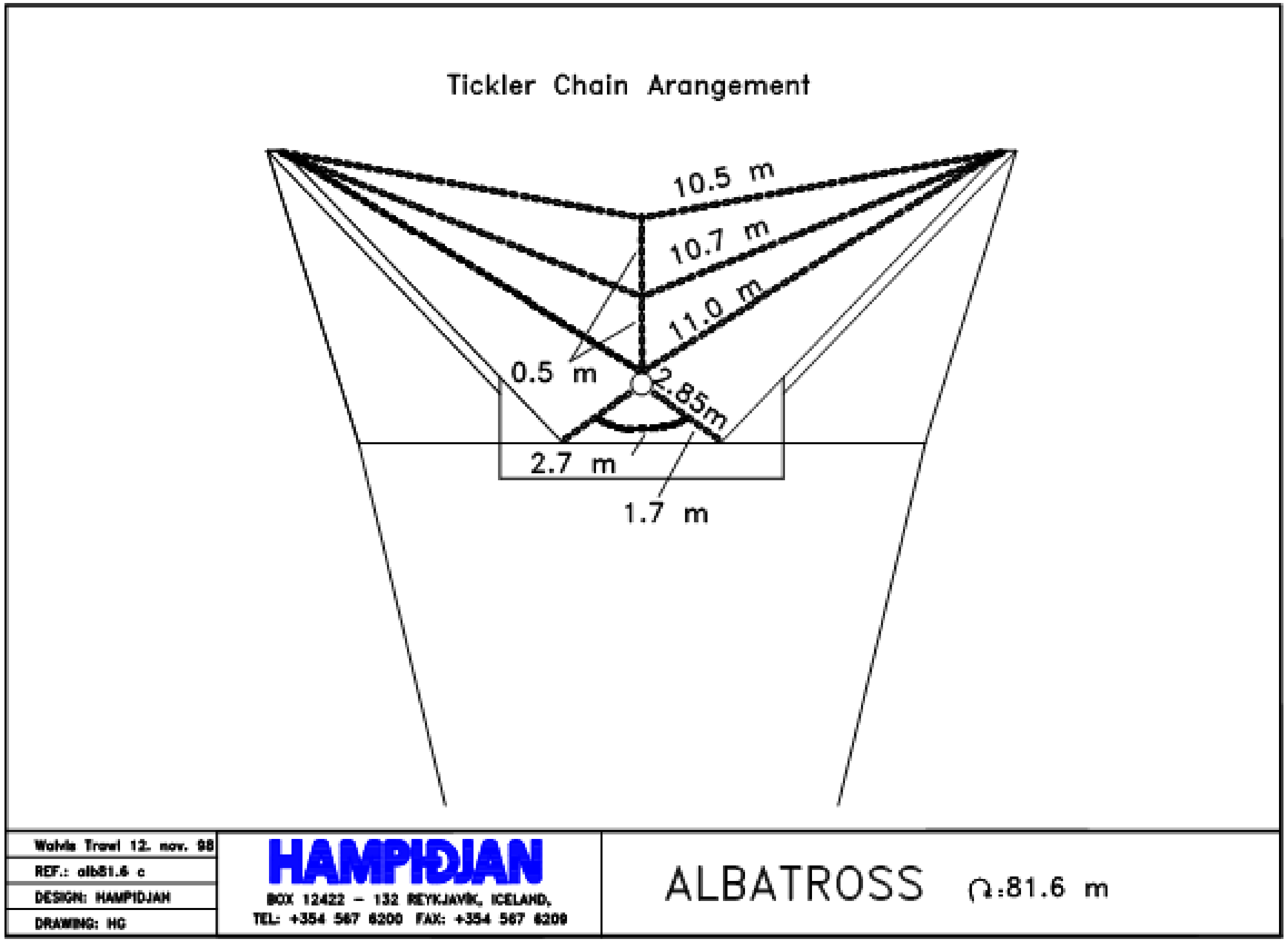


Figure 7: Standardized bottom trawl net for the Namibian monkfish biomass. Configuration of tickler chains.

4.3 Sweep lines and bridles

Sweep lines and bridles are important fish herding cables towards the trawl path. The combined length of the sweep line and bridles should be maintained to uphold the ideal angle of attack of the bridle-sweep lines. The latter is important to keep the trawl's ground affected area and the herding effect of the bridle-sweep lines consistent.

The standard length for monkfish biomass is a twin bridle of 25 m each and a single sweep of 20 m connected to an extension chain of 8.3 m long (Figure 8). The bridles, sweeps and sweeps extension lines are linked together with hammerlocks of 19 mm diameter. The lower bridle is connected to a triangle attached to the footrope and fishing line. There is no extension on the upper bridle.

