# Data Guide

# TigerRAY 2024 moored deployment

**Contact**: Curtis Rusch, curusch@uw.edu

## Summary of data

Deployment occurred on January 10th, 2024. Note that the dates for each day listed in this table refer to the date in Pacific time when the data was collected. Some of the storms occurred late in the day Pacific time, which resulted in UTC timestamps reporting the next day's date.

| Date | Time on | Avg power peak | Wave peak | Wave Direction (degrees clockwise from N) Approximate, see data for specifics |
|---|---|---|---|---|
| Jan 10 | 4:30 | 0 W | 0 m | N/A (deployment day) |
| Jan 12 | 1:45 | 16 W | 0.39 m | 325° |
| Jan 13 | 0:30 | 0 W | 0.26 m | 0° |
| Jan 22 | 0:30 | 1 W | 0.25 m | 190° |
| Jan 23 | 1:30 | 1 W | 0.22 m | 200° |
| Jan 24 | 0:30 | <1 W | 0.28 m | 165° |
| Jan 25 | 0:30 | <1 W | 0.22 m | 175° |
| Jan 31 | 2:00 | 8 W | 0.34 m | 120° |
| Feb 12 | 2:00 | 28 W | 0.44 m | 200° |
| Feb 25 | 10:00 | 55 W | 0.55 m (with both PTOs working) - 0.7 m after both stopped | 205° |
| Feb 28 | 6:00 | 24 W | 0.5 m | 160° → 200° |
| Feb 29 | 1:00 | 3 W | 0.31 m (just missed ~0.45, short peak) | 200° |

| | | | | |
|---|---|---|---|---|
| Mar 2 | 2:00 | 22 W | 0.43 m | 205° |
| Mar 3 | 6:00 (~1:30 of down time in middle) | 10 W | 0.36 m (with PTO on) | 210° |

Note that, in the first release of the dataset, there is no IMU data for the heave plate on January 12th or 13th.

Note also that hydrophone data (ambient noise) were collected on one of the SWIFT crown lines, but those data are not included here.

# Data structure

## SWIFT data

**Filename:** reprocessedSWIFTdata_2024.mat
**Contains:** Reprocessed SWIFT data from the entire 2024 moored deployment. Three structures, named SWIFT22_rp, SWIFT23_rp, and SWIFT24_rp are contained.
**Notes:** Reprocessing of the data was done to remove frequency components in the wave spectra with frequencies < 0.2 Hz. The remaining energy is distributed between 0.2 Hz and 1 Hz. New significant wave height, peak period, energy period, and peak direction were then calculated from these trimmed energy spectra

| Field | Description | Units |
|---|---|---|
| SWIFT.ID | Hull number of the buoy | N/A |
| SWIFT.airpres | Ambient air pressure | Atm |
| SWIFT.airpresstddev | Standard deviation of air pressure | Atm |
| SWIFT.airtemp | Air temperature at 1 m height above the wave following surface | Degrees Celcius |
| SWIFT.airtempstddev | Air temperature standard deviation | Degrees Celcius |
| SWIFT.date | Human readable date as day, month, year | N/A |
| SWIFT.driftdirT | Drift direction TOWARDS (equivalent to ‘course over ground’) | Degrees True |
| SWIFT.driftdirTstddev | Standard deviation of drift direction | Degrees true |

| | | |
|---|---|---|
| SWIFT.dirftspd | Drift speed (equivalent to ‘speed over ground’) | m/s |
| SWIFT.driftspdstddev | Standard deviation of drift speed | m/s |
| SWIFT.lat | Latitude | Decimal degrees |
| SWIFT. lon | Longitude | Decimal degrees |
| SWIFT.metheight | Height of MET station | m |
| SWIFT.peakwavedirT | Peak wave direction (BEFORE reprocessing) | Degrees from north |
| SWIFT.peakwaveperiod | Peak of period orbital velocity spectra (BEFORE reprocessing) | s |
| SWIFT.sigwaveheight | Significant wave height (BEFORE reprocessing) | m |
| SWIFT.time | Timestamp in MATLAB datenum format (serial days since 0 Jan 0000) | UTC |
| SWIFT.wavespectra.energy | Wave energy spectral density, as a function of frequency, derived from orbital motions (trimmed) | $m^2$/Hz |
| SWIFT.wavespectra.freq | Spectral frequencies (trimmed) | Hz |
| SWIFT.wavespectra.a1 | Normalized spectral directional moment (positive east) (trimmed) | N/A |
| SWIFT.wavespectra.b1 | Normalized spectral directional moment (positive north) (trimmed) | N/A |
| SWIFT.wavespectra.a2 | Normalized spectral directional moment (east-west) (trimmed) | N/A |
| SWIFT.wavespectra.b2 | Normalized spectral directional moment (north-south) (trimmed) | N/A |
| SWIFT.wavespectra.check | Spectral comparison of horizontal to vertical motion. Should be equal to 1 for good data in deep water | N/A |
| SWIFT.wavespectra.energy alt | Alternate calculation for the wave energy spectra that is based purely on the GPS velocities (as opposed to GPS and IMU combined) | $m^2$/Hz |
| SWIFT.winddirT | True wind direction | Degrees from north |

| | | |
|---|---|---|
| SWIFT.winddirTstddev | Standard deviation of true wind direction | Degrees from north |
| SWIFT.windspd | Wind speed at 1 m height above the wave following surface | m/s |
| SWIFt.windspdstddev | Standard deviation of wind speed | m/s |
| SWIFT.sigwaveheight_alt | Significant wave height calculation using only GPS velocities (before reprocessing) | m |
| SWIFT.peakperiod_alt | Peak period calculation using only GPS velocities (before reprocessing) | s |
| SWIFT.hs_new | Significant wave height, calculated from the trimmed wave spectra as $H_s = 4\sqrt{\Sigma(E\,df)}$ | m |
| SWIFT.tp_new | Peak period, calculated from the trimmed wave spectra as $T_p = 1/f_p$ where $f_p$ is the frequency at maximum of the energy spectrum | s |
| SWIFT.te_new | Energy period, calculated from the trimmed wave spectra as $T_e = \Sigma E/\Sigma(Ef)$ | s |
| SWIFT.dp_new | Peak direction, calculated from the trimmed wave spectra as the direction associated with the maximum energy. Calculated using SWIFTdirectionalspectra.m, see [https://github.com/jthomson-apluw/SWIFT-codes](https://github.com/jthomson-apluw/SWIFT-codes) for more information | Degrees from north |

