PERÚ Ministerio de la Producción

IMARPE
INSTITUTO DEL MAR DEL PERÚ

Lima, Peru | May 18 - 22, 2026

Jack Mackerel Benchmark Workshop (SCW16)

SPRFMO
South Pacific Regional Fisheries Management Organisation

Use of acoustic data collected by fishing vessels for estimating the abundance/biomass of anchovy and Chilean jack Mackerel in Peru

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INTRODUCTION

Acoustic data collected by industry fishing vessels has been systematically used in Peru since 2008 for estimating the abundance/biomass of anchovy, Jack mackerel and mackerel.

All data was collected using Simrad ES60/70/80 sounders operating at a single frequency (120 Khz) Split beam.

Sounders were calibrated following ICES standards.

CSV files were created by exporting from Echoview data from cells, regions and regions by cells by species.

It was assumed that this data is “unbiased” due to fish migration, fish avoidance, wrong detection etc.

It was used a Elementary Sampling Distance Unit (ESDU) of 1.0 n.mi. NASC values were measured for every ESDU.

It was used a stratification of NASC values (zeroes included) in square areas of 6 by 6 and 15 by 15 minutes of latitude and longitude (so that in a complete degree there are 10 x 10 or 4 x 4 squares).

Then it has been calculated the mean NASC (m2/n.mi.2) of fish in every square.

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Portapapeles | Fuente | Alineación | Número | Estilos | Celdas | Edición | Complementos | Adobe Acro...