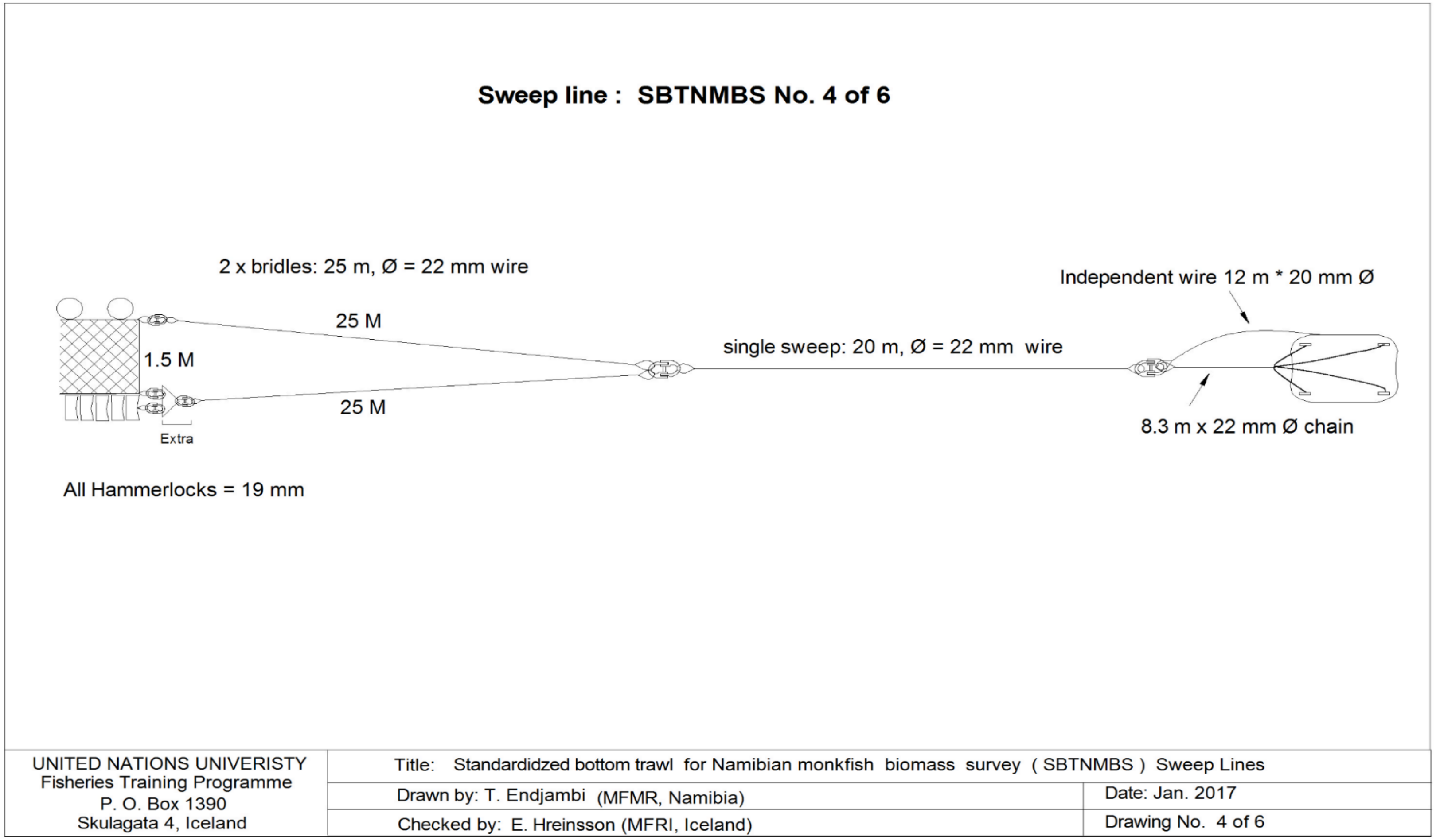


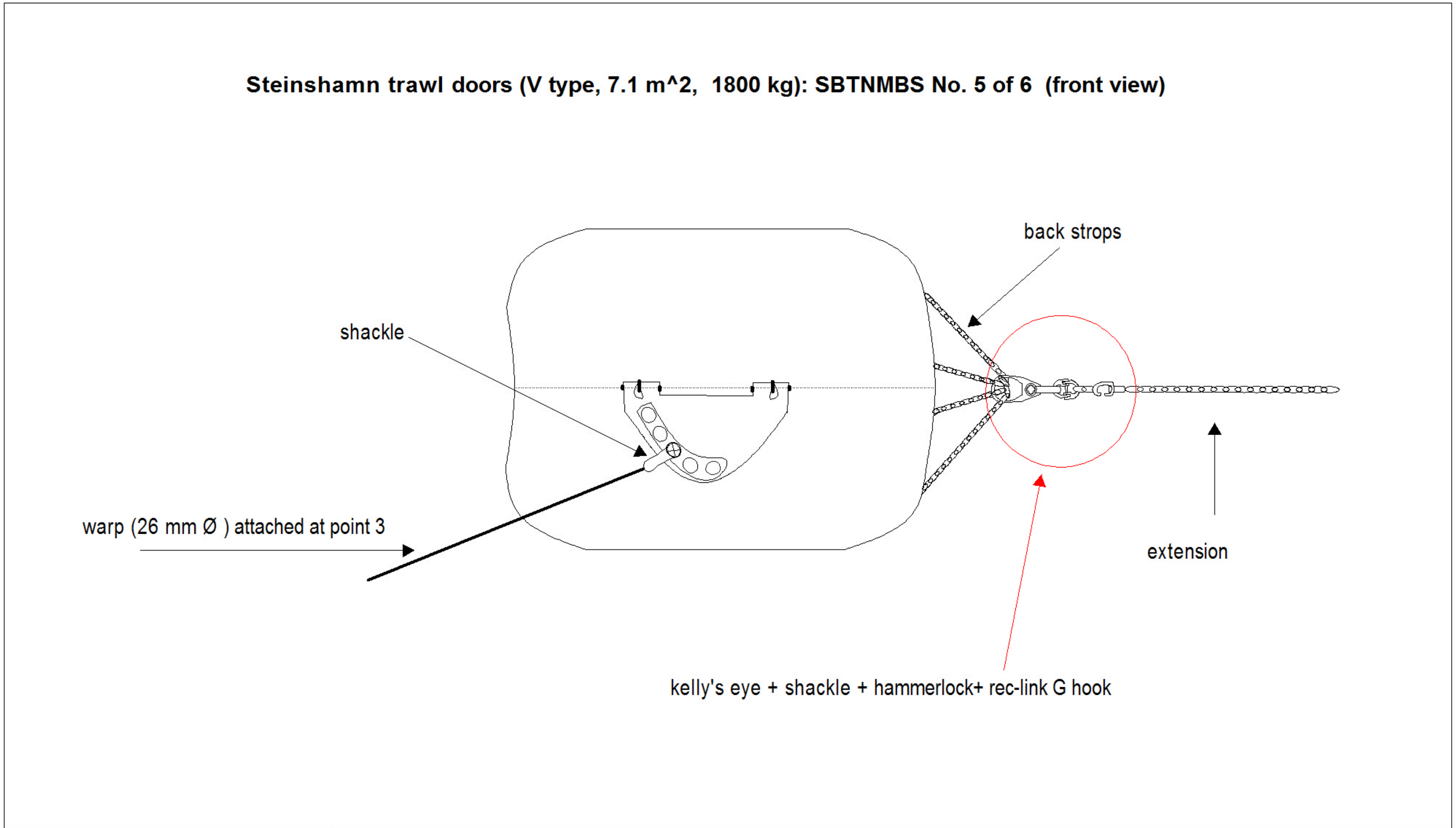
Figure 8: Standardized bottom trawl for the Namibian monkfish biomass survey. Sweep lines.

4.4 Trawl doors

The trawl doors aid in maintaining the wing spread of the trawl net. A standard rigging of the trawl doors minimizes the variation in the mouth opening of the trawl net and keeps the swept area constant.

The *Steinshamn* V type pattern trawl doors of 7.1 m^2 area, weighing 1800 kg are used for the monkfish annual biomass survey (Figure 9 &10; Appendix A: Figure A1-A3). On the front side of the trawl doors is a towing bracket consisting of five option points of warp attachment. For the monkfish biomass survey, the warp is attached to the third point (Figure 9; Appendix A: Figure A3). The thickness of the warp wire used to tow the trawl is 26 mm. At the back of the doors are two free running chains (back strops) of 3.6 m length. The upper back strop is linked to a 0.7 m long extension chain (Figure 10).

The *Steinshamn* trawl doors were first used in 2016 for the monkfish biomass survey. The recorded median door spread for 2016 was 90 m (min = 78 m; max = 96 m). The door spread can be affected by the warp-depth ratio used. It is recommended that the door parameters are monitored during the tow with the aim to keep the spread closer to the 2016 benchmark.



UNITED NATIONS UNIVERISTY Fisheries Training Programme P. O. Box 1390 Skulagata 4, Iceland	Title: Steinshamn V type trawl doors Standardized bottom trawl for Namibian monkfish biomass survey: front view	
	Drawn by: T. Endjambi (MFMR, Namibia)	Date: Jan. 2017
	Checked by: E. Hreinsson (MFRI, Iceland)	Drawing No. SBTNMBS No. 5 of 6

Figure 8: Standardized bottom trawl for the Namibian monkfish biomass survey. Trawl doors: front view.

