Defence Research and Development Canada
Recherche et développement pour la défense Canada

Standard Operating Procedures for Deployment and Recovery of Distributed Underwater Sensor Networks (DUSN) Nodes and Associated Small Gear

Michael Simms
Field Trial Support Services
DRDC – Atlantic Research Centre

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Abstract

As part of the Force Anti-Submarine Warfare (FASW) project, Defence Research and Development Canada (DRDC) had a requirement to deploy a variety of scientific moorings. This Reference Document describes the standard operating procedures developed and implemented for the deployment and recovery of the DRDC Distributed Underwater Sensor Networks (DUSN) nodes and associated small gear during the 2018 field trials.

Résumé

Dans le cadre du projet de lutte anti-sous-marine de la force (FASW), Recherche et développement pour la défense Canada (RDDC) a dû procéder à divers amarrages scientifiques. Ce document de référence énonce les instructions permanentes d'opération élaborées et mises en place en vue du déploiement et de la récupération des nœuds du réseau distribué de capteurs sous-marins de RDDC et du petit matériel connexe au cours des essais sur le terrain en 2018.

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1 Introduction

1.1 Scope

This Reference Document describes the standard operating procedures developed for the deployment and recovery of the Defence Research and Development Canada (DRDC) Distributed Underwater Sensor Networks (DUSN) nodes and small gear used in support of the Force Anti-Submarine Warfare (FASW) project. Procedures for the following equipment will be covered:

- DUSN node
- DUSN node & gateway buoy
- Gateway buoy
- Conductivity, Temperature, Depth (CTD)
- icListen

These procedures are based on practical experience and were successfully implemented over the course of several field trials taking place in both the Bedford Basin and the Canadian Forces Maritime Experimental Test Ranges (CFMETR).

This Reference Document shall be considered only as a recommendation to the Master, who is ultimately responsible for decisions on the deployment and recovery of equipment.

1.2 Applicability

This Standard Operating Procedure (SOP) is intended for use with a Torpedo & Ship Ranging Vessel (TSRV), but may be applicable to other vessels outfitted with an appropriate crane and deck space. Note that use of a smaller, low-sided vessel with adequate deck space and crane will simplify DUSN recoveries. This will allow recovery via a single vessel, avoiding the need for a simultaneous operation.

1.3 Interferences

- Minimum & maximum depth advised for this operation is ± 5 m of the target depth.
- Maximum sea state advised for this deployment is 2 (World Meteorological Organization (WMO) Sea State Code)
- Maximum sea state advised for this recovery is 2 (WMO Sea State Code)
- Maximum wind force advised for this deployment is 15 Knots
- Maximum wind force advised for this recovery is 15 Knots
- Maximum ship’s speed advised for this operation is 0 Knots
- Minimum ship’s speed advised for this operation is 0 Knots

1.4 Health & Safety Warnings

All personnel shall:

- Conform to Master's orders at all times.
- Bring on board and wear personal protection equipment (hard hats, safety shoes, life jackets).
- Never remain under a suspended load during hoisting operations.
- Never attempt to stop by hand, movement of loads due to ship rolling motion.
- Only essential personnel will be on deck during deployment operations.
- Stay clear of hazardous areas if not strictly involved in the operations.

1.5 Testing & Certification

All elements of each scientific system within this SOP have been previously tested.

All lifting bridals and release hooks supplied have been tested and certified in accordance with C-28-020-001/TB-001 Tests of Shipboard Lifting Appliances. This is the standard used for Canadian Forces ships including submarines and auxiliaries.

2 Equipment Details

2.1 Gateway Buoy

The gateway buoy is comprised of a surface float containing an electronics canister and an antenna. It has a Benthos modem, dual Sub Sea Sonics acoustic releases and cable mooring.

Table 1: *Gateway buoy technical specifications.*

Item	**Description**
Sensor type	Acoustic modem and data radio
Package	Cylindrical
Package material	PVC, Syntactic foam
Overall dimensions	25 in. (diameter) 33 in. (height) (64 cm x 84 cm) excluding antenna
Maximum working depth	0 m (surface buoy with varied mooring length)
Total weight excluding anchor	55 kg, 120 lb
Anchor weight (concrete)	59 kg, 130 lb (32 kg, 70 lb in water)

Figure 1: *Gateway buoy.*

2.2 DUSN Node

A DUSN node is comprised of a Vertical Line Array (VLA), processor canister, two battery canisters, outer frame structure with float box, benthos modem, dual Sub Sea Sonics acoustic releases, and a sacrificial anchor. It is intended to be deployed subsurface.

Table 2: *DUSN node technical specifications.*

Item	Description
Sensor type	Acoustic modem and data radio
Package	Cube
Package material	PVC & Syntactic foam
Overall dimensions	40 in. x 40 in. x 33 in. (L x W x H) (1 m x 1 m x 0.84 m)
Maximum working depth	300 m
Total weight excluding anchor	145 kg, 320 lb
Anchor weight (steel)	59 kg, 130 lb (52 kg, 115 lb in water)

