NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N6118 **NAFO SCR Doc. 12/56**

NAFO/ICES PANDALUS ASSESSMENT GROUP—OCTOBER 2012

Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2012 in NAFO Div. 3LNO

by

Casas[1], J.M., E. Román[1], J. Teruel[1], and G. Ramilo[1]

[1] Instituto Español de Oceanografía, Aptdo. 1552. 36200 - Vigo. Spain.

Abstract

The Spanish Institute of Oceanography carried out in 2012 two bottom trawl surveys in the NAFO Regulatory Area in Division 3NO and 3L during the months of June and August respectively. The results on Northern shrimp (*Pandalus borealis*) are presented and compared with those from previous surveys from the same series. In 2012 the catch (0.923 kg.) and estimated biomass (3.864 t.) confirm the decrease of shrimp importance from 2004 in 3NO. In 3L Division, northern shrimp indices show consecutive and drastic declines (55.7% with respect to 2011) and confirm the downward trend initiated in 2009. Estimated biomass increased from 2003-2006; then, the values of these indices declined in 2007 (about 10%) and increased again in 2008 up to its historical maximum (149265 t.). In 2012 the biomass estimated 10784 t. in 3L and 4 t. in 3NO were the lowest in the Spanish surveys series.

Catch results from the surveys and data analysis are discussed in this paper.

Introduction

Northern shrimp (*Pandalus borealis* Krøyer, 1883) is a protrandric, circumpolar species, discontinuously distributed in the North Atlantic and of considerable commercial importance. The greatest abundance is being in the Northwest Atlantic at latitudes above 46ºN. The stock of this species in Div. 3LNO, NAFO is distributed along the entire edge of the grand banks, at depths generally ranging from 185 to 550 metres, although historically at least 92.7% of the 3LNO shrimp biomass had been found within Division 3L.The proportion of biomass in 3LNO within the NAFO Regulatory Area (NRA), over the period 1996 – 2011, accounted for between 11.0 and 32.6% (Orr and Sullivan, 2012).

Since 1995, Canadian multi-species stratified random surveys have been used to estimate northern shrimp biomass and abundance indices within NAFO Div. 3LNO. In this series of surveys, Div. 3N accounts for between 0.1 and 8.1% of the total 3LNO biomass. Between 0 and 100% of the 3N biomass was located outside the 200 Nmi limit. The biomass in Division 3O accounts for less than 1% of the biomass in Div. 3LNO and only a negligible amount of the biomass in Div. 3O is beyond the 200 mile limit (Orr and Sullivan, 2012).

The Oceanographic Spanish Institute (IEO) is conducting research cruises since 1995 in the NAFO Regulatory Area in Div. 3NO beyond Canada's EEZ. A stratified, random, bottom trawl, multi-species research sampling program was carried out to obtain abundance and biomass indices as well as other biological data for the most important commercial species present in the area. In the surveys conducted between 1995 and 2000, the catches of

northern shrimp were insignificant. This could be explained by the low efficiency of the fishing gear "pedreira", with this species (Paz *et al*., 1995), used in those years.

Since 2001, the survey was carried out on board R/V "*Vizconde de Eza*" using a Campelen 1800 net (*Walsh et al., 2001*). Despite the improvements incorporated with the new vessel and the use of a Campelen 1800 net, which is highly efficient for this species (*Vazquez, 2002*), total catches in 2001 were poor, i.e., 29 kg.

In the following years a significant increase of the catches of northern shrimp was noted in 3NO Division where catches were higher than 300 kg. Since 2007 the catches have declined to levels next to the lowest in the historical series.

Also, since 2003 a new research survey was conducted in Division 3L as an extension of the survey carried out in 3NO (Román *et al.*, 2008). The estimated biomass in 3L Division always was very superior to that estimated in 3NO. Since 2008 year the catches have declined to levels next to the lowest in the historical series.

This work presents data on the geographical distribution in the NAFO Regulatory Area (Div. 3LNO), on biomass, length frequencies, age structure and length-weight relationship of catches of northern shrimp on Spanish bottom trawl surveys 2012.