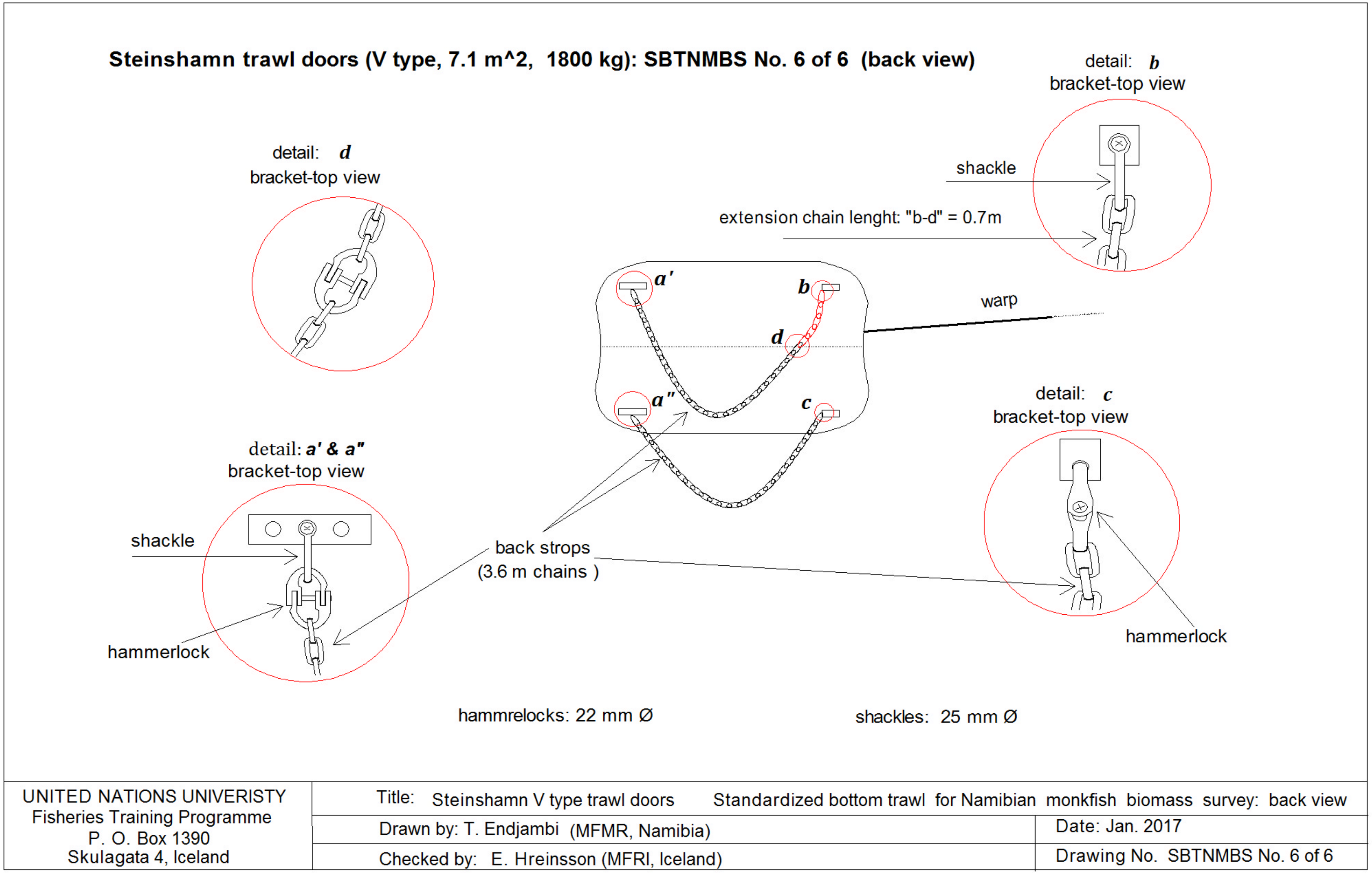


Figure 9: Standardized rigging of the *Steinshamn* trawl doors used for the Namibian monkfish biomass survey. Trawl doors: back view.

4.5 Trawl inspection and repair

The sampling gear should always be set up in accordance with the set standards (Table 4 & 5). The gear must be inspected by the relevant specialist at the net-loft responsible for trawl maintenance, the fishing master/deckhand of the vessel (before the net is taken on the survey vessel) and the cruise leader/gear technologist before the vessel leave the harbour.

The standard measurement of the mesh size is from the centre of one knot to the centre of the opposite knot in a P-direction taken when the mesh is fully stretched (Figure 11). It is recommended that an average of ten random measurements are taken when measuring the size of meshes. A 5% tolerance is allowed when measuring (ICES, 2012).

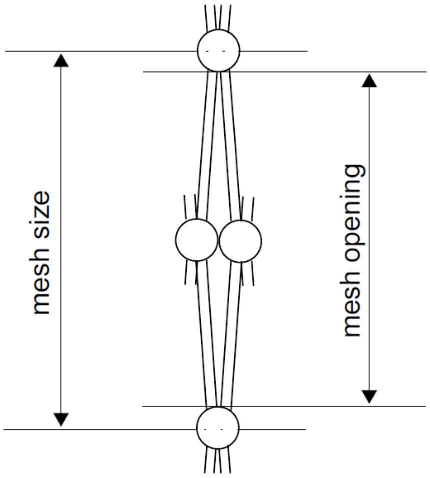


Figure 10: Standard measurement of mesh size. (Adapted from ICES, 2012).

Table 4: Trawl net specifications

Bridle -Sweeps-trawl doors	**Checked by:**	**Date:**
Bridle length	25 m	
Bridle diameter	22 mm	
Sweep line length	20 m	
Sweeps wire diameter	22 mm	
Sweeps extension chain length	8.3m x 22 mm Ø	
Sweeps extension chain diameter	22mm	
Back strops length	3.6 m	
upper back strop extension chain	0.7 m*16 mm Ø	
Independent wire	12 m * 20 mm Ø	
Warp wire	26 mm Ø	
Otter boards: *Steinshamn* Area + weight	V 7.1 m^2 + 1800 kg	

Table 5: Bridle, sweeps and trawl doors specifications.

Trawl net ID:	**Checked by:**	**Date:**
Trawl part	**Standard**	**Checked**
Headline		
Headline (polywire)– length	50.3 m	
Headline (polywire) – diameter	20 mm	
Number of floats (200 mm) – on headline	30 floats	
Float volume	4L	
Float weight	1500 g	
Float buoyancy	2470 gf	
Total floats buoyancy	74 100 gf	
Fishing line & Footrope		
Bolslines	16 mm PPF	
Fishing line (chain) - length	63.9 m	
Fishing line (chain) - diameter	11 mm LL	
Fishing line wings sections -weight per metre	2.2 kg/m	
Fishing line wings sections - Total weight	87.6 kg	
Fishing line centre section -weight per metre	2.9 kg/m	
Fishing line centre section- Total weight	69.9 kg	
Centre footrope (chain) - length	23.6 m	
Centre footrope chain - diameter	13 mm LL gr 8	
Centre footrope chain - weight per metre	2.9 kg/m	
Centre footrope chain - total weight	68.4 kg	
Wings footrope (wire) - length ((11.6 + 8.1) *2)	39.4 m	
Wings footrope (wire) - diameter	18 mm	
Wing footrope wire - weight per metre	1.2 kg	
Wings footrope wire - total weight (for 39.4 m)	47.3 kg	
Total footrope length including hammerlocks	63 m	
Footrope-headline connecting rings	2 links, 9 mm LL chain	
Rings diameter	12 mm * 35 mm hole	
Distance between rings	70 cm	
Centre footrope rubber discs' diameter	200 mm	
Centre footrope rubber discs (centre hole) diameter	50 mm	
Wings footrope rubber discs' diameter	110 mm	
Wing footrope rubber discs' middle hole diameter	30 mm	
Total footrope rubbers weight	700 kg	
Total weight of footrope chains + wire	115.7 kg	
Total weight of fishing line	157 kg	
Total weight of tickler chain	132.8 kg	
Total tickler chain length	73.8 m	
Tickler chain diameter	10 mm ML	

5 STANDARD OPERATING PROCEDURES FOR THE NAMIBIAN MONKFISH BIOMASS SURVEY

5.1 Preparation of the survey cruise

Preparations of the survey should be done well in advance. The Namibian annual monkfish biomass survey is traditionally conducted during the month of November for a period of about three weeks. It is recommended that the preparation of the trawl, sampling instruments and consumables should be secured at least a month before the survey. The cruise leader or the fishing gear technologist and the deckhand should inspect if the trawl gear is in conformity with the standardized specifications.