The significant wave heights can be plotted using

```
scatter(datetime([SWIFT22_rp.time],'ConvertFrom','datenum'),[SWIFT22_rp.hs_new])
```

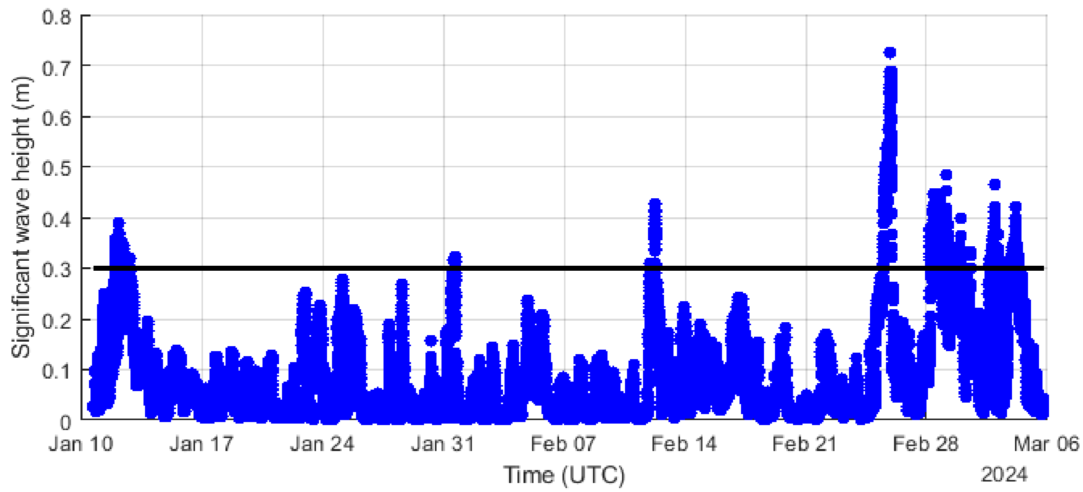



Figure 1: Significant wave height from reprocessed data as reported by all three SWIFTs over the duration of the moored deployment. The horizontal line represents the approximate wave height required to generate power (0.3 m).

## TigerRAY data

**Filename:** DDMMMYYYY_TigerRAYdata.mat
**Description:** A .mat file is saved for each day in which data was collected, and contains a single variable, data, which is formatted as described in the table below.

| Name | Description | Frequency |
|---|---|---|
| data.loadcell | 2 column vector containing time stamps and load cell readings from the heave plate | 100 Hz |
| data.hppressure | 3 column vector containing time stamps and data from the two heave plate mounted pressure sensors | 100 Hz |
| data.hpimu | Structure containing data from the heave plate mounted IMU. Time stamps were recorded at 100 Hz, but some products appear to be sampled at a lower rate. | 100 Hz timestamps, varied for different products |
| data.electronics | 18 column vector containing data collected by the central data acquisition system in the nacelle | 100 Hz |
| data.enc1 | 3 column vector containing timestamps and data from encoder 1 | 40 Hz |

| | | |
|---|---|---|
| data.enc2 | 3 column vector containing timestamps and data from encoder 2 | 40 Hz |
| data.naimu | Structure containing data from the nacelle mounted IMU. Time stamps were recorded at 100 Hz, but some products appear to be sampled at a lower rate. | 100 Hz timestamps, varied for different products |
| data.scx | Structure containing data from the satellite compass mounted to the mast of the nacelle. | 40 Hz timestamps, but varied collection rates for different products |

The following tables contain a more detailed breakdown of the data contained in each of these variables

## data.loadcell

The load cell (Submersible Tension Link Load Cell, P/N 12177-10, 5,000 lbf Capacity, 0.1 to 10.1 VDC Output, from Sensing Systems Corporation), outputs a voltage signal. This signal was converted to a force in pounds by multiplying the voltage by 500 and subtracting 50, and then converted to Newtons by multiplying by 4.44822.

| **Column number** | **Description** | **Units** |
|---|---|---|
| 1 | Time stamps for data (in posix format) | UTC |
| 2 | Load cell measurement (at junction between strength umbilical and heave plate) | N |

## data.hppressure

Heave plate pressure sensor data is collected using Omega absolute pressure sensors. For the heave plate pressure sensors, the output signal was converted to PSI using the following equation: 11.234 * V - 6.224, where V is the output voltage from the pressure sensor. Data from January 12th did not log properly, and has therefore been excluded from the dataset.

| **Column number** | **Description** | **Units** |
|---|---|---|
| 1 | Time stamps for data (in posix format) | UTC |
| 2 | Absolute pressure for heave plate pressure sensor 1 | psi |
| 3 | Absolute pressure for heave plate pressure sensor 2 | psi |

## data.hpimu

The heave plate IMU is an SBG ellipse. It has onboard processing and outputs a wide range of data, including heave estimates. It should be noted that most data sets contain a large number of NaN values. The timestamps are recorded at 100 Hz, but no data streams are recorded at that speed. Heave estimates are at 50 Hz, and most other data streams in the IMU are collected at 10 Hz. The coordinate frame is defined as North East Down (NED). NOTE: There is an issue with the clock on the heave plate IMU, and times seem to be starting from near 00:00:00 January 31 2023 for all cases. This is likely because there is no GPS on the heave plate, and the IMU is meant to set its clock from an integrated GPS receiver. To plot data from the imu, one approach is as follows (replacing ‘variable’ with your variable of interest).

```
ids = find(~isnan(data.hp_imu_raw.variable));
figure
plot(data.hp_imu_raw.ts(ids),data.hp_imu_raw.variable(ids));
```

| Quantity | Description | Units |
|---|---|---|
| ts | Timestamps in datetime format - this data product appears inaccurate - reading as January 31st 2023 for most cases | Not accurate |
| Angles | Roll, pitch, yaw | Radians |
| Rotational speed | Derivatives of roll pitch yaw | Rad/s |
| Velocity | | m/s |
| Latitude | Degress, positive North, negative South | Degrees |
| Longitude | Degrees, positive East, negative West | Degrees |
| Ship motion | Surge positive forward, sway positive right, heave positive down | m |