Materials and Methods

The 2012 Spanish bottom trawl surveys were carried out in June, from 3th to 21th, in 3NO and from 28th July to 20th August in 3L following set guidelines previously established for the series of Spanish research surveys (Walsh *et al.*, 2001). These surveys took place in Div. 3NO and 3L, with a total of 122 and 98 valid hauls respectively ranging depths between 40 and 1450 m approximately. This year all strata were surveyed.

Shrimp samples of approximately 1.5 kg were taken to determine length frequencies in hauls where the amount and good condition of the specimens caught permitted to sample them. Males and females were separated with reference to the endopod of the first pleopod (Rasmussen, 1953). Following this criterion, individuals that were in the middle of a sex change were considered as females. The females were differentiated into mature and immature, following the sternal spines criteria (McCray, 1971). Ovigerous females were considered as an independent group not included within the mature females.

Individuals were measured onboard by noting the distance from the base of the eye to the posterior mid dorsal point of the carapace -CL- (Shumway *et al*., 1985). Such measurements were made to the lower half millimetre using electronic callipers.

Furthermore, in 2012 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 63 and 5253 individuals were selected in 3NO and 3L Divisions respectively, dried and weighed with a precision of 0.1g to calculate the length-weight relationship in each Division.

Results and Discussion

The Table 1 shows the catches, biomass and standard errors estimated by swept area method of northern shrimp from the Spanish multi-species surveys, carried out by IEO Vigo from 1995-2012 in the NAFO Div. 3NO and from 2003-2012 in Division 3L. In the summer of 2005 the research survey could not be carried out in Division 3L. From the year 2002 an abrupt increase with respect to earlier years occurred in 3NO Division, both in terms of catch and biomass (Diaz *et al*., 2002). These initial data were considered with caution due to the fact that, until 2001, the "Pedreira" gear used as a sampler (Paz *et al*., 1995) was not efficient for catching shrimp. However, although in 2001, the gear "type Pedreira" was changed for a new type "Campelen 1800" (Walsh *et al*., 2001) with high efficiency for catching this species (Vazquez, 2002), the catches and biomass estimated stayed at low levels.

After 2002 year, the increase in northern shrimp catch in 3NO was confirmed, in terms of the period 1995-2001 although in the last five years both the catches and estimated biomasses of shrimp have decreased markedly to levels of biomass in 2012 around 4 t. (Figure 1).

Unlike 3NO, the estimated biomass in Division 3L since the beginning of the new survey in 2003 showed a general upward trend from 63647 t. in 2003 to 149265 t. in 2008. This trend changed in 2009 with the strong decline of the biomass estimated (74091 t., about 50% with respect to 2008) and since then the biomass has decreased. In 2012, the estimated biomass was 10784 t, which represents a decrease of 55.7%.

The distribution of northern shrimp catches in the Spanish trawl survey 2012 is shown in Figure 2. As in previous years the main catches were located at medium depths from 51 to 200 fathoms (93- 350 m) in Div. 3L. In 3NO Division the catches were residuals.

The tables 2 and 3 show the shrimp biomass by depth strata from 1995 to 2012 surveys in Divisions 3NO and from 2003 to 2012 in 3L. Although it is considered that the shrimp in Div. 3LNO is distributed along the entire edge of the grand banks, at depths generally ranging from 51 to 300 fathoms (93-550 m.), the depth of the bulk of biomass present differences in 3L and 3NO Divisions. While in 3L Division practically the total of the biomass (>95%) was produced all years in depths lower than 200 ft., in 3NO the percentage of the estimated biomass in depths lower than 200 ft. varied along the years, showing a deeper distribution in 2004, 2005 and 2011 where the percentage of the shrimp catches was in depths bigger than 200 ft.

The length distribution by sex estimated in the 3NO and 3L are presented in tables 4, 5 and figure 3. The main modes were around 21 mm. for males and 24 mm. for females. In 2012 the sex ratio was similar in both Divisions, showing a higher percentage of the males.

The MIX modal size analysis programme was used with the length distribution by sex estimated in 3L Divisions (Table 6). From the cited analysis the males presented three modes at 15.3, 18.5 and 21.1 mm. corresponding with ages 2, 3 and 4 respectively. The sex change occurs mainly at ages 3 and 4. The females showed several modes at 18.9, 22.2, 24.4 and 26.7 mm. (ages 3, 4, 5 and 6 respectively).

The Table 7 shows the length-weight relationship estimated in 