AN2

```
=UNIRCADENAS(;;UNIRCADENAS(;;TEXTO(((ABS(ENTERO(AL2+1))));0);SI((-(ABS(ENTERO(AL2+1))+AL2))>0.75;"75";SI(-(ABS(ENTERO(AL2+1))+AL2)>0.5;"50";SI((-(ABS(ENTERO(AL2+1))+
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	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
1	Ping_E	Ping_M	Dist_S	Dist_E	Dist_M	VL_start	VL_end	VL_mid	Week	Date_S	Time_S	Date_E	Time_E	Date_M	Time_M	Lat_S	Lon_S	Lat_E	Lon_E	Lat_M	Lon_M	CODE	Exclude_bel	Program_ver	Processing_v	Processing_
2	9417	4708	0	0.999438	0.129975	13745.989	13746.895	13746.065	8	20260102	04:36:34.94	20260102	05:09:05.78	20260102	04:52:47.95	-9.114482	-78.57249	-9.116763	-78.58669	-9.11546	-78.57246	9007850	46.542945	15.1.75.0	3	20260127
3	10883	10150	1.000193	1.99935	1.493402	13746.896	13747.89	13747.387	8	20260102	05:09:05.99	20260102	05:14:17.26	20260102	05:11:40.21	-9.116764	-78.5867	-9.119151	-78.60335	-9.117973	-78.59491	9007850	7.599503	15.1.75.0	3	20260127
4	12223	11553	2.000058	2.999659	2.483803	13747.89	13748.884	13748.37	8	20260102	05:14:17.48	20260102	05:19:24.01	20260102	05:16:46.15	-9.119152	-78.60336	-9.121489	-78.61994	-9.120822	-78.61131	9007850	17.031562	15.1.75.0	3	20260127
5	13486	12855	3.000103	3.999599	3.498358	13748.885	13749.878	13749.381	8	20260102	05:19:24.26	20260102	05:24:30.60	20260102	05:21:56.97	-9.121488	-78.61994	-9.116463	-78.63535	-9.120571	-78.62828	9007850	25.586224	15.1.75.0	3	20260127
6	14742	14114	4.00048	4.999473	4.500016	13749.879	13750.872	13750.375	8	20260102	05:24:30.84	20260102	05:29:34.98	20260102	05:27:03.09	-9.116454	-78.63536	-9.108045	-78.64978	-9.111671	-78.64224	9007850	25.303084	15.1.75.0	3	20260127
7	16013	15378	5.000021	5.99993	5.501917	13750.872	13751.865	13751.371	8	20260102	05:29:35.22	20260102	05:34:39.45	20260102	05:32:07.97	-9.10804	-78.64979	-9.09902	-78.66391	-9.103267	-78.65671	9007850	23.870475	15.1.75.0	3	20260127
8	17296	16655	6.000827	6.999226	6.500628	13751.866	13752.858	13752.363	8	20260102	05:34:39.70	20260102	05:39:43.37	20260102	05:37:11.80	-9.099012	-78.66392	-9.088609	-78.677	-9.094272	-78.67085	9007850	22.320921	15.1.75.0	3	20260127