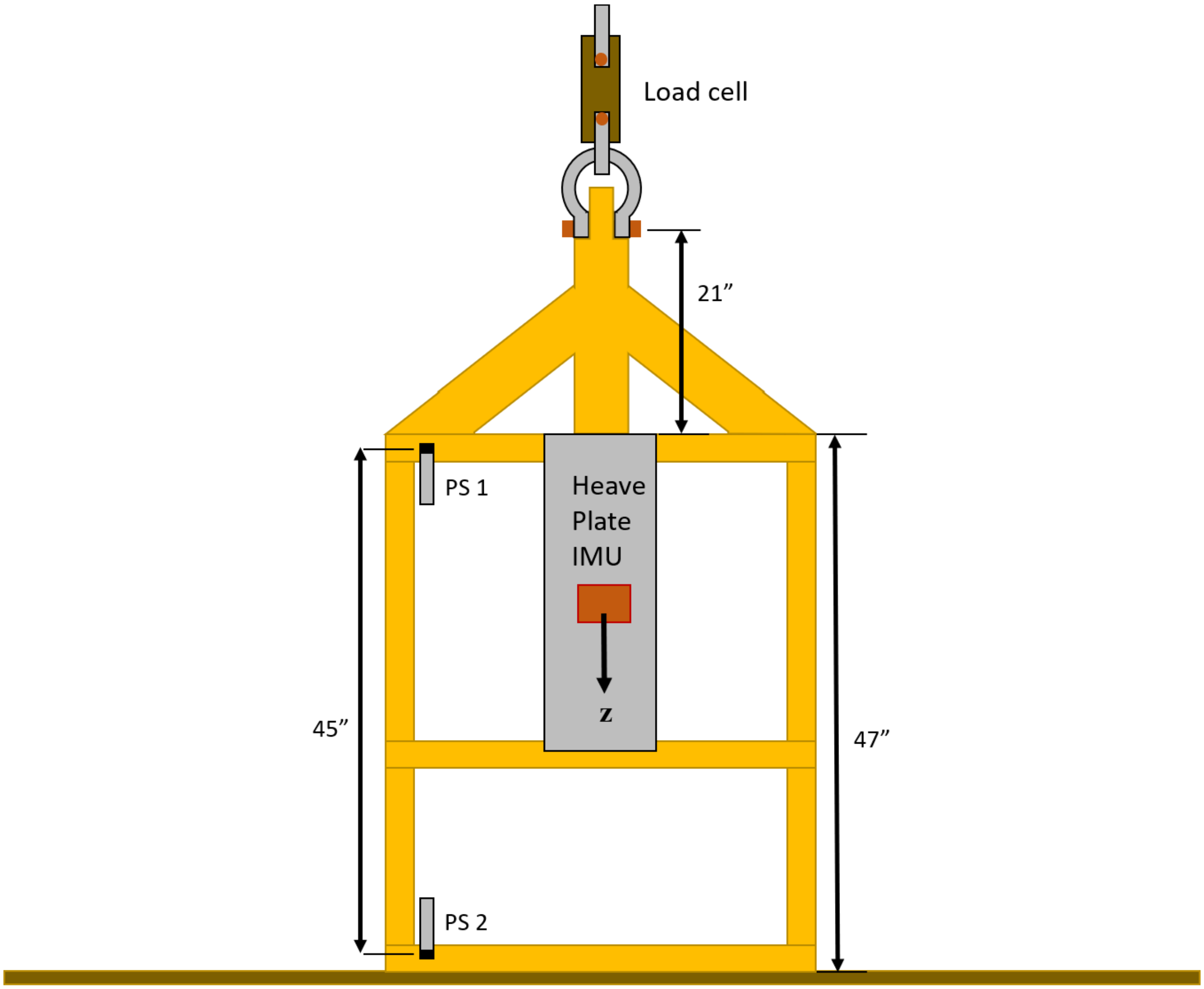


Figure 2: Location of pressure sensors, IMU, and load cell on TigerRAY heave plate.

## Data.electronics

Note: For data prior to January 22nd, there is no pressure data from the nacelle, and the control voltages are instead control currents, in mA. For this data, ‘input’ voltage and current refers to measurements that occur between the generator and the power electronics, and ‘output’ refers to measurements that take place between the power electronics and the output supercapacitor. As such, the output voltage is equal to the voltage of the supercapacitor. See Fig. 3 for a description of the location of the three nacelle pressure sensors.

| Column number | Description | Units |
|---|---|---|
| 1 | Time stamps for data (in posix format, seconds.nanoseconds) | UTC |
| 2 | Input voltage for PTO 1 | V |

| | | |
|---|---|---|
| 3 | Output voltage for PTO 1 | V |
| 4 | Input current for PTO 1 | A |
| 5 | Output current for PTO 1 | A |
| 6 | Active/inactive flag for PTO 1 (1 = on, 0 = off) | N/A |
| 7 | Control voltage PTO 1 (voltage of the control signal for the power electronics for PTO 1) | V |
| 8 | Target input current for PTO 1 | A |
| 9 | Input voltage for PTO 2 | V |
| 10 | Output voltage for PTO 2 | V |
| 11 | Input current for PTO 2 | A |
| 12 | Output current for PTO 2 | A |
| 13 | Active/inactive flag for PTO 2 (1 = on, 0 = off) | N/A |
| 14 | Control voltage for PTO 2 | V |
| 15 | Target input current for PTO 2 | A |
| 16 | Pressure sensor 1 absolute pressure | psi |
| 17 | Pressure sensor 2 absolute pressure | psi |
| 18 | Pressure sensor 3 absolute pressure | psi |