A pre-survey meeting is usually done two weeks before the survey is scheduled to start. During the meeting the cruised leader discusses the survey methods and elucidate the responsibilities of all participants. The preparation of the sampling instruments is also discussed.

Before leaving harbour, it is necessary to confirm if all instruments are on board and in working condition. The cruise leader, together with vessel members, should confirm if the trawl is configured according to the standardized specifications.

5.2 Survey design and objectives

5.2.1 Study area

The survey is carried out within the boundary of the Namibian Exclusive Economic Zone (EEZ) between latitudes 17°S and 30°S following 94 pre-determined trawl stations (Figure 12)

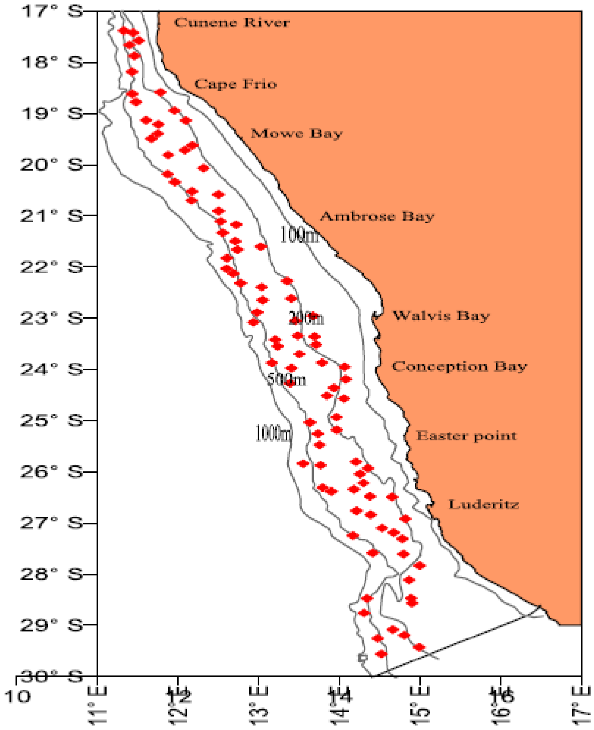


Figure 11: The monkfish biomass survey trawl stations followed during 2015 off Namibian coastline (Nangolo *et al.*, 2016b).

5.2.2 Survey design

The survey follows a design established by Schneider & Johnsen (2000). The study area was defined by a polygon of smaller cells. Eleven trawl positions were randomly selected in each cell. The first station on the list was considered first and if it was found non-trawlable, due to irregular or muddy bottom, the next position was trawled with the aim to find one trawlable position in each cell. A number of trawl stations were left out in the following years due to rough bottom, along with stations that were shallower than 100 m as no monkfish was caught in water shallower than 100 m in 2000 (Schneider, 2001). Currently the survey follows fixed trawling positions (Appendix D) that were found trawlable over the years (Nangolo *et al*. 2016b).

5.2.3 Objectives

The survey contributes to the annual stock assessment of monkfish which is used to advice the government on the exploitation of the resource such as setting of TAC. The key objectives are therefore:

1. To obtain biomass indices of the Namibian monkfish.
2. To monitor recruitment.
3. To map out the geographical distribution of monkfish.
4. To collect biological information (length, sex, maturity) from monkfish and other commercially important species.
5. To collect environmental data and establish linkages between the environment and the monkfish distribution.
6. To train Namibians on survey techniques.

5.3 Fishing methods

It is critical to maintain the fishing procedures during the entire survey. The captain is responsible for making sure that the towing speed, tow duration, trawl geometry (door spread and vertical opening) are within a tolerant range. The trawl deployment and retrieval should be done in a consistent manner. Monkfish biomass is conducted all day and night.

5.3.1 Towing speed and duration

A typical standard tow is done at a towing speed of 3.0 knots for 30 minutes in a northerly direction. However, due to various factors such as uneven or muddy bottom and large catches at the onset of the tow, it is not always possible to achieve 30 minutes. Therefore, a tow should be considered valid when it is more than 15 minutes (to reduce the start-end effects) but less than 35 minutes (see Appendix E, for additional factors to consider when validating tows). Reasons for shortening a tow should be registered on the tow form. The start time of the tow is defined as the moment when the net reached the bottom and both the vertical net opening and door spread are stable. The tow end time is defined as the start of the winches hauling trawl back on board. The captain is responsible for constant monitoring of the speed. The speed should not drop below 2.5 or exceed 3.5 knots. Excess speed may result in the centre of footrope lifting off the bottom (Stauffer, 2004).

5.3.2 Warp-depth ratio

The length of the towing warp of each tow is not fixed but should be like the registered length from the 2016 monkfish biomass survey. The warp-depth ratio has an influence on the net geometry and bottom contact, hence constant monitoring of door spread is required. The ratio ranges from 2.40 to 2.86 (warp/depth) and varies a lot at similar depth (Figure 13). Since different warp length was used at similar depth, it is sensible to use the warp length used per station during the 2016 survey (Appendix D) to obtain similar door spread.

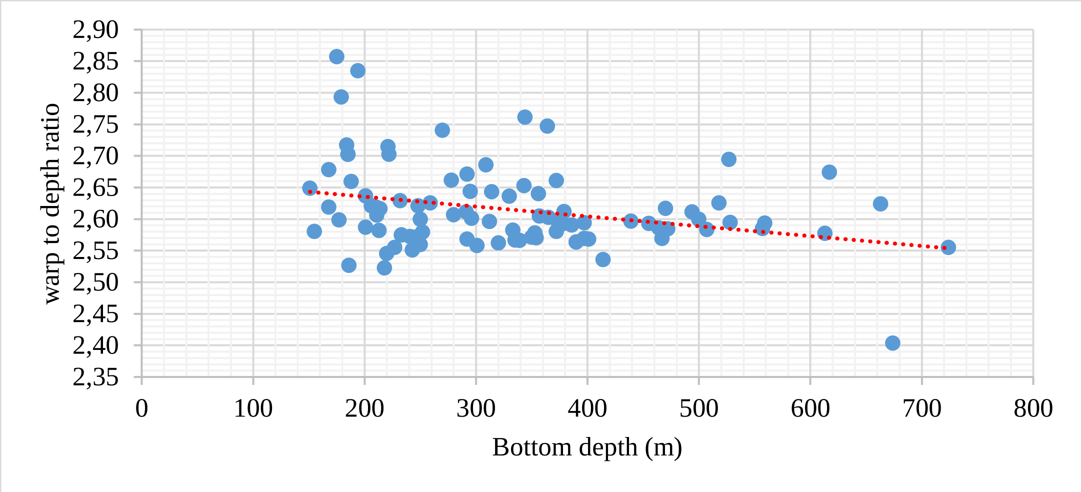


Figure 12: Warp to depth ratio (warp/depth) plotted against bottom depth. Data from the 2016 Namibian monkfish biomass survey.

5.4 Haul sampling procedures

The sampling leader decides on the order of the sampling. However, the sampling procedures of a trawl catch should be uniform at all sampling stations. The main target is to get an estimate of the total number and weight (kg) of monkfish from each haul. **All monkfish are sorted out of the catch on deck**. Due to the fairly low catches of monkfish, length frequency and biological data is collected from all the monkfish landed.

