

3rd MEETING OF THE IHO TIDES, WATER LEVEL AND CURRENTS WORKING GROUP



MEASUREMENTS OF STRONG CURRENTS

EXPERIENCES OF CHILE AT THE MAGELLAN STRAIT

Juan Fierro C.

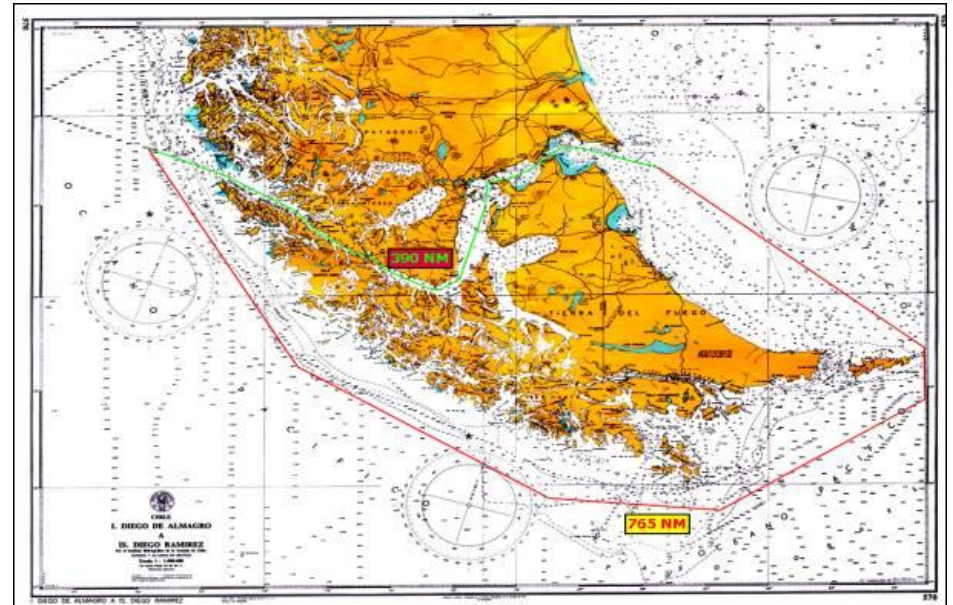
BACKGROUND



BACKGROUND

Location of the Magellan Strait

The Strait of Magellan is the most important natural passage between the Pacific and Atlantic Oceans. It has a length of 390 nm and has excellent conditions for navigation, compared to the Drake Passage, where hurricane winds of more than 60 knots and waves of 10 to 12 meters in height are common.



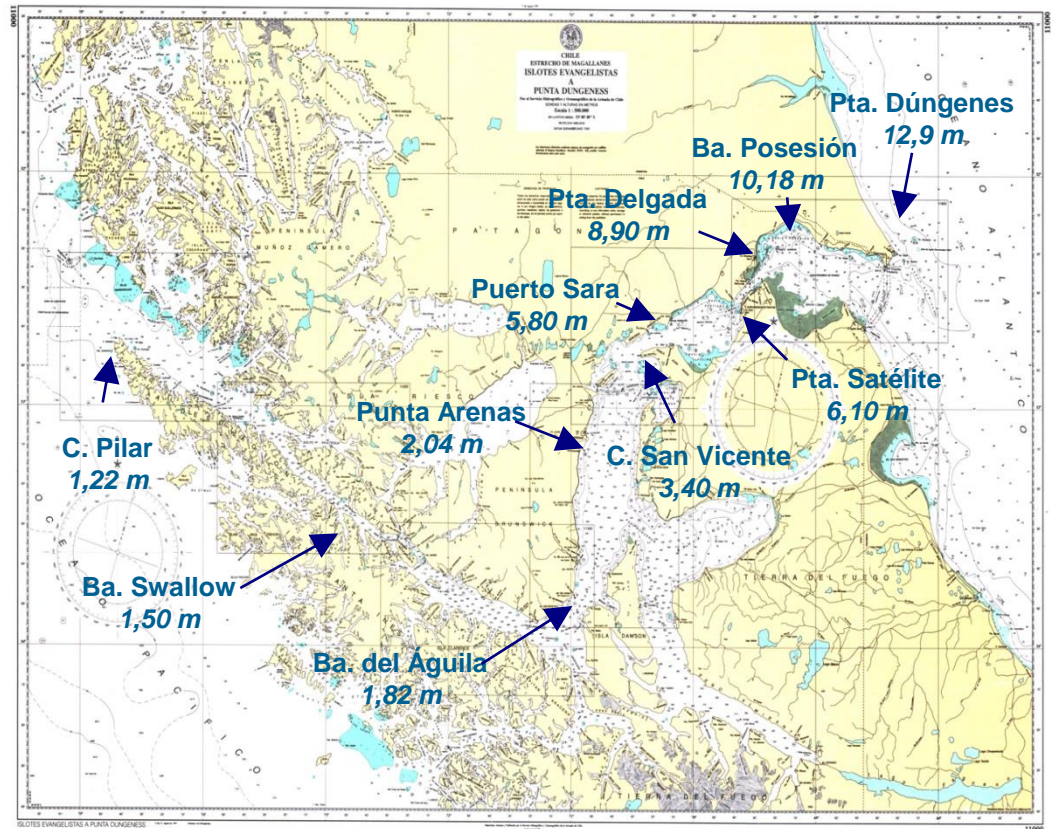
A TANKER NAVIGATING DRAKE PASSAGE



BACKGROUND

Tidal Range

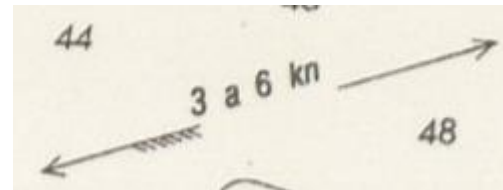
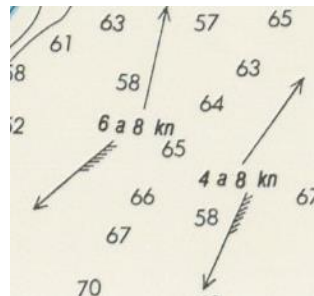
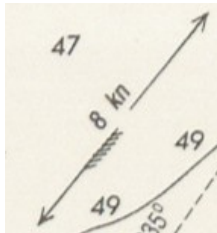
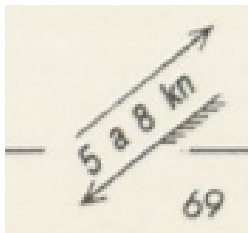
The tidal range varies from 1 m at Cape Pilar to 13 m at Posesion Bay. The greatest attenuation of the tidal wave occurs on the eastern side, where the tidal form number changes from 0.12 to more than 0.25 less than 125 km from the Atlantic (eastern mouth, Second Narrow).



BACKGROUND

Tidal Stream

The tidal currents can exceed 3 m s^{-1} in the narrows. In the First Narrow there is a hydraulic phenomenon that is governed by the difference in the tidal ranges in their mouths and the tidal current can reach up to 5 m s^{-1} .