9	18577	17937	7.000023	7.99987	7.500374	13752.859	13753.852	13753.356	8	20260102	05:39:43.61	20260102	05:44:44.53	20260102	05:42:14.31	-9.088601	-78.67701	-9.077123	-78.68926	-9.082877	-78.68316	9007850	20.956507	15.1.75.0	3	20260127
10	19876	19227	8.000758	8.999829	8.500846	13753.853	13754.849	13754.353	8	20260102	05:44:44.77	20260102	05:49:49.02	20260102	05:47:17.00	-9.077113	-78.68927	-9.06569	-78.70154	-9.071403	-78.69542	9007850	20.386692	15.1.75.0	3	20260127
11	21171	20524	9.000586	9.999551	9.498699	13754.85	13755.844	13755.346	8	20260102	05:49:49.25	20260102	05:54:50.75	20260102	05:52:20.07	-9.065682	-78.70155	-9.054265	-78.71382	-9.060022	-78.7077	9007850	19.769086	15.1.75.0	3	20260127
12	22471	21821	10.000433	10.999983	10.503929	13755.844	13756.84	13756.345	8	20260102	05:54:50.98	20260102	05:59:52.60	20260102	05:57:21.85	-9.054253	-78.71383	-9.042626	-78.72591	-9.048349	-78.71987	9007850	19.166336	15.1.75.0	3	20260127
13	23771	23121	11.000861	11.999874	11.498422	13756.84	13757.833	13757.335	8	20260102	05:59:52.83	20260102	06:04:54.71	20260102	06:02:23.52	-9.042616	-78.72592	-9.031012	-78.73802	-9.036822	-78.73193	9007850	19.531306	15.1.75.0	3	20260127
14	25058	24415	12.000765	12.999224	12.498734	13757.833	13758.827	13758.33	8	20260102	06:04:54.94	20260102	06:09:56.50	20260102	06:07:25.39	-9.031003	-78.73803	-9.019107	-78.74982	-9.025078	-78.74392	9007850	20.388599	15.1.75.0	3	20260127
15	26330	25694	13.000017	13.999414	13.496634	13758.827	13759.821	13759.32	8	20260102	06:09:56.73	20260102	06:14:58.88	20260102	06:12:26.84	-9.019098	-78.74983	-9.007022	-78.76145	-9.013121	-78.75563	9007875	21.928768	15.1.75.0	3	20260127
16	27562	26946	14.000334	14.99912	14.492968	13759.821	13760.814	13760.312	8	20260102	06:14:59.13	20260102	06:20:01.53	20260102	06:17:28.76	-9.00701	-78.76146	-8.994445	-78.77251	-9.000805	-78.76691	9007875	27.91232	15.1.75.0	3	20260127
17	28744	28153	15.000062	15.999744	15.492927	13760.814	13761.808	13761.304	8	20260102	06:20:01.78	20260102	06:25:04.42	20260102	06:22:31.32	-8.994433	-78.77252	-8.981853	-78.78359	-8.988215	-78.77796	8757875	34.709422	15.1.75.0	3	20260127