For sampling non-targeted commercial species and determination of catch composition, the following is the standard way to follow when a trawl comes on deck:

1. If the catch is small such that it can be completed before the next haul is on deck, the whole catch should be taken and sorted by species.
2. If the catch is large, a portion of the catch should be randomly sampled after sorting out all monkfish.
3. All samples should be put in sampling baskets and each basket should be filled to the top. The number of sampled baskets depend on the size of the catch and is decided by the sampling leader.
4. All species in a sample are sorted and identified.
5. All sorted species are counted and weighted. The weight and number of the sampled individual species is raised to the total catch by multiplying the sample (weight and number) with the raising factor (RF) determined as follow:

$$RF = \frac{Total\ catch\ (baskets)}{Sampled\ catch\ (baskets)}$$

6. If the sampled catch has a large number of a particular species which is difficult to count, a subsample is taken from the sampled catch. A subsample is done by taking a portion of a sampled species, weight it and count the number of the organisms. The number of the subsampled individual species is raised to the sampled catch as follow:

$$N_s = \frac{W_s * n_{sb}}{w_{sb}}$$

   Where N_s is the number of organisms belonging to the same species in a sample, W_s is the weight of the total number of species in a sample, n_s is the number of subsampled organisms and w_{sb} is the corresponding total weight of the subsample.
7. After a sample is taken from the catch on deck, the remaining catch is discarded using baskets to count the number of discarded baskets. The number of discarded baskets is added to the number of sampled baskets to determine the total catch.
8. The number of sampled (sorted) and discarded baskets should be recorded on both the deck form (Appendix F) and Trawl form (Appendix G).
9. Length frequency of monkfish and non-targeted commercial species should be recorded (section 5.6.).
10. Biological sampling is only done for monkfish (section 5.7.).

5.5 Species identification

At each tow station, species sampled are identified with the help of the taxonomists on board the research vessel. All species should be identified to their lowest taxonomic hierarchy known. The book "*FAO species identification field guide for fishery purposes. The living marine resources of Namibia"* by Bianchi *et al* (1999) is used for Namibian surveys. Other literatures found to be helpful in species identification are also used. For monkfish, there are two species that should be carefully identified.

The two monkfish species landed from the Namibian surveys are *Lophius vomerinus* and *Lophius vaillanti* (Figure 14). *L. vomerinus* makes up most of the total catch and it is the only species considered for the Namibian monkfish biomass estimates. The distinctive features for the two species are well explained by Bianchi *et al.*, (1999): Both species appear to be brownish in colour but *L. vomerinus* is darker above and pale on the ventral side with darkish patches in front of pelvic fins. *Lophius vomerinus* has a fleshy esca on the first cephalic spine (illicium) that is absent from *L. vaillanti*. The frontal ridge of *L. vaillanti* is smooth, but rugose for *L. vomerinus*. *L. vomerinus* is distributed along the entire coastline of Namibia while *L. Vaillanti* is commonly found north of Walvis Bay.

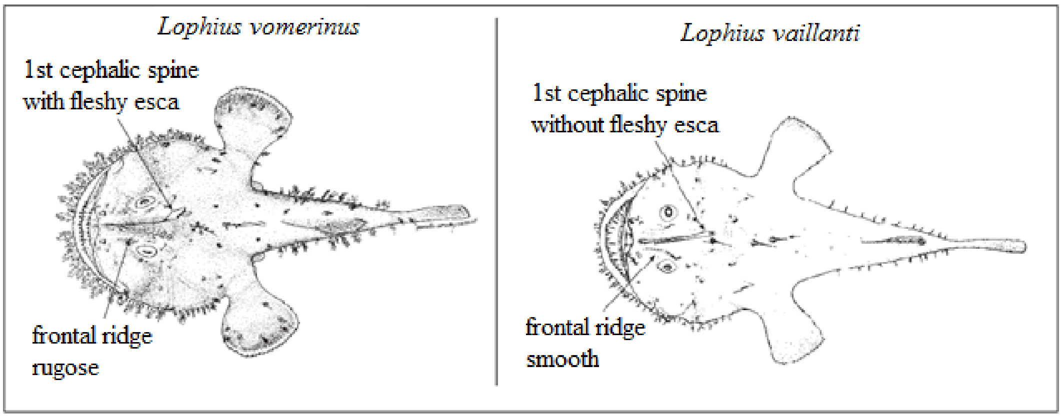


Figure 13: Monkfish: *Lophius vomerinus* and *L. vaillanti* (Bianchi *et al.*,1999).

5.6 Length measurement

There are two types of length measured for commercial species during the monkfish biomass survey. The total length or full body length is measured from the tip of the snout to the tip of the tail while the fork length is measured from the tip of the snout to the middle of the caudal fin (Figure 15). It is important that the fish is stretched out to its natural relaxed length (pre-rigor mortis) and the mouth should be closed. The length should be recorded to the nearest centimetres (cm) on the length frequency form (Appendix H).

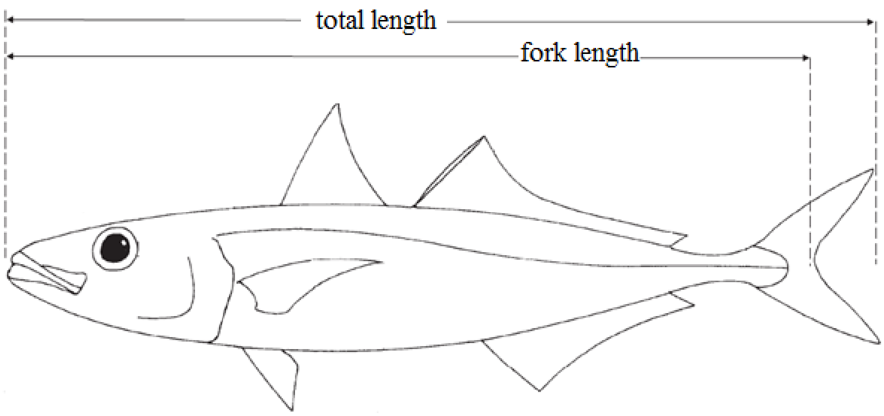


Figure 14: standard measurement of fish length during the Namibian annual monkfish biomass survey (adapted from Bianchi *et al.*, 1999).

During the monkfish biomass survey, the following lengths are measured:

1. **Total length**: Monkfish, Hake, Sole, Orange roughy and Kingklip
2. **Fork length**: Angelfish, Horse mackerel, Dentex, Slender beryx and Snoek.

5.7 Biological sampling for monkfish

Biological data collected from monkfish are; sex (male or female), length, maturity stage, individual weight (with and without stomach content) and collection of illicia.

5.7.1 Sex determination

In order to determine the sex of the monkfish it is necessary to make an incision through the body wall, from the anus up to the base of the pelvic fins. The next step is to open the body, so the intestines and sex organ are visible.

5.7.2 Maturity stage

Both the female and male gonads are classified in different stages of sexual maturity and both sexes should be determined according to the following criteria (Table 6):

Table 6: Guideline for determining maturity stage of monkfish.

Maturity stage	Description
1. Immature	**Ovaries** are greyish-pink in colour, relatively small, ribbon like and appear almost empty with no vascularisation. **Testes** are white to tan in colour and very small.
2. Resting	**Ovaries** are orange-pink larger than the immature stage and with little vascularisation. No ova are visible. **Testes** are white to tan in colour, much larger than the immature stage and small amount of milt is sometimes present when dissected.
3. Developing	**Ovaries** are orange, highly vascular and ova are visible. **Testes** blotchy cream to tan in colour and very film in texture. Moderate amount of milt is present when dissected.
4. Ripe	**Ovaries** are straw-coloured to almost clear and highly vascular. Distinct ova are present. **Testes** are blotchy cream to tan coloured with areas of pink, extremely firm in texture and copious amounts of milt are present when dissected.
5. Spent	**Ovaries** are grey in colour, extremely flaccid, moderately vascular and appear empty. Ova appear as black or white dots. **Testes** are greyish-tan, extremely flaccid, edges appear translucent and a small amount of milt is sometimes present when dissected.