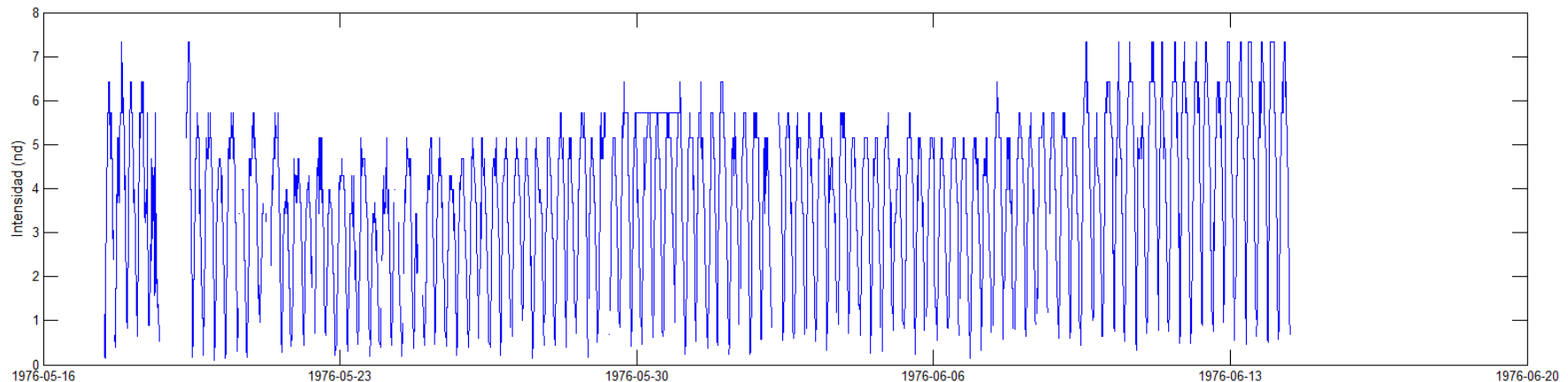


BACKGROUND

First Observed Current Time Series

In 1976, the first data of surface currents were obtained by using a Plessey current meter. A time span of 28 days was recorded at the Second Narrow and 12 days in First Narrow. The data analysis indicated that Second Narrow possessed more intense currents than first one.

Intensidad/ nudos	Sicigias		Cuadratura	
	Flujo	Reflujo	Flujo	Reflujo
1a Angostura	5.8	5.8	3.0	3.0
2a Angostura	6.0	6.0	4.0	3.7



BACKGROUND

Through relationships between the current registered at the narrows and the Punta Delgada tide, a daily forecast of currents was designed for both locations, which was published at the Tide Tables for 38 years (1979 - 2017). In 1999 some relations were modified.

		Primera Angostura	Segunda Angostura
FLUJO	EAF	P – 01:32	P – 00:40
	HMF	P + 01:48	P + 02:06
	IMF	$(\frac{Rango\ marea}{5,82}) * 4,20$	$(\frac{Rango\ marea}{5,94}) * 5,40$
	Dirección	200° V	218° V
REFLUJO	EAR	B – 02:28	B – 01:40
	HMR	B + 00:30	B + 01:41
	IMR	$(\frac{Rango\ marea}{5,82}) * 4,70$	$(\frac{Rango\ marea}{5,94}) * 5,70$
	Dirección	029° V	038° V

PRIMERA ANGOSTURA, ESTRECHO DE MAGALLANES, 2017

Lat. 52° 34' 30" S
Long. 69° 40' 00" W

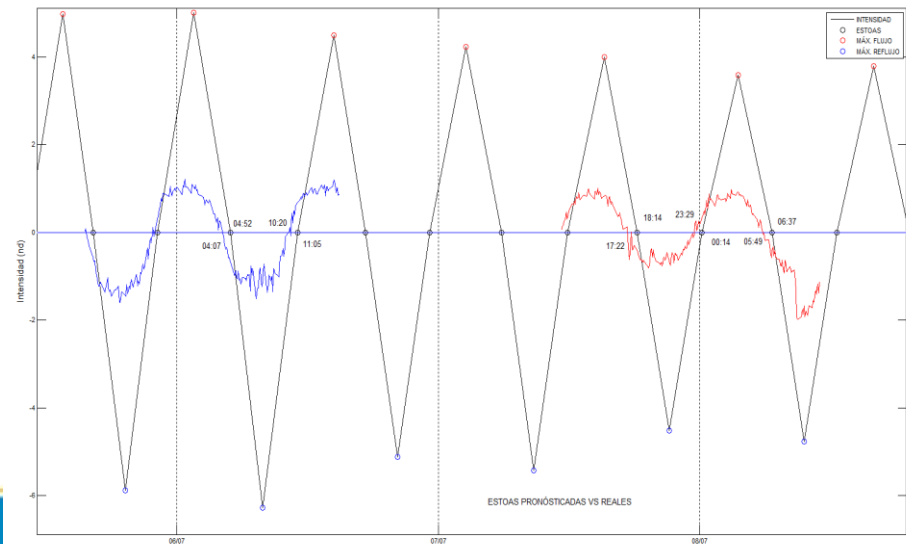
[illegible]

F = FLUJO, DIREC. 200° V., R = REFLUJO, DIREC. 029° V.
EL TIEMPO EMPLEADO CORRESPONDE AL MERIDIANO 60° W, UTC -4.
ESTACIÓN PATRÓN DE CORRIENTE DE MAREA. PROVENIENTE DE PUB. SHOA Nº 3009

BACKGROUND

Another information

- A bad experience: In 2006, SHOA deployed two ADCPs with an MTRBM system in First and Second Narrows.
- Delay confirmed: Recent observations carried on by private companies in geographical coordinates near the coast, confirm the time delay in the daily current predictions.



DESIGN



DESIGN

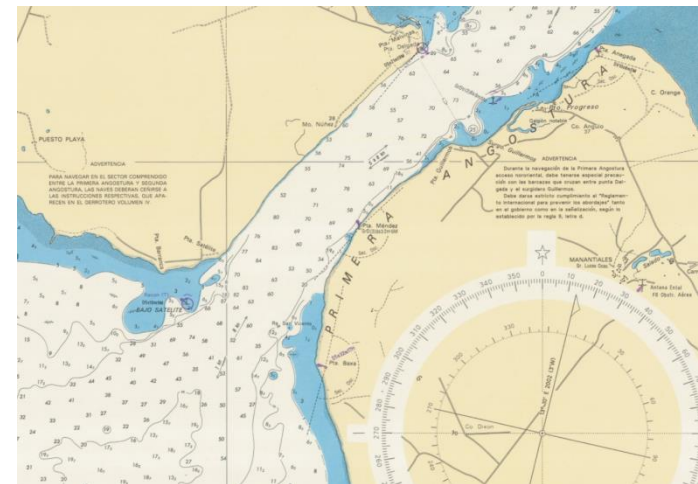
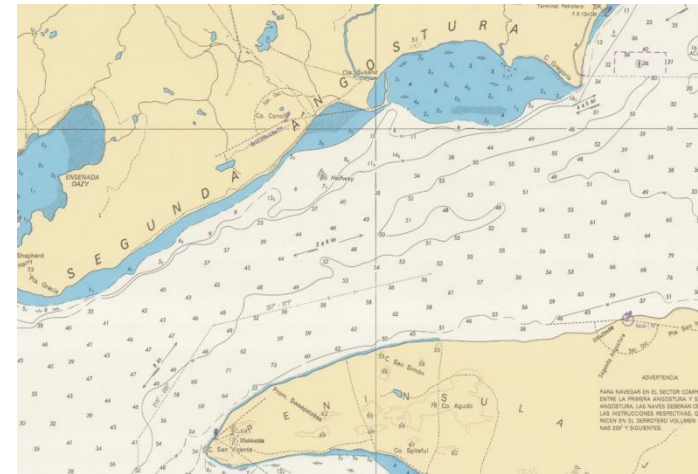
Collecting accuracy current time series

Aspects to consider:

- Strong currents (surface and bottom)
- Traffic of vessels

What is required?

