Aquadopp and Aquapro
-
experiments in current test tank and at sea

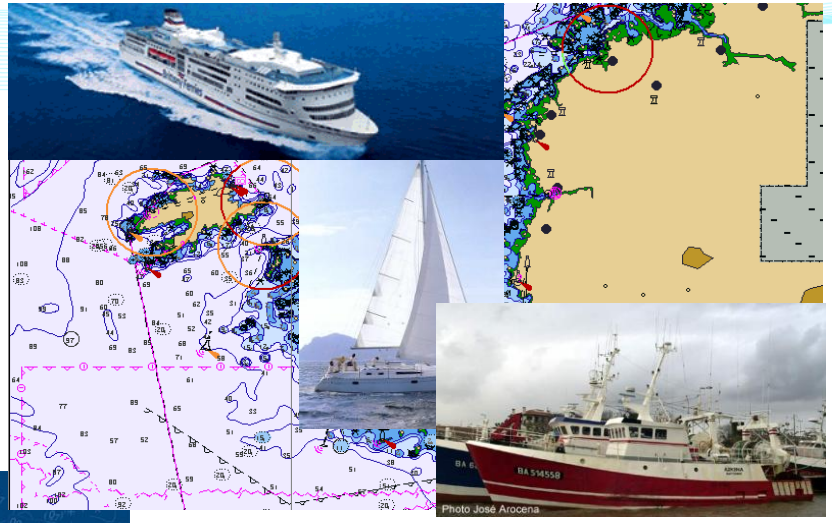
Michel Outre - Andre Lusven

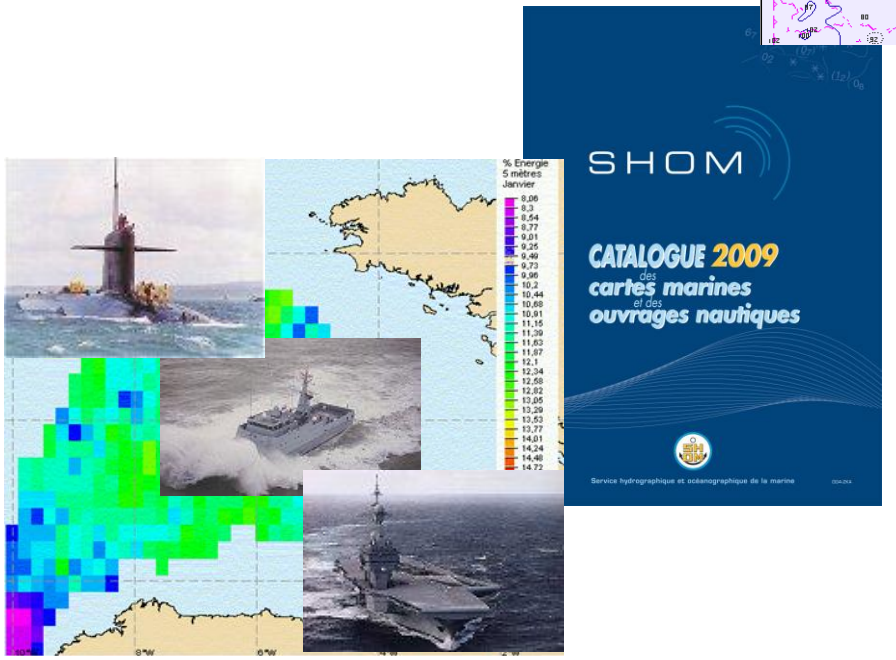
Specialized in oceanographic instrumentation for SHOM

European Nortek Symposium – June 2010

1. SHOM presentation
2. Metrology at SHOM
3. Aquadopp test tank
4. Aquapro 2MHz in test tank
5. Test at sea
6. « Frequency test » in lab

SHOM : French Navy Hydrographic and Oceanographic Service





SHOM's vocation is to ensure the quality and the availability of the physical maritime, coastal and ocean environment information, in order to meet public requirements, both civilian and military, at the lowest possible cost

Facilities

- *Brest (main office)*
- *Toulouse*
- *Saint Mandé (sub direction), Toulon, Tahiti (Papeete), New Calédonia (Nouméa)*

The hydro-oceanographic squadron

All equipped with multi-beam echosounders

Coastal Survey
La Pérouse, Borda, Laplace
1 000 t

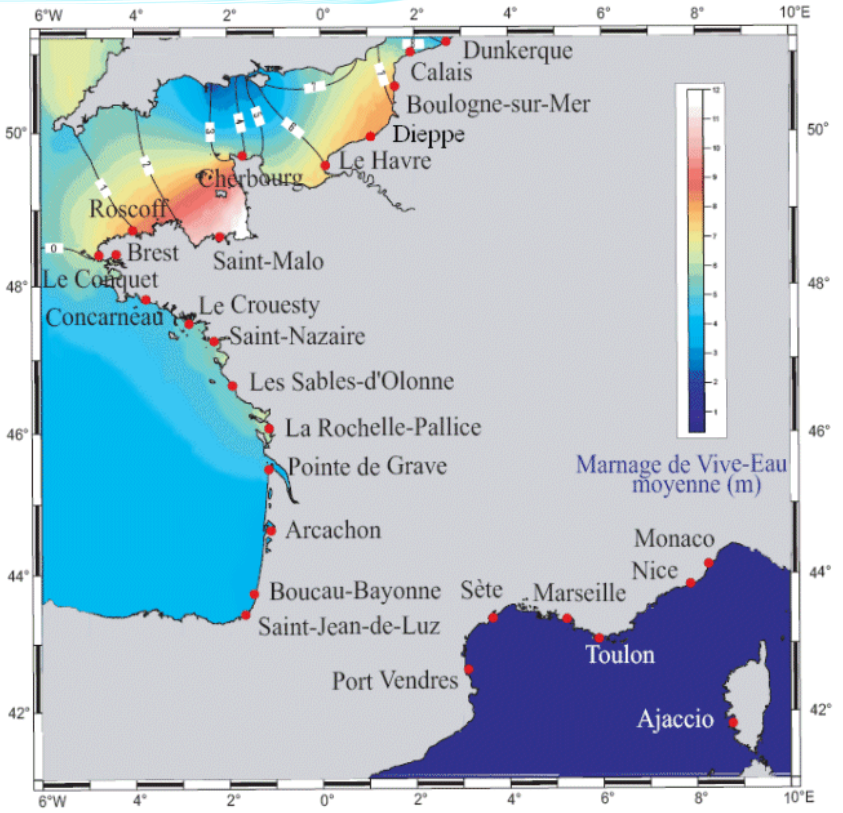
7 Coastal Survey launches

Ocean Survey
Beautemps-Beaupré - 3 300 t
Co-financed by Defence (95%) & Research (5%)

Ocean Research *Pourquoi pas?* – 6 600 t
Co-financed by Research (55%) & Defence (45%)

3 majors missions

- **National Hydrographic Service** : SHOM is the national service designated by the government to carry out general hydrography for the benefit of all seafarers.
- **Defence Support** :Within its areas of competence, SHOM supports the defence expertise and operational requirements in maritime environment.
- **Support to maritime public policies** : SHOM supports government maritime policies in a variety of fields.

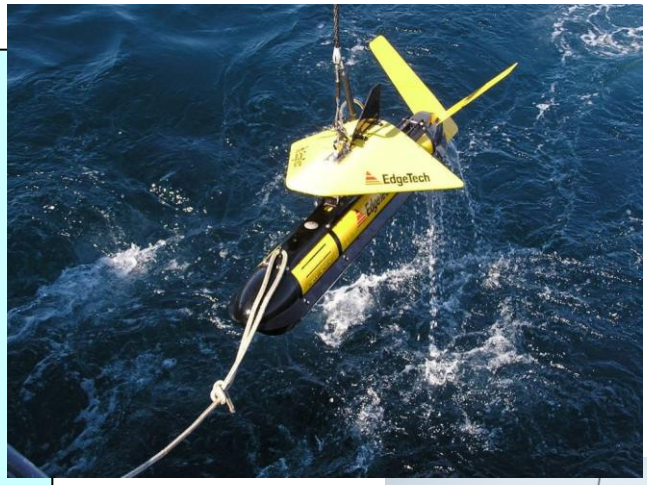


For example, SHOM purchase, deploy and maintain many water level measurements stations in France. The data of these permanent tidal observatories are used to validate coastal numerical models, to do statistical studies on extreme levels, to reduce the hydrographic surveys ….

Scientific equipments in SHOM

Hydrography:

- 12 multibeam echosounder
- 43 side-scan sonar
- 55 GPS receiver
- 52 sound velocity sensor
- 57 autonomous tide recorders



Oceanography:

- 7 CTD Seabird 911 plus
- 5 Water sampler 12 bottles SBE32
- 2 towed vehicles for CTD
- More than 20 drifting buoys and 10 Argo floats per year
- Currentmeters ……

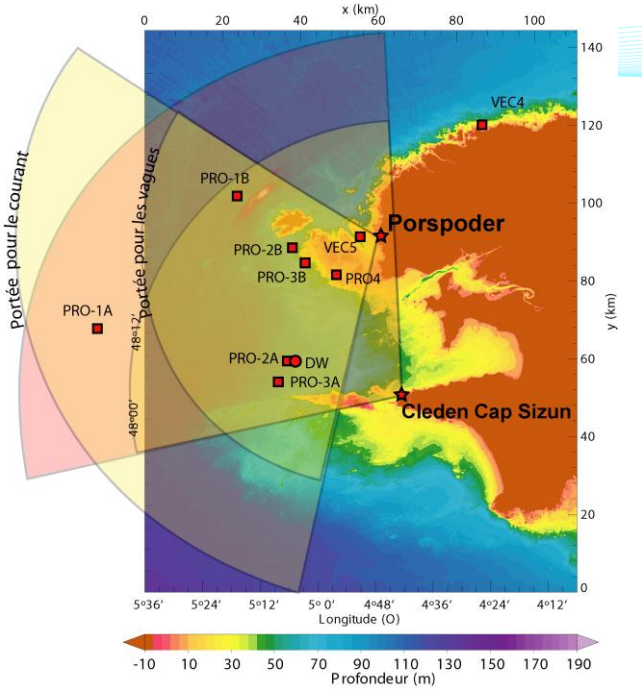
Current meters in SHOM

Different than Nortek:

- 4 VMADCP on 2 vessels
- 6 autonomous deep water (3000 and 6000 meters) ADCP
- 1 radar HF for real time currents and sea state

Nortek:

- 2 Vector, 35 Aquadopp
- 26 aquapro, 3 continental, 4 AWAC
- 13 « antirion » frame moorings, more than 30 tripodes



Certification ISO9001:2000

SHOM is certified ISO9001:2000 for :

- **COLLATION OF MARINE PHYSICAL ENVIRONMENT DATA, INCLUDING NAUTICAL INFORMATION.**
- ELABORATION AND PROVISION OF NAUTICAL INFORMATION AND PUBLICATION TO MEET THE REQUIREMENTS OF SAFE MARITIME NAVIGATION AND MARINE DOMAIN USERS.
- ELABORATION AND PROVISION OF HOM (HYDROGRAPHIC, OCEANOGRAPHIC AND METEROLOGIC) PRODUCTS TO SUPPORT DEFENCE MISSIONS.
- R&D MANAGEMENT, PROVISION OF SPECIFIC TRAINING AND EXPERTISE IN THE RELATED FIELDS.