5.7.3 Collection of illicia

Illicia is a cephalic spine above the head of a monkfish (Figure 14). The structure is used for age determination of monkfish. The collection of illicia should target all length classes starting from the smallest caught. At each station, 5 illicia pairs per each length caught, per species and sex type should be collected. Illicia is cut at the root to get the whole structure and put in envelopes marked with length, sex, weigh and station number. The sampled fish/illicia number should be noted on the biological sampling form (Appendix F).

5.8 Environmental data collection

Since the 2016 monkfish biomass survey, environmental data are collected with a Conductivity Temperature Depth (CTD) probe that is mounted on the trawl net (square panel) around the headline bosom. The CTD is switched on when deploying the trawl and turned off immediately when hauling back the trawl as soon as the square panel of the trawl net is on deck. Environmental parameters measured by the CTD are: conductivity, temperature, depth, salinity and oxygen throughout the water column at each tow station.

5.9 Tow information collection

Information of each tow, such as gear ID, tow duration, towing speed, position of the station etc. are recorded on the trawl/bridge form (Appendix G) at the bridge by the cruise leader. It is important to record the tow speed, door spread, net opening, symmetrical ratio, and temperature on an interval basis. These readings should be taken every 5 minutes.

5.10 Data handling

All data collected on forms are attached together and given to the cruise leader for entering them into the *Nansis* database on board the vessel. Biomass calculations and cruise report are done after the survey by the cruise leader.

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APPENDICES

Appendix A: Rigging of *Steinshamn* trawl doors

Figure A1: Steinshamn V type door back strops arrangement

Figure A2: Accessories for connecting back strops to the extension chains

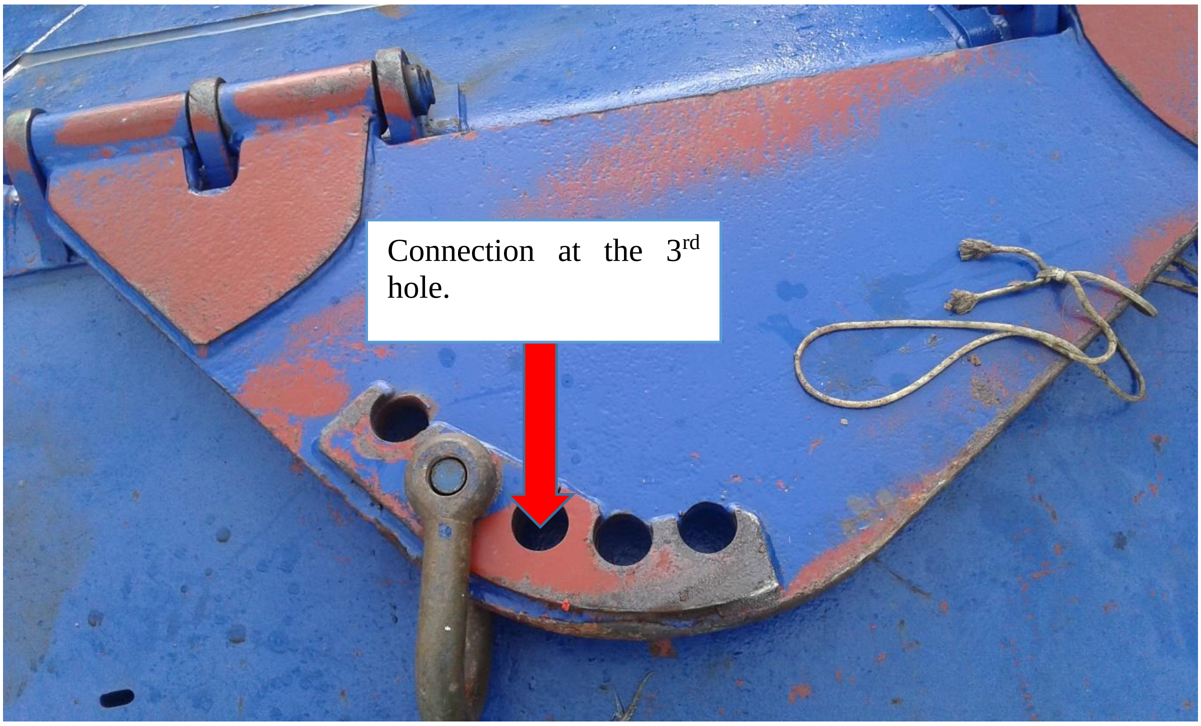

Figure A3: Rigging of trawl doors to the warp wires.

Appendix B: *Thyboron* trawl doors

Appendix C: *Poly Ice* trawl doors

Appendix D: Station information from the November 2016 monkfish biomass survey

R/V MIRABILIS
Trawl: Albatross

MONK BIOMASS SURVEY **VOY. No: 007/2016-17**

Trawl Data Sheet

Departure Date: **08-11-2016** Arrival Date: **24.11.2016**

Date	Position	Crs	Speed (knot)	Time Start	Time End	Distance (nm)	Duration (minutes)	Bottom Depth (m)	Net Open. (m)	Gear Temp (°C)	Wire Out	Door Sprd (m)	Comment/ Remark
08/11/16	22° 58.6' S - 013° 40.5' E	344°	3.0	18:38	19:08	1.56	30	151	1.1	11.8	400	85	
08/11/16	23° 58.4' S - 013° 26.1' E	179°	3.0	21:07	21:37	1.51	30	292	1.1	10.8	750	92	
09/11/16	23° 19.6' S - 013° 29.1' E	185°	3.0	00:46	01:16	1.53	30	233	1.1	11.3	600	90	
09/11/16	23° 21.9' S - 013° 39.7' E	157°	3.0	02:51	03:21	1.50	30	168	1.0	11.6	450	88	
09/11/16	23° 30.9' S - 013° 40.5' E	140°	3.0	05:39	06:09	1.51	30	188	1.1	11.4	500	91	
09/11/16	23° 40.6' S - 013° 29.8' E	154°	3.0	08:13	08:43	1.55	30	250	1.0	10.9	640	92	
09/11/16	23° 51.9' S - 013° 47.0' E	128°	3.0	11:29	11:53	1.20	24	227	1.1	10.8	580	90	Spread reduced
09/11/16	23° 56.5' S - 014° 03.8' E	180°	3.0	14:34	15:04	1.51	30	184	1.1	11.0	500	86	
09/11/16	24° 11.6' S - 014° 04.4' E	185°	3.0	16:57	17:17	1.00	20	175	1.6	11.2	500	78	Spread reduced
09/11/16	24° 20.2' S - 013° 55.8' E	180°	3.0	19:11	19:41	1.55	30	250	1.1	10.1	650	89	
09/11/16	24° 30.5' S - 013° 50.3' E	167°	3.0	22:06	22:36	1.49	30	296	1.1	9.9	770	90	
10/11/16	24° 34.4' S - 014° 03.3' E	168°	3.0	00:16	00:41	1.30	25	155	-	11.1	400	83	Spread reduced
10/11/16	24° 56.8' S - 013° 58.2' E	340°	3.0	04:01	04:31	1.53	30	179	1.0	11.1	500	83	
10/11/16	25° 14.6' S - 013° 57.4' E	175°	3.0	07:51	08:09	0.96	18	218	1.0	10.9	550	91	Bad ground
10/11/16	25° 49.2' S - 014° 13.1' E	141°	3.0	13:20	13:50	1.52	30	233	1.1	10.3	600	92	
10/11/16	25° 56.6' S - 014° 21.0' E	175°	3.0	15:13	15:43	1.52	30	210	1.1	10.1	550	91	
10/11/16	26° 03.1' S - 014° 15.4' E	176°	3.0	17:25	15:55	1.50	30	221	1.1	10.2	600	90	
11/11/16	26° 12.9' S - 014° 17.8' E	140°	3.1	13:03	13:24	1.10	21	220	1.1	10.7	560	86	
11/11/16	26° 24.3' S - 014° 23.0' E	145°	3.0	15:02	15:32	1.49	30	314	1.1	9.6	830	95	
11/11/16	26° 29.7' S - 014° 39.1' E	167°	3.0	17:41	18:11	1.52	30	211	1.1	10.0	550	90	