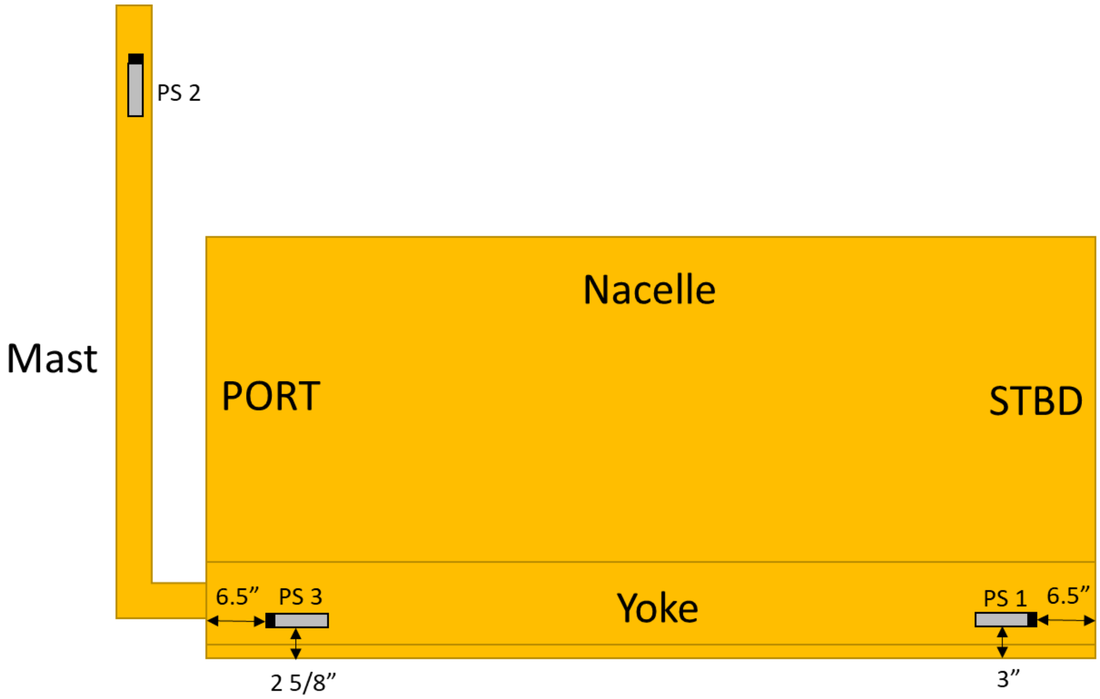


Figure 3: Location of pressure sensors on TigerRAY nacelle.

## data.enc1

The angle data from both encoders has been processed such that a reading of 0 degrees corresponds to straight up in the air. Rotation of the forward float down towards the water is positive, and rotation of the aft float down towards the water is negative. See figure 4. Data from prior to January 22nd has been processed to reduce the sampling frequency, yielding a frequency of about 27 Hz (compared to 40 Hz for the rest of the deployment).

| Column number | Description | Units |
|---|---|---|
| 1 | Time stamps for data (in posix format, seconds.nanoseconds) | UTC |
| 2 | Encoder counts for PTO 1 | N/A |
| 3 | Encoder angle for PTO 1 | Degrees |

## data.enc2

| Column number | Description | Units |
|---|---|---|
| 1 | Time stamps for data (in posix format, | UTC |

| | | |
|---|---|---|
| | seconds.nanoseconds) | |
| 2 | Encoder counts for PTO 2 | N/A |
| 3 | Encoder angle for PTO 2 | Degrees |

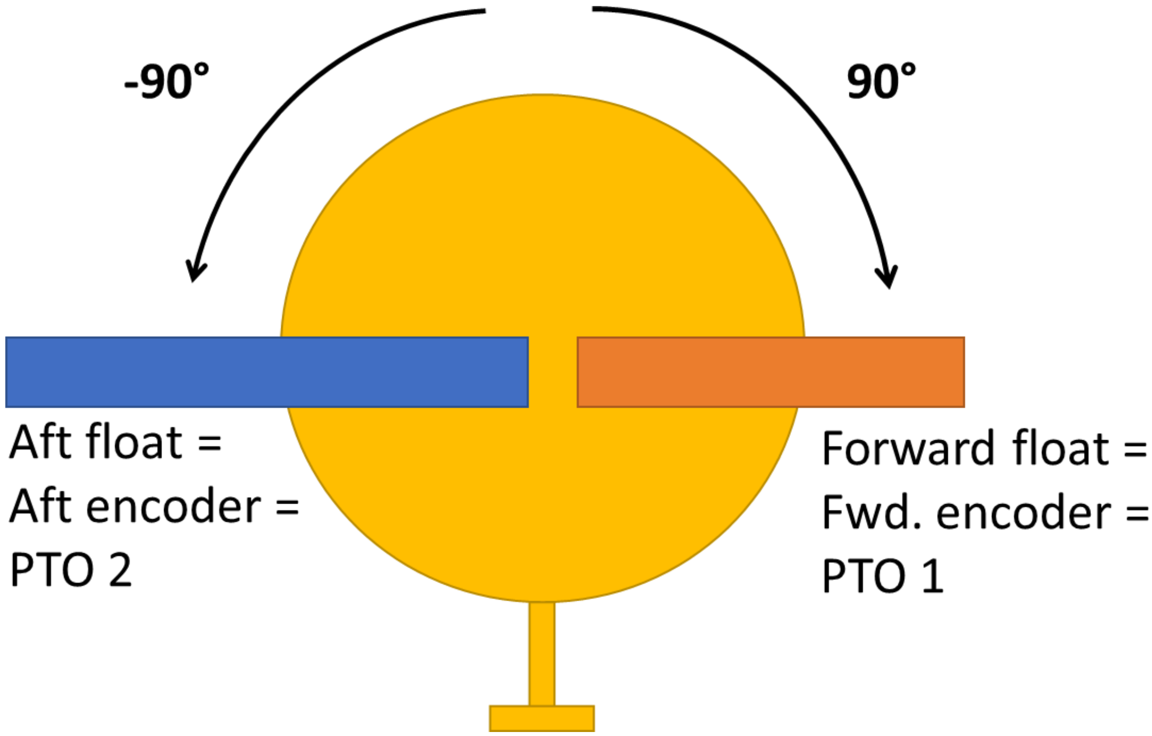



Figure 4: Simplified side view of TigerRAY, with example of encoder ratings for the case where the arms are oriented horizontally. For both encoders, 0 degrees corresponds to 'up'.