BUREAU VERITAS Certification

Certification

Attribuée à

SHOM : SERVICE HYDROGRAPHIQUE ET OCEANOGRAPHIQUE DE LA MARINE
Adresse civile : 13 Rue du Chatellier, BP 30316, 29603 BREST CEDEX
Adresse navale : BP4, 29240 BREST ARMEES
Et les sites listés en annexe
FRANCE

Bureau Veritas Certification certifie que le système de management de la qualité de l'entreprise susmentionnée a été évalué et jugé conforme aux exigences de la norme :

Standard

NF EN ISO 9001 : 2000

Domaine d'activité

- RECUEIL DES DONNEES DECRIVANT L'ENVIRONNEMENT PHYSIQUE MARIN, INCLUANT LES INFORMATIONS NAUTIQUES,
- ELABORATION ET DIFFUSION D'INFORMATIONS ET DE PUBLICATIONS NAUTIQUES REPONDANT AUX BESOINS DE LA SECURITE DE LA NAVIGATION MARITIME ET DES USAGERS DU DOMAINE MARITIME,
- ELABORATION ET DIFFUSION DE PRODUITS HOM (HYDROGRAPHIQUES, OCEANOGRAPHIQUES, METEOROLOGIQUES) EN SOUTIEN AUX MISSIONS DE DEFENSE,
- PILOTAGE DE LA R&D, ACTIONS DE FORMATION SPECIFIQUES ET PRESTATIONS D'EXPERTISE DANS LES DOMAINES AFFERENTS.

- COLLATION OF MARIN PHYSICAL ENVIRONMENT DATA, INCLUDING NAUTICAL INFORMATION,
- ELABORATION AND PROVISION OF NAUTICAL INFORMATION AND PUBLICATIONS TO MEET THE REQUIREMENTS OF SAFE MARITIME NAVIGATION AND MARINE DOMAIN USERS,
- ELABORATION AND PROVISION OF HOM (HYDROGRAPHIC, OCEANOGRAPHIC AND METEOROLOGICAL) PRODUCTS TO SUPPORT DEFENCE MISSIONS,
- R&D MANAGEMENT, PROVISION OF SPECIFIC TRAINING AND EXPERTISE IN THE RELATED FIELDS.

Date de certification originale : **9 mai 2007**

Sous réserve du fonctionnement continu et satisfaisant du système de management de la qualité de l'entreprise, ce certificat est valable jusqu'au : **15 mars 2010**
Pour vérifier la validité du certificat appelez au : + 33(0) 4 78 66 82 60
Tout éclaircissement sur cette certification peut être obtenu auprès de l'entreprise certifiée.

Date : 9 mai 2007
Numéro d'affaire : 1671765

Romain PETIT
Directeur Général

BUREAU EN CHARGE : Bureau Veritas Certification France – 60, avenue du Général de Gaulle – 92046 Paris La Défense
BUREAU EMETTEUR : Bureau Veritas Certification France – 41, chemin des Peupliers – BP 58 – 69573 Dardilly Cedex

1. SHOM presentation
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Consequence of the certification: Control of all the physical parameters measured.

For all the instruments, SHOM determined user tolerances. Necessity to check at regular intervals that the systems are in accordance with the specifications needed.

To calibrate classical parameters, SHOM developed his own metrology laboratory equipped with :

- 2 thermoregulated baths of seawater or fresh water.
- 4 salinometers
- 3 pressure reference for differents scales.

Consequences of the certification concerning the Nortek currentmeters ….

- *Pressure sensor:* ***difficulty to calibrate the pressure sensors (no thread).***
- *Temperature sensor:* ***the temperature sensor are verified in our regulated tanks.***
- *Compass:* ***a specific platform for compass calibration is under construction in SHOM.***
- *Modulus of the current:* ***each single point currentmeter are controlled in a current test tank to confirm its ability to measure modulus of the current better than 5 cm/s. Afterwards, the single point currentmeters qualified are used as reference during sea trials with profiler currentmeters.***

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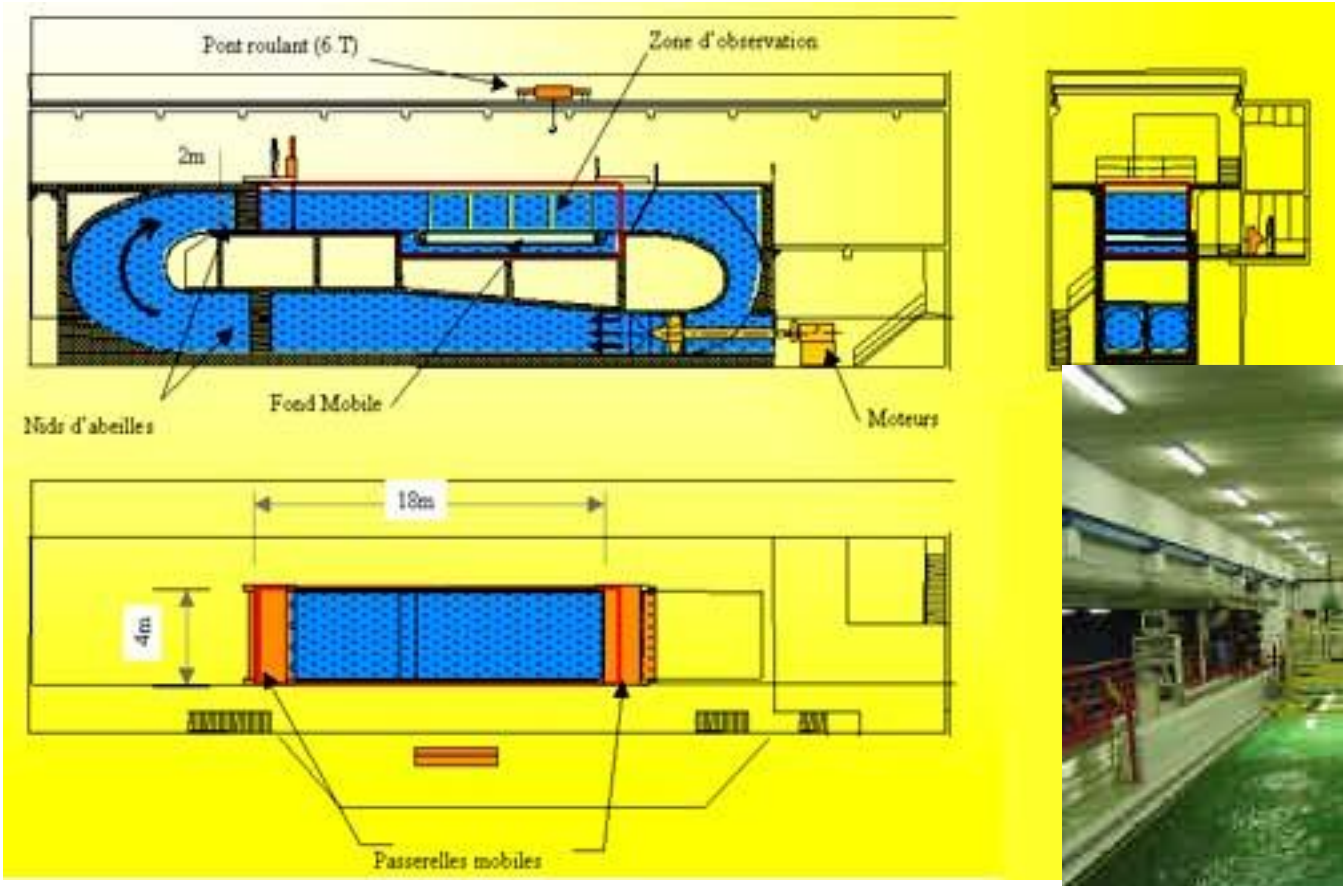
Aquadopp in current test tank

1. **Trials in tank of water circulation (2007):** homogeneous water flow around the aquadopp



Results concerning the faisability:

Avantage:

the integration period can be as long as in situ.

Disadvantage:

The signal strength was too weak at 50 cm/s or smaller speeds to have significant results.

In conclusion, the results were acceptable only for one part of the scale tested.

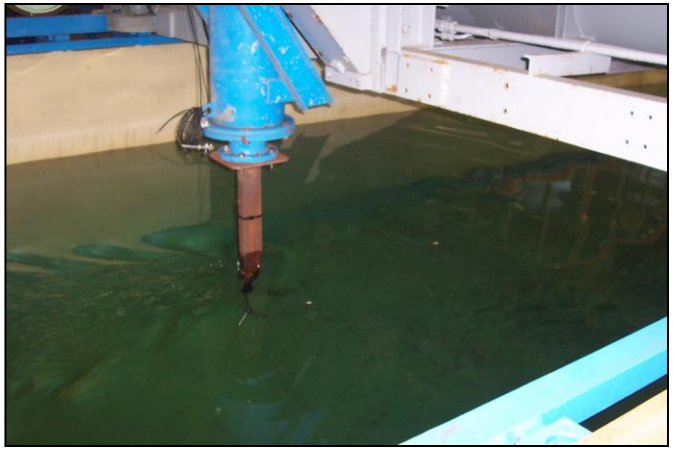
Since this experiment, we observe better conditions in a traction canal.

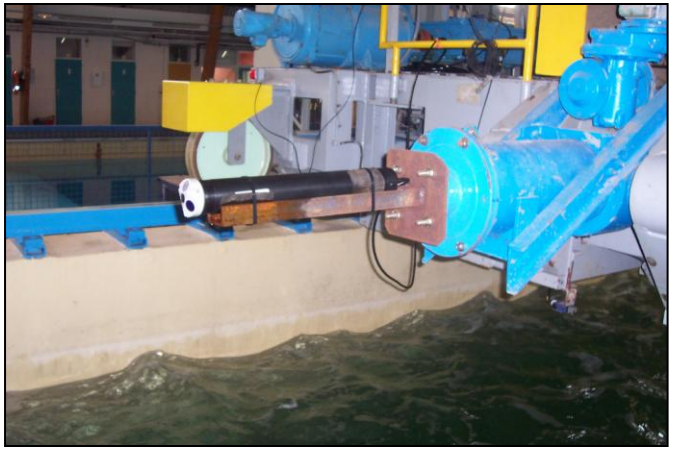
2. Trials in a traction canal: results obtained in may 2010

Characteristics

- Length: 50 m
- Width: 4 m
- Height: 3 m
- Speed programmable from 0 to 1 m/s with an accuracy of 0,2cm/s.