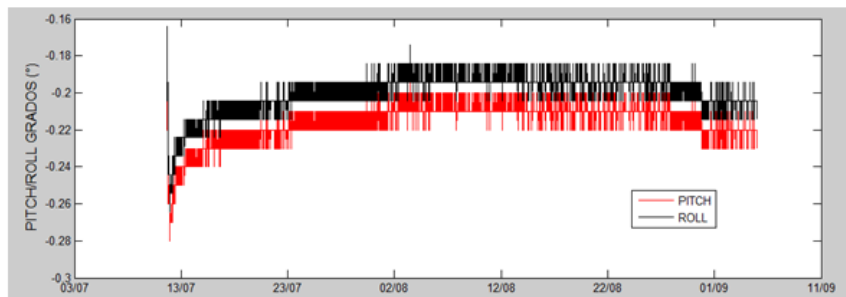
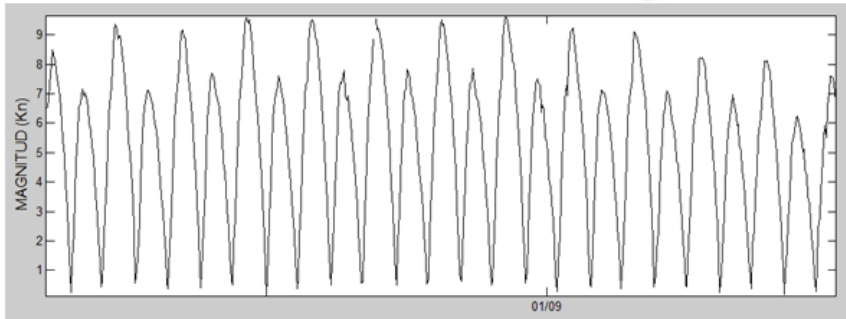
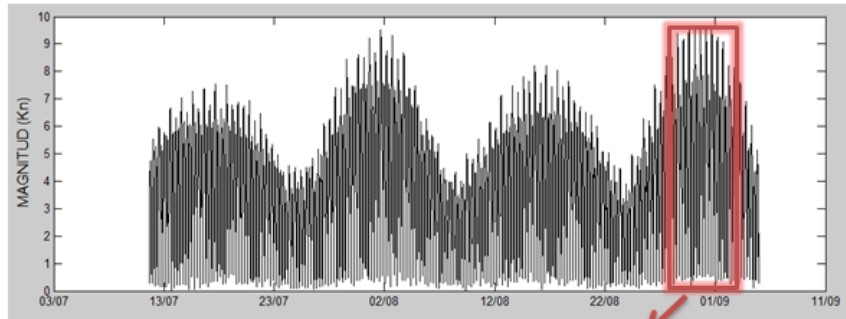
- stability of the platform
- Resistant to strong currents (operating at least 45 days)
- ADCP upward-looking configuration under the track of navigation
- ADCP Mooring: type trawl (seabed) or in a mooring line (near the bottom)
- Feasibility of deployment and recovery



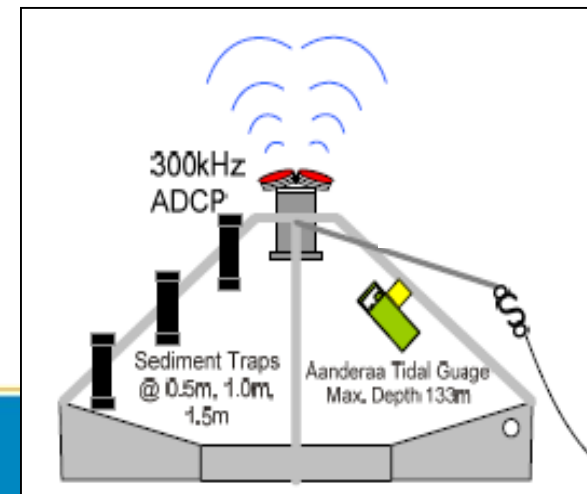
DESIGN

Previous experiences (private company)

- Chacao channel, Chile
- Fixed platform 28 m depth
- 1000 kg anchor
- Current 10 knots
- Maximum pitch / roll 0.3°

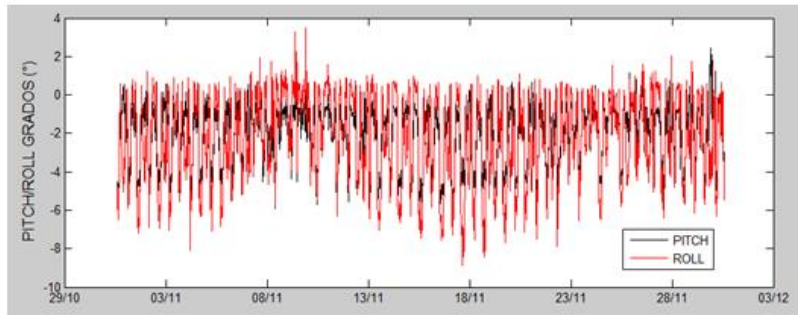
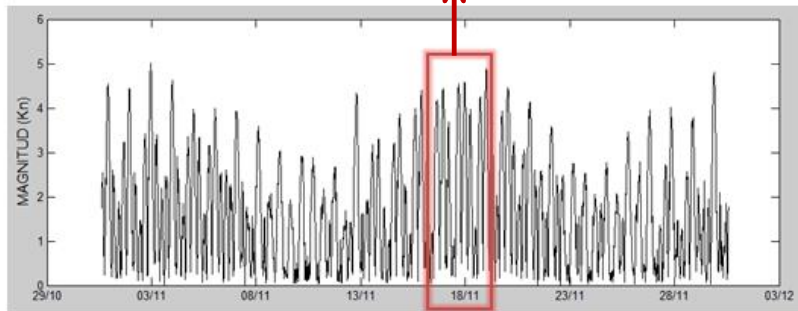
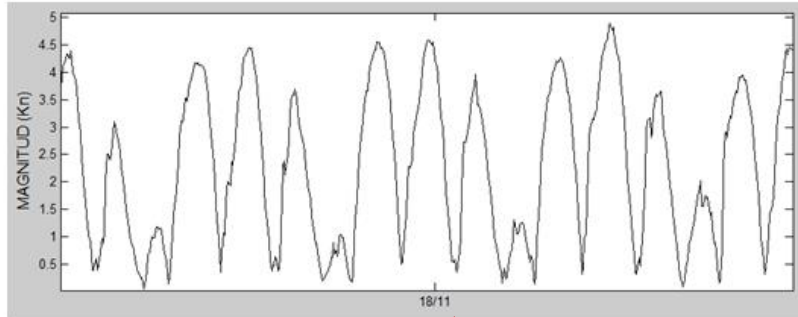