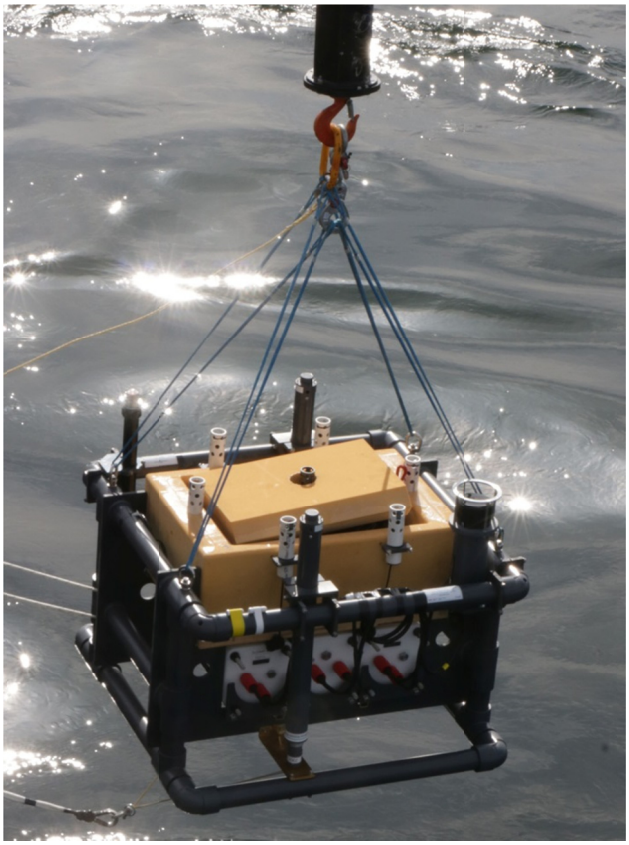

Figure 2: *DUSN node and deployment bridal.*

2.3 icListen

The icListen is a system comprised of a hydrophone, 7.5 m cabling and a battery canister. It is intended to be deployed subsurface.

Table 3: *icListen technical specifications.*

Item	Description
Sensor type	Broadband Digital Hydrophone
Package	Cylindrical
Overall dimensions	1.75 in. (diameter) 8.6 in (length)
Maximum working depth	200 m (max battery canister depth may differ)
Total weight excluding anchor	9.09 kg, 20 lb (in water including battery canister)
Anchor weight (concrete)	59 kg, 130 lb (32 kg, 70 lb in water)

Figure 3: *icListen.*

2.4 CTD

CTD's are used to log salinity, conductivity, temperature, and depth. Typical deployments include a surface expression.

Table 4: *CTD technical specifications.*

Item	Description
Sensor type	Conductivity (salinity), temperature, pressure (depth)
Package	Cylindrical housing with swordfish clips
Overall dimensions (housing)	1 in. (diameter), 4 in. (long)
Maximum working depth	Varies
Anchor weight (concrete)	59 kg, 130 lb (32 kg, 70 lb in water)

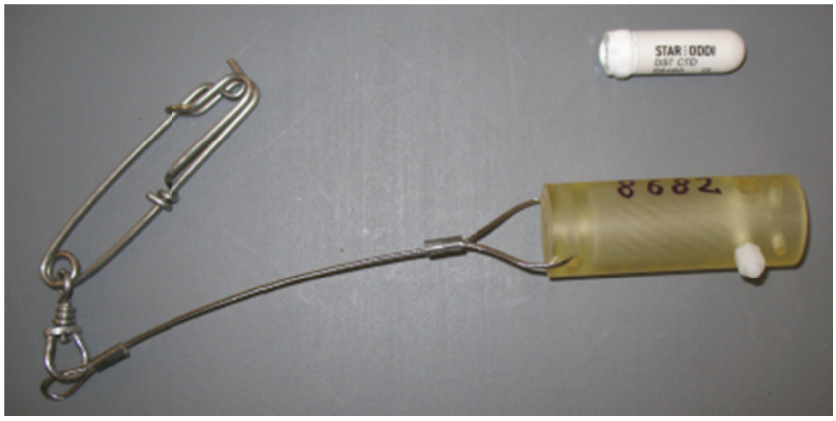

Figure 4: *CTD and housing.*

3 Deployment & Recovery Procedures

These procedures have been carefully thought out to reduce risk and determine the safest way possible for successful deployment and recovery of equipment. Deployment and recovery from a ship can be dangerous and good seamanship practises are expected from everyone involved.

All moorings will be deployed from a TSRV and/or workboat. Some of the deployments and most recoveries may require use of multiple vessels simultaneously. Some will require the use of a crane and or capstan, given the weight of the equipment and anchors.

All anchors being deployed are intended to be sacrificial and therefore will not be recovered unless deemed necessary. This will be done by use of Sub Sea Sonics Acoustic Releases. Care should be taken not to shock load these releases during anchor deployment as they are only marginally strong enough for this application. These release units employ electro-chemical erosion to release a tether. The erosion process is not fast. Typical surfacing times are generally 10 to 15 minutes after the release has been triggered, depending on water depth and salinity. It is important for all recovery vessels to maintain a distance of a few hundred metres from the deployed equipment's coordinates so as to avoid any hull damage from surfacing equipment, yet close enough to spot equipment once at the surface.

During all deployments and recoveries, caution should be exercised in keeping all lines and equipment away from the ship's propellers.