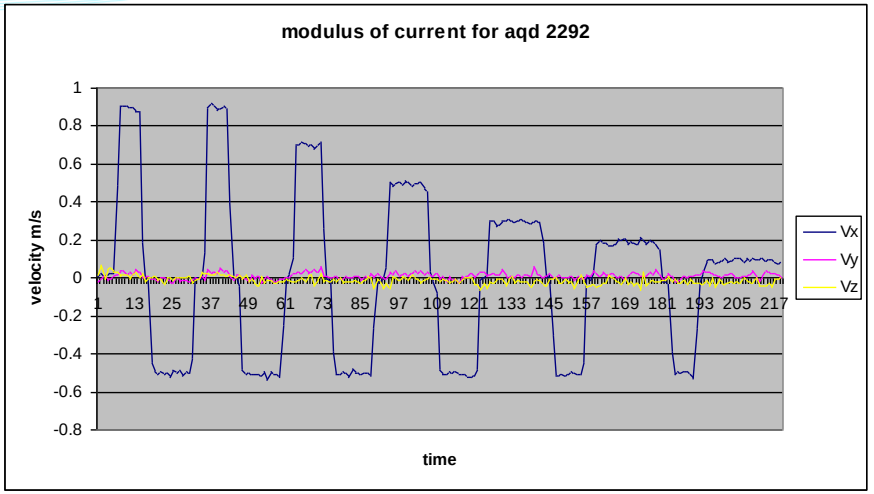
Pictures of Nortek instruments in test may2010

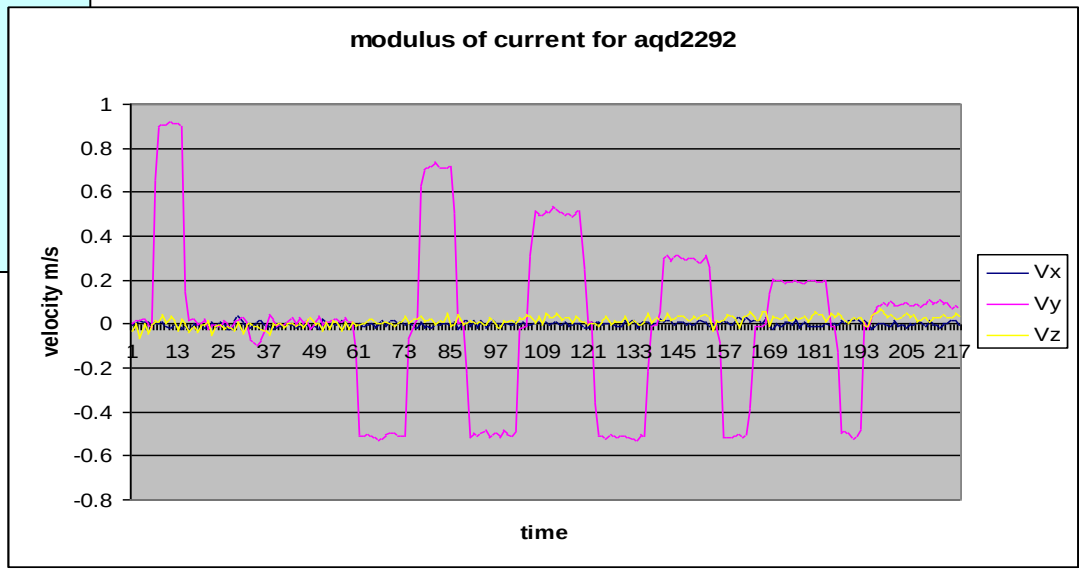




Visualisation of raw data

- Currentmeters are placed in acquisition mode.
- Differents runs from 10 cm/s until 90 cm/s.
- Returns to the start zone at 50 cm/s.
- The 2 axis are experimented.





Results for an aquadopp 200 meter

Aqd200 n°3187 :
average interval of 5s, tested along the X axis and the Y axis.

Velocity cm/s	10	20	30	50	70	90
Vx	Vmin= 5,5 Vmax= 12,8 Numb= 23 Vmoy= 8,9	Vmin= 15,7 Vmax= 20,4 Numb= 16 Vmoy= 18,5	Vmin= 26,3 Vmax= 32,2 Numb= 14 Vmoy= 28,9	Vmin= 47,5 Vmax= 50,3 Numb= 12 Vmoy= 48,7	Vmin= 66,1 Vmax= 71,7 Numb= 8 Vmoy= 68,5	Vmin= 86,4 Vmax= 90,5 Numb= 6 Vmoy= 89,3
Vy	Vmin= 6,7 Vmax= 11,8 Numb= 22 Vmoy= 9,5	Vmin= 15,4 Vmax= 22,1 Numb= 18 Vmoy= 19,4	Vmin= 25,9 Vmax= 30,9 Numb= 15 Vmoy= 29,3	Vmin= 48,3 Vmax= 52,4 Numb= 12 Vmoy= 50,7	Vmin= 68,8 Vmax= 71,9 Numb= 9 Vmoy= 70,1	Vmin= 88,0 Vmax= 92,2 Numb= 6 Vmoy= 90,0
Pass / Fail +/-5 cm/s	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**

Results for an aquadopp 2000 meter

Aqd2000 n°2292 :
average interval of 5s, tested along the X axis and the Y axis.

Velocity cm/s	10	20	30	50	70	90
Vx	Vmin= 7,6 Vmax= 10,7 Numb= 20 Vmoy= 9,4	Vmin= 16,7 Vmax= 21,0 Numb= 18 Vmoy= 18,9	Vmin= 27,4 Vmax= 30,7 Numb= 16 Vmoy= 29,7	Vmin= 47,9 Vmax= 51,0 Numb= 11 Vmoy= 49,7	Vmin= 68,0 Vmax= 71,5 Numb= 9 Vmoy= 70,2	Vmin= 88,4 Vmax= 91,9 Numb= 7 Vmoy= 90,6
Vy	Vmin= 8,0 Vmax= 11,1 Numb= 21 Vmoy= 9,2	Vmin= 18,1 Vmax= 20,2 Numb= 16 Vmoy= 19,4	Vmin= 27,7 Vmax= 31,5 Numb= 13 Vmoy= 29,8	Vmin= 48,7 Vmax= 53,2 Numb= 10 Vmoy= 50,7	Vmin= 70,3 Vmax= 73,9 Numb= 8 Vmoy= 71,4	Vmin= 89,6 Vmax= 92,1 Numb= 7 Vmoy= 90,6
Pass / Fail +/-5 cm/s	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**

Conclusions single point current meter

- *The method used by SHOM to link the modulus current measurements with a reference velocity is applicable.*
- *The modulus of current along the 2 horizontal axis can be checked.*
- *During the last 3 years, more than 30 current meters tested.*

We observe that the aquadopp 2000 or 6000 are always more precise than the aquadopp 200.

*We tried to link a **2 Mhz aquadopp profiler** with this velocity reference.*

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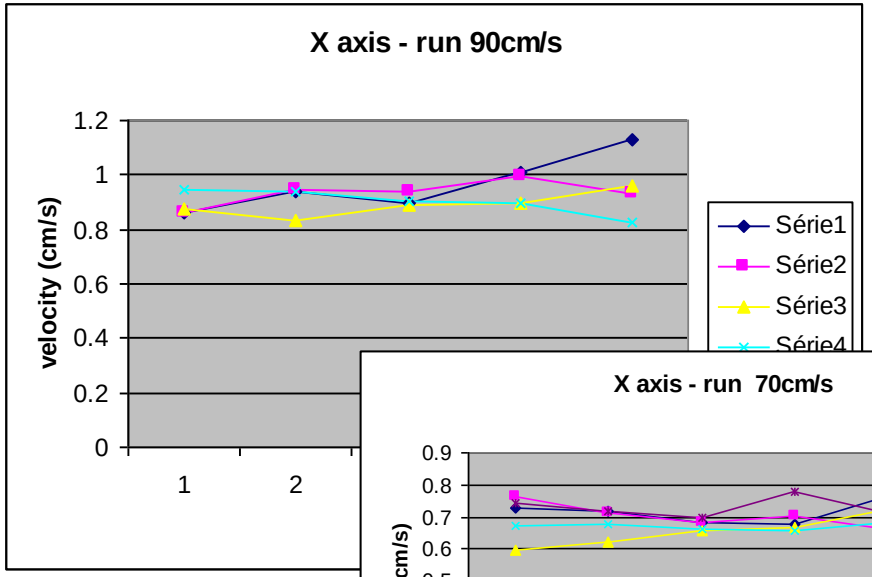
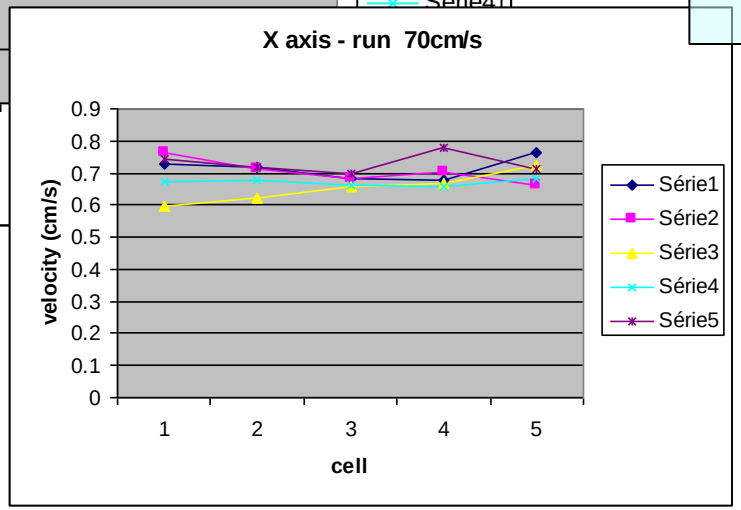
Willingness to have a profiler connected to a reference : test with an AQUAPRO 2 MHz

Test conditions :

- The AQP2MHz is integrated in the frame, put down in the water and oriented on the X or Y axis.
- It is placed in acquisition mode
  - Profile interval : 7 s
  - Average interval : 7 s
- Then, runs at differents speeds 90, 70, 50 and 30 cm/s are realized.