Note: Same scheme of mooring was used in Minas basin, Canada (depth 70 m, anchor 700 kg)



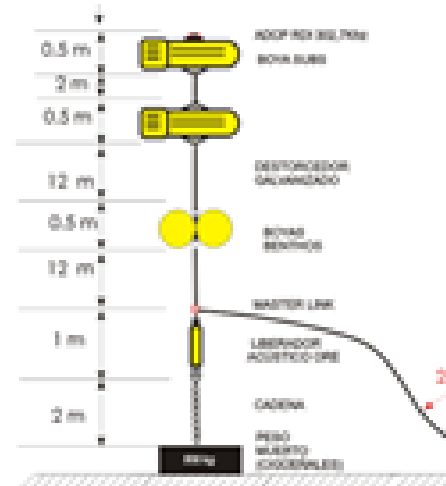
DESIGN

Previous experiences (SHOA)



- Ingles pass, Magellan Strait, Chile.
- SHOA.
- Buoyant platform (Subs). 50 m depth.
- 500 kg anchor .
- Current 5 knots.
- Maximum pitch / roll 8.0° .

Note: Same scheme of mooring was used in Minas basin, Canada (depth 35 m, anchor 400 kg)

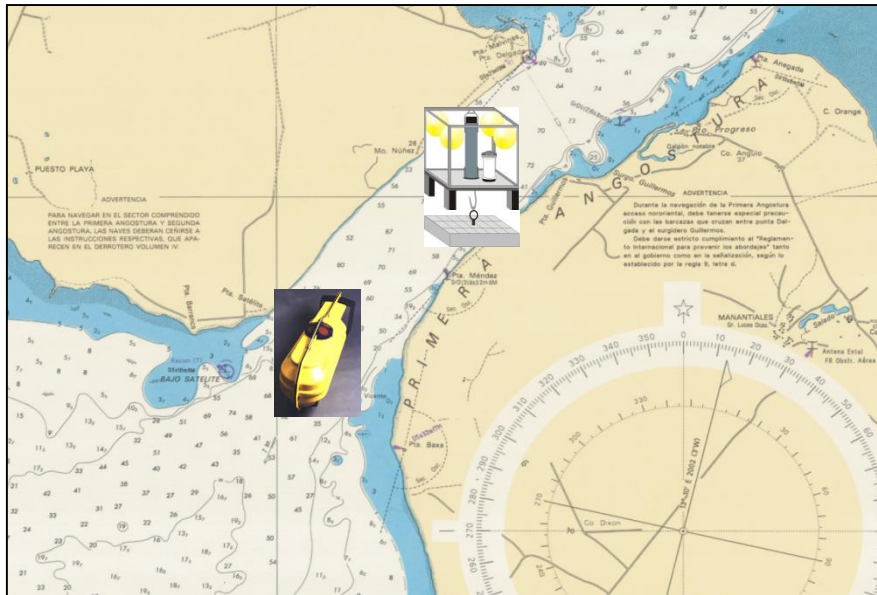


ANCHORING



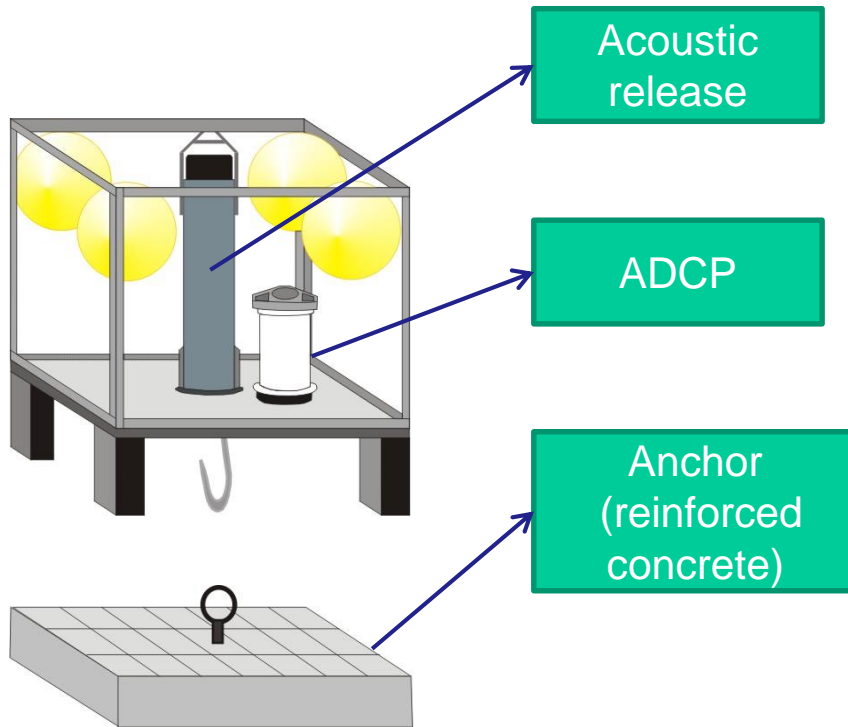
ANCHORING

- Two anchorages were installed at the First Narrow and another one in the Second Narrow.
- Buoyant platform (Subs) and fixed. 70 m - First Narrow.
- Bottom type: sand, gravel.
- Expected current 10 knots.
- Anchor 700 effective kg in water (reinforced concrete).
- Winds and sea level were also registered.



ANCHORING

Seabed mooring



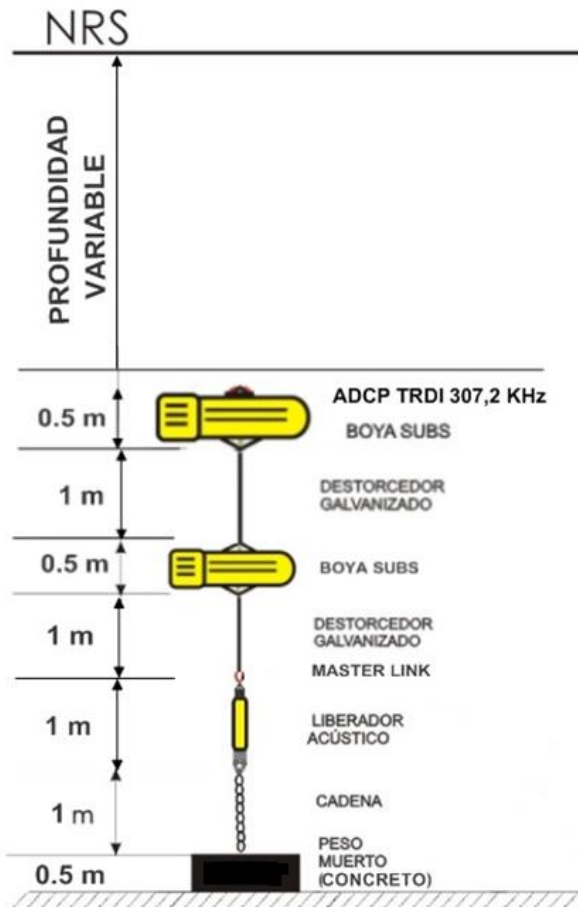
- DART II buoyancy experience (SHOA).
- 70 m depth.