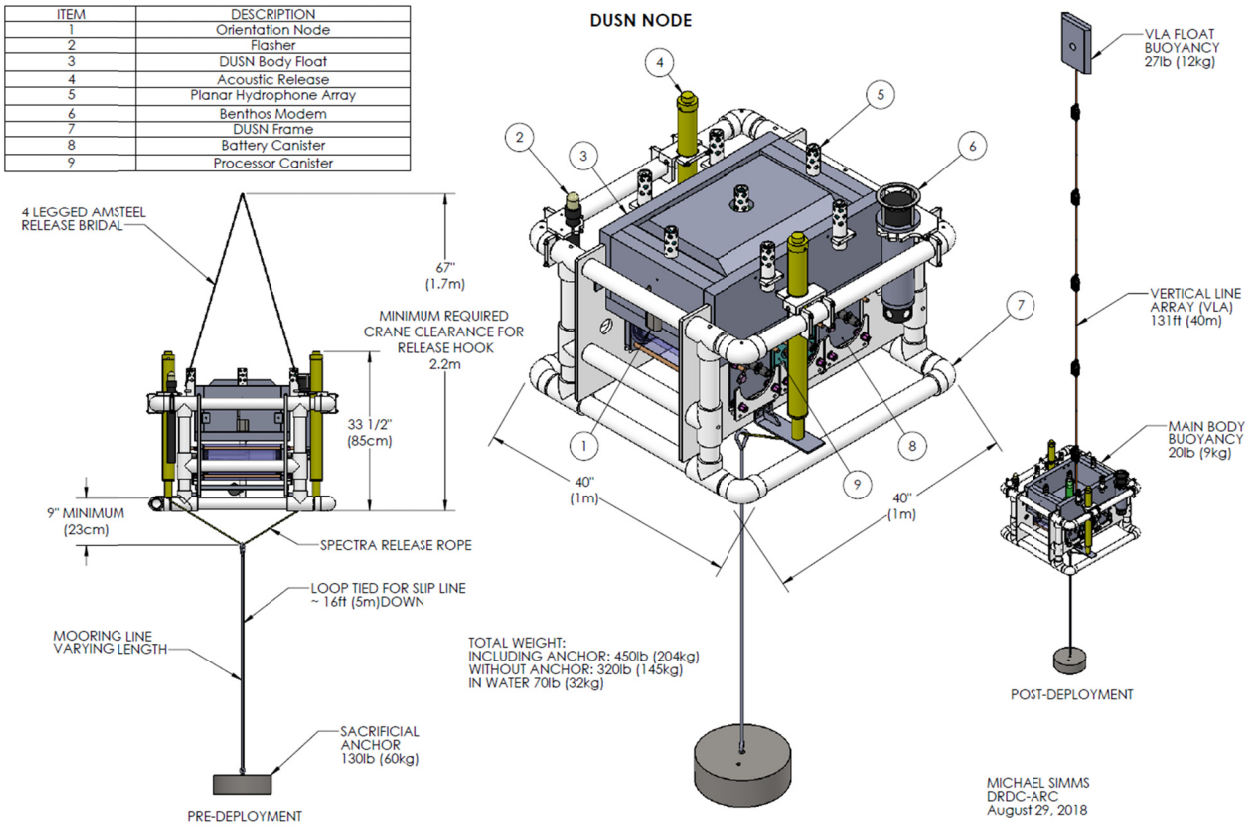

Figure 5: *DUSN node configuration.*

3.1 DUSN Node

3.1.1 Deployment

The deployment of each DUSN node will be done from a TSRV. In preparation for deployment, the DUSN node will be preloaded with the VLA and all necessary checks will be made. The 130 lb steel anchor will be attached via a length of Sampson braid mooring which will change in length depending on the DUSN number and location. The other end of this rope will be attached to the spectra rope which is attached to acoustic releases. In the majority of the deployments, given the length of the mooring, the anchor will be tied off over the side of the ship.

The release of the DUSN body will be a single point release. To achieve this, a quick-release hook will be hung from the ship's crane and positioned just above the DUSN. Also hanging from the crane hook, will be an Amsteel release bridal. The four legs of this bridal pass down through the stainless steel eyes at the top of the DUSN body from the outside and come *back up on the inside* to the release hook. Ensure no lines are crossed.

The release hook is then snapped shut. **Once the hook is armed, it is critical that the individual manning the release line pay close attention and allow plenty of slack to the line to prevent accidental release of the DUSN node.** A slip line is to be run around one of the lower frame tubes to steady the load in air.

Commencing the deployment, The TSRV shall position itself far enough up wind of the intended waypoint to allow time to deploy the anchor. It shall be orientated such that the deployment will be done on the windward side of the vessel as this will prevent drifting over top of any lines. Once all manoeuvring has ceased, the crane will lift the DUSN high enough to safely clear the side of the ship and position it over the water. The anchor can then be untied and lowered into the water by its mooring line making use of a capstan or bollard to support the weight. Five metres from the DUSN end of the rope will be a loop. Once this loop has passed to the water side of the capstan or bollard, the load will be transferred to a slip line and removed from the capstan or bollard. The line will slowly be slipped until the full load has been transferred to the DUSN, taking care not to shock load the acoustic releases. This slip line can then be pulled back on deck.

At this point, the Chief Scientist or his delegate on board will confirm that we are at the correct location. The crane will then lower the DUSN until the float is just touching the water and the slip line on the node will be pulled back in. The individual manning the release line will give the line a fast, sharp pull. The DUSN will slip from the bridal, which will remain on the crane hook, upon which the crane can be retracted back to its resting position on deck. The DUSN will begin deploying the array on its way down and at full extension the float will be pulled under the water.

3.1.2 Recovery

Recovery of the DUSN will be done from both a TSRV as well as a low-sided work boat. It will start by sending a signal to the acoustic releases which will release the sacrificial anchor. This will allow both the VLA float as well as the DUSN body to float to the surface.

Once both floats have surfaced, hand retrieval of the system will commence from the work boat and the mooring will be recovered in sequence. First in will be the VLA float, followed by the array. Care must be taken not to damage the nodes or cable on the array as it is coiled on deck. Once the array is recovered and the body is next to the boat, the array will be disconnected and blanking plugs installed, taking care not to get either connector wet. The steel lifting bridle will then be attached to all four lifting eyes on the DUSN.

The crane operator on the TSRV should have the crane standing by to lift the DUSN body out of the water. A tag line can be passed from the TSRV on the hook. For safety, a sling extension with a snap-hook can be added to the crane if required to move the large crane hook further above the workboat. The workboat shall slowly tow the node under the crane in such a way as to prevent the node from moving under the hull. The bridle will then be put on the crane hook, tag line attached and the DUSN can be landed safely back on the deck of the TSRV.

3.1.3 Cautions

When the release hook is closed, ensure it is completely snapped into place.

Everyone including the line handler should be standing clear of the DUSN while it is hanging from the crane. The handler of the release line must be extremely vigilant and provide enough slack to prevent accidental release. Ensure the line does not get caught or tangled while the DUSN in in the air. If it does, IMMEDIATELY yell out "Stop!" Remain clear of the suspended load until operations have paused. Once it is safe to do so, carefully free the line without pulling on it. If required, the DUSN shall be lowered back to the deck first.

Upon release of the node, be aware of the location of the crane hook. Depending on weather conditions and sea state, it may tend to swing on its return to position.

