Fishing gear as a platform for sensors:
Implementation of real-time quality control of in-situ temperature and salinity data collected via fishing gear

Version 1

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1. Introduction

This document describes the implementation of the automated checks that are performed on CTD (Conductivity, Temperature, Depth) data that are collected via fishing gear as a platform for sensors. Trajectory data describe the positions and time of the fishing vessel.

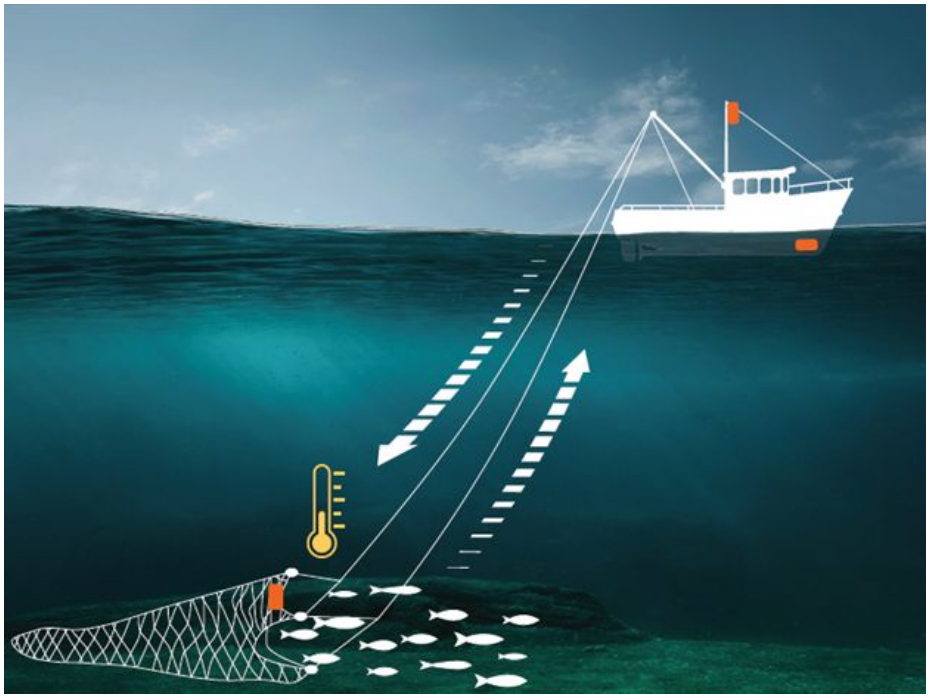


Figure 1. A fishing vessel as a data collection platform.

2. Flags

The data collected by fishing vessels of opportunity, i.e. with sensors attached to fishing gear, is aimed to be interoperable and used by different users with different requirements. In order to maximize (re)usability, the data is quality controlled and flagged to characterize data. Flags are always included in the data delivery, to optimize data reliability and consistency.

Quality checks are based on the tests described by IOOS (U.S. Integrated Ocean Observing System, 2020) and the Argo network (Wong et al., 2020).