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20	32033	31502	18.000726	18.999011	18.496285	13763.798	13764.791	13764.291	8	20260102	06:35:10.03	20260102	06:40:11.74	20260102	06:37:39.95	-8.956692	-78.80575	-8.944165	-78.81684	-8.950447	-78.81122	8757875	52.307675	15.1.75.0	3	20260127
21	33080	32557	19.000115	19.999087	19.497308	13764.791	13765.786	13765.287	8	20260102	06:40:12.03	20260102	06:45:14.77	20260102	06:42:42.76	-8.944152	-78.81685	-8.931743	-78.8281	-8.937978	-78.82245	8757875	55.809395	15.1.75.0	3	20260127
22	2486	1243	0	0.999721	0.563849	0	0	0	8	20260102	06:45:11.10	20260102	06:51:53.70	20260102	06:48:32.24	-7.551566	-79.65482	-7.546242	-79.64214	-7.548904	-79.64848	7507950	39.488061	15.1.69.0	3	20260202
23	34110	33595	20.000187	20.998919	20.498307	13765.787	13766.782	13766.283	8	20260102	06:45:15.07	20260102	06:50:17.50	20260102	06:47:45.52	-8.931729	-78.82811	-8.919306	-78.83934	-8.925543	-78.83372	8757875	59.30213	15.1.75.0	3	20260127
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26	36141	35636	22.000006	22.999711	22.49908	13767.779	13768.773	13768.275	8	20260102	06:55:20.48	20260102	07:00:22.99	20260102	06:57:51.28	-8.906838	-78.85058	-8.894315	-78.86173	-8.900565	-78.85612	8757875	63.070806	15.1.75.0	3	20260127
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29	38145	37644	24.000346	24.999229	24.497912	13769.768	13770.764	13770.265	8	20260102	07:05:25.17	20260102	07:10:27.96	20260102	07:07:56.17	-8.881808	-78.87292	-8.869265	-78.88403	-8.875548	-78.87844	8757875	63.78866	15.1.75.0	3	20260127
30	11441	10286	3.000137	3.999455	3.474881	0	0	0	8	20260102	07:09:57.24	20260102	07:16:07.85	20260102	07:13:02.95	-7.559629	-79.65526	-7.56848	-79.66711	-7.561561	-79.66235	7507950	41.043237	15.1.69.0	3	20260202
31	39142	38644	25.000261	25.999818	25.500873	13770.765	13771.761	13771.264	8	20260102	07:10:28.26	20260102	07:15:30.58	20260102	07:12:59.25	-8.869252	-78.88404	-8.856727	-78.89518	-8.862982	-78.88962	8757875	63.78866	15.1.75.0	3	20260127
32	40136	39639	26.000819	26.999471	26.498146	13771.762	13772.756	13772.257	8	20260102	07:15:30.88	20260102	07:20:32.91	20260102	07:18:01.59	-8.856714	-78.89519	-8.844053	-78.90614	-8.850469	-78.90071	8757875	63.156519	15.1.75.0	3	20260127