During recovery, care must be taken not to damage the DUSN due to waves or current bumping against the boat.

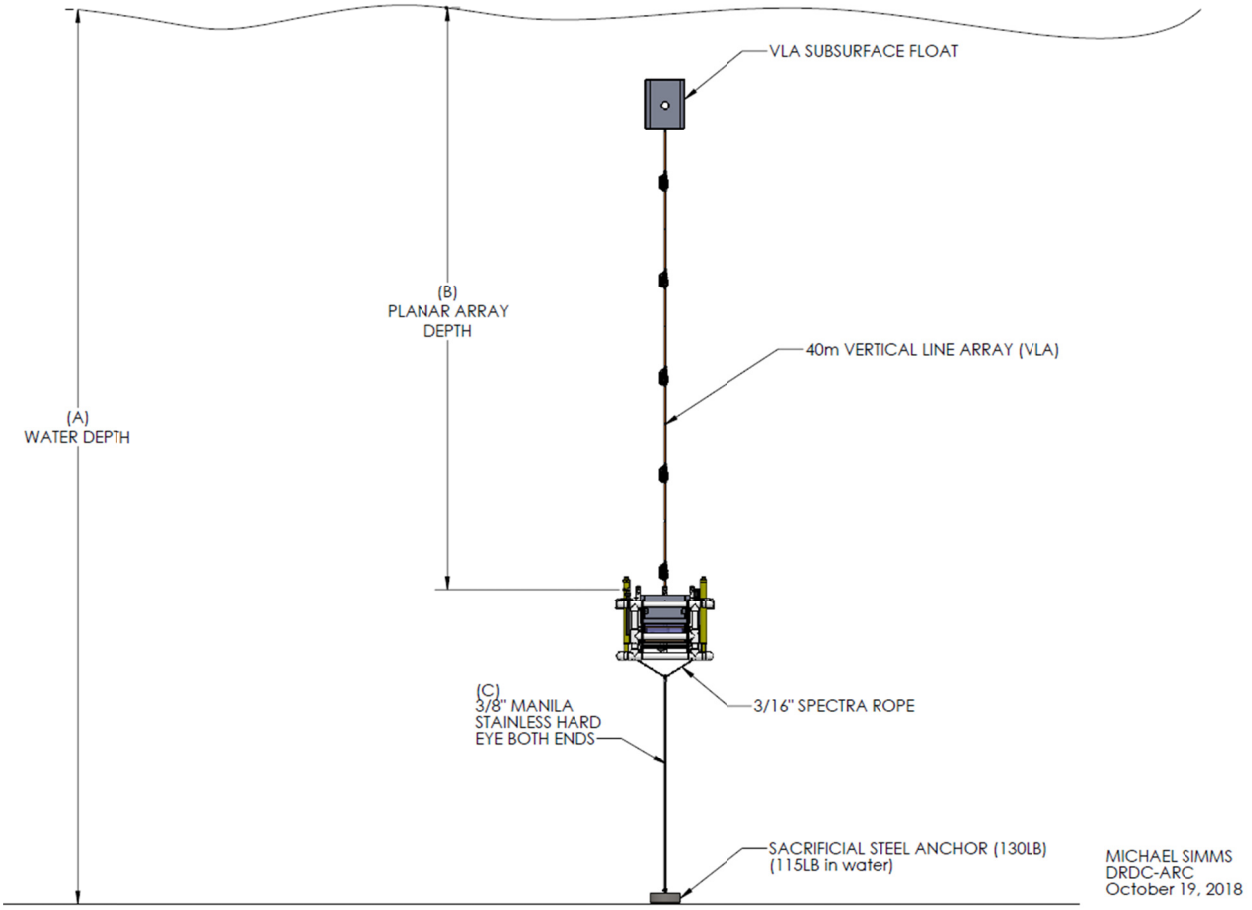

Figure 6: *DUSN node mooring.*

Table 5: *Values corresponding to Figure 6.*

DUSN #	A (m)	B (m)	C (m)

3.2 DUSN Node & Gateway Buoy

3.2.1 Deployment

The deployment of the DUSN node and electrical cable will be done by a TSRV. The gateway buoy float will be done after the fact by a workboat.

In preparation for the deployment, the married cable will be flaked out on the deck in figure-eight style bundles. One end will be attached to the DUSN node. The other, attached to a Sampson braid rope and anchor assembly in place of the buoy. Another anchor assembly will be attached near the electrical cable's midpoint. Both anchors will be positioned near the edge of the ship. The DUSN node will be preloaded with the VLA and all necessary checks will be completed. The DUSN anchor will be attached via a length of Manila rope mooring which will change in length depending on the DUSN number and location. The other end of this rope will be attached to the acoustic releases. In the majority of the deployments, given the length of the mooring, the anchor will be tied off over the side of the ship.

The release of the DUSN body will be a single point release. To achieve this, a quick-release hook will be hung from the ship's crane and positioned just above the DUSN. Also hanging from the crane hook, will be an Amsteel release bridal. The four legs of this bridal pass down through the stainless steel eyes at the top of the DUSN body from the outside and come *back up on the inside* to the release hook. Ensure no lines are crossed. A slip line is to be run around one of the lower frame tubes to steady the load in air.

The release hook is then snapped shut. **Once the hook is armed, it is critical that the individual manning the release line pay close attention and allow plenty of slack to the line to prevent accidental release of the DUSN node.**

Commencing the deployment, The TSRV shall position itself far enough up wind of the intended waypoint to allow time to deploy the anchors. It shall be orientated such that the deployment will be done on the windward side of the vessel to prevent drifting over any lines. Once all manoeuvring has ceased, the crane will lift the DUSN over the side of the ship and position it over the water. The DUSN anchor can then be untied and lowered into the water by its mooring line making use of a capstan or bollard to support the weight. Five meters from the DUSN end of the rope will be a loop. Once this loop has passed to the water side of the capstan or bollard, the load will be transferred to a slip line and removed from the capstan or bollard. The line will slowly be slipped until the full load has been transferred to the DUSN, taking care not to shock load the acoustic releases. This slip line can then be pulled back on deck. At this point, the DUSN node will be lowered just above the water and the crane operator and line handlers will standby.