ANCHORING

Line mooring

- SHOA experience.
- 40 and 70 m depth.

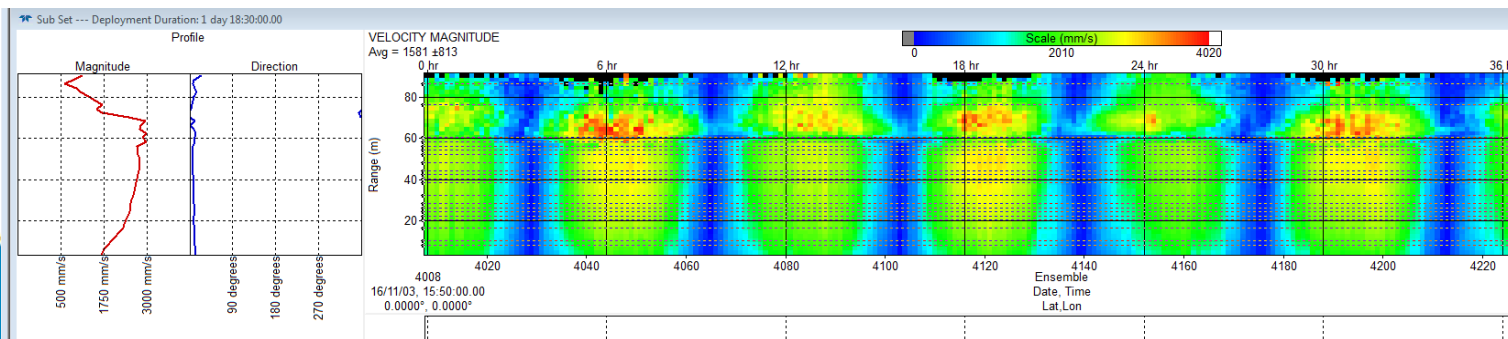
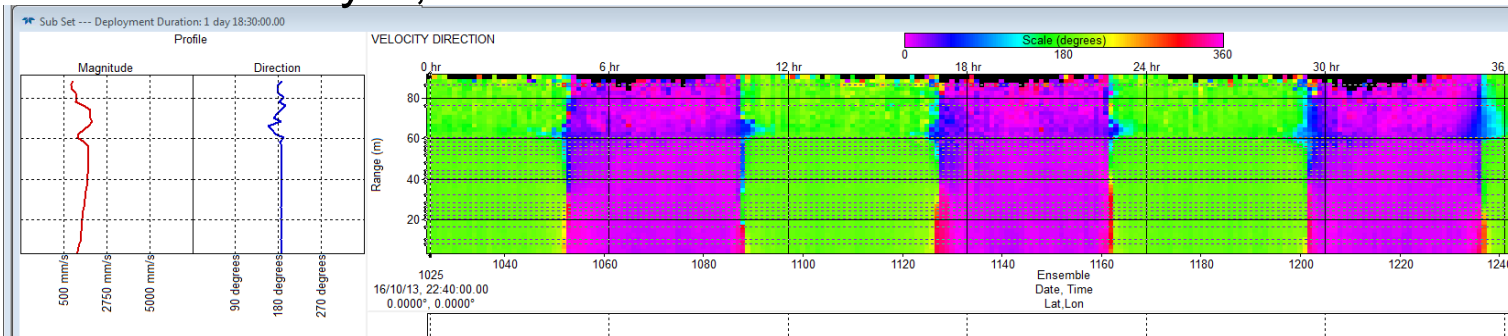
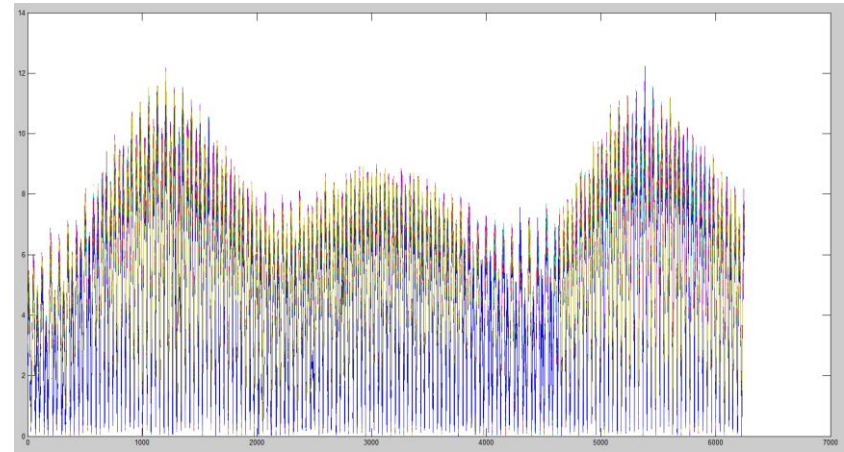


RESULTS



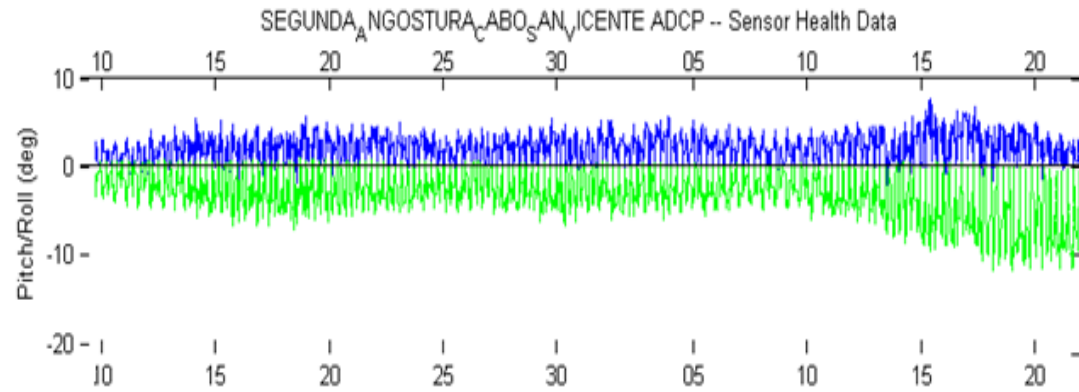
RESULTS

- 40 days were recorded in First Narrow and 43 days in Second Narrow.
- Measurements included three springs periods, once with Moon in perigee.
- Maximum intensity recorded surface layer, 12 knots.