## data.naimu

The nacelle IMU is also an SBG ellipse - this data should be more accurate than the heave plate IMU data, because it is a GPS-aided IMU. It has onboard processing and outputs a wide range of data, including heave estimates. It should be noted that most data sets contain a large number of NaN values. The timestamps are recorded at 100 Hz, but no data streams are recorded at that speed. Heave estimates are at 50 Hz, and most other data streams in the IMU are collected at 10 Hz. The coordinate frame is defined as North East Down (NED). To plot data from the imu, one approach is as follows (replacing 'variable' with your variable of interest).

```
ids = find(~isnan(data.hp_imu_raw.variable));
figure
plot(data.hp_imu_raw.ts(ids),data.hp_imu_raw.variable(ids));
```

| Quantity | Description | Units |
|---|---|---|

| | | |
|---|---|---|
| ts | Timestamps in datetime format | UTC |
| Angles | Roll, pitch, yaw | Radians |
| Rotational speed | Derivatives of roll pitch yaw | Rad/s |
| Velocity | | m/s |
| Latitude | Degress, positive North, negative South | Degrees |
| Longitude | Degrees, positive East, negative West | Degrees |
| Ship motion | Surge positive forward, sway positive right, heave positive down | m |

### data.scx

The satellite compass was mounted to the mast of TigerRAY, and is a Furuno SCX21. The primary data set of interest from this instrument is the heading, which is more accurate than that reported by the IMU. A heading of 0 degrees would indicate that TigerRAY is oriented with the port side pointed to the north. A heading of 90 degrees would indicate that TigerRAY is oriented with the port side to the east. The table below provides an overview of the two variables of interest from this instrument.

| **Quantity** | **Description** | **Units** |
|---|---|---|
| data.scx.ts | Timestamp for data | UTC |
| data.scx.heading | Angle for heading of TigerRAY. North is 0 degrees, positive in the clockwise direction | Degrees |

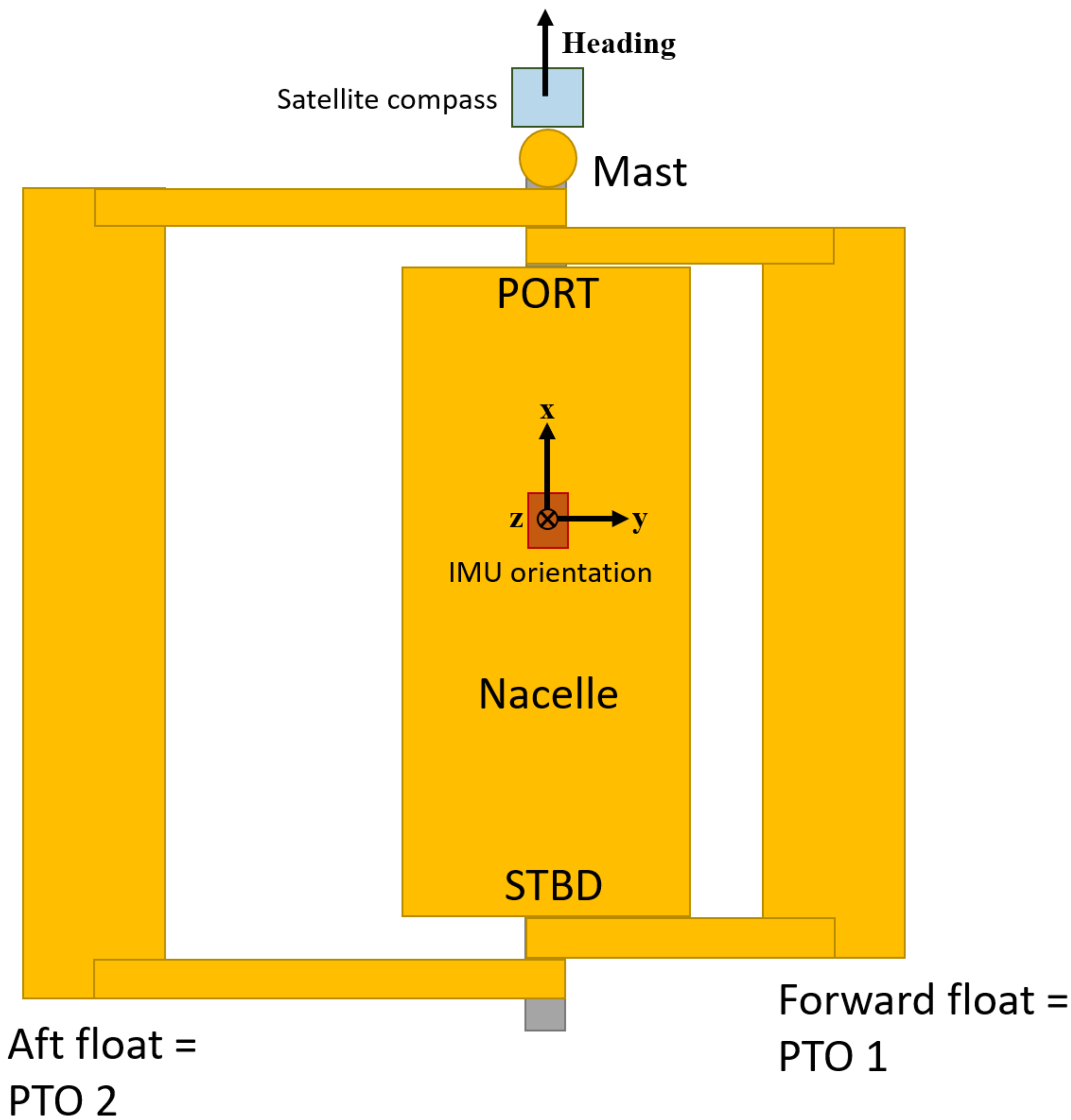



Figure 5: Top-down view of TigerRAY, noting the orientation of the IMU and satellite compass.