33	13665	12553	4.000007	4.999422	4.498463	0	0	0	8	20260102	07:16:08.02	20260102	07:22:03.81	20260102	07:19:06.01	-7.568489	-79.66711	-7.583695	-79.6611	-7.576632	-79.6654	7507950	41.860234	15.1.69.0	3	20260202
34	41131	40634	27.000514	27.999651	27.500049	13772.757	13773.751	13773.253	8	20260102	07:20:33.22	20260102	07:25:35.76	20260102	07:23:04.45	-8.844039	-78.90615	-8.831378	-78.91713	-8.837687	-78.91161	8757875	61.270368	15.1.75.0	3	20260127
35	15993	14829	5.000023	5.999694	5.525583	0	0	0	8	20260102	07:22:03.97	20260102	07:28:17.19	20260102	07:25:09.74	-7.583704	-79.66109	-7.579927	-79.64613	-7.582331	-79.6536	7507950	42.471703	15.1.69.0	3	20260202
36	42127	41629	28.00072	28.999663	28.499764	13773.752	13774.747	13774.249	8	20260102	07:25:36.06	20260102	07:30:38.86	20260102	07:28:07.30	-8.831365	-78.91714	-8.818728	-78.92813	-8.825036	-78.92261	8757875	59.348047	15.1.75.0	3	20260127
37	18152	17073	6.000293	6.999883	6.499803	0	0	0	8	20260102	07:28:17.35	20260102	07:34:01.24	20260102	07:31:09.60	-7.579925	-79.64612	-7.58885	-79.63374	-7.584074	-79.63958	7507950	44.102654	15.1.69.0	3	20260202
38	43127	42627	29.000787	29.999484	29.499625	13774.748	13775.744	13775.245	8	20260102	07:30:39.16	20260102	07:35:43.21	20260102	07:33:10.92	-8.818713	-78.92814	-8.806107	-78.93917	-8.812407	-78.93364	8757875	56.707449	15.1.75.0	3	20260127

Tabla | Calas | K anc | Biomasa | Data

Activar Windows
Ve a Configuración para activar Windows.

Listo | Accesibilidad: es necesario investigar | 75%

Buscar | 24°C Nublado | ESP | 12:46 16/05/2026

Coding of every NASC values in the "cells" and "regions by cells" datasets; example:

Latitude: -11.213456 Longitude: -77.368712
Code: 112 + 773 = 112773

Used equations:

TS = 20 * log L – 66; dB (Peña 2008, for Jack mackerel)
TS = 30 * log L – 89; dB (Simmonds et al. 2009 for anchovy)
$\sigma = 4 * \pi * 10^{TS/10}$; m2
$Wi = a * L^b/1'000,000$ Ton ; L: fish size (cm); a and b from literature
a = 0.02341
b = 2.94

Bi :Biomass per square (ton)
$Bi = NASC_i / \sigma_{ij-1} * w_{ij} * A_i * \cos(Lat_i) * P_{ij}$
B: Total biomass
$B = \Sigma B_i$

A_i : Area of every square "i" (n.mi.2) , 6 x 6 or 15 x 15 n.mi.
Lat_i: mean Latitude of every square
P_{ij}: corresponding fraction per square "i" and "j" fish size Interval (1 cm) being 1.0 the sum of all P_{ij}