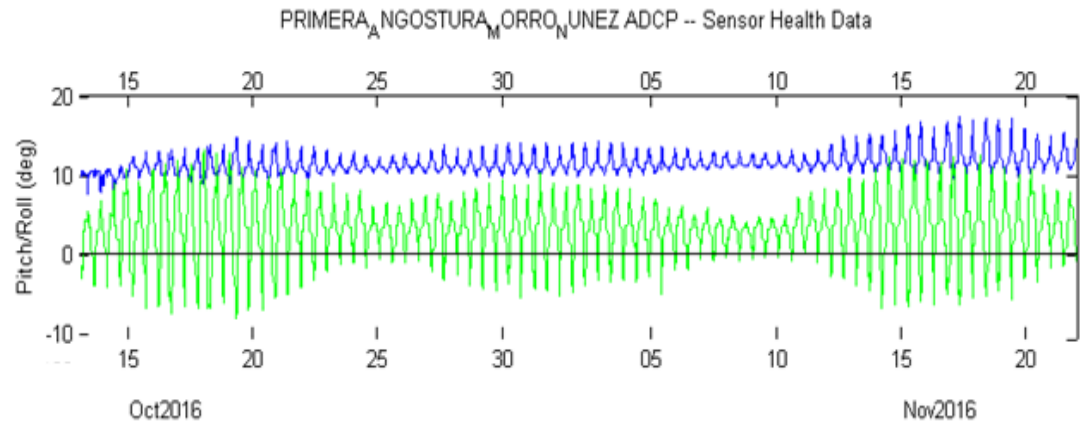


RESULTS

- Platforms were stable, with maximum pitch / roll range of 12° .



Buoyant platform (Subs)

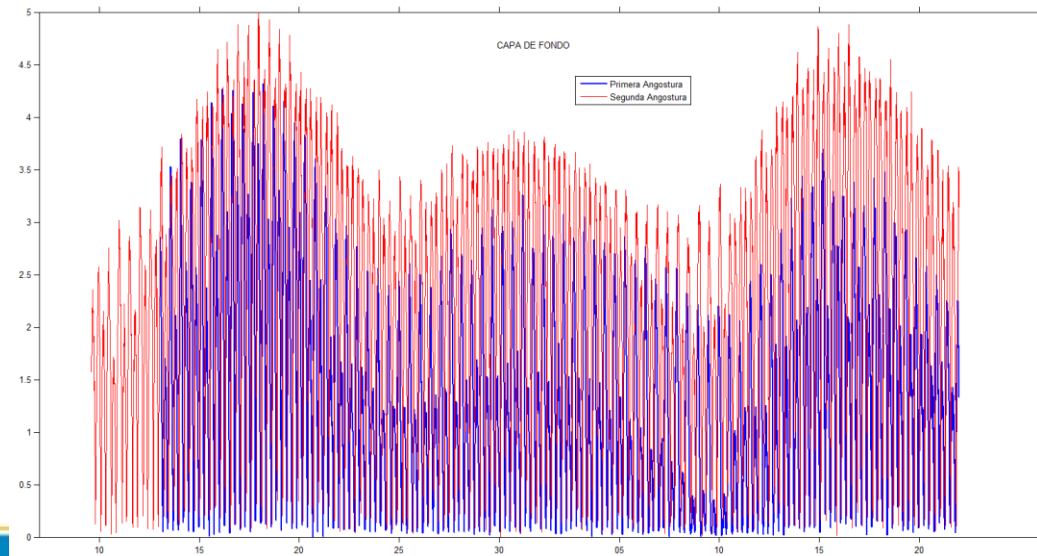
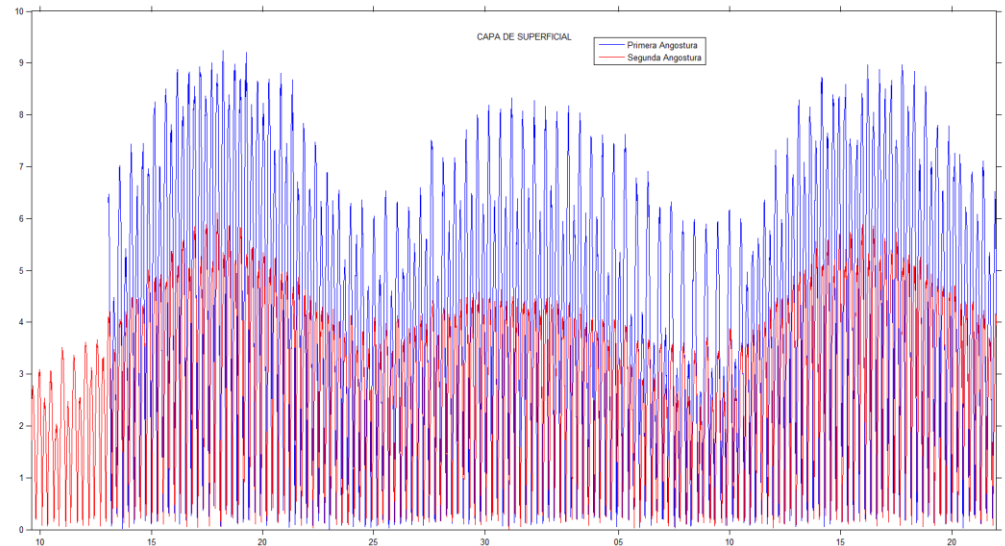


Fixed platform



RESULTS

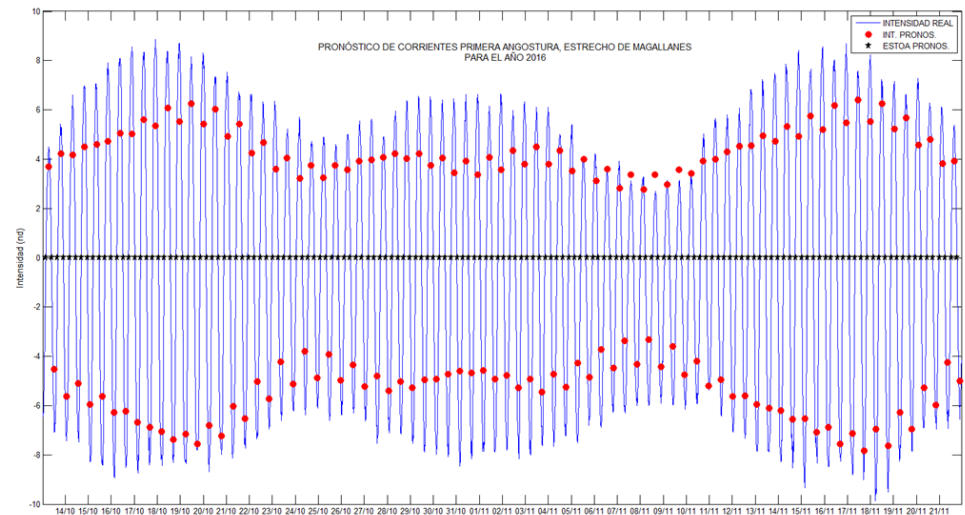
- In upper layers, First Narrow show greater intensity than Second Narrow.
- In the bottom, Second Narrow is relatively more intense and current reaches 5 knots of intensity.