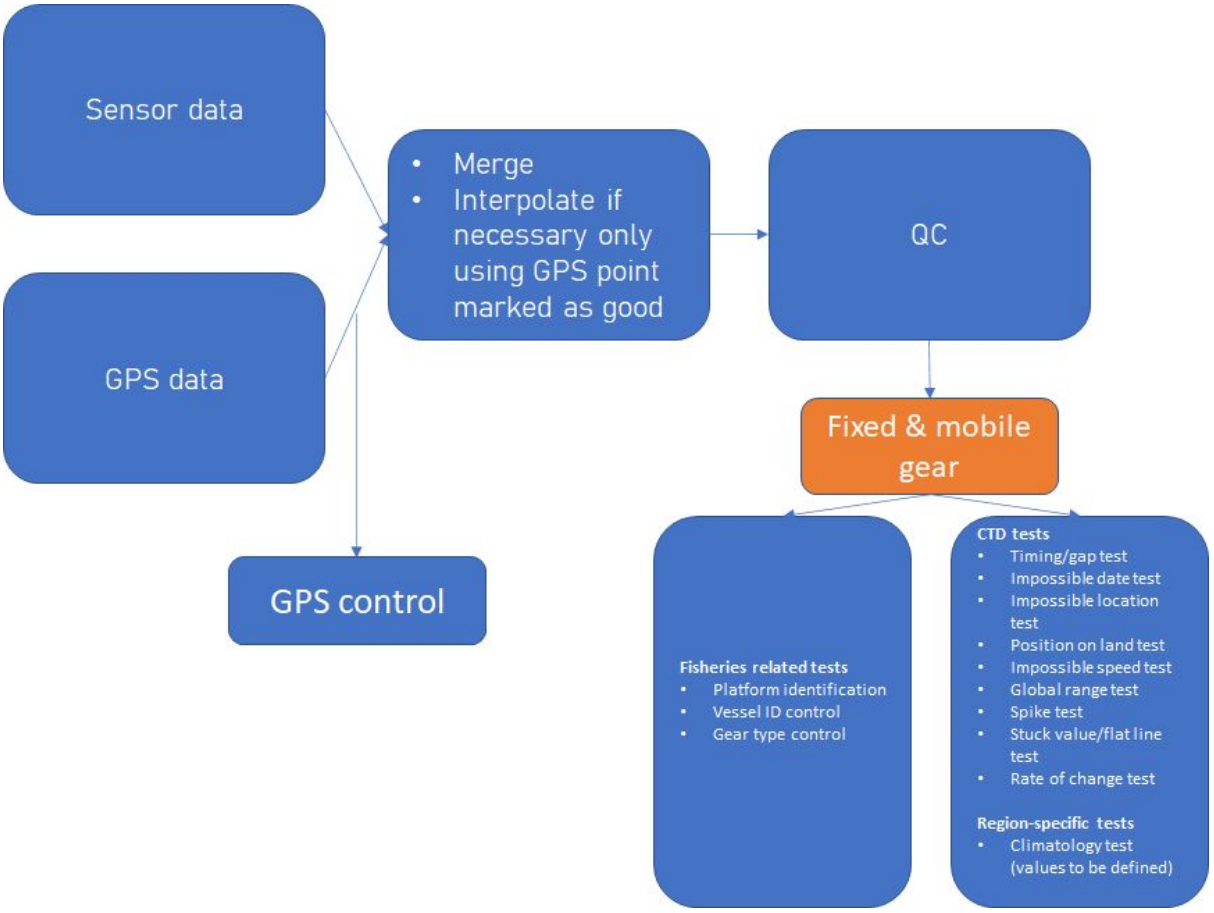
The flags used by BDC to indicate QC status are based on existing standards defined by other programs and datasets for oceanographic observations. Flags are indicated in table 1.

Table 1. Quality flags.

Code	**Meaning**
0/NA	No QC was performed
1	Good data
3	Suspect data
4	Bad data
5	Corrected data
9	Missing value

- Data flagged as (0) are not quality controlled, and therefore recommended not to be used without QC performed by the user.
- Data flagged as (1) have been quality controlled, and can be used safely.
- Data flagged as (3) have been quality controlled, and marked as suspect. These data can't be used directly, but have the potential to be corrected in delayed mode.
- Data flagged as (4) have been quality controlled and should be rejected.
- Data flagged as (5) have been corrected.
- Data flagged as (9) are missing.

3. Real-time Quality control



2.1. Fisheries quality control tests

1. Platform identification (under development)

Check if there is an unknown sensor ID/Vessel ID.

2. Vessel ID control (under development)

This test determines whether a sensor has the correct vessel assigned, by checking if the vessel is operating in an expected region, as defined in Table 2. Vessels that are located outside those regions will be marked as suspect, and controlled in delayed mode.

Table 2. Coordinates that define the different operating regions for vessels.

Region	**Longitude min**	**Longitude max**	**Latitude min**	**Latitude max**

Greenland	-60	-15	55	90
North Sea and Baltic	-15	30	45	60
Atlantic	-75	30	55	90
New Zealand	160	185 (on a 0-360 degree scale) or -175 (on a -180-180 scale)	-50	-30
Alaska	-180	-125	45	90

3. Gear type control (under development)

Check if the gear type assigned is correct.

2.2. Quality control tests CTD

4. Timing/gap test

This test controls whether the most recent measurement has been received within the expected time period.
Measurements failing this test are only marked as suspect, to be controlled later.

Flags	**Description**
Suspect (3)	*Check for the arrival of data* Data didn't come in as expected: NOW – TIM_STMP > TIM_INC
Pass (1)	*Applies for test pass condition.*

5. Impossible date test

The date of the profile can be no earlier than 01/01/2010 and no later than current date in UTC

Flags	**Description**
Fail (4)	*Impossible date* 01/01/2010 < Date > UTC

Pass (1)	*Applies for test pass condition.*

6. Impossible location test

This simple test controls whether the geographic location is sensible, based on the global limits for longitude and latitude.

Flags	**Description**
Fail (4)	*Impossible location* -180 < longitude > 180 -90 < latitude > 90
Pass (1)	*Applies for test pass condition.*

7. Position on land test (under development)

This test requires that the observation latitude and longitude from a float profile be located in an ocean. In this case a 5 minute bathymetry file (ETOPO5/TerrainBase) downloaded from http://www.ngdc.noaa.gov/mgg/global/etopo5.html is used.