The available data include fish length data by sets, also oceanographic data.

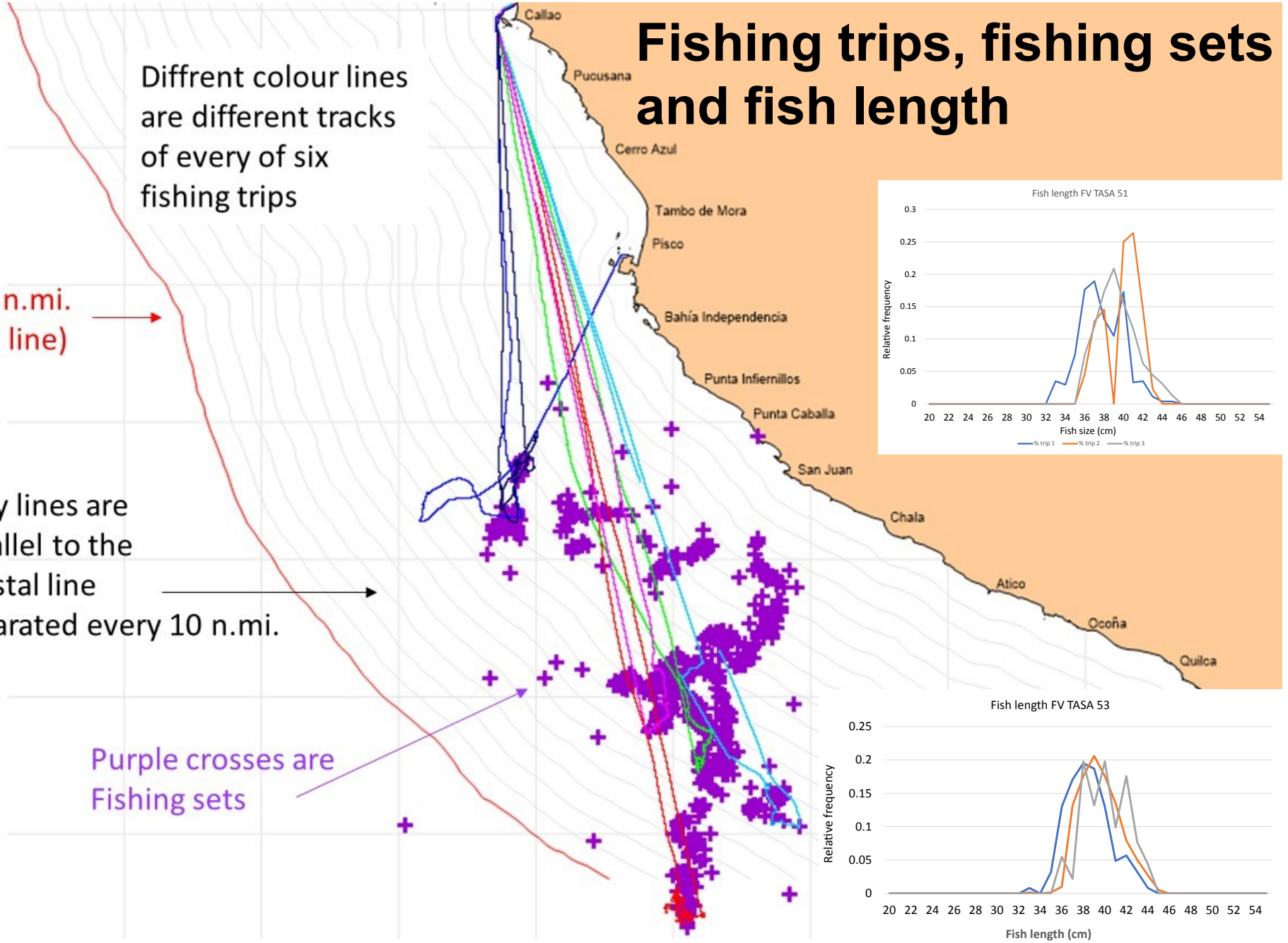
Fishing trips, fishing sets and fish length

Diffrent colour lines are different tracks of every of six fishing trips

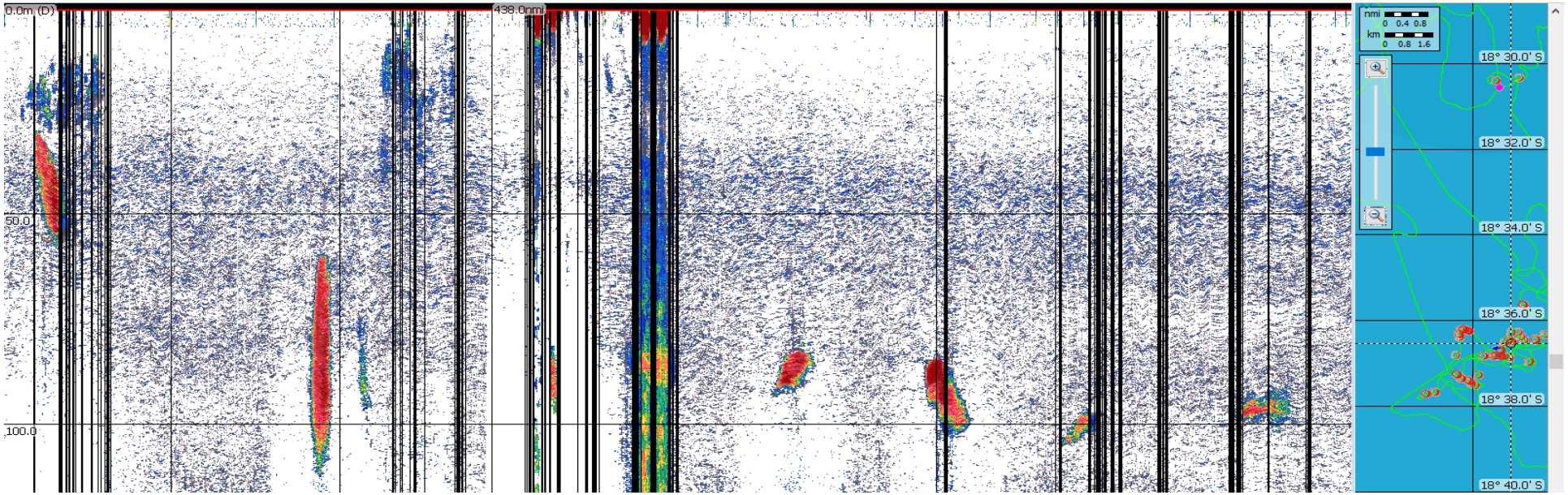
200 n.mi. (red line)

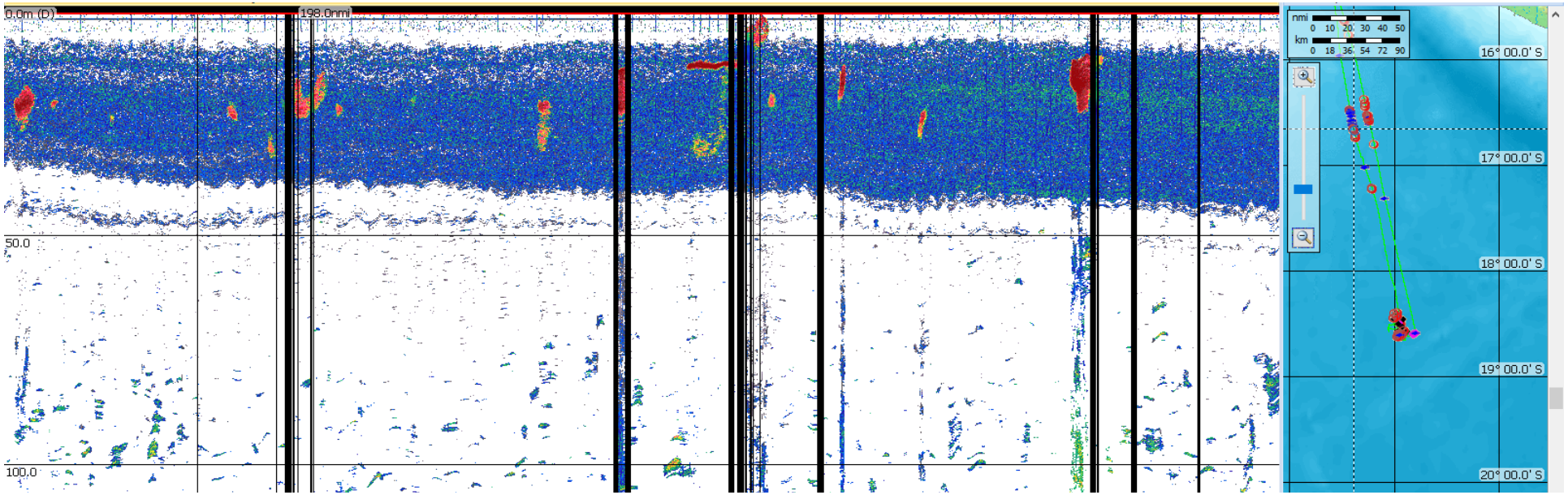
Grey lines are parallel to the coastal line separated every 10 n.mi.

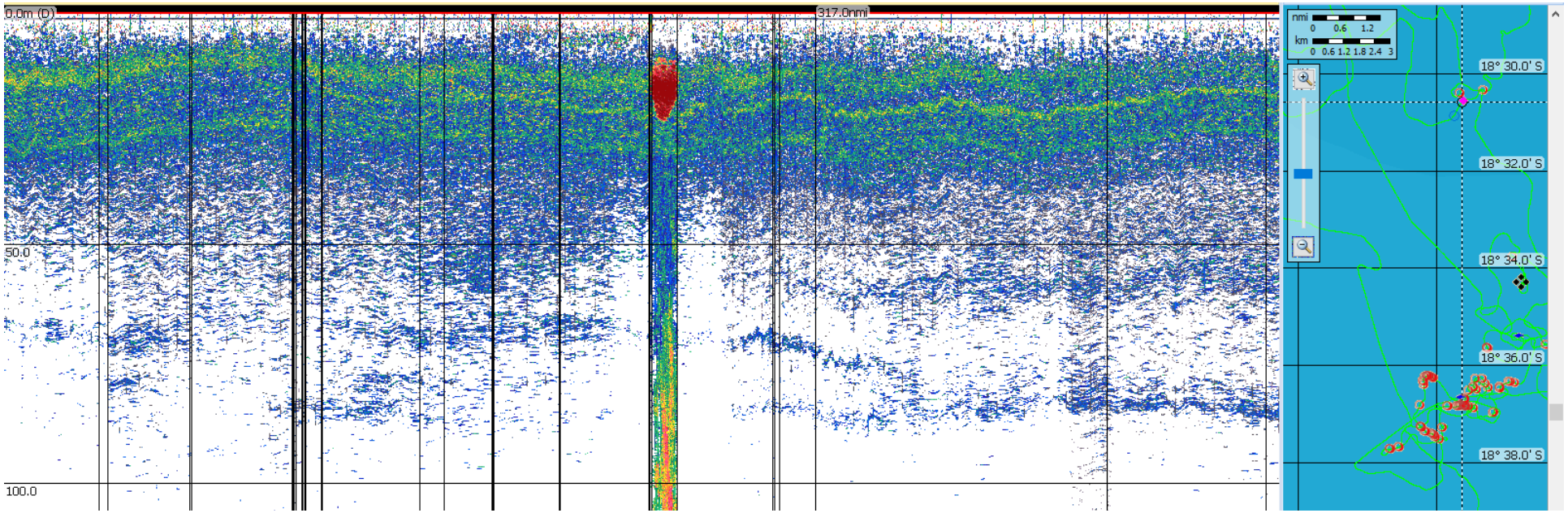
Purple crosses are Fishing sets

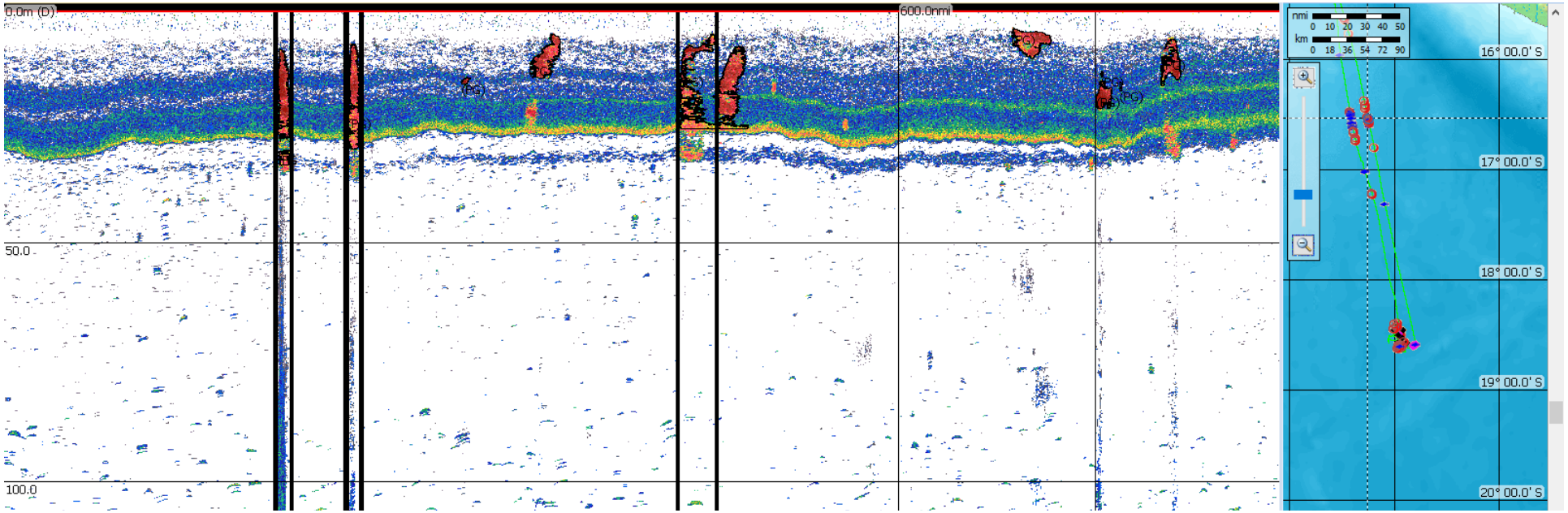


Sample echograms (Echoview 12.1)

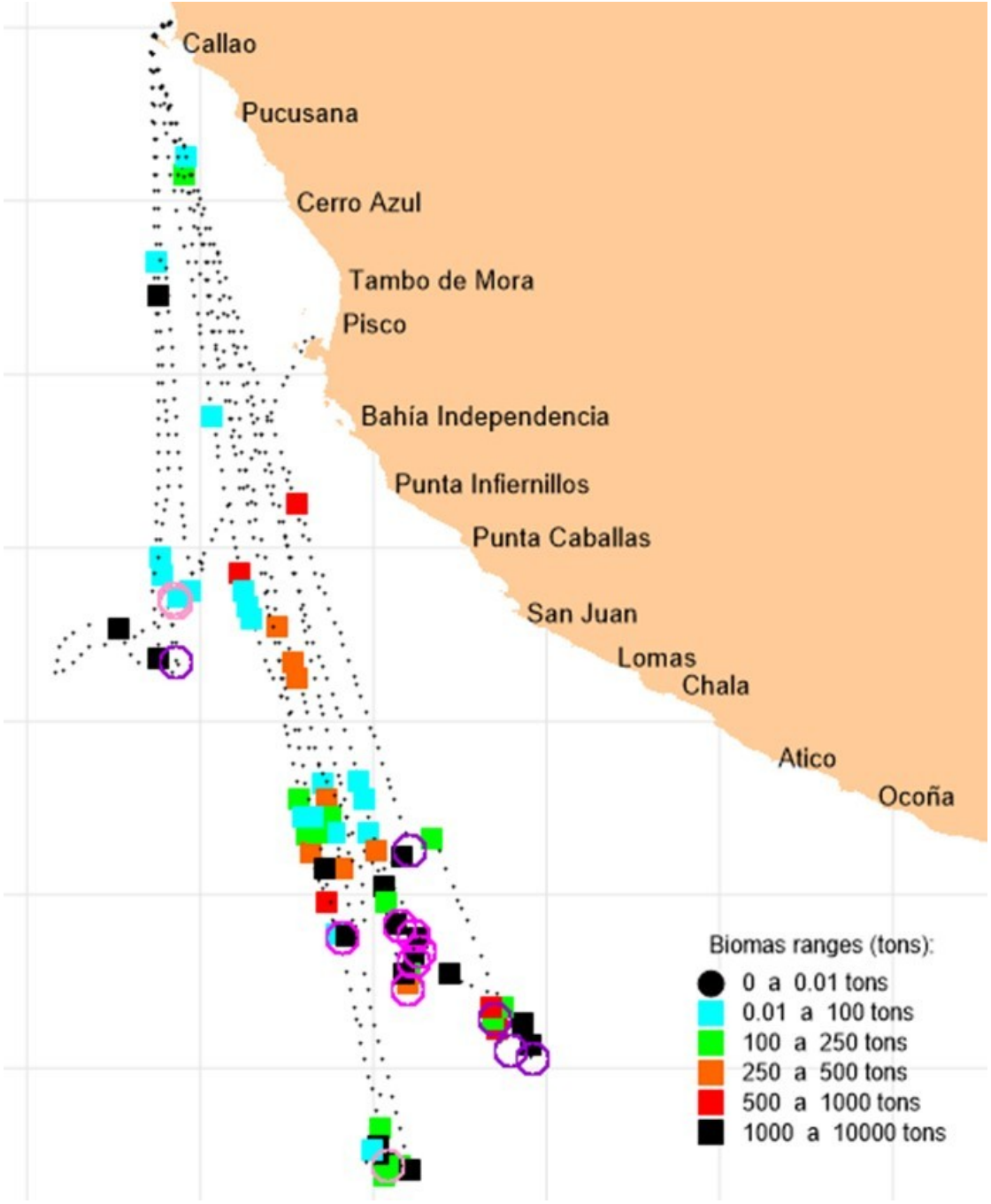





0.0m (D)
317.0nmi
50.0
100.0
nmi
0 0.6 1.2
km
0 0.6 1.2 1.8 2.4 3
18° 30.0' S
18° 32.0' S
18° 34.0' S
18° 36.0' S
18° 38.0' S

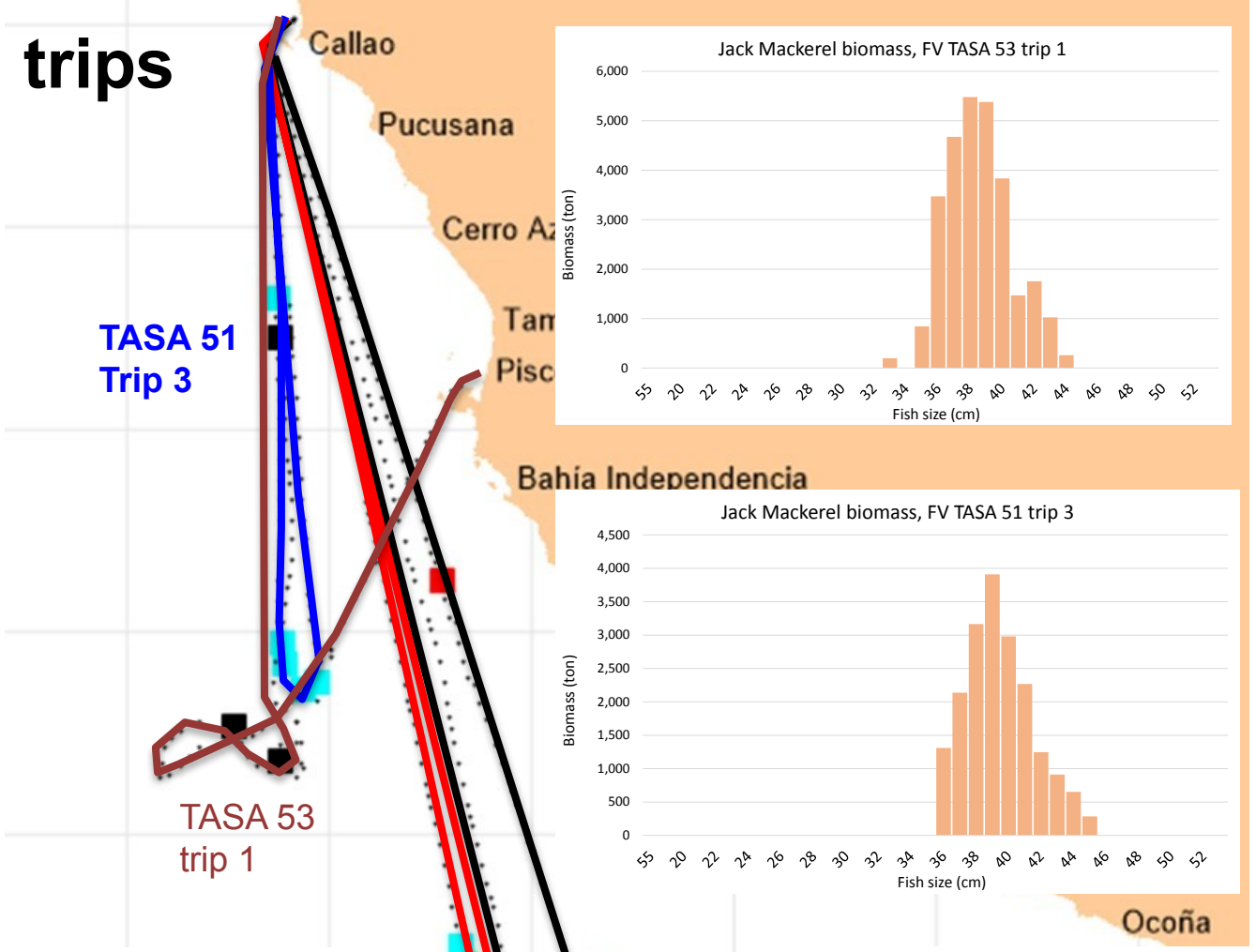

0.0m (D)
600.0nmi
50.0
100.0
nmi
0 10 20 30 40 50
km
0 18 36 54 72 90
16° 00.0' S
17° 00.0' S
18° 00.0' S
19° 00.0' S
20° 00.0' S

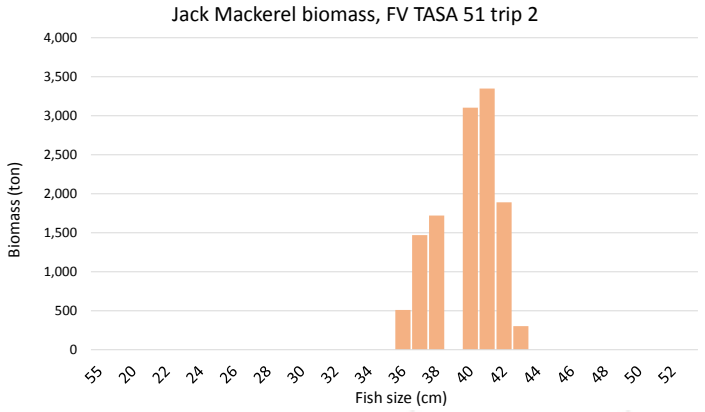
Squares

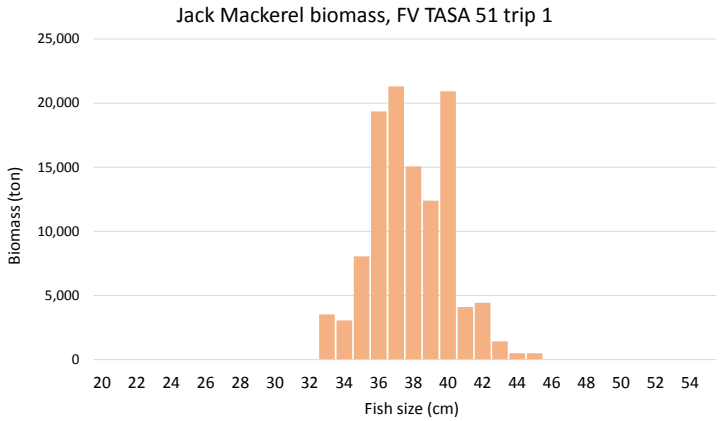


Colour circles indicate fishing sets made by FV TASA 51 and TASA 53 during the selected trips

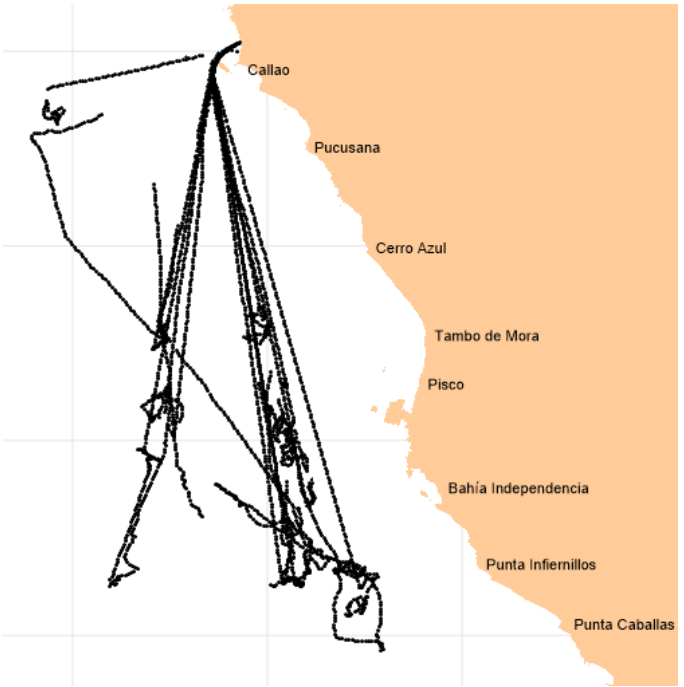
Fishing trips

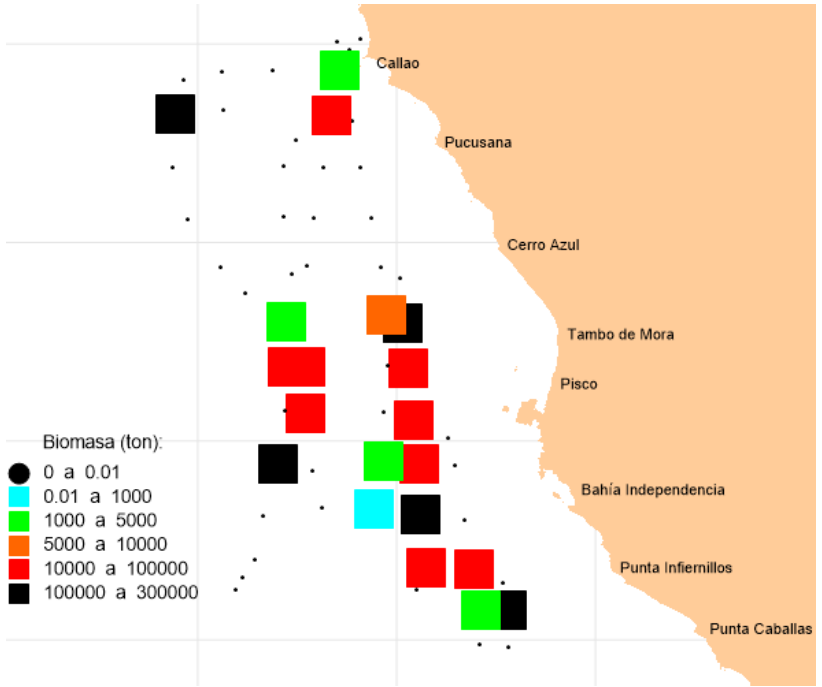


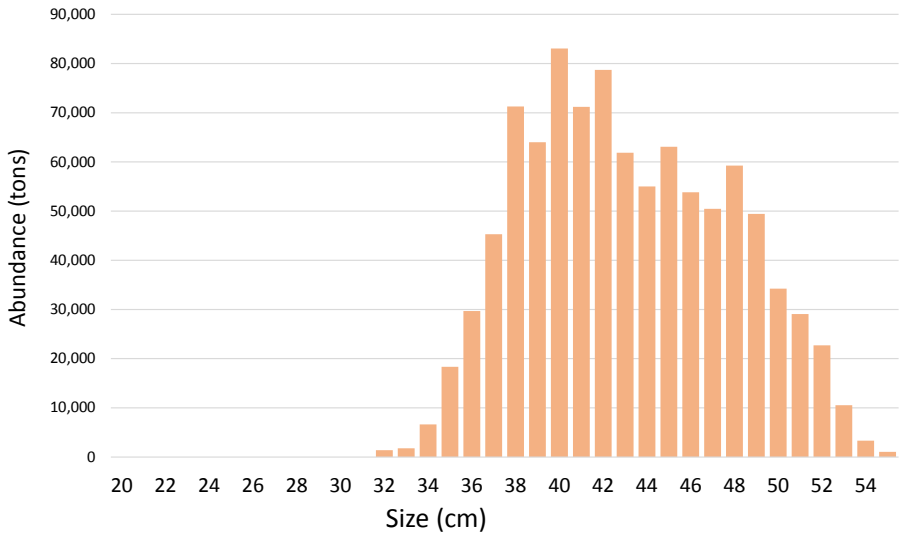




Acoustic abundance of Jack mackerel calculated by statistical squares.



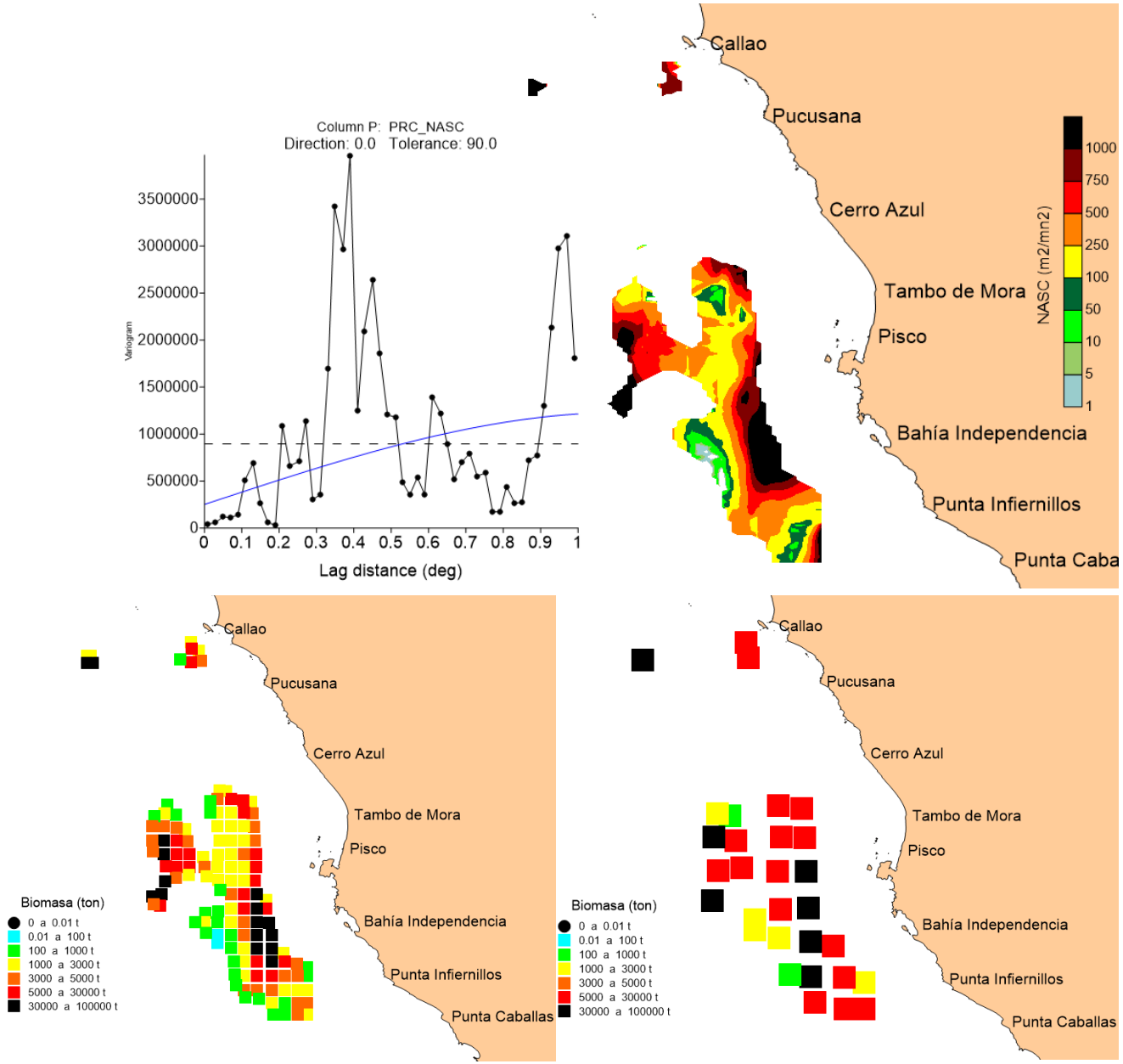


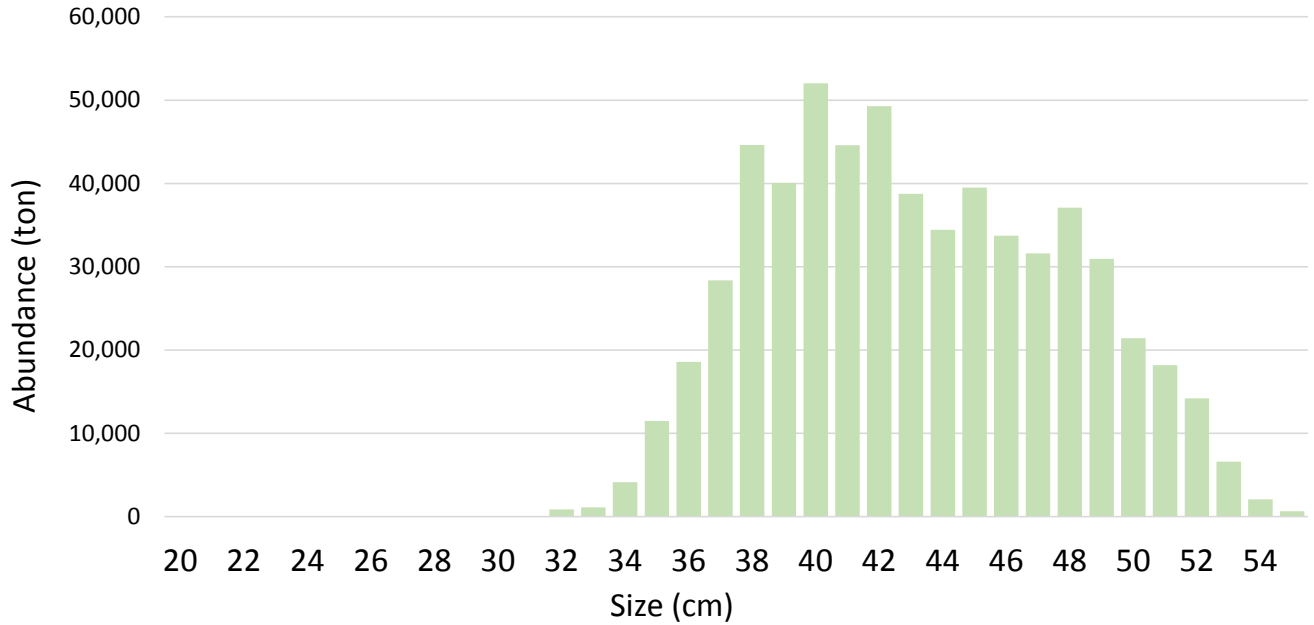


RESULTS

Number of squares:	20.00	units
Area :	4,369.97	n.mi.2
Total NASC:	16,973.62	m2/n.mi.2
Mean NASC per square:	848.68	m2/n.mi.2
Standard deviation:	1,370.55	m2/n.mi.2
Number of ESDUs:	2,453.00	unidades
Weigthed mean NASC:	781.21	m2/n.mi.2
Weigthed variance:	61,732.05	unidades
Conversion factor:	0.26	ton/m2
Mean density:	200.83	ton/n.mi.2
Demnsity variance:	4,079.70	units
Coefficiente of variation (CV):	**31.80**	**%**
Abundance method 1:	**965,286.48**	**ton**
Abundance method 2:	877,617.55	ton
Difference:	9.08	%
Confident limits:	**0.82**	**%**

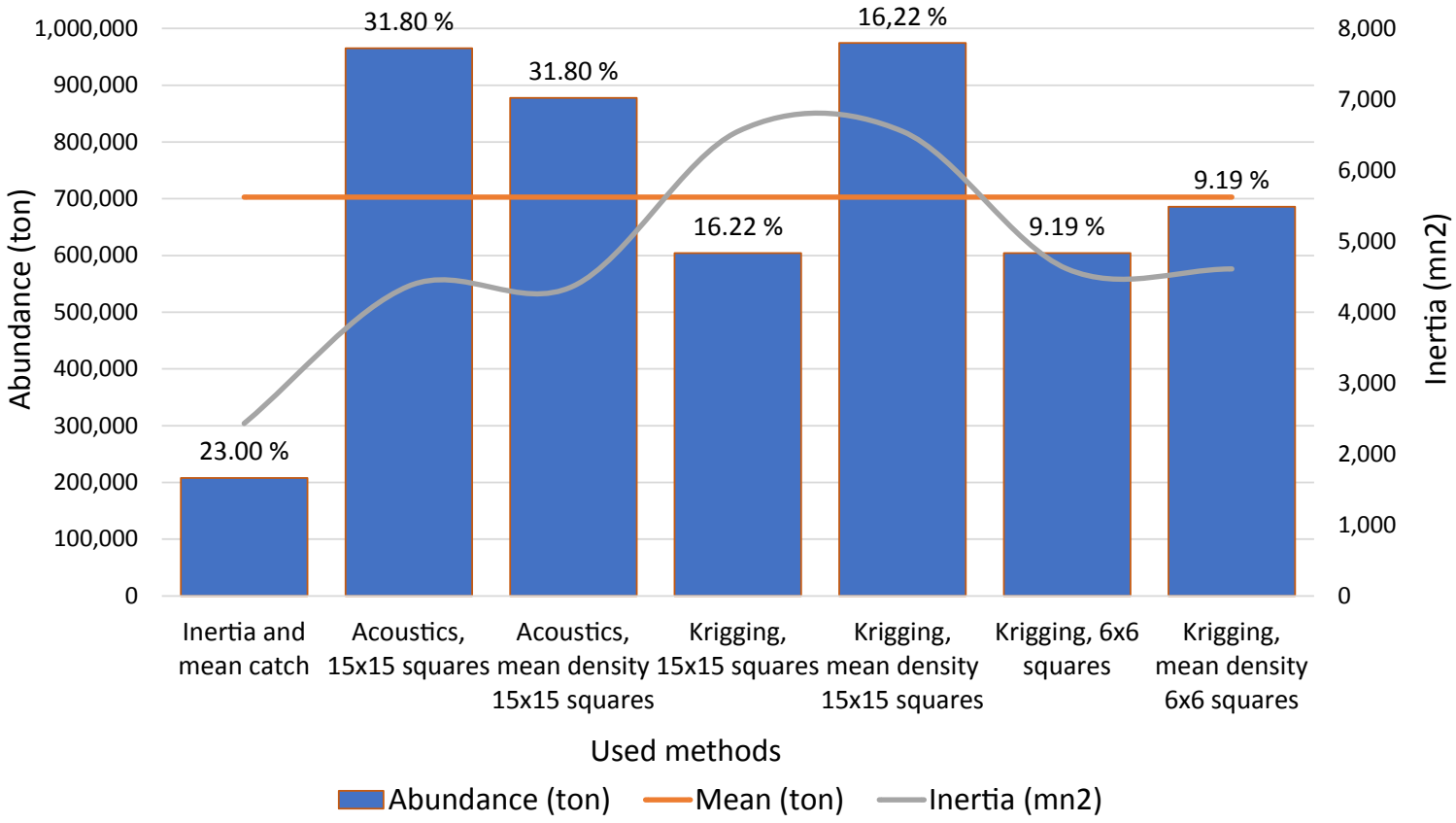
Jack mackerel abundance using krigging and stratification by squares of 6 by 6 and 15 by 15 n.mi.



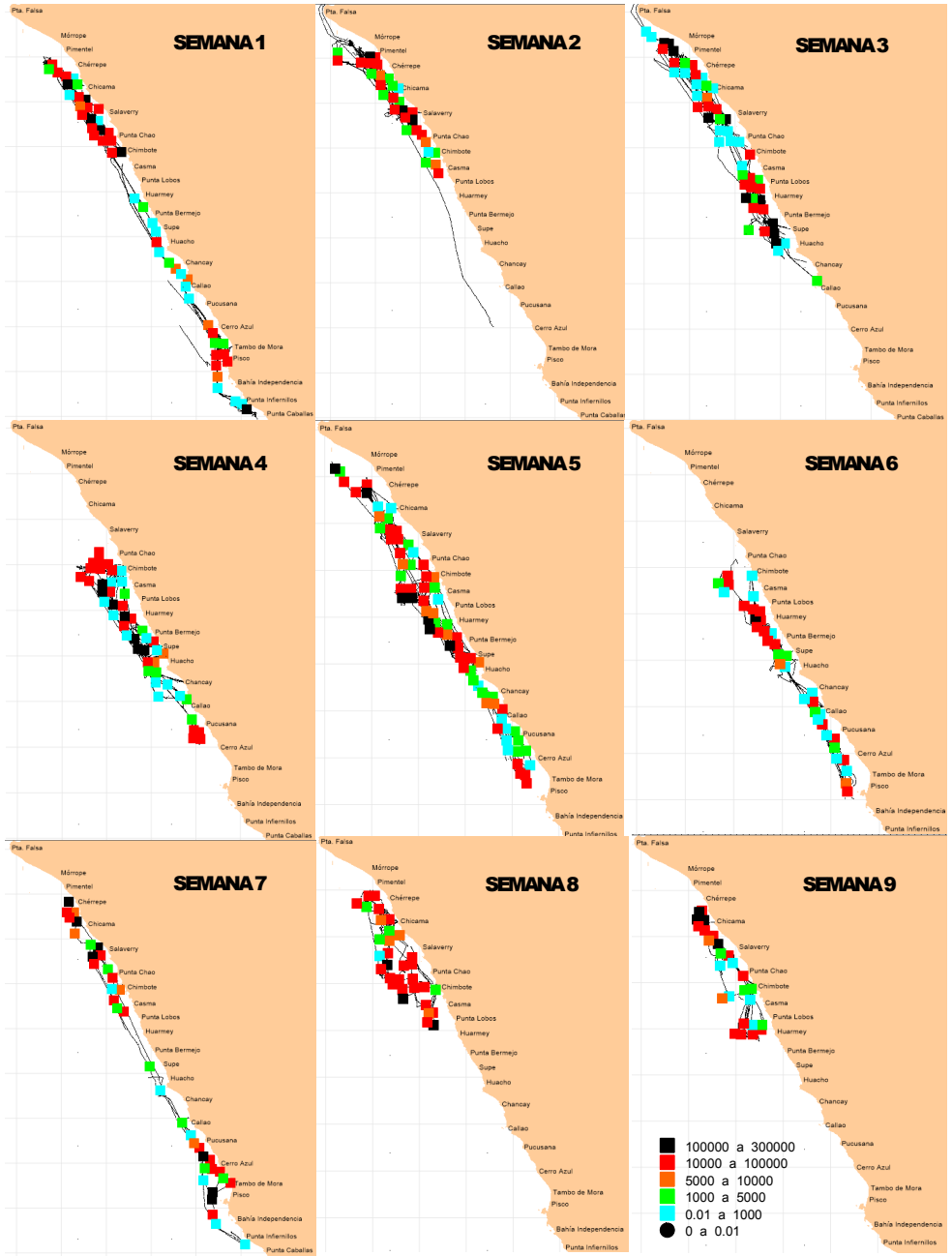