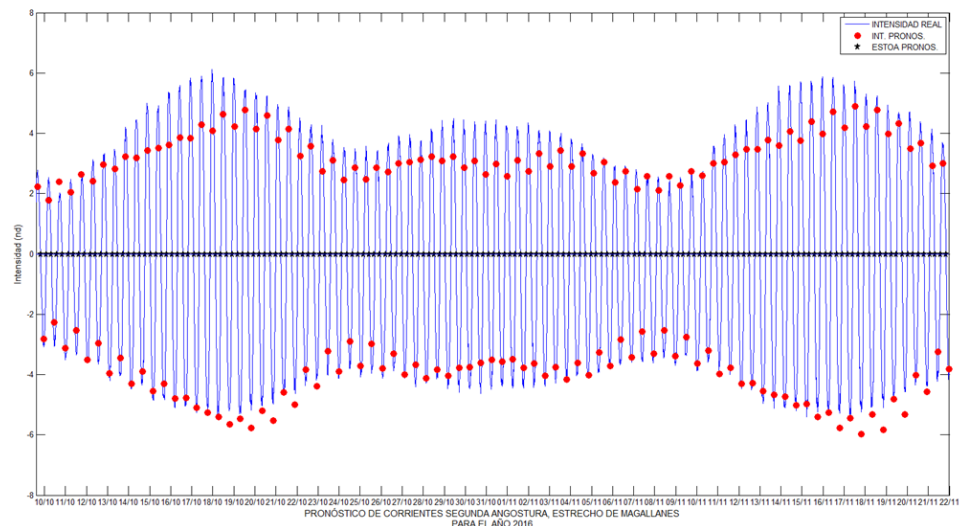
RESULTS

- Data recorded in both places were of greater magnitude than current forecast.
- In neap period, current recorded at First Narrow was 4 knots greater than predictions.
- Second Narrow presented minor differences.

PRIMERA ANGOSTURA

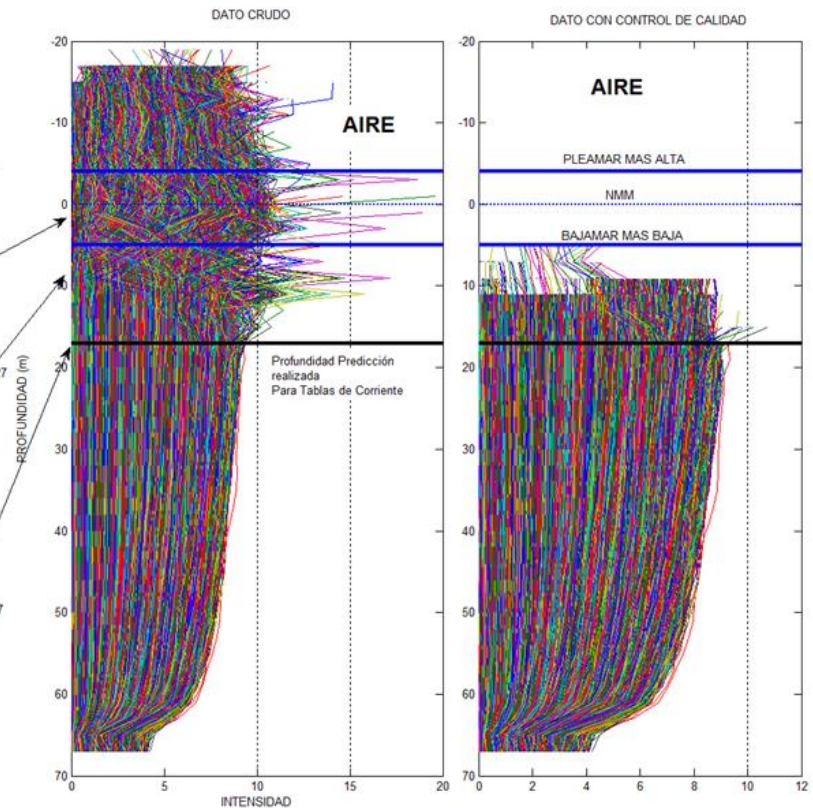
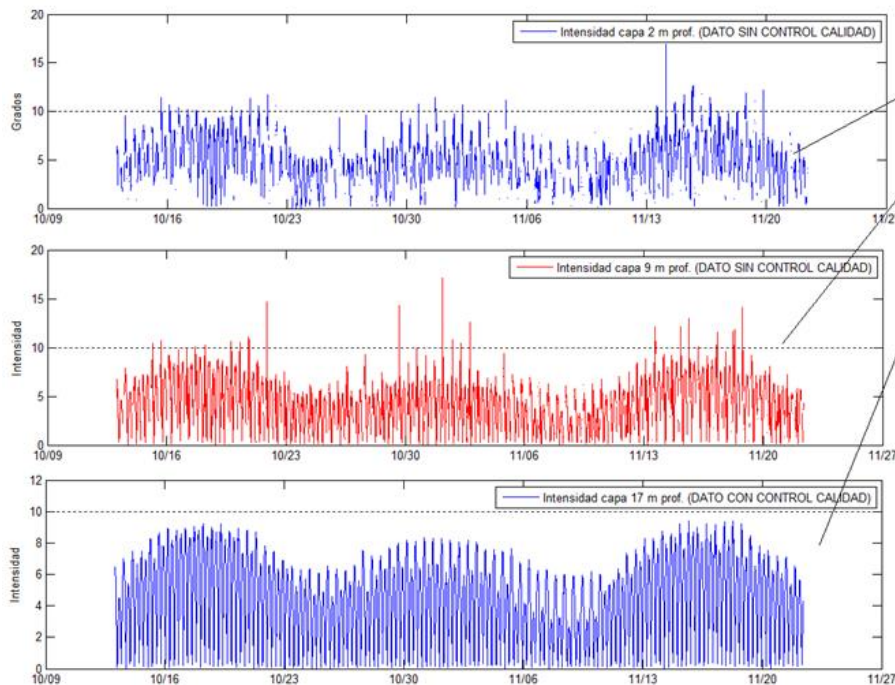


SEGUNDA ANGOSTURA



RESULTS

- Quality control and cell selection for new tidal stream predictions. Data collected at the First Narrow are shown.



RESULTS

- New predictions of First and Second Narrow, by harmonic methodology.
- New predictions were included in tidal current tables version 2018.