The anchor attached to the Sampson braid rope will then be deployed by hand, followed by electrical cable until the second anchor is deployed. The mid-point anchor should be deployed at the gateway buoys intended waypoint. As the remaining cable is paid out, the DUSN slip line will be pulled free. Once all cables are clear of the ship, the individual manning the release line will give it a fast, sharp pull. The DUSN will slip from the bridal, which will remain on the crane hook, upon which the crane can be retracted back to its resting position on deck. The DUSN will begin deploying the array on its way down and full extension the float will be pulled under the water.

Post-deployment, the work boat will bring out the gateway buoy. The anchor on the Sampson braid line will be released, bringing the electrical connector back to the surface. This line will be removed and the buoy connected. The buoy will then be deployed by over the side of the boat and placed upright, in the water. If available, a crane or davit can aid with this however, previously it has been accomplished manually with two people.

3.2.2 Recovery

Recovery of the DUSN will be done from both a TSRV as well as a work boat. It will start by sending a signal to both the acoustic releases of the DUSN and gateway which will release the sacrificial anchors. This will allow both the VLA float as well as the DUSN body to float to the surface.

Hand retrieval of the system will then commence from the work boat once both DUSN floats have come to the surface. First, the gateway buoy is lifted onto the boat, being careful not to damage the antenna. Again, if available, a crane or davit can aid with this however, previously it has been accomplished manually with two people. The married cable, buoy and releases are then recovered by hand and coiled neatly on deck. Once the DUSN is reached, it will be disconnected from the married electrical cable and blanking plugs installed.

Next to be recovered will be the array. Care must be taken not to damage the nodes or cable on the array as it is coiled on deck. Once the array is recovered and the body is next to the boat, the steel lifting bridle will then be attached to all four lifting eyes on the DUSN.

The crane operator on the TSRV should have the crane standing by to lift the DUSN body out of the water. A tag line can be passed from the TSRV on the hook. For safety, a sling extension with a snap-hook can be added to the crane if required to move the large crane hook further above the workboat. The workboat shall slowly tow the node under the crane in such a way as to prevent the node from moving under the hull. The bridle will then be put on the crane hook, tag line attached and the DUSN can be landed safely back on the deck of the TSRV.

3.2.3 Cautions

When the release hook is closed, ensure it is completely snapped into place.

Everyone including the line handler should be standing clear of the DUSN while it is hanging from the crane. The handler of the release line must be extremely vigilant and there must be enough slack to prevent accidentally pulling the release pin. Ensure the line does not get caught or tangled while the DUSN in in the air. If it does, IMMEDIATELY yell out “Stop!” Remain clear of the suspended load until operations have paused. Once it is safe to do so, carefully free the line without pulling on it. If possible, the DUSN shall be lowered back to the deck first.

Caution should be taken when placing the gateway buoy in and out of the water not to dip the antenna or the electrical connector on top of the float in the water. Ensure that the buoy is placed upright when deployed.

Caution should be taken when paying out cable as the boat pulls away. At no point during this procedure should the married cable come taught. This will take clear communication between vessel and line handlers. Ensure that at no point is anyone standing in the bite of the cable.