RESULTS	Squares 15x15 n.mi.	Squares 6x6 n.mi.	
Number of squares:	30.00	132.00	units
Area :	6,551.33	4,611.50	n.mi.2
Total NASC:	20,494.56	88,661.54	m2/n.mi.2
Mean NASC per square:	683.15	671.68	m2/n.mi.2
Standard deviation:	787.96	763.37	m2/n.mi.2
Number of ESDUs:	2,365.00	2,365.00	unidades
Weigthed mean NASC:	578.57	578.57	m2/n.mi.2
Weigthed variance:	8,807.08	2,827.65	unidades
Conversion factor:	0.26	0.26	ton/m2
Mean density:	148.74	148.74	ton/n.mi.2
Demnsity variance:	582.04	186.87	units
Coeffi ciente of variation (CV):	16.22	9.19	**%**
Abundance method 1:	604,336.99	604,336.99	**ton**
Abundance method 2:	974,418.49	685,895.67	ton
Difference:	62.02	88.11	%
Confident limits:	5.63	0.07	**%**

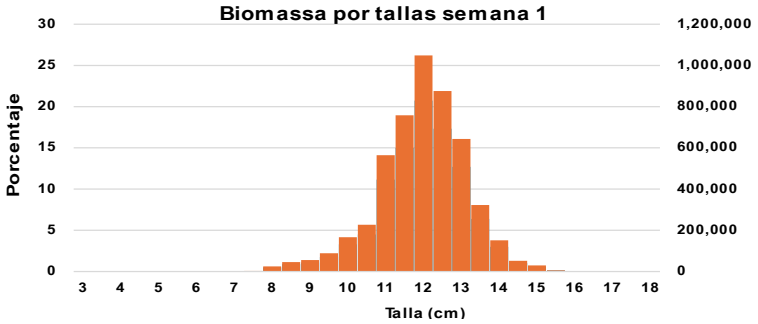
Synthesis of jack mackerel abundance estimates through various assessment methods for a single week

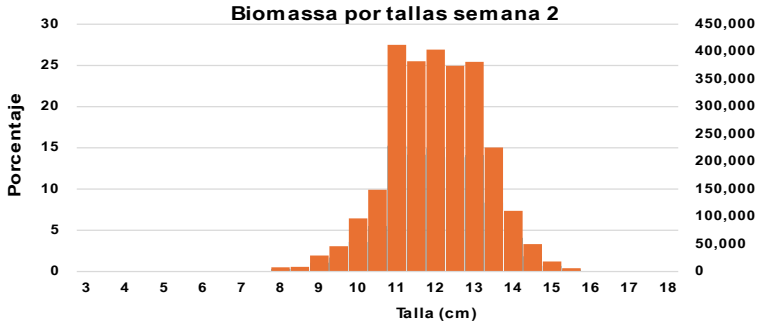


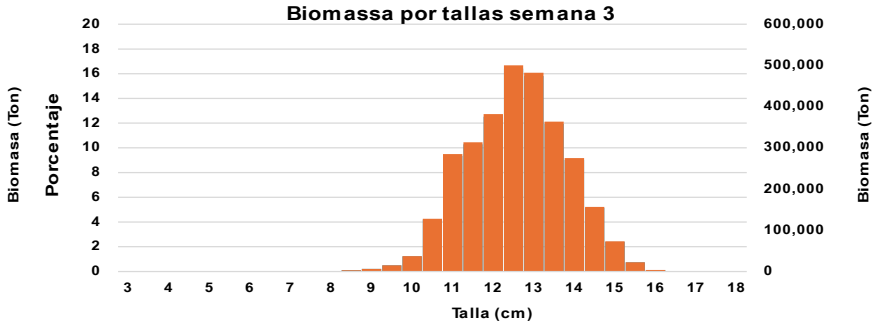
Sample case for anchovy

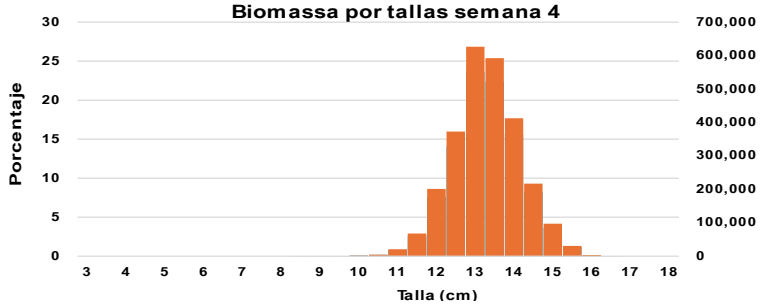


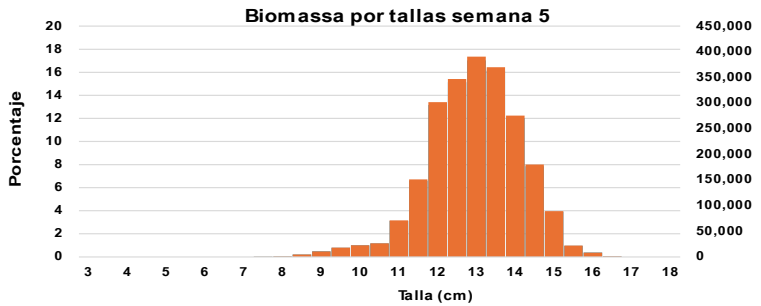
Biomass by sizes and weeks

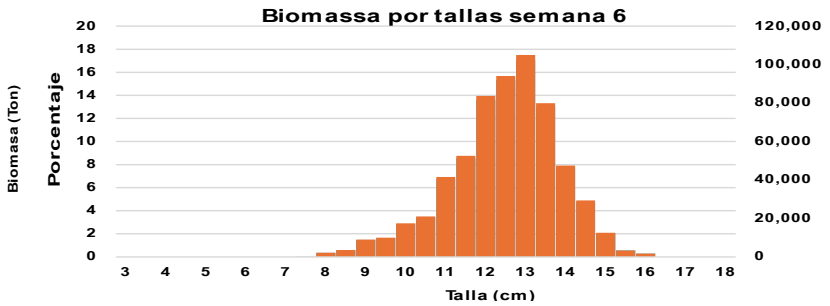


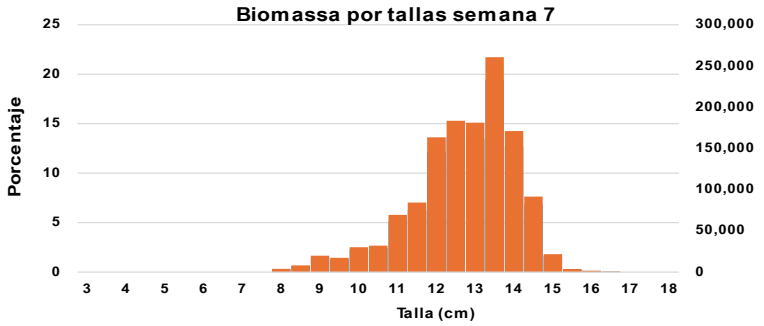


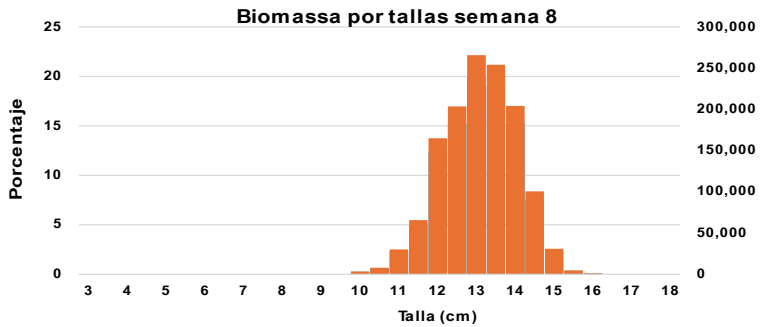


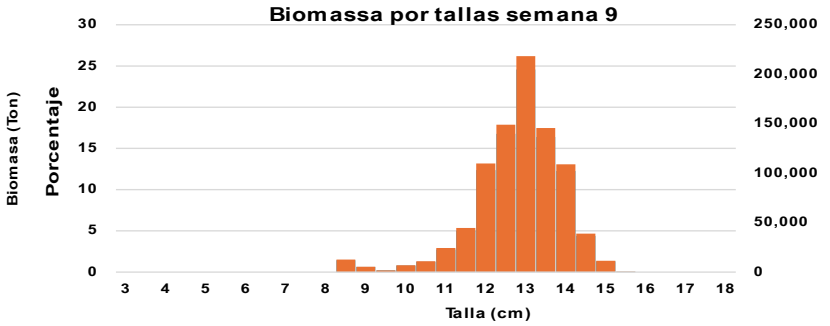












Detailed biomass by weeks

Parametros	Semana 1	Semana 2	Semana 3	Semana 4	Semana 5	Semana 6	Semana 7	Semana 8	Semana 9	Unidades
Número de cuadrados positivos:	54.00	34.00	52.00	48.00	69.00	35.00	37.00	32.00	26.00	unidades
Area con anchoveta:	11,934.95	7,577.03	11,556.28	10,619.00	15,274.31	7,722.59	8,170.21	7,119.52	5,780.11	n.mi.2
NASC:	56,939.27	30,079.28	33,670.73	28,780.30	25,088.74	6,827.66	14,838.95	14,548.47	9,715.51	m2/n.mi.2
NASC promedio:	1,054.43	884.68	647.51	599.59	363.60	195.08	401.05	454.64	373.67	m2/n.mi.2
Desviación estándar:	2,094.37	1,506.14	1,109.01	911.80	616.64	323.31	629.71	622.71	500.62	m2/n.mi.2
Número de UBMs con anchoveta	5,291.00	7,782.00	8,310.00	7,972.00	11,320.00	6,798.00	2,183.00	2,755.00	2,860.00	unidades
NASC promedio ponderado:	4,041.65	2,408.41	1,366.51	845.90	512.19	159.14	1,644.85	1,245.09	1,745.80	m2/n.mi.2
Varianza ponderada:	3,132.70	164.11	114.90	71.80	20.37	8.56	1,922.85	328.77	582.16	unidades