PRIMERA ANGOSTURA, ESTRECHO DE MAGALLANES, 2018

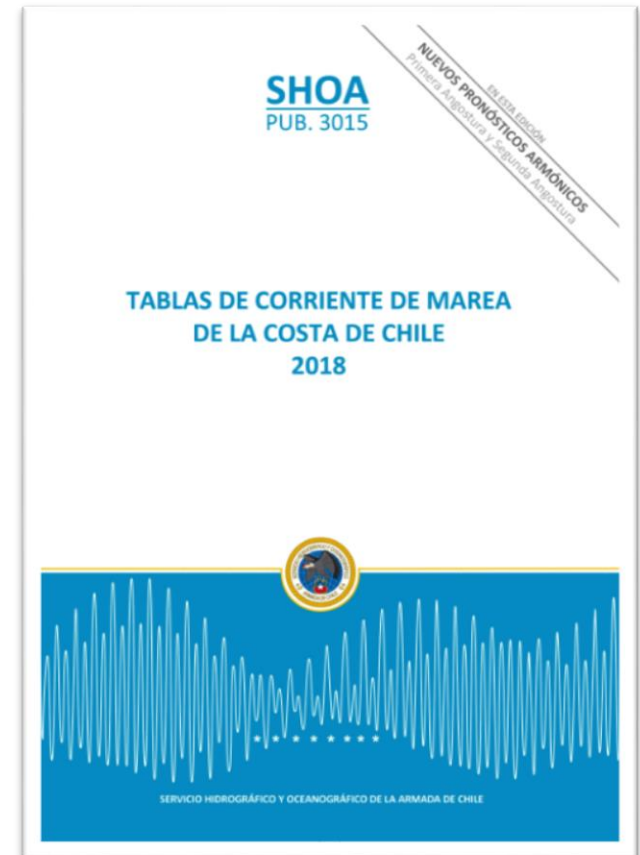
PREDICCIONES DIARIAS DE CORRIENTES

Lat. 52° 29' 44" S
Long. 69° 34' 33" W

ENERO

FEBRERO

ESTOA			CORRIENTE			ESTOA			CORRIENTE			ESTOA			CORRIENTE			ESTOA			CORRIENTE			ESTOA			CORRIENTE		
MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA			MÁXIMA		
DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS	DIA	H.M.	H.M. NUDOS
01	0003	0324 7.9R	11		0032 5.9R	21		0025 5.5F	01	0133	0449 9.0R	11		0154 6.2R	21		0114 5.4F	01	0133	0449 9.0R	11		0154 6.2R	21		0114 5.4F	01	0133	0449 9.0R
LU	0609	0933 6.8F	JU	0350	0652 4.2F	DO	0313	0633 8.0R	JU	0725	1100 8.2F	DO	0511	0757 3.6F	MI	0418	0740 7.8R	LU	0609	0933 6.8F	JU	0350	0652 4.2F	DO	0313	0633 8.0R	JU	0725	1100 8.2F
	1230	1548 7.9R		0941	1300 6.1R		0940	1248 5.2F		1357	1709 9.0R		1038	1405 5.8R		1043	1334 5.5F		1230	1548 7.9R		0941	1300 6.1R		0940	1248 5.2F		1357	1709 9.0R
	1822	2155 7.6F		1616	1926 4.3F		1536	1858 7.8R		1944	2321 8.8F		1706	1959 4.0F		1648	2010 7.8R		1822	2155 7.6F		1616	1926 4.3F		1536	1858 7.8R		1944	2321 8.8F
				2209			2201						2253			2317													
02	0054	0414 8.5R	12		0134 6.3R	22		0103 5.0F	02	0218	0533 9.3R	12		0233 6.4R	22		0212 4.6F	02	0218	0533 9.3R	12		0233 6.4R	22		0212 4.6F	02	0218	0533 9.3R
MA	0653	1022 7.5F	VI	0449	0754 4.5F	LU	0353	0715 7.7R	VI	0810	1144 8.4F	LU	0543	0826 3.8F	JU	0509	0835 7.0R	MA	0653	1022 7.5F	VI	0449	0754 4.5F	LU	0353	0715 7.7R	VI	0810	1144 8.4F
	1320	1635 8.5R		1037	1355 6.4R		1025	1326 4.7F		1442	1754 9.1R		1113	1439 6.0R		1138	1440 4.8F		1320	1635 8.5R		1037	1355 6.4R		1025	1326 4.7F		1442	1754 9.1R
	1908	2244 8.3F		1703	2015 4.7F		1618	1944 7.5R		2031			1734	2027 4.5F		1746	2108 7.0R		1908	2244 8.3F		1703	2015 4.7F		1618	1944 7.5R		2031	
				2258			2250						2326																
03	0143	0501 9.0R	13		0224 6.8R	23		0150 4.4F	03		0006 8.8F	13		0304 6.6R	23		0307 3.8F	03		0006 8.8F	13		0304 6.6R	23		0307 3.8F	03		0006 8.8F
MI	0738	1110 8.0F	SA	0533	0838 4.7F	MA	0438	0804 7.1R	SA	0304	0618 9.1R	MA	0607	0852 4.3F	VI	0612	0942 6.1R	MI	0738	1110 8.0F	SA	0533	0838 4.7F	MA	0438	0804 7.1R	SA	0304	0618 9.1R
	1408	1722 8.9R		1120	1439 6.7R		1115	1417 4.3F		0858	1229 8.2F		1145	1508 6.4R		1243	1613 4.3F		1408	1722 8.9R		1120	1439 6.7R		1115	1417 4.3F		0858	1229 8.2F
	1956	2332 8.6F		1736	2050 5.0F		1708	2035 7.1R		1528	1841 8.8R		1801	2058 5.0F		1855	2220 6.2R		1956	2332 8.6F		1736	2050 5.0F		1708	2035 7.1R		1528	1841 8.8R
				2336			2346			2122			2357																
04	0231	0547 9.2R	14		0305 7.1R	24		0256 3.9F	04		0054 8.2F	14		0330 6.9R	24		0136 0502 3.5F	04		0054 8.2F	14		0330 6.9R	24		0136 0502 3.5F	04		0054 8.2F
JU	0826	1157 8.2F	DO	0607	0909 4.9F	MI	0531	0901 6.5R	DO	0351	0706 8.5R	MI	0629	0921 4.9F	SA	0730	1100 5.6R	JU	0826	1157 8.2F	DO	0607	0909 4.9F	MI	0531	0901 6.5R	DO	0351	0706 8.5R
	1456	1809 9.0R		1154	1514 6.9R		1212	1528 4.0F		0950	1318 7.5F		1216	1536 6.9R		1359	1735 4.3F		1456	1809 9.0R		1154	1514 6.9R		1212	1528 4.0F		0950	1318 7.5F
	2046			1803	2115 5.4F		1807	2134 6.5R		1618	1932 8.1R		1830	2132 5.5F		2017	2343 5.9R		2046			1803	2115 5.4F		1807	2134 6.5R		1618	1932 8.1R
										2219																			
05		0021 8.6F	15	0008	0337 7.7R	25	0052	0411 3.5F	05		0146 7.2F	15	0029	0355 7.4R	25	0258	0619 3.9F	05		0146 7.2F	15	0029	0355 7.4R	25	0258	0619 3.9F	05		0146 7.2F
VI	0320	0634 9.0R	LU	0634	0934 5.2F	JU	0633	1007 6.0R	VI	0442	0759 7.7R	JU	0654	0954 5.5F	DO	0859	1222 5.7R	VI	0320	0634 9.0R	LU	0634	0934 5.2F	JU	0633	1007 6.0R	VI	0442	0759 7.7R
	0916	1247 7.9F		1223	1543 7.1R		1315	1643 3.9F		1049	1413 6.4F		1249	1607 7.5R		1518	1849 4.9F		0916	1247 7.9F		1223	1543 7.1R		1315	1643 3.9F		1049	1413 6.4F
	1545	1859 8.7R		1830	2139 5.9F		1916	2243 6.1R		1712	2029 7.2R		1901	2208 5.9F		2139													
	2140									2324																			



THANKS