11/11/16	26° 49.0' S - 014° 38.3' E	174°	3.0	21:12	21:42	1.57	30	248	1.1	9.4	650	93	
11/11/16	27° 05.9' S - 014° 31.3' E	160°	3.0	23:54	00:24	1.52	30	335	1.1	8.8	860	90	
12/11/16	27° 11.2' S - 014° 44.1' E	155°	3.0	02:09	02:39	1.51	30	278	1.0	9.1	740	91	
12/11/16	27° 18.4' S - 014° 45.0' E	159°	3.0	04:34	05:04	1.52	30	295	1.0	7.7	780	90	
12/11/16	27° 36.3' S - 014° 47.7' E	150°	3.0	07:27	07:53	1.38	26	333	1.0	7.9	860	91	Spread reduced
12/11/16	27° 48.4' S - 014° 58.9' E	180°	3.0	09:48	10:09	1.10	21	186	1.1	8.6	470	91	Spread reduced
12/11/16	28° 07.0' S - 014° 51.7' E	147°	3.0	13:14	13:44	1.52	30	201	1.1	9.8	530	89	
12/11/16	28° 28.7' S - 014° 53.5' E	170°	3.0	16:18	16:48	1.51	30	185	1.2	9.4	500	89	
12/11/16	28° 33.8' S - 014° 54.2' E	167°	3.0	17:47	18:17	1.52	30	185	1.2	9.4	500	82	
12/11/16	29° 04.1' S - 014° 39.3' E	180°	3.0	23:18	23:38	1.00	20	243	1.2	9.6	620	91	Spread reduced
13/11/16	29° 11.7' S - 014° 47.9' E	170°	3.1	01:36	02:06	1.54	30	222	1.2	9.8	600	89	
13/11/16	29° 26.0' S - 014° 59.1' E	135°	3.0	04:53	05:24	1.56	31	194	1.0	10.1	550	91	
13/11/16	29° 33.5' S - 014° 31.0' E	340°	3.0	08:43	09:13	1.54	30	557	1.1	5.9	1440	92	
13/11/16	29° 17.1' S - 014° 29.0' E	346°	3.1	11:12	11:33	1.00	21	500	1.0	6.1	1300	92	Spread reduced
13/11/16	28° 47.1' S - 014° 18.5' E	348°	3.1	14:50	15:20	1.56	30	617	-	6.1	1650	91	T/S nt working
13/11/16	28° 29.0' S - 014° 21.6' E	359°	3.1	18:33	19:03	1.60	30	527	1.1	7.0	1420	87	
14/11/16	27° 25.6' S - 014° 25.0' E	332°	3.0	07:50	08:20	1.50	30	414	1.1	8.8	1050	96	
14/11/16	27° 15.0' S - 014° 10.3' E	331°	3.0	10:15	10:45	1.53	30	467	1.1	7.9	1200	95	
14/11/16	26° 50.6' S - 014° 23.4' E	347°	3.0	13:49	14:19	1.52	30	344	1.1	8.9	950	92	
14/11/16	26° 45.8' S - 014° 12.7' E	350°	3.0	15:49	16:19	1.51	30	379	1.1	8.9	990	88	
14/11/16	26° 35.5' S - 014° 06.0' E	344°	3.0	18:04	18:34	1.53	30	390	1.0	9.2	1000	92	
14/11/16	26° 23.6' S - 014° 54.4' E	332°	3.0	21:31	22:01	1.52	30	397	1.1	9.4	1020	93	
14/11/16	25° 18.7' S - 014° 47.5' E	337°	3.0	23:10	23:40	1.52	30	401	1.1	9.5	1030	89	
15/11/16	25° 52.4' S - 013° 46.2' E	334°	3.0	09:37	10:07	1.51	30	397	1.1	9.9	1030	91	
15/11/16	25° 49.1' S - 013° 32.4' E	347°	3.0	12:43	13:13	1.52	30	724	1.1	4.6	1850	94	
15/11/16	25° 27.9' S - 013° 45.0' E	340°	3.0	16:06	16:37	1.52	30	343	1.1	9.4	910	94	
15/11/16	25° 15.5' S - 013° 44.0' E	350°	3.0	18:07	18:37	1.52	30	309	1.0	10.0	830	91	
15/11/16	25° 01.7' S - 013° 38.2' E	356°	3.0	21:11	21:41	1.54	30	455	1.1	8.5	1180	90	
16/11/16	24° 16.2' S - 013° 23.1' E	330°	3.1	02:22	02:52	1.56	30	372	1.1	9.6	990	84	