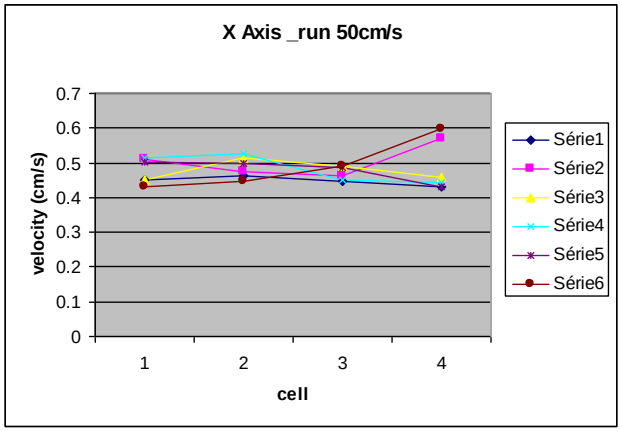
test with an AQUAPRO 2 MHz : Results





On the X and Y axis, for the velocity of 90 cm/s, 70 cm/s and 50 cm/s, the value of the current is respectively 92.3 cm/s, 69.5 cm/s, 46.4 cm/s of the mean current value.

It's in the limit of the SHOM référence : +/- **5 cm/s**



test with an AQUAPRO 2 MHz : Results for 30 cm/s

X axis

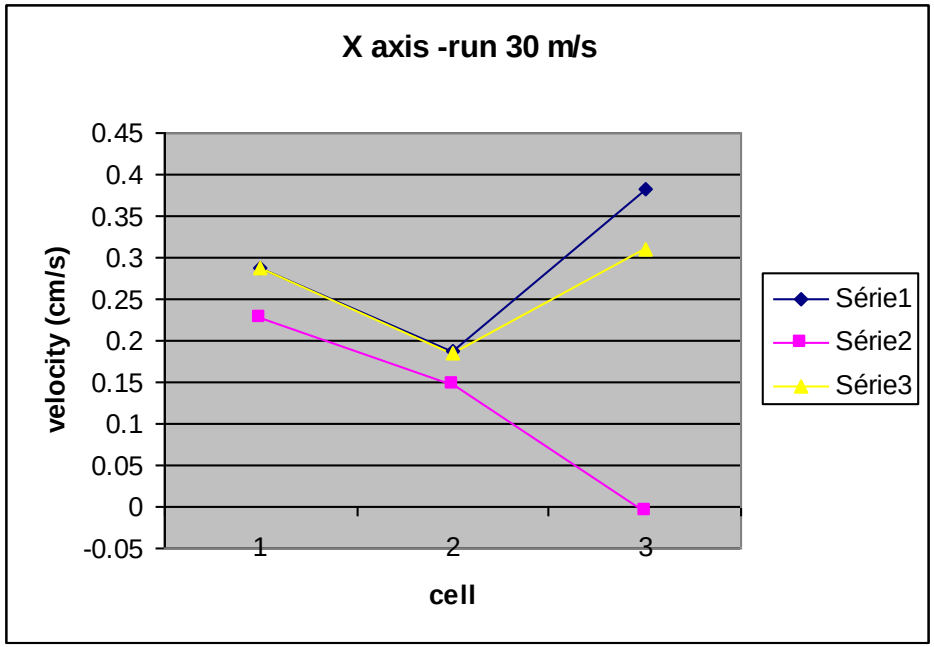
For the velocity of 30 cm/s, limits appears.

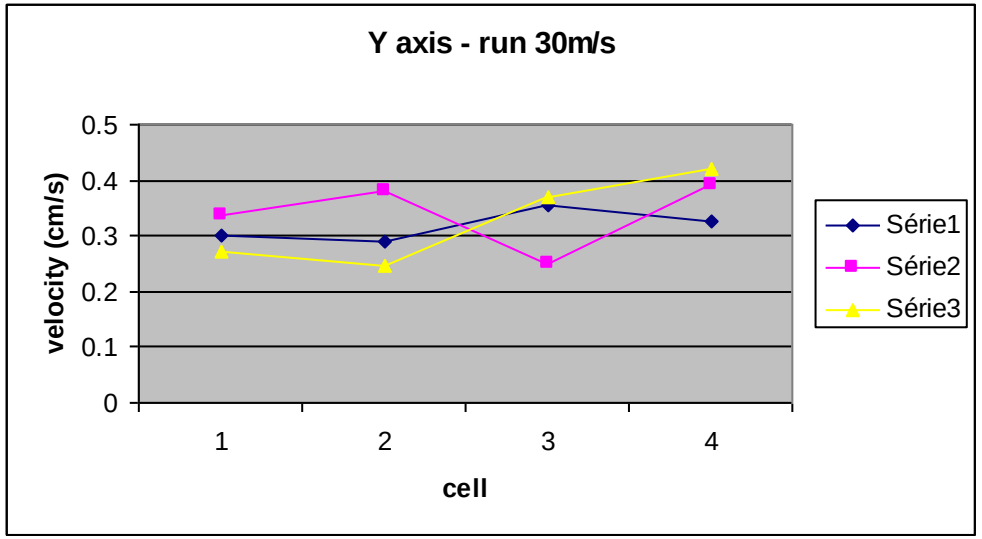
- a mean value of 22.3 cm/s
- a lot of dispersion

Y axis

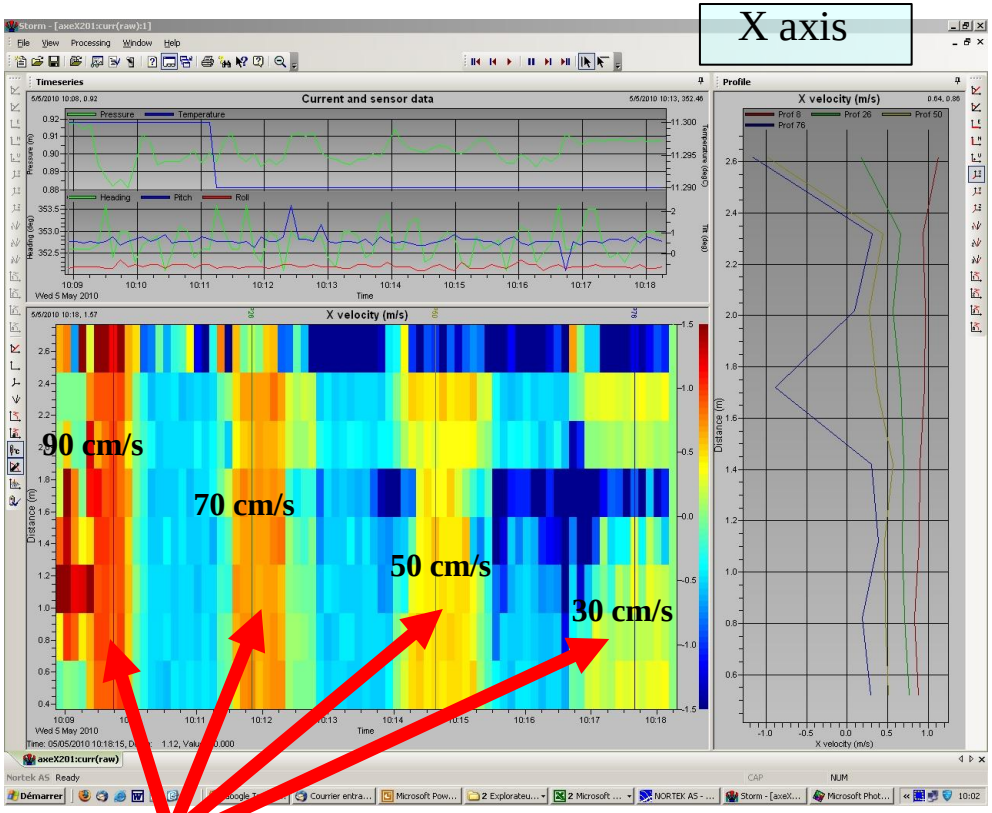
For the velocity of 30 cm/s, good results.

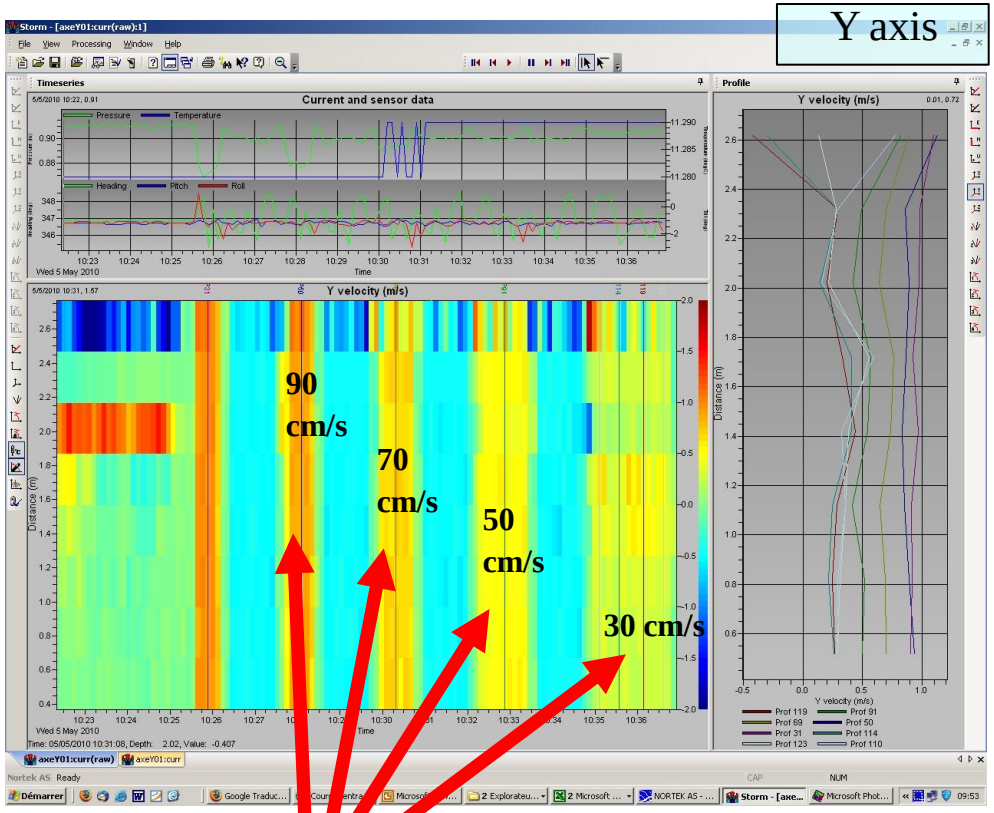
- a mean value of 32.8 cm/s,
- in the limit of the SHOM référence : +/- **5 cm/s**





test with an AQUAPRO 2 MHz : A look on Storm





Difference of water conditions (particules suspended in water)

- X axis

- Y axis

Conclusions current profiler

This test shows the difficults to measure in a test tank with a profiler.