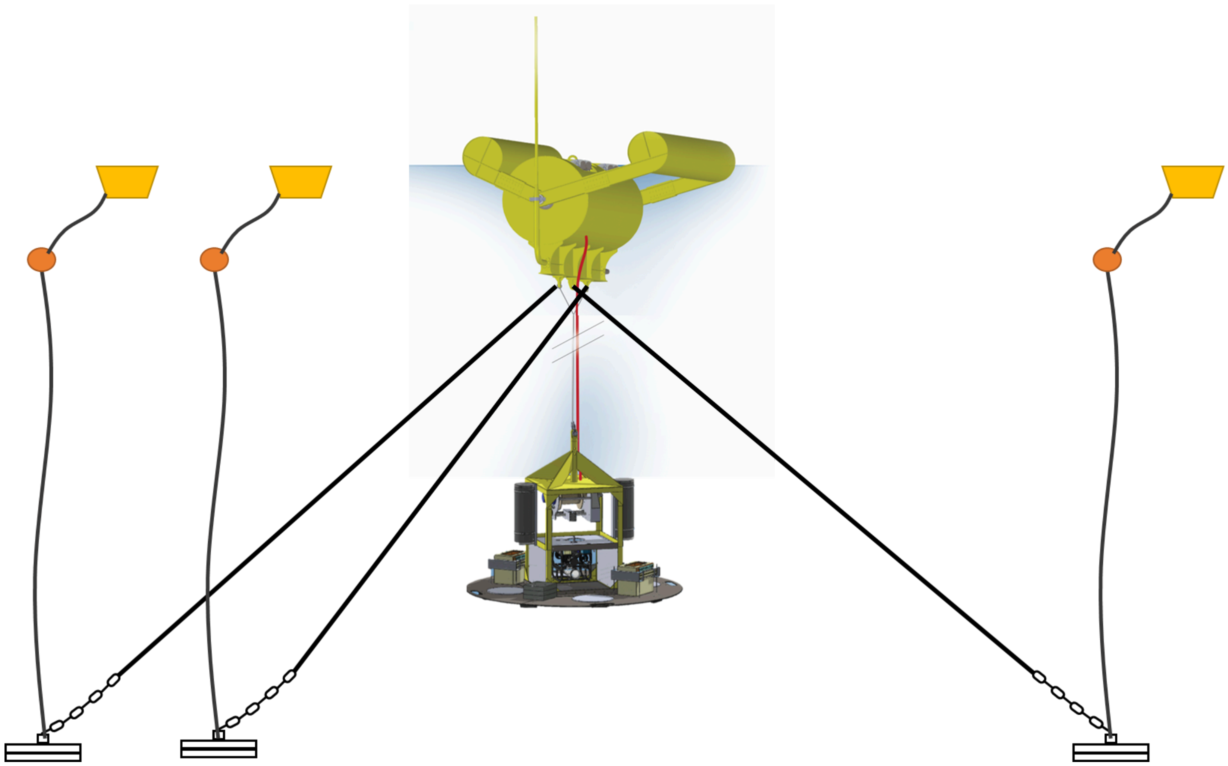


Figure 6: Schematic (not to scale) of the deployed setup for TigerRAY moored deployment.

# TigerRAY physical specifications

| Component | Mass | Dimensions | Notes |
|---|---|---|---|
| Aft float | 334 kg | OD = 0.45 m<br>Length = 3.0 m | Float + arms<br>Arm length = 130.5 cm |
| Fore float | 264 kg | OD = 0.45 m<br>Length = 2.8 m | Float + arms<br>Arm length = 79.7 cm |
| Nacelle + mast | 831 kg | OD = 0.98 m<br>Length = 2.6 m | Also has a rigid yoke welded to underside (shown in Fig. 2) |
| Total surface body | 1430 kg | | Measured in air, March 18, 2022 |
| Heave plate | 990 kg dry weight | 2.4 m max diameter, 1.7 m height | Load cell measurements indicate ~7,038 N wet weight, or 717 kg wet |

| | | | |
|---|---|---|---|
| | | | weight |
| Strength umbilical | 1” Courland Nylon Brait | See drawing below - about 17 m total length of line | |
| Anchors | 800 kg each | | 3 anchors |
| Mooring line | ½” chain and ⅝” Yale Lugger Anchor Line | 5 m of chain<br>156 m anchor line | ~3 kg weight attached mid line to each mooring line to keep below the surface |

## Deployment coordinates

Note that, in calm conditions, the geometry of this layout means that the anchor legs are slack. When wind and waves act on the WEC, it comes up taut on two anchor legs.

Target TigerRAY location: 47 40 46.26 (47.679517 N), 122 13 49.80 (122.230500 W)
Anchor locations:
N anchor: 47 40 50.65 (47.68074), 122 13 47.34 (122.2299)
SW anchor: 47 40 45.41 (47.67928), 122 13 56.72 (122.23242)
SE anchor: 47 40 42.57 (47.67849), 122 13 45.19 (122.22922)
(All anchors were deployed within 5 m of the target location)