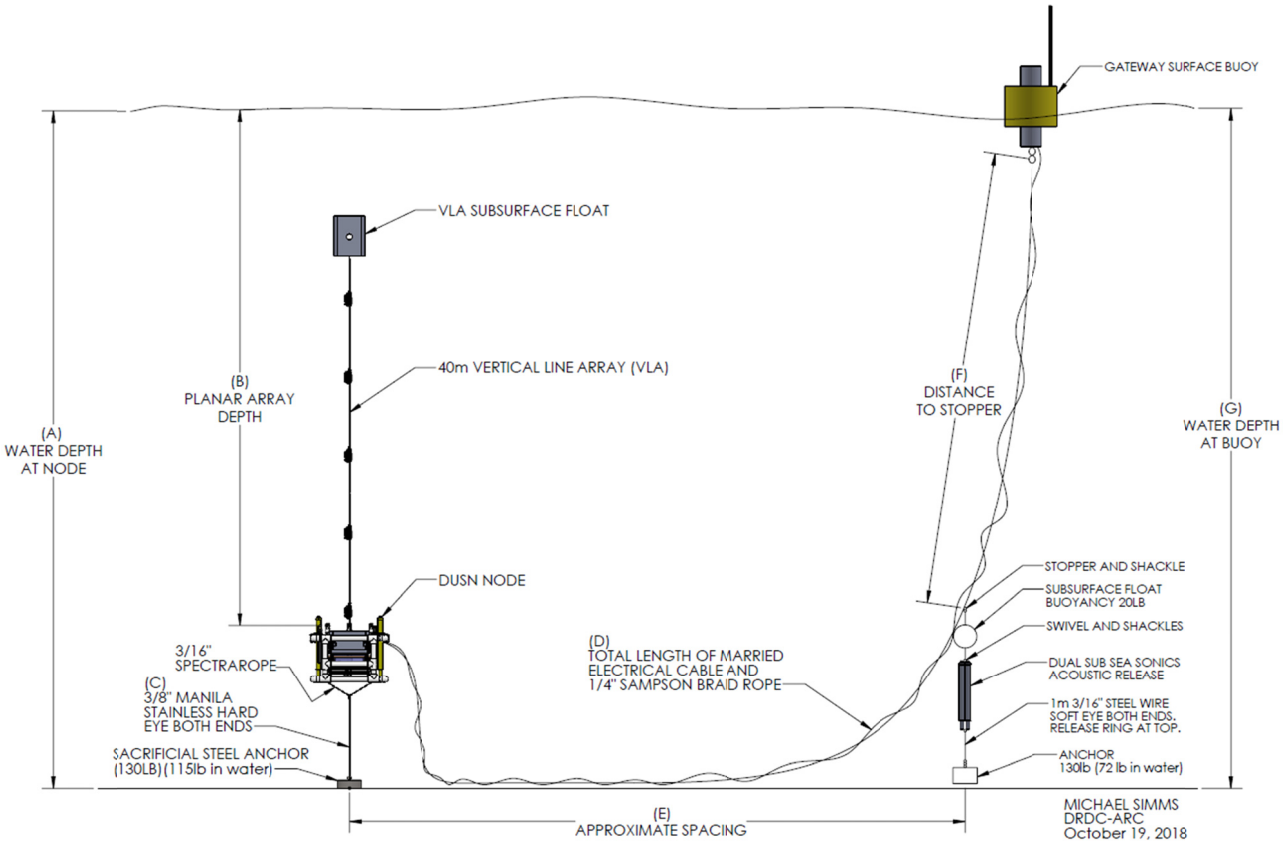

Figure 7: *DUSN node & gateway buoy mooring.*

Table 6: *Values corresponding to Figure 7.*

DUSN #	A (m)	B (m)	C (m)	D (m)	E (m)	F (m)	G (m)

3.3 Gateway Buoy

3.3.1 Deployment

The gateway buoy will be a fairly low risk, hand deployment, which can be done from a work boat. Prior to deployment, the electrical cable and Sampson braid moorings will be coiled neatly on deck. The

modem, acoustic release and anchor will all be connected. The anchor will be set next to the edge of the work boat, in preparation for deployment.

Beginning the deployment, the work boat shall position itself upwind of the intended waypoint with the deployment occurring on the windward side of the boat. The gateway buoy will be lifted over the side of the boat and placed upright, in the water. If available, a crane or davit can aid with this however, previously it has been accomplished manually with two people.

Once the buoy is in the water, the boat will drift away toward the waypoint as the electrical cable is paid out by hand. When the modem is reached, it will then be carefully lowered into the water and the mooring will continue to be paid out past the subsurface float, until the acoustic releases can be carefully lowered over the side into the water.

At this point, the Chief Scientist or his delegate on board will confirm that we are at the correct location. Once the order is given, the anchor will be pushed off the boat ensuring that it doesn't land on the releases and coordinates marked. Watch for the buoy as it will then be drawn towards the boat as the anchor sinks.

3.3.2 Recovery

Recovery of the gateway buoy can be done from a work boat. It will start by sending a signal to the acoustic releases which will release the sacrificial anchor. This will allow the subsurface float to come to the surface.

Once spotted, hand retrieval of the system will commence in the same order it was deployed. First, the gateway buoy is lifted onto the boat, being careful not to damage the antenna. Again, if available, a crane or davit can aid with this however, previously it has been accomplished manually with two people. The remaining cable, modem, rope, buoy and releases are then recovered by hand and coiled neatly on deck.

3.3.3 Cautions

Caution should be taken when placing the gateway buoy in and out of the water not to dip the antenna or the electrical connector on top of the float in the water. Ensure that the buoy is placed upright when deployed.