Tests conditions are very important for the repetability of the measure

- number of particules in water
- signal reverberation. (number and cell size)

The Aquapro 2 MHz is connected to a reference like the aquadopp for a major part of velocity scale.

They (Aquadopp & Aquapro 2MHz) can be used for IN SITU comparison.

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Test at sea

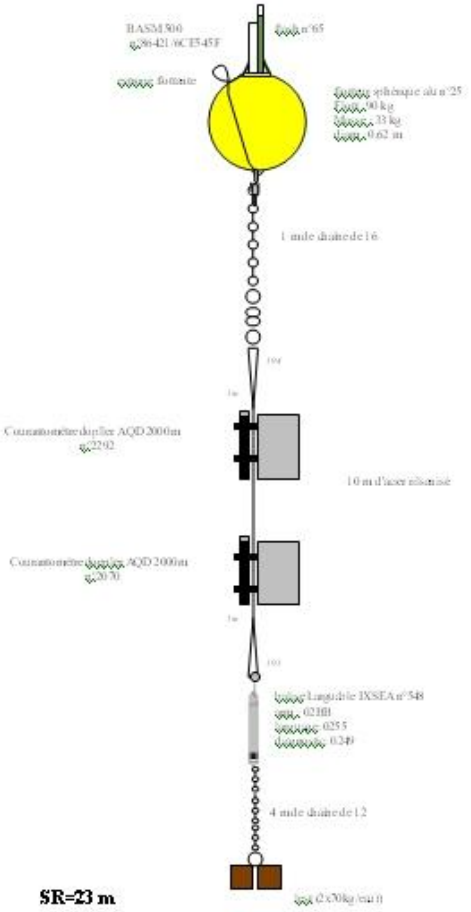
SHOM need : verify the current data of the Aquapro profiler.

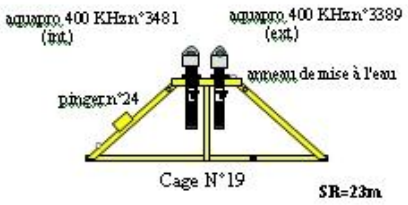
Strategy : compare at sea the profilers Aquapro to the Aquadopp and Aquapro calibrated in test tank.

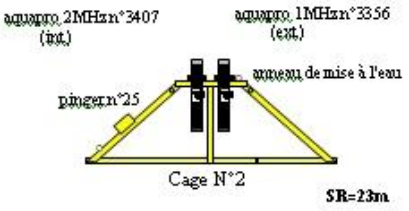
Means : Intercomparaison moorings

Intercomparison moorings

- two tripodes frames with 2 Aquapro each
- One mooring line with 2 reference Aquadopps.

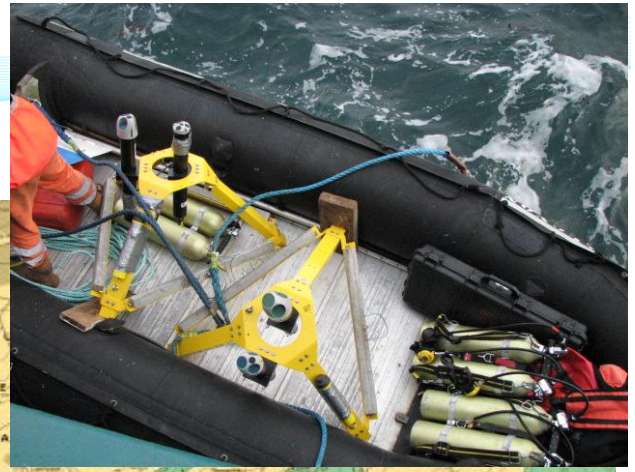


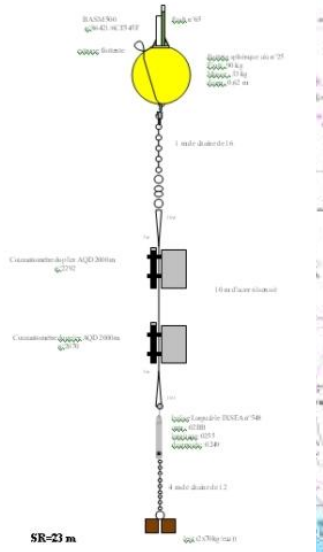


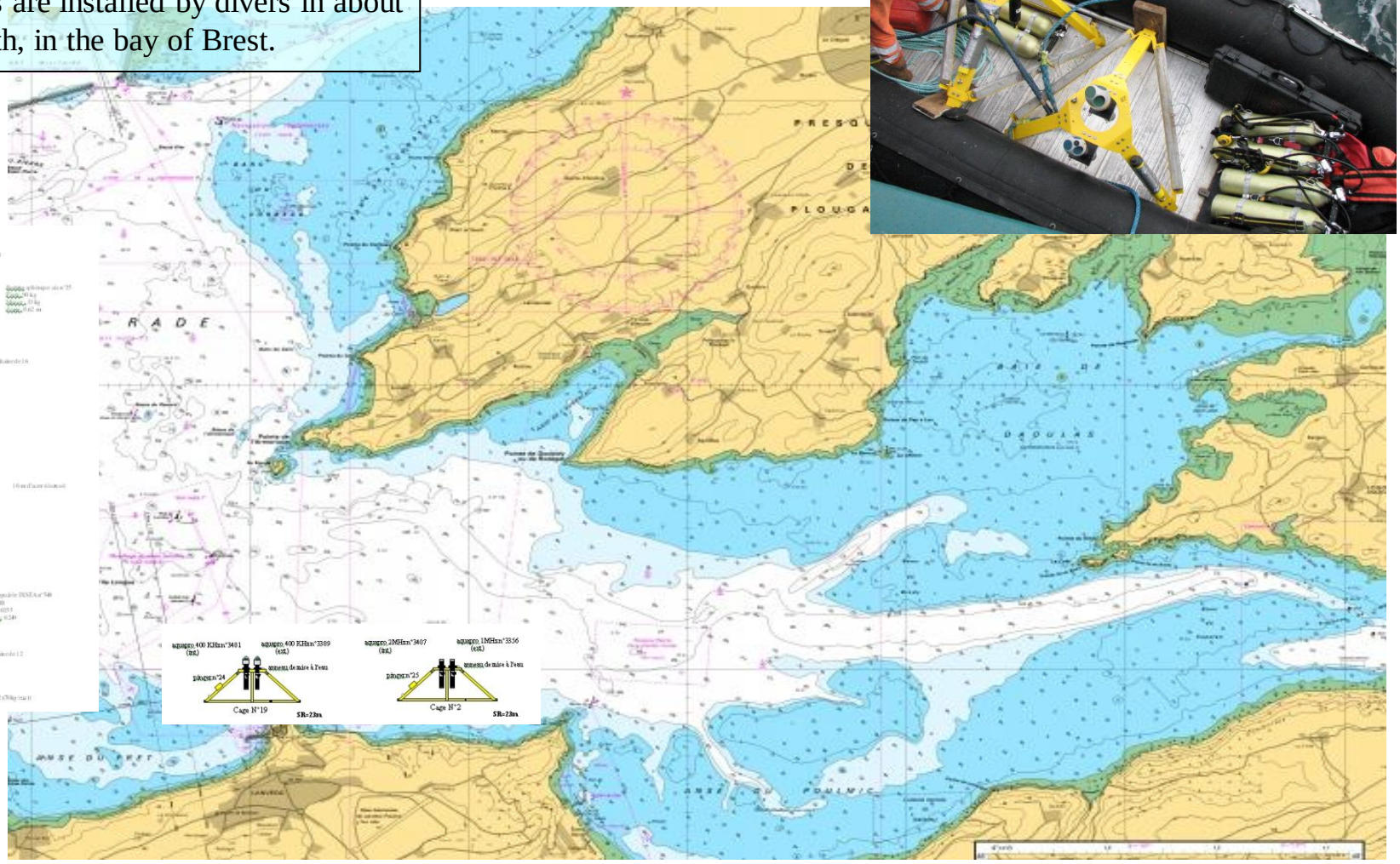


Intercomparison moorings

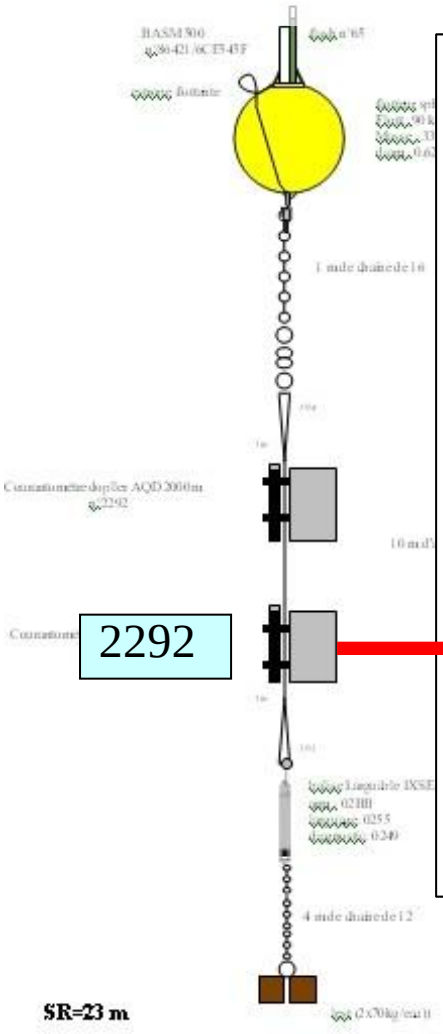
The moorings are installed by divers in about 25 meter depth, in the bay of Brest.