16/11/16	23° 58.9’ S - 013° 24.7’ E	339°	3.1	04:54	05:24	1.55	30	292	1.1	10.7	780	86	
16/11/16	23° 52.8’ S - 013° 09.9’ E	346°	3.0	08:14	08:44	1.50	30	494	1.1	7.3	1290	93	
16/11/16	23° 33.3’ S - 013° 14.2’ E	004°	3.0	10:54	11:24	1.52	30	353	1.0	9.8	910	86	
16/11/16	23° 26.1’ S - 013° 12.1’ E	360°	3.0	12:33	13:03	1.47	30	386	1.1	8.6	1000	89	
16/11/16	23° 05.1’ S - 012° 56.3’ E	350°	3.0	16:51	17:21	1.52	30	674	1.1	5.6	1620	91	
16/11/16	22° 56.5’ S - 013° 02.5’ E	338°	3.0	18:55	19:25	1.54	30	364	1.1	9.6	1000	89	
17/11/16	22° 38.0’ S - 013° 25.0’ E	322°	3.0	20:57	21:27	1.52	30	252	1.0	11.5	650	90	
18/11/16	22° 42.9’ S - 013° 07.3’ E	342°	3.0	00:23	00:53	1.53	30	320	1.1	10.4	820	91	
18/11/16	22° 23.8’ S - 013° 02.1’ E	342°	3.0	02:58	03:28	1.48	30	280	1.0	11.2	730	90	
18/11/16	22° 18.3’ S - 012° 46.2’ E	345°	3.0	05:23	05:53	1.60	30	472	1.1	7.6	1220	87	
18/11/16	22° 08.5’ S - 012° 41.0’ E	334°	3.0	08:23	08:53	1.55	30	559	1.2	7.3	1450	91	
18/11/16	22° 03.0’ S - 012° 36.1’ E	350°	3.0	10:09	10:39	1.57	30	663	1.1	6.1	1740	93	
18/11/16	21° 50.7’ S - 012° 36.6’ E	352°	3.0	12:34	13:04	1.55	30	613	1.1	6.4	1580	96	
18/11/16	21° 40.2’ S - 012° 44.1’ E	350°	3.0	15:42	16:12	1.48	30	354	1.1	9.9	910	93	
18/11/16	21° 30.1’ S - 012° 42.5’ E	353°	3.0	17:30	18:00	1.55	30	353	1.1	9.7	910	93	
18/11/16	21° 19.1’ S - 012° 32.7’ E	346°	3.0	19:44	20:14	1.53	30	464	1.1	8.7	1200	91	
18/11/16	21° 12.8’ S - 012° 43.1’ E	002°	3.0	22:57	23:27	1.54	30	350	1.1	10.0	900	92	
19/11/16	21° 07.7’ S - 012° 32.2’ E	350°	3.0	01:09	01:39	1.56	30	439	1.1	8.9	1140	94	
19/11/16	20° 55.0’ S - 012° 30.0’ E	330°	3.0	03:14	03:44	1.56	30	390	1.1	9.3	1000	95	
19/11/16	20° 41.1’ S - 012° 09.4’ E	324°	3.0	07:10	07:40	1.52	30	528	1.2	7.6	1370	90	
19/11/16	20° 30.7’ S - 012° 10.0’ E	327°	3.0	09:07	09:37	1.50	30	357	1.1	10.0	930	90	
19/11/16	20° 21.7’ S - 012° 58.4’ E	330°	3.0	11:16	11:46	1.50	30	507	1.1	7.4	1310	93	
19/11/16	20° 12.7’ S - 011° 52.1’ E	325°	3.0	14:11	14:41	1.52	30	518	1.1	7.3	1360	90	
19/11/16	19° 47.7’ S - 011° 52.5’ E	347°	3.0	17:28	17:58	1.50	30	365	1.1	10.5	950	91	
20/11/16	19° 44.4’ S - 012° 05.4’ E	344°	3.0	18:29	18:59	1.54	30	291	1.1	12.3	760	90	
20/11/16	19° 30.2’ S - 011° 40.4’ E	346°	3.0	22:51	23:21	1.48	30	372	1.1	9.3	960	89	
21/11/16	19° 23.6’ S - 011° 44.9’ E	347°	3.0	00:31	01:01	1.52	30	339	1.1	9.9	870	-	Door sensor n/a
21/11/16	19° 14.2’ S - 011° 44.1’ E	342°	3.0	02:11	02:41	1.55	30	330	1.2	10.1	870	89	
21/11/16	19° 08.0’ S - 011° 36.4’ E	330°	3.0	04:42	05:12	1.53	30	301	1.1	10.9	770	91	
21/11/16	18° 48.1’ S - 011° 25.5’ E	354°	3.0	07:39	08:09	1.51	30	378	1.1	9.3	980	88	
21/11/16	18° 37.6’ S - 011° 25.8’ E	005°	3.0	09:27	09:57	1.50	30	356	1.2	9.8	940	89	
21/11/16	18° 14.8’ S - 011° 25.0’ E	010°	3.0	13:14	13:44	1.53	30	470	1.1	8.0	1230	89	
22/11/16	17° 53.9’ S - 011° 27.7’ E	345°	3.0	01:59	02:29	1.52	30	232	1.2	12.3	610	91	

22/11/16	17° 39.7’ S - 011° 24.0’ E	353°	3.0	04:05	04:35	1.55	30	270	1.2	11.7	740	90	
22/11/16	17° 22.6’ S - 011° 19.6’ E	351°	3.0	06:30	07:00	1.51	30	374	1.0	9.0	970	91	
22/11/16	17° 25.1’ S - 011° 26.5’ E	177°	3.0	08:19	08:49	1.47	30	214	1.1	13.9	560	87	
22/11/16	18° 34.3’ S - 011° 30.6’ E	164°	3.0	10:01	10:31	1.53	30	168	1.1	14.3	440	89	
22/11/16	18° 34.9’ S - 011° 46.7’ E	147°	3.0	17:21	17:51	1.55	30	177	1.1	15.1	460	89	
22/11/16	18° 56.3’ S - 011° 57.0’ E	148°	3.0	20:18	20:48	1.51	30	213	1.1	13.4	550	88	
22/11/16	19° 07.6’ S - 012° 05.2’ E	148°	3.0	22:17	22:47	1.52	30	201	1.1	13.2	520	88	
23/11/16	19° 36.9’ S - 012° 10.4’ E	173°	3.0	02:30	03:00	1.54	30	245	1.1	12.6	630	89	
23/11/16	20° 02.7’ S - 012° 18.0’ E	144°	3.0	05:53	06:23	1.55	30	241	1.1	12.8	620	87	
23/11/16	20° 34.2’ S - 012° 29.9’ E	144°	3.0	09:45	10:15	1.51	30	312	1.1	11.8	810	88	
23/11/16	21° 36.6’ S - 013° 01.3’ E	149°	3.0	18:07	18:37	1.53	30	259	1.1	12.0	680	90	
23/11/16	22° 15.6’ S - 013° 20.8’ E	158°	3.0	23:23	23:53	1.51	30	206	1.1	12.1	540	90	

Appendix E: Factors to consider when validating a tow

A tow is considered valid if the towing speed was 3.0 knots on average and the duration of the trawl is ≥ 15 or 35 ≤ minutes for Namibian monkfish biomass survey. However, the cruise leader must consider other factors. The following factors are based on those considered in the Icelandic groundfish survey (MRI, 2010):

1. If there is a hang up or net damage after a towing duration of less than 15 minutes at a constant speed of 3.0 knots. The tow is repeated.
2. If something is wrong in relation to the trawl, such as if the codend is stuck to the headline, the wings are wounded, or something is wrong with the trawl doors, the tow is invalid and has to be repeated.
3. If parts of the headline, the footrope or the bridles are broken the tow is only valid if it is known precisely when the rope broke down (for example, if it broke down due to snagging of the trawl) and the tow was fished at least for 15 minutes.
4. If the codend has a hole or is ragged the tow is invalid and must be repeated. If the net in the upper or lower belly, wings and the square have holes or is ragged the tow is only valid if it is believed to have had no effect on the sampling efficiency of the trawl.

Number of repetitions: When invalid tows are repeated, a towing duration of 15 minutes should be sufficient especially in areas where the bottom is rough.

NB: If the above conditions and their solutions are to be adopted for the Namibian monkfish biomass survey, they should be applied uniformly at each station.

Appendix F: Deck sampling form

	Number of Baskets					
Deck form	Thrown	Sorted	Total	*RF*:		
Species	Sample		Sub-sample		Total Catch	
	W	N	W	N	W	N

Appendix G: Trawl form

R/V:	Survey No:	Station No:	Total Baskets:	Baskets Sampled:	Baskets Thrown:

Date:		Region:	Purpose:	Gear Cond.:	Validity:	Gear (Type+No.):

Position (S°, E°)	Start	Stop		Trawl height (m):	
Lat. (S)				Temperature (C):	
Long (E)				Door spread (m):	
			Duration	Notes:	
Time:	:	:			
Log:	0.00				
Gear depth:					
Bottom depth:					
Course:				Sample Weight (kg):	Total Catch (kg):
Wire out:		Speed:	knots		

Species Name	Species Code	Sample (kg)	Sample (no)	Sub-Sample (kg)	Sub-Sample (no.)	Total catch (kg)	Total catch (no.)	Sample No.

Appendix H: Length frequency sampling form

Vessel name: ***Survey #*** ***Date: ___________________***

Species:			Species:		
Station number:			Station number:		
Species code:			Species code:		
Sample number:			Sample number:		
Weight of sample:			Weight of sample:		
Number in sample:			Number in sample:		
0			0		
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
0			0		
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
0			0		
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
0			0		

Appendix F: Biological data sampling form

BIOLOGICAL SAMPLING FORM

Date: ______ Depth: ______

Time: ______

Sta. #: ______

Fish No.	Length	Full weight	Weight without stomach	Sex	Mat	Stomach W (gm)	Fullness	Illicia No.	Comments
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									