Factor de conversión:	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	ton/m2
Factor k medio:	4.76	4.77	4.59	5.50	4.88	4.77	5.12	7.16	4.77	t/m2/n.mi.2
Densidad media:	1,530.01	911.73	517.31	320.23	193.89	60.24	622.68	471.34	660.89	ton/n.mi.2
Varianza de la densidad:	448.94	23.52	16.47	10.29	2.92	1.23	275.56	47.12	83.43	unidades
Coeficiente de variación (CV):	1.38	0.53	0.78	1.00	0.88	1.84	2.67	1.46	1.38	%
Biomasa metodo 1:	**5,060,246.75**	**2,702,592.66**	**3,049,491.65**	**2,649,429.01**	**2,292,827.50**	**614,433.91**	**1,343,698.76**	**1,337,264.79**	**888,555.15**	**ton**
Biomasa método 2:	18,260,645.45	6,908,224.98	5,978,149.47	3,400,477.44	2,961,609.75	465,229.53	5,087,405.33	3,355,733.79	3,820,039.31	ton
Diferencia:	-260.86	-155.61	-96.04	-28.35	-29.17	24.28	-278.61	-150.94	-329.92	%
Límites de confianza:	8.98	9.80	5.92	4.15	4.31	5.07	10.53	8.45	15.82	%
Biomasa adultos	3,127,903.46	1,570,653.67	2,259,614.67	2,554,059.09	1,986,489.79	457,115.01	1,079,167.39	1,230,370.91	782,232.45	ton
Porcentaje adultos	61.81	58.12	74.10	96.40	86.64	74.40	80.31	92.01	88.03	%
Biomasa juveniles	1,932,343.30	1,131,938.99	789,876.98	95,369.93	306,337.72	157,318.90	264,531.37	106,893.89	106,322.70	ton
Porcentaje juveniles	38.19	41.88	25.90	3.60	13.36	25.60	19.69	7.99	11.97	%

CONCLUSIONS

- Results are only representative of regions where the vessels operate.
- Ideally few vessels should be used because:
- Fishing trips must be carefully selected to avoid double or multiple overestimation since these are random (not systematic) trajectories (fish moves and those detected could be detected again in a different square).
- Data must also be separated in time units (days, weeks) to reduce all posible biases.
- It has been found (Vargas 2012) that often catches were obtained where no acoustic echotraces were observed, which is an evidence of fish avoidance to vessels (underestimation).
- Fish length data must also carefully collected and assigned to the right squares.
- Juveniles are poorly represented in results due to strong restrictions from PRODUCE regarding the catch of juveniles of all species.

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