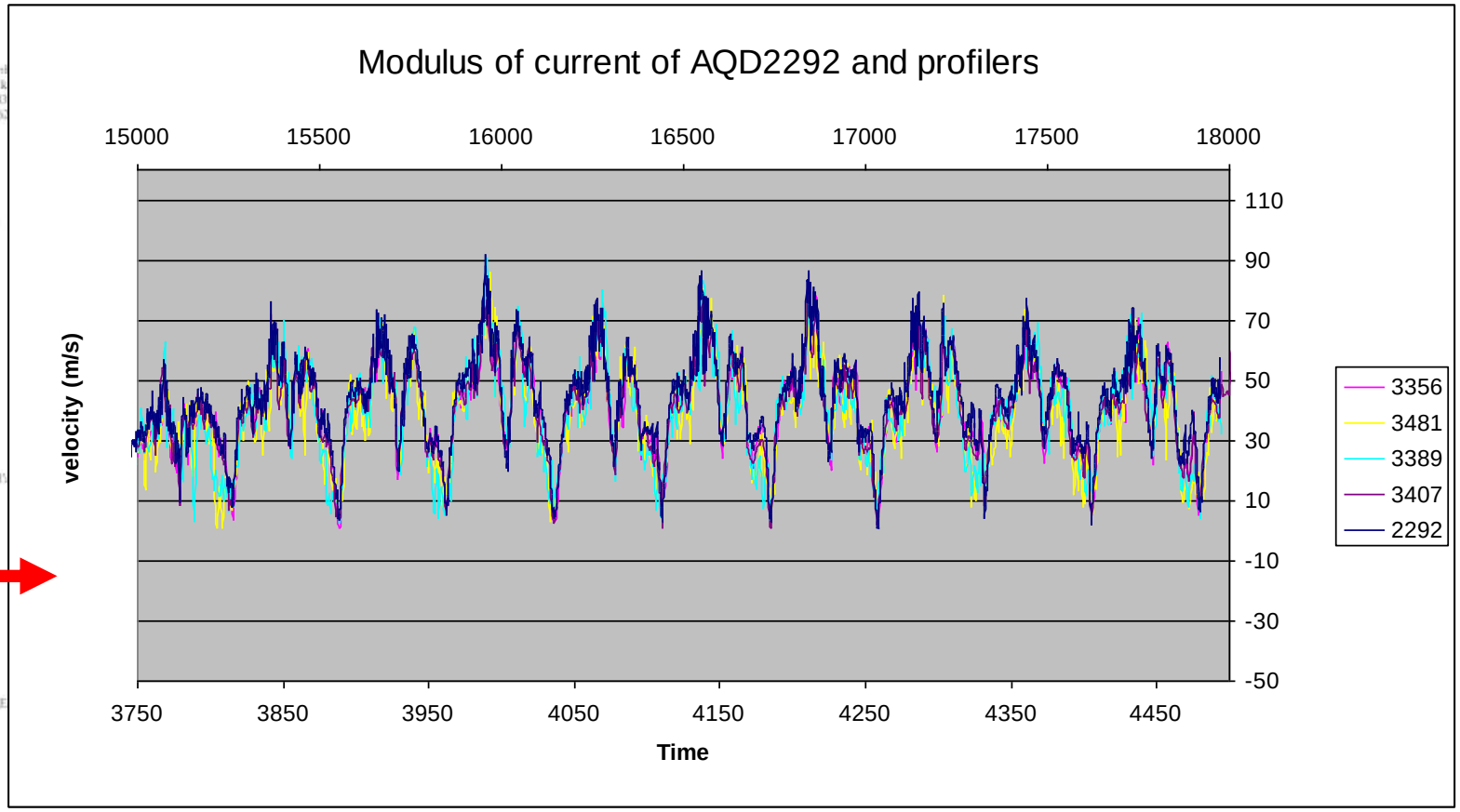






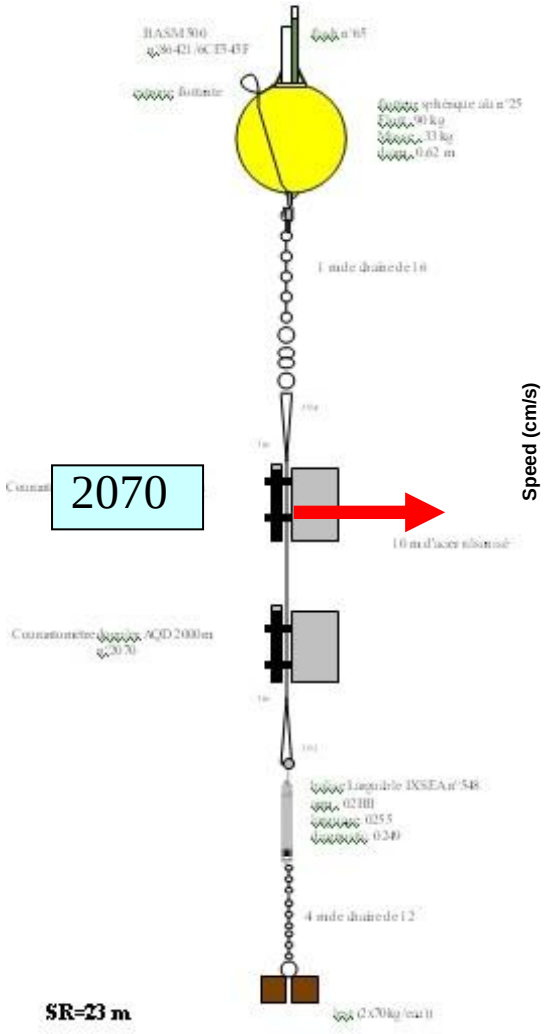
Results : comparison modulus of current between AQD and AQP

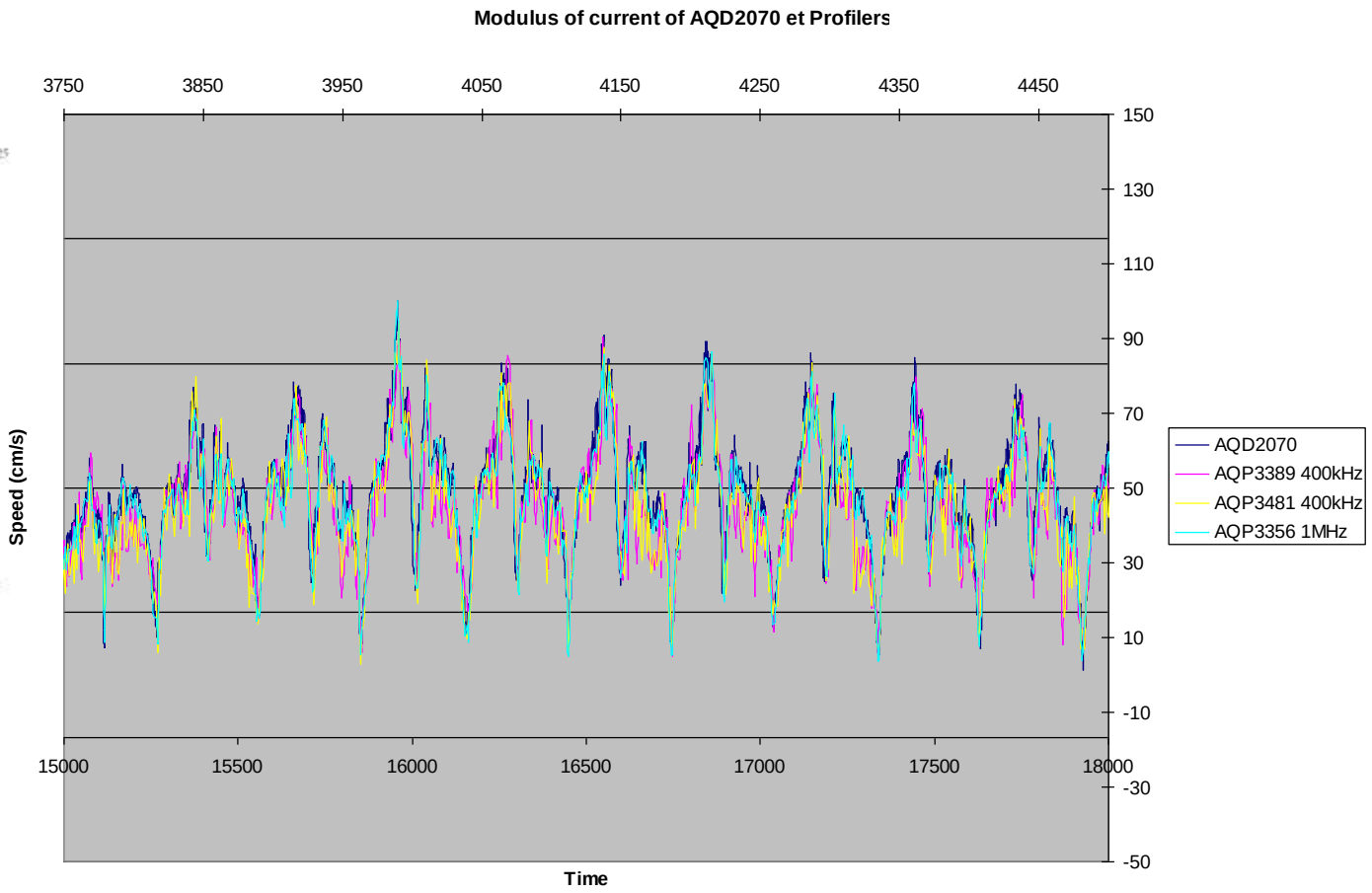




modulus of current : data coherence between time series Aquadopp n°2292 and Profilers