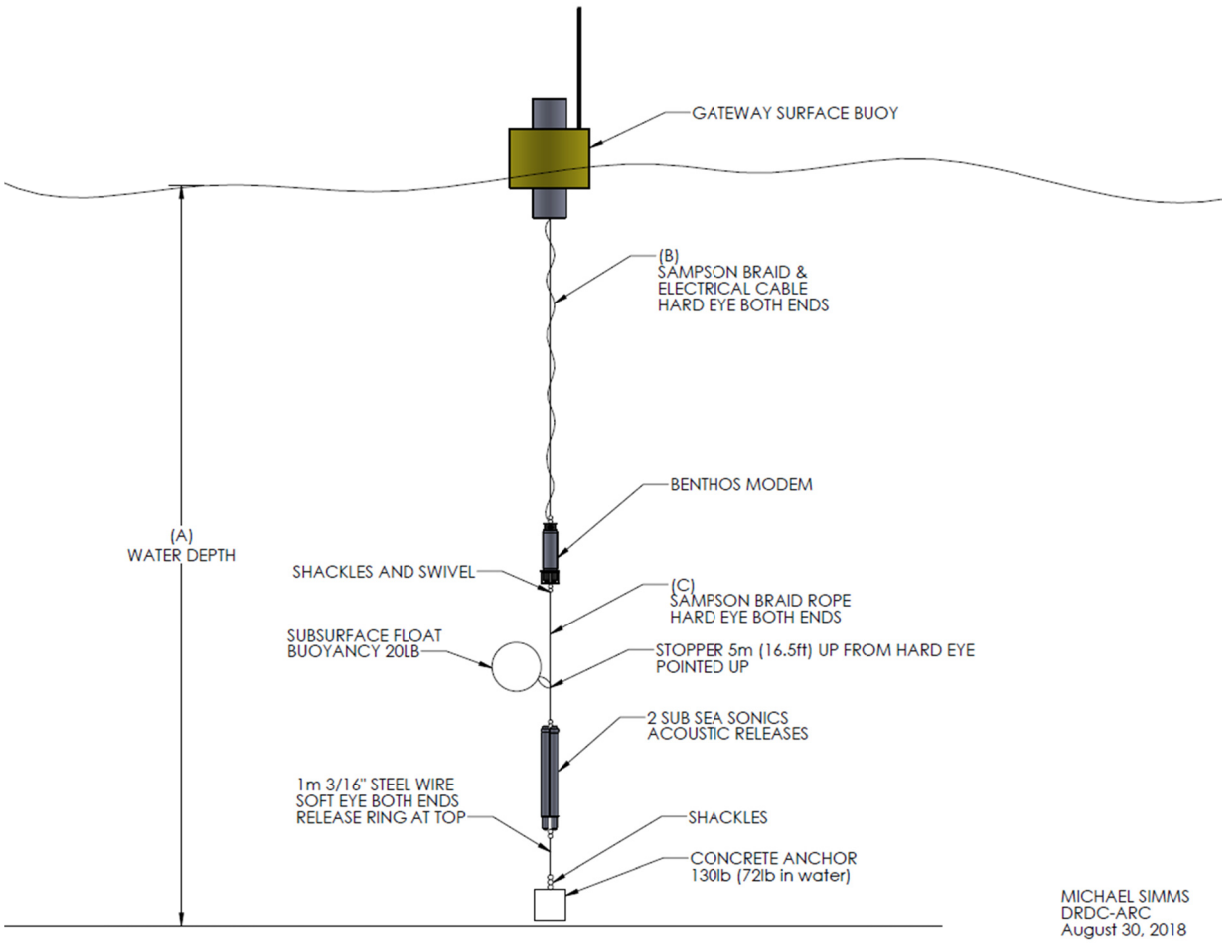

Figure 8: *Gateway buoy mooring.*

Table 7: *Values corresponding to Figure 8.*

Buoy #	A (m)	B (m)	C (m)

3.4 icListen

3.4.1 Deployment

The icListen will be a fairly low risk, hand deployment, which can be done from a work boat. Prior to deployment, Sampson braid moorings will be coiled neatly on deck. The subsurface float, icListen, battery can, acoustic release and anchor will all be connected. The anchor will be set next to the edge of the boat in preparation for deployment.

Beginning the deployment, the work boat shall position itself upwind of the intended waypoint with the deployment occurring on the windward side of the boat. The icListen float will be lowered into the water over the side of the boat. Once the float is in the water the boat will drift away toward the waypoint as the mooring is paid out by hand. The mooring will continue to be paid out until the acoustic releases are reached. They will be lowered over the side into the water using the 1 m of steel wire and Sampson braid attached to the anchor.

At this point, the Chief Scientist or his delegate on board will confirm that we are at the correct location. Once the order is given, the anchor will be released, ensuring that it doesn't land on the releases and coordinates marked.

3.4.2 Recovery

Recovery of the icListen can be done from a work boat. It will start by sending a signal to the acoustic releases which will release the sacrificial anchor. This will allow the subsurface float to come to the surface.

Once it is spotted, the hand retrieval of the system will then commence in the same order it was deployed. First, the icListen float is lifted onto the boat. The Sampson braid mooring is then coiled neatly on deck and lastly, the acoustic releases.

3.4.3 Cautions

Caution should be taken when recovering the icListen not to damage it against the side of the boat.

When recovering battery can, ensure that you are pulling up on the Sampson braid rope and not on the electrical cable.

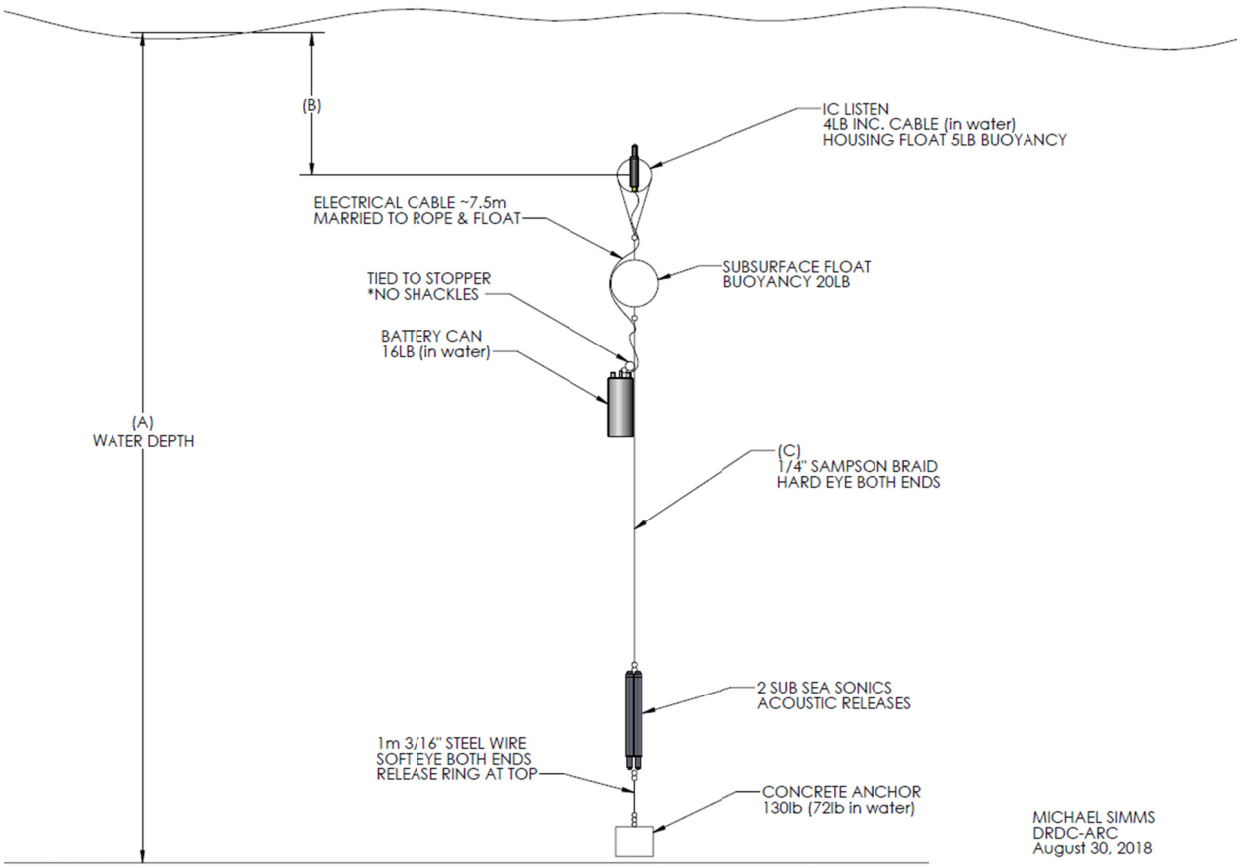

Figure 9: *icListen mooring.*

Table 8: *Values corresponding to Figure 9.*

icListen #	A (m)	B (m)	C (m)

3.5 CTD

3.5.1 Deployment

The CTD will be fairly low risk, hand deployment, which can be done from a work boat. Prior to deployment, the Sampson braid mooring will be coiled neatly on deck. The floats, acoustic release and anchor will all be connected. All CTD's will be attached during deployment with swordfish clips. The anchor will be set next to the edge of the boat in preparation for deployment.