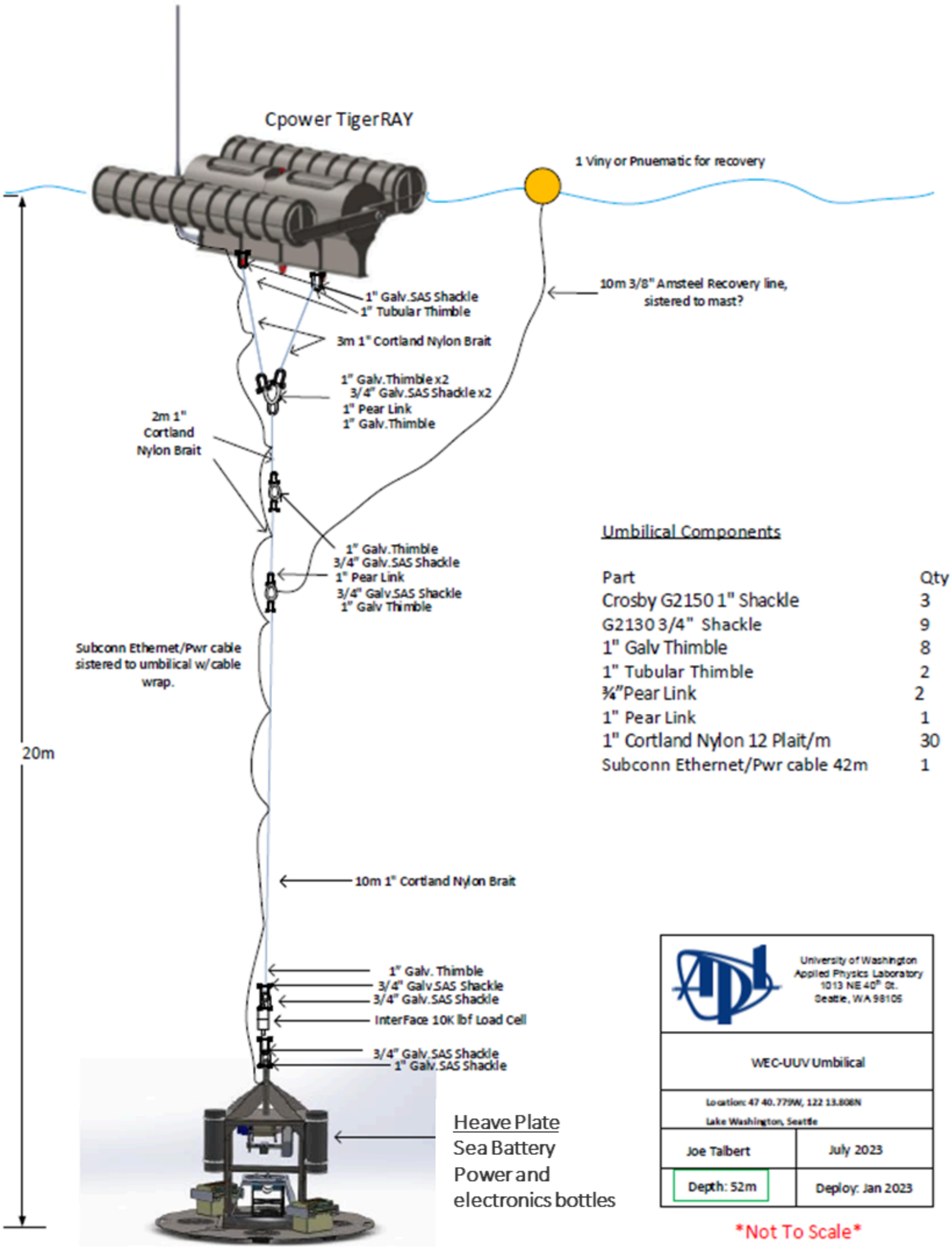



Figure 7: Diagram for strength umbilical connecting the heave plate to TigerRAY. Note that, for this moored deployment, the heave plate contains lead weight in place of the ROV and winch.

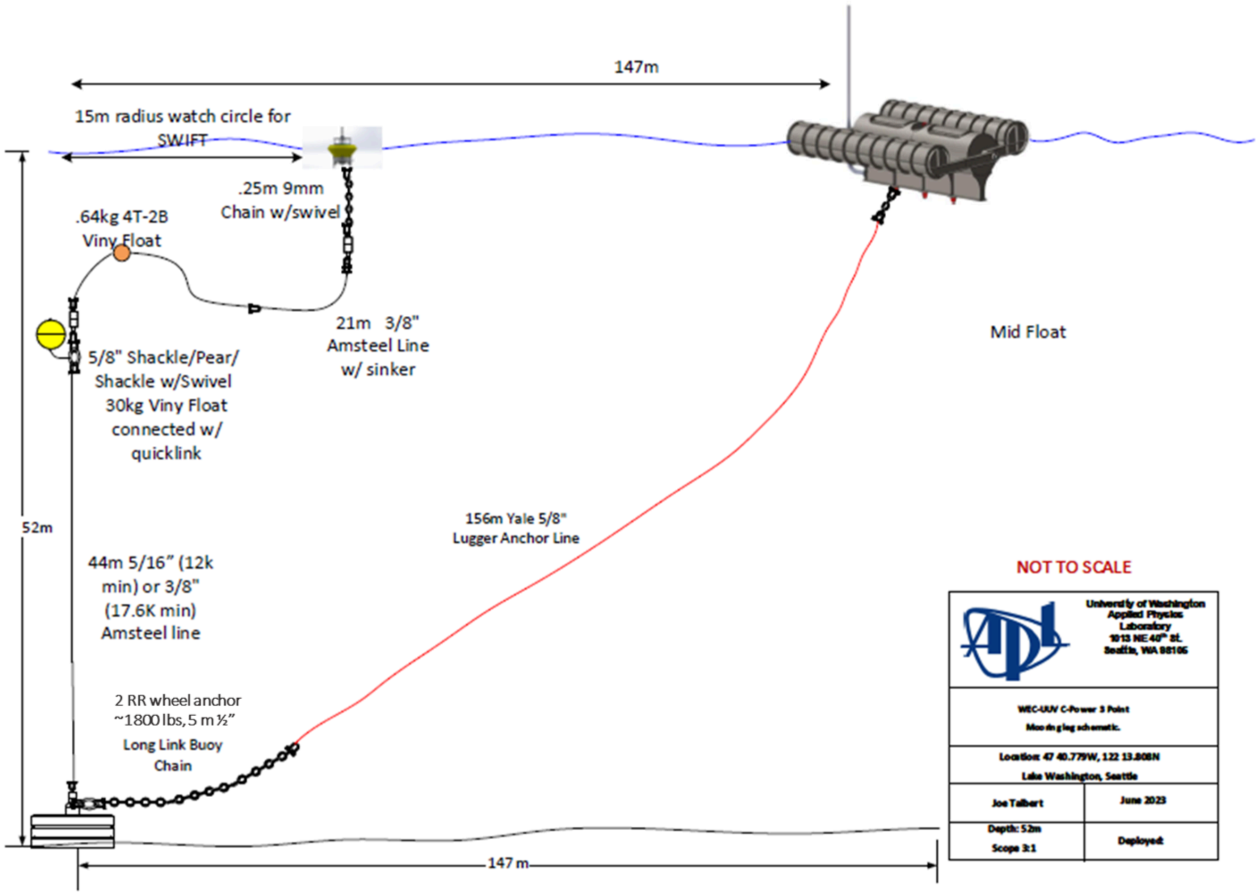



Figure 8: Note that the anchor is a 2 RR wheel anchor at 1800 lbs, NOT a 3 wheel stack. Also, after deployment, approximately 3 kg of weight was added to the middle of each anchor line to keep it subsurface, since the lines are buoyant.

TECH SHEET

# Nylon 12 Plait

**Nylon 12 Plait provides high strength, high elongation and excellent abrasion resistance in a single braid construction.** Nylon 12 Plait is easily spliced using a standard tuck splice and is 25% stronger than three strand or 8 plait nylon. Its torque free braided construction provides easy handling and prevents kinks and hockles.

Nylon 12 Plait is available standard with an overlay marine finish.