Results : comparison modulus of current between AQD and AQP





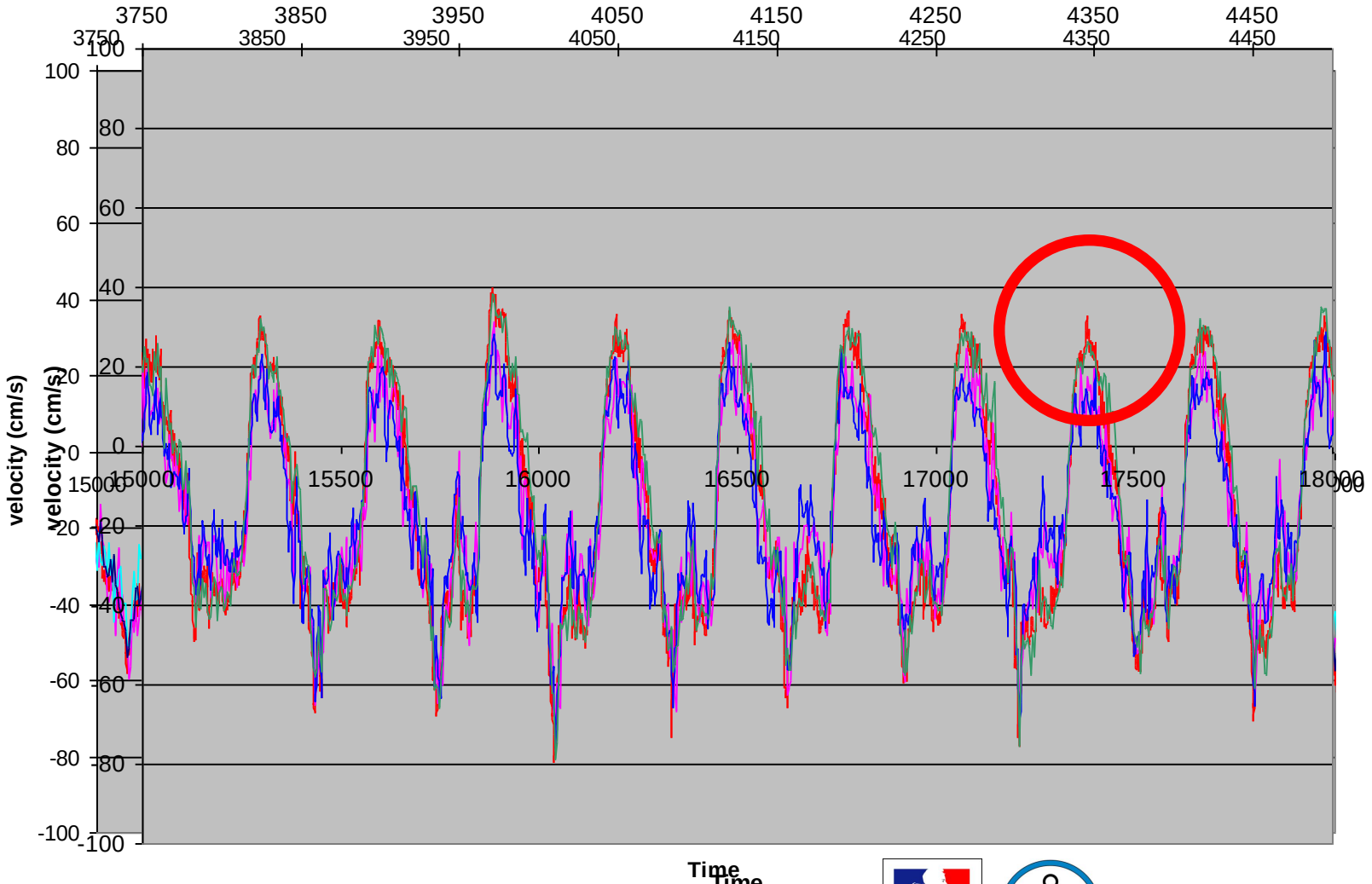
modulus of current : data coherence between Aquadopp n°2070 and Profilers

North-South

Differences between

- the reference (Aqd2292), AQP 1MHz
- and the 400kHz AQP

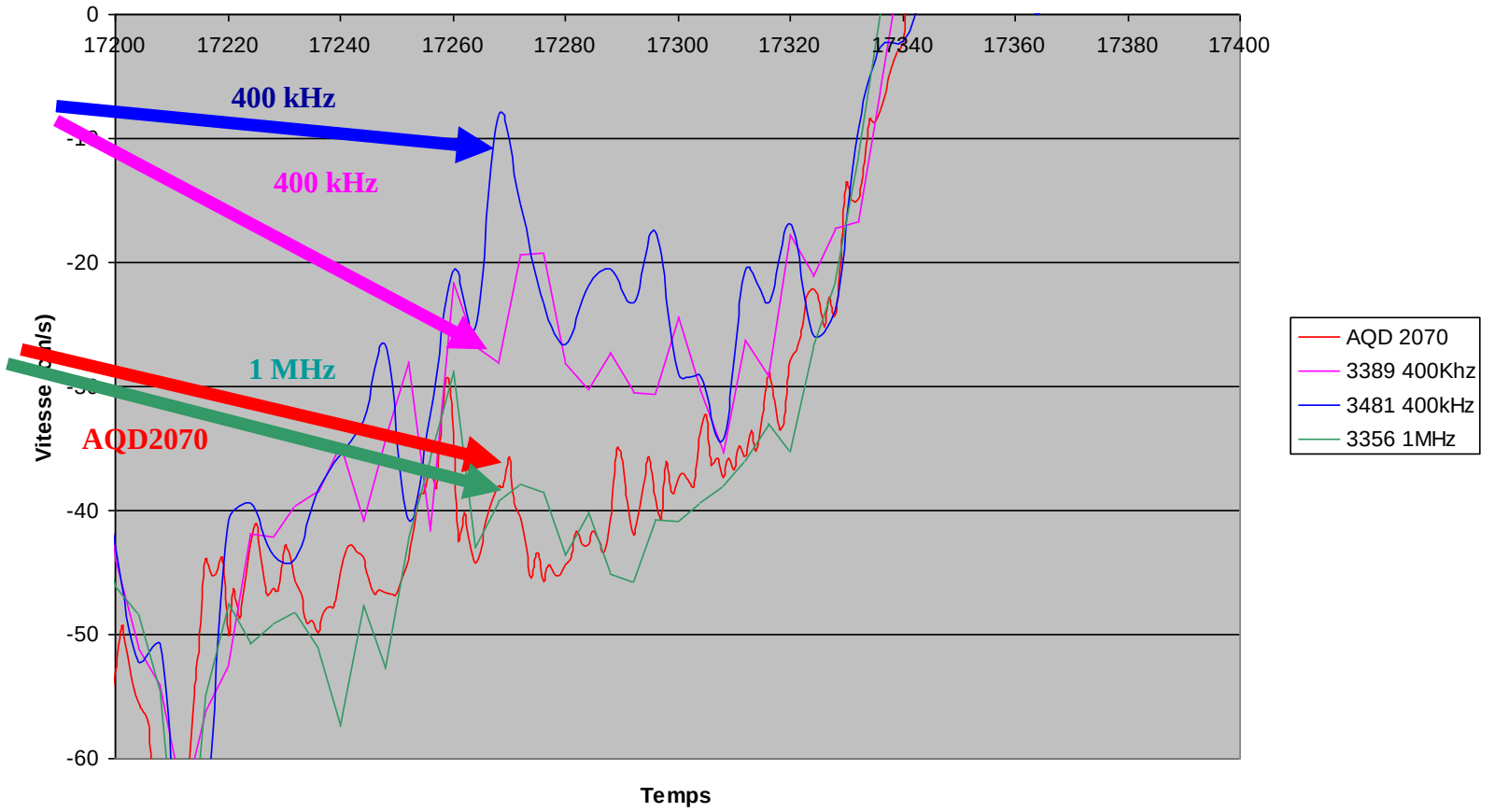
Results : difference in direction N/S and E/O



Results : difference in direction E/W

On composante E/W

AQP 400 kHz values are different of the AQP 1 Mhz and the reference AQD2070 which are similar



Conclusion intercomparison

similar current module

but some differences on the direction current curve between :

- the Aquadopp (reference), the Aquapro 2MHz (reference), the Aquapro 1MHz
- and the Aquapro 400kHz

CONSEQUENCES

We must be careful of the :

- Compass calibration – deployment in X, Y, Z coordinate system
- Pressure sensor to control regularly – minimum one time per year
- Difference of frequency

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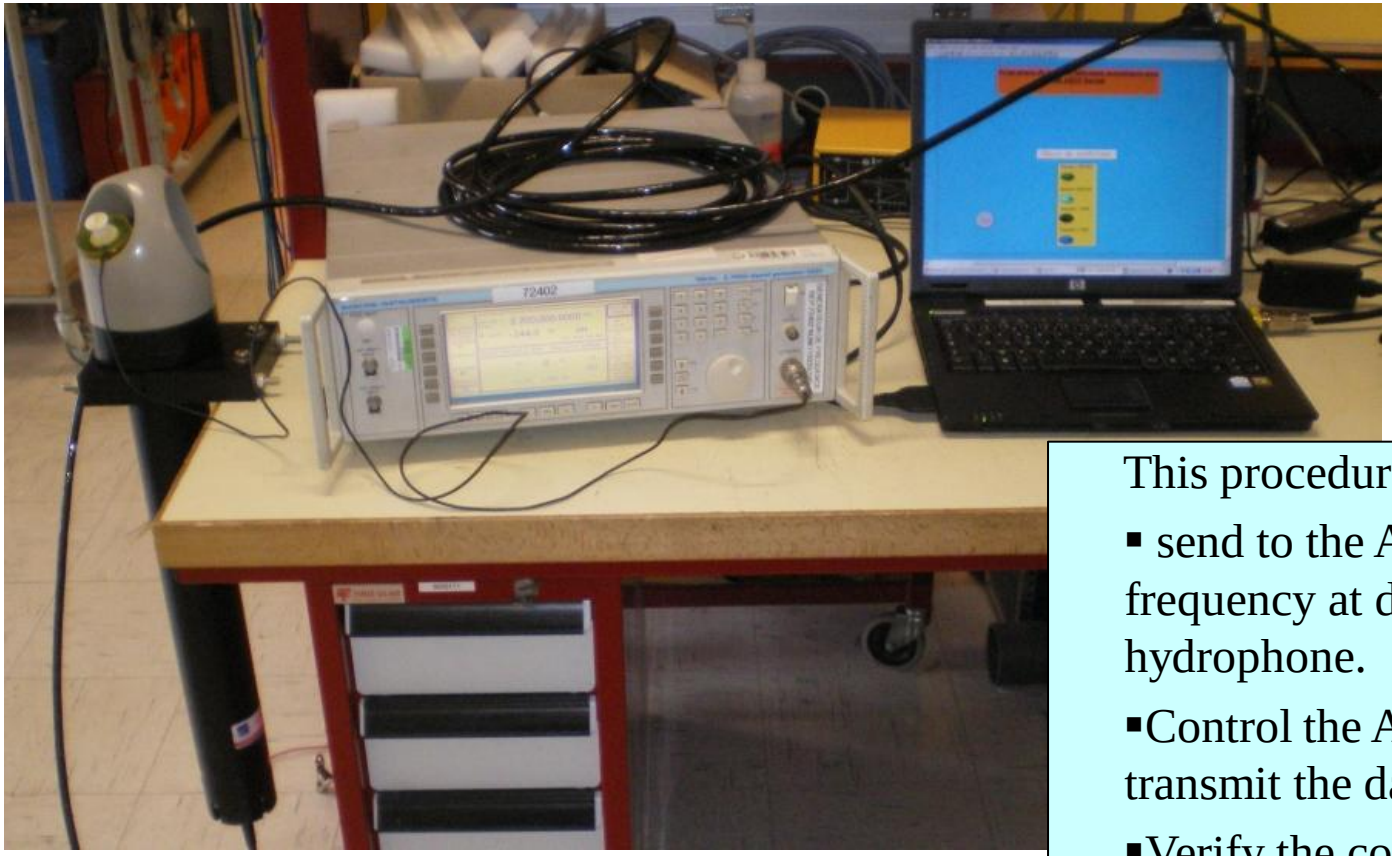
Frequency test

SHOM acquire about 30 profilers (Aquapro, Continental, AWAC) in last three years,

and try to establish some procedures to follow their evolution (Ageing).

One of them is a procedure to control the Aquapro transducers in air by comparing frequency and current velocity data.