Flags	**Description**
Fail (4)	*Measurement is on land.*
Pass (1)	*Applies for test pass condition.*

8. Impossible speed test

This test controls whether there are no erroneous locations provided. The speed of the vessels are generated given the positions and times of the vessel. Vessel speed is expected not to exceed 3 ms−1. Otherwise, it means either the positions or times are bad data, or a vessel is sailing full speed rather than fishing.
This test is helpful for determining if there is an error in merging the sensor and GPS data, often due to setting a sensor to a time zone other than UTC.

Flags	**Description**
Fail (4)	*Speed is too high for mobile gear fishing.*

	Vessel speed > 4.12 ms−1 (8 knots)
Pass (1)	*Applies for test pass condition.*

9. Global range test

Gross filter on the observed values of pressure, temperature and salinity based on the sensor ranges (NKE TD, NKE CTD and ZebraTech Moana TD).

This test applies a gross filter on the observed values of pressure, temperature and salinity.

Flags	**Description**
Fail (4)	*Measurement outside sensor operating range* -5 < Pressure -2 < Temperature > 35 °C 2 < Salinity > 42 PSU
Suspect (3)	-5 <= Pressure < 0 Pressure > Max sensor depth + 10%
Pass (1)	*Applies for test pass condition.*

10. Climatology test (under development)

Test that data point falls within seasonal expectations.
This test is a variation on the gross range check, where the thresholds T_Season_MAX and T_Season_MIN are adjusted monthly, seasonally, or at some other operator-selected time period (TIM_TST) in a specific region. Because of the dynamic nature of T and S in some locations, no fail flag is identified for this test and measurements will only be marked as 'suspect'.

Flags	**Description**
Suspect (3)	*Measurement outside climatology range* Seas_min_T < Temperature> Seas_max_T Seas_min_S < Salinity > Seas_max_S
Pass (1)	*Applies for test pass condition.*

11. Spike test

The spike tests checks whether there is a significant difference between sequential measurements, by comparing a measurement to its adjacent ones. The test does not consider differences in pressure, and rather assumes measurements that adequately reproduce changes in temperature and salinity with pressure.

$$Test\ value\ =\ |V2\ -\ (V3 + V1)/2|\ -\ |(V3 - V1)/2|$$

Here, V2 is the tested value, and V1 and V3 are the values before and after. Spikes consisting of more than one data point are difficult to capture, but their onset may be flagged by the rate of change test.
Cut-off values are based on (Wong et al., 2020), and V2 will be flagged based on the following values.

Flags	**Description**
Fail (4)	*Measurement differs significantly from its neighbours* Pressure < 500 dbar: Test value T > 6.0 °C Test value S > 0.9 PSU Pressure > = 500 dbar: Test value T > 2.0°C Test value S > 0.3 PSU
Pass (1)	*Applies for test pass condition.*

12. Stuck value/ flat line test

It is possible that, when sensors fail, continuously repeated observations of the same value are produced. In this test, the present observation is compared to several previous observations. The present observation is flagged if the present observation is the same as all previous observations, calculating in a tolerance value. This tolerance value is based on the sensor precision point.

Flags	**Description**
Fail (4)	*The five most recent observations are equal*

	Tolerance values: Temperature: 0.05 °C Salinity: 0.05 PSU Pressure: 0.5 dbar
Suspect (3)	*The three most recent observations are equal*
Pass (1)	*Applies for test pass condition.*

13. Rate of change test

This test is applied per segment (Up-Down-Bottom), and inspects the segments on a rate of change exceeding a threshold defined by the operator. In this case the thresholds are based on the IOOS examples (U.S. Integrated Ocean Observing System, 2020), where the rate of change between measurement Tn-1 and Tn must be less than three standard deviations (3*SD). The SD of the T time series is computed over the full segment.
This test needs to find a balance between setting a threshold too low, triggering too many false alarms, and setting a threshold too high, triggering too little alarms.
Measurements failing this test are marked as suspect (3).

Flags	**Description**
Suspect (3)	*The rate of change exceeds the selected threshold.*
Pass (1)	*Applies for test pass condition.*

4. References

Annie Wong, Robert Keeley, Thierry Carval and the Argo Data Management Team (2020). Argo Quality Control Manual for CTD and Trajectory Data. http://dx.doi.org/10.13155/33951

U.S. Integrated Ocean Observing System, 2020. Manual for Real-Time Quality Control of In-situ Temperature and Salinity Data Version 2.1: A Guide to Quality Control and Quality Assurance of In-situ Temperature and Salinity Observations. 50 pp. https://doi.org/10.25923/x02m-m555