### Features & Benefits

- High stretch
- High strength
- Excellent shock absorption
- Soft hand
- Torque free
- Easy splicing

### Applications

- Mooring lines
- Anchor lines
- KERR towing Lines
- Tug hawsers and stretchers
- Commercial fishing nets
- Security barriers

### Type approved product

| Nominal Diameter | | Size (circ in.) | Approximate Weight | | Minimum Tensile Strength Spliced Rope | | Minimum Tensile Strength ISO Unspliced Rope | |
|---|---|---|---|---|---|---|---|---|
| inch | mm | | lbs/ 100ft | kg/ 100m | lbs | MT (tonnes) | lbs | MT (tonnes) |
| **5/8** | 16 | **2** | **11** | 16.4 | **13,900** | 6.3 | **15,400** | 7.0 |
| **3/4** | 18 | **2-1/4** | **15** | 22.3 | **17,900** | 8.1 | **19,900** | 9.0 |
| **7/8** | 22 | **2-3/4** | **22.6** | 33.6 | **26,200** | 11.9 | **29,100** | 13.2 |
| **1** | 24 | **3** | **26.3** | 39.1 | **30,100** | 13.7 | **33,400** | 15.2 |
| **1-1/8** | 28 | **3-1/2** | **33.8** | 50.3 | **39,400** | 17.9 | **43,800** | 19.9 |
| **1-1/4** | 30 | **3-3/4** | **39.5** | 58.8 | **45,400** | 20.6 | **50,400** | 22.9 |
| **1-5/16** | 32 | **4** | **45.1** | 67.1 | **51,200** | 23.2 | **56,900** | 25.8 |
| **1-1/2** | 36 | **4-1/2** | **56.4** | 83.9 | **64,800** | 29.4 | **72,000** | 32.7 |
| **1-5/8** | 40 | **5** | **67.7** | 100.8 | **76,300** | 34.6 | **84,800** | 38.5 |
| **1-3/4** | 44 | **5-1/2** | **79** | 117.6 | **92,100** | 41.8 | **102,300** | 46.4 |
| **2** | 48 | **6** | **95.9** | 142.7 | **106,500** | 48.3 | **118,300** | 53.7 |
| **2-1/8** | 52 | **6-1/2** | **113** | 168.2 | **128,000** | 58.1 | **142,200** | 64.5 |
| **2-1/4** | 56 | **7** | **135** | 200.9 | **152,000** | 69.0 | **168,900** | 76.6 |
| **2-1/2** | 60 | **7-1/2** | **152** | 226.2 | **170,000** | 77.1 | **188,900** | 85.7 |
| **2-5/8** | 64 | **8** | **169** | 251.5 | **189,000** | 85.8 | **210,000** | 95.3 |
| **2-3/4** | 68 | **8-1/2** | **192** | 285.7 | **214,000** | 97.1 | **237,800** | 107.9 |
| **3** | 72 | **9** | **222** | 330.4 | **245,000** | 111.2 | **272,200** | 123.5 |
| **3-1/4** | 80 | **10** | **271** | 403.3 | **288,000** | 130.7 | **320,000** | 145.2 |
| **3-5/8** | 88 | **11** | **321** | 477.7 | **338,000** | 153.4 | **375,600** | 170.4 |
| **4** | 96 | **12** | **389** | 578.9 | **418,000** | 189.7 | **464,400** | 210.7 |

Tensile Strengths are determined in accordance with Cordage Institute 1500, Test Methods for Fiber Rope. With extended immersion in water, all nylon ropes will lose up to 10% of their strength. Weights are calculated at linear density under standard preload ($200d^2$) plus 7%. See reverse side for application and safety information.

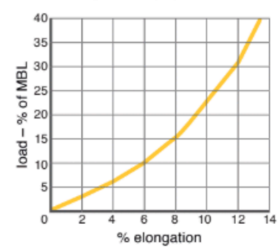
*Please note that the Minimum Tensile Strengths of Black Nylon 12 Plait products are normally 15% below published specifications. Type approval of Nylon 12 Plait does not apply to Black Nylon 12 Plait.*

### Technical Information

| | |
|---|---|
| Specific gravity | **1.14*** |
| Melting point | **414°F (212°C)** |
| Critical temp. | **300°F (149°C)** |
| Coefficient of friction | **0.12–0.15*** |
| Elongation at break | **30–35%** |
| Fiber water absorption | **3–5%** |
| UV resistance | **good** |
| Wet abrasion | **excellent** |
| Dry abrasion | **excellent** |

* value based on data supplied by the fiber manufacturer for new, dry fiber

### Nylon 12 Plait Elongation (%)



PRODUCT SPECIFICATIONS

# TENEX™

Tenex is a 12-strand single braid that offers high strength with low stretch and outstanding abrasion resistance. It is Samthane coated to provide abrasion resistance, enhance wear life, snag resistance, and increase ease of splicing. It is a viable alternative to using double braids when easy field splicing and economy are major considerations.

**FEATURES AND BENEFITS:**

> Available in long lengths
> Easy to inspect
> Easy to splice
> Economical
> Excellent abrasion resistance
> Excellent snag resistance
> Firm construction
> High strength per diameter
> High strength-to-weight ratio
> Samthane coated

**APPLICATIONS INCLUDE:**

> Other Fishing Line
> Purse Seine Line

**PRODUCT CODE:** 826

**FIBER:** Polyester

**SPECIFIC GRAVITY:** 1.38

**SPLICE/CLASS:** 12-Strand Class I

**ELASTIC ELONGATION:**

At percent of break strength

10% ..................................1.40%

20% ..................................2.30%

30% ..................................3.00%

**COLOR OPTIONS:**

Coated black, blue, clear, green, orange, red, or yellow

| DIAM. (INCH) | CIRC. (INCH) | WEIGHT PER 100 FT. (LBS) | AVG. STRENGTH (LBS) | MIN. STRENGTH (LBS) |
|---|---|---|---|---|
| 3/16 | 9/16 | 1.3 | 2,000 | 1,800 |
| 1/4 | 3/4 | 2.1 | 3,400 | 3,100 |
| 5/16 | 1 | 3.2 | 5,100 | 4,600 |
| 3/8 | 1 1/8 | 3.9 | 6,300 | 5,700 |
| 7/16 | 1 1/4 | 6.3 | 9,300 | 8,400 |
| 1/2 | 1 1/2 | 8 | 12,500 | 11,300 |
| 9/16 | 1 3/4 | 10 | 14,400 | 13,000 |
| 5/8 | 2 | 12 | 18,500 | 16,700 |
| 3/4 | 2 1/4 | 17.2 | 24,400 | 22,000 |
| 7/8 | 2 3/4 | 25.8 | 36,200 | 32,600 |
| 1 | 3 | 38.5 | 51,900 | 46,700 |
| 1 1/8 | 3 1/2 | 43 | 62,600 | 56,300 |
| 1 1/4 | 3 3/4 | 52.2 | 71,400 | 64,300 |
| 1 5/16 | 4 | 59.7 | 83,000 | 74,700 |
| 1 1/2 | 4 1/2 | 71.5 | 97,400 | 87,700 |

*Specifications are for spliced strengths.*