Frequency test



This procedure consist in :

- send to the Aquapro a range of frequency at different levels with a hydrophone.
- Control the Aquapro to read and transmit the data one by one,
- Verify the conformity : frequency / speed current

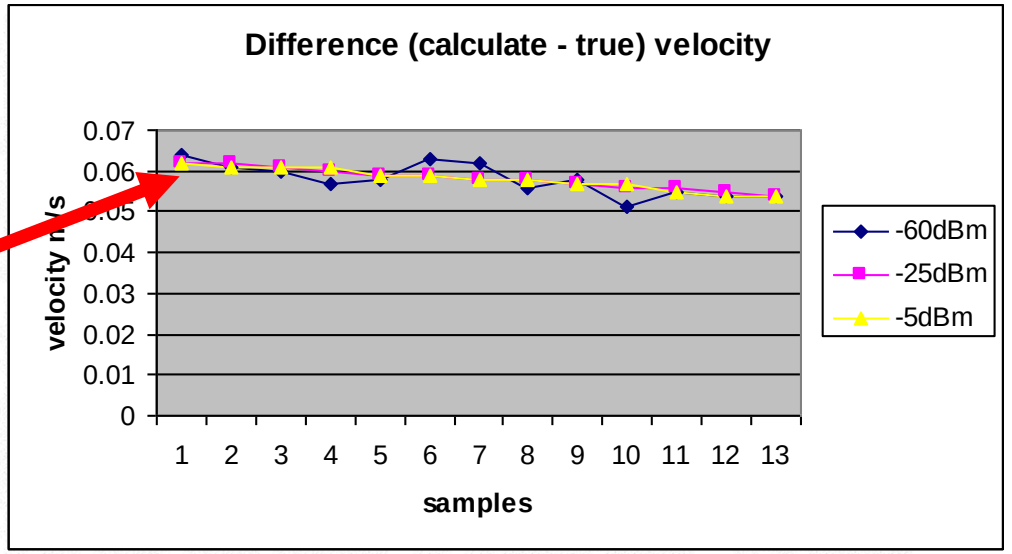
Frequency test

Fichier Edition Format Affichage ?

```
Date : mardi 18 mai 2010
AQP 1 MHz
Transducteur n°1
Temps de mesure : 3000 ms
Pas de mesure : 0.50 m/s
Incrément : 657 Hz
1ère série : -60 dBm
Mesure n°01: 13 03 53 43 54 18 1524.4 15.6  55.8   0.0   0.3   0.482 22.09   3064   -216   -228  81  22  24   996089 996005   84 3.000 0.064
Mesure n°02: 13 03 53 43 54 21 1524.4 15.6  55.3  -0.1   0.1   0.468 22.09   2561   2319   1680  81  23  24   996746 996666   80 2.500 0.061
Mesure n°03: 13 03 53 43 54 24 1524.4 15.6  55.8   0.1   0.1   0.479 22.10   2060   3813  -1185  81  22  24   997403 997324   79 2.000 0.060
Mesure n°04: 13 03 53 43 54 27 1524.4 15.5  55.2   0.0   0.1   0.470 22.10   1557   2371  -1347  81  24  24   998060 997985   75 1.500 0.057
Mesure n°05: 13 03 53 43 54 30 1524.4 15.6  55.0   0.0   0.1   0.476 22.10   1058   3786    616  81  23  23   998717 998641   76 1.000 0.058
Mesure n°06: 13 03 53 43 54 33 1524.4 15.5  55.8   0.0   0.1   0.480 22.10    563    478   -209  81  23  22   999374 999291   83 0.500 0.063
Mesure n°07: 13 03 53 43 54 36 1524.4 15.6  56.0   0.0   0.1   0.469 22.10     62    494    168  81  22  22  1000031 999950   81 0.000 0.062
Mesure n°08: 13 03 53 43 54 39 1524.4 15.6  55.8   0.0   0.1   0.473 22.10   -444   1548   -587  82  23  23  1000688 1000614   74 -0.50 0.056
Mesure n°09: 13 03 53 43 54 42 1524.4 15.6  55.9   0.0   0.2   0.478 22.11   -942   1373   2671  81  22  22  1001345 1001269   76 -1.00 0.058
Mesure n°10: 13 03 53 43 54 45 1524.4 15.6  55.7   0.0   0.2   0.469 22.11  -1449   2461   1336  81  22  23  1002002 1001935   67 -1.50 0.051
Mesure n°11: 13 03 53 43 54 48 1524.4 15.6  56.0   0.1   0.2   0.475 22.11  -1945   2861   3574  81  23  23  1002659 1002587   72 -2.00 0.055
Mesure n°12: 13 03 53 43 54 51 1524.4 15.6  55.8   0.0   0.1   0.479 22.11  -2446   3486    579  81  23  23  1003316 1003245   71 -2.50 0.054
Mesure n°13: 13 03 53 43 54 54 1524.4 15.6  56.6   0.1   0.2   0.472 22.11  -2946   2921    733  81  23  22  1003973 1003902   71 -3.00 0.054
                                                                                .1   0.475
                                                                                .1   0.476
                                                                                .0   0.481
                                                                                .3   0.483
                                                                                .1   0.485
                                                                                .0   0.477
                                                                                .1   0.471
                                                                                .2   0.492
                                                                                .1   0.470
Mesure n°10: 13 03 53 43 56 25 1524.5 15.6  55.8   0.0   0.1   0.480
Mesure n°11: 13 03 53 43 56 28 1524.5 15.6  55.7   0.0   0.2   0.473
Mesure n°12: 13 03 53 43 56 31 1524.5 15.6  56.3   0.0   0.2   0.4
Mesure n°13: 13 03 53 43 56 34 1524.5 15.6  56.1   0.0   0.1   .480
                                                                                0.1   0.484
                                                                                0.2   0.480
                                                                                0.1   0.481
                                                                                0.1   0.472
                                                                                0.1   0.482
                                                                                0.1   0.477
                                                                                0.1   0.489
                                                                                0.1   0.488
                                                                                0.2   0.469
Mesure n°10: 13 03 53 43 58 05 1524.6 15.6  56.0   0.0   0.2   0.479
Mesure n°11: 13 03 53 43 58 08 1524.6 15.5  55.8   0.0   0.2   0.475
Mesure n°12: 13 03 53 43 58 11 1524.6 15.6  55.8   0.0   0.1   0.487
Mesure n°13: 13 03 53 43 58 14 1524.6 15.6  56.3   0.0   0.2   0.475 22.19  -2946  -2947  -2949 204  96  96 1003973 1003902   71 -3.00 0.054
```

Result is a file with Aquapro data

We measure the difference between the theorical velocity and true velocity of aquapro.

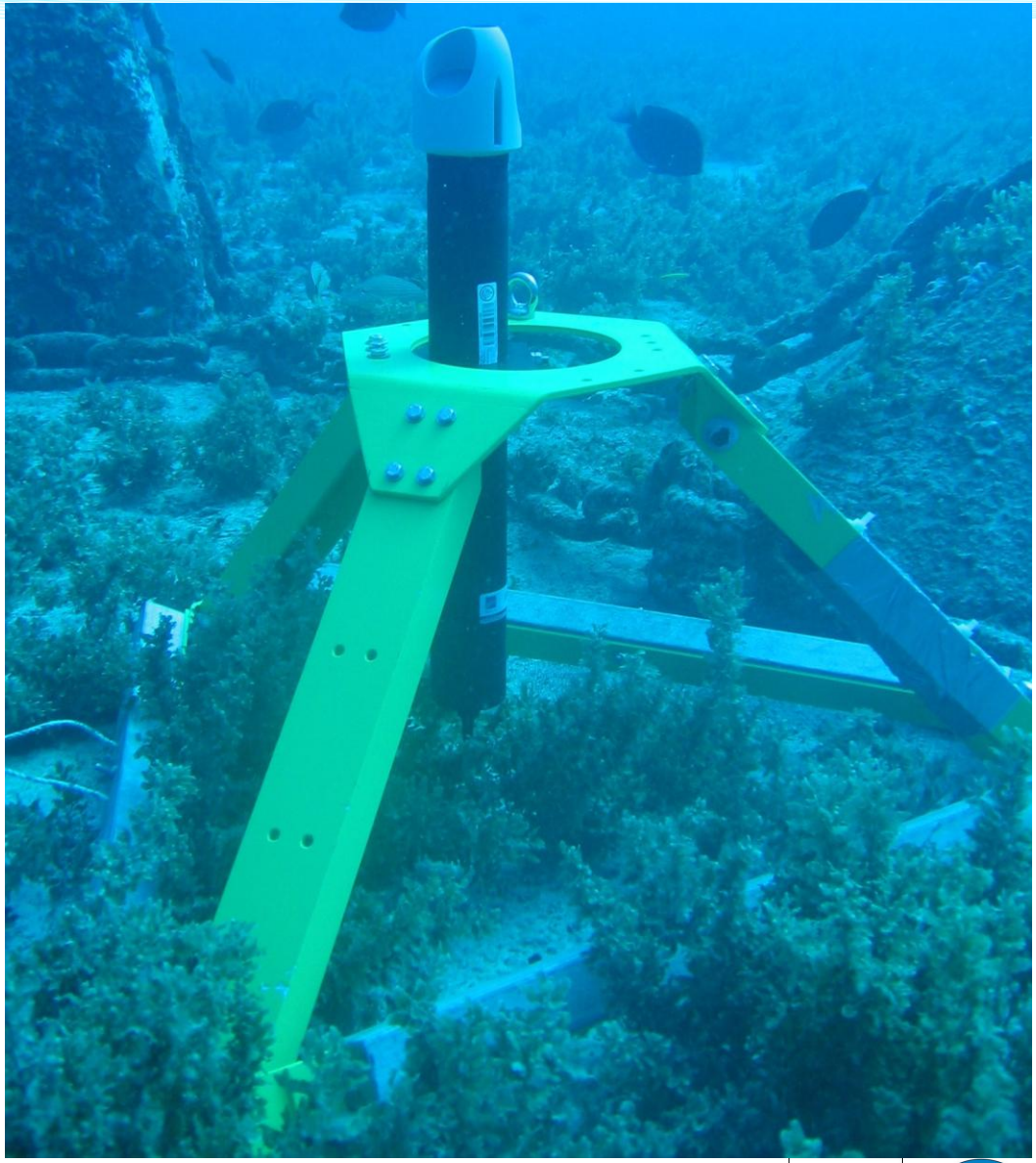


- Mean error of about 6 cm/s.
- Due to real transmit frequency, not absolutly equal to 1 MHz

Conclusion

- Possibility to rattach AQD to a reference and to control AQP
- Compass and pressure controls have to be improved
- Thanks to the Nortek support, particularly NORTEKMED

Thank you!



Any questions?

In French, if possible….