Beginning the deployment, the work boat shall position itself upwind of the intended waypoint with the deployment occurring on the windward side of the boat. The surface float and flasher will be lowered into the water over the side of the boat. Next, the boat will drift toward the waypoint as the mooring is paid out by hand. As the mooring is paid out, CTD loggers will be attached at previously marked locations

along the mooring via swordfish clips and serial numbers will be recorded in order. Once all loggers have been deployed and the end of the line is reached, the acoustic releases can be carefully lowered into the water.

At this point, the Chief Scientist or his delegate on board will confirm that we are at the correct location. Once the order is given, the anchor will be carefully released and coordinates marked.

3.5.2 Recovery

Recovery of CTD's can be done from a work boat. It will start by sending a signal to the acoustic releases which will release the sacrificial anchor. This will allow the subsurface float to come to the surface.

Once it is spotted, the hand retrieval of the system will then commence in the same order it was deployed. First, the acoustic releases are lifted onto the boat. The entire mooring is then coiled neatly on deck. The CTD loggers will be removed after the fact.

3.5.3 Cautions

Caution should be taken when attaching the swordfish clips to the line. Ensure they are snug before releasing to prevent accidental loss.

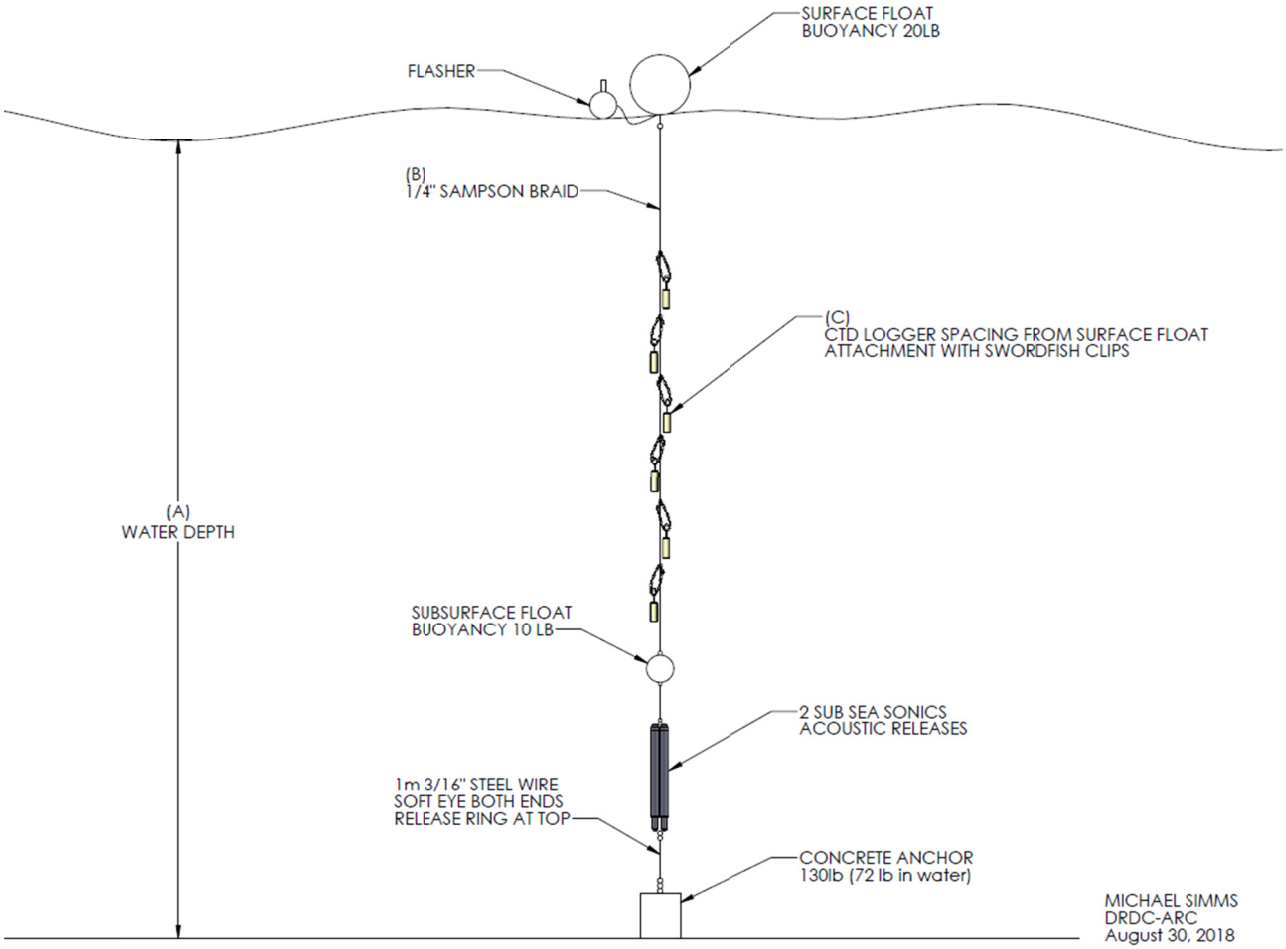

Figure 10: CTD mooring.

Table 9: Values corresponding to Figure 10.

CTD #	A (m)	B (m)	C (m)

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13. ABSTRACT (When available in the document, the French version of the abstract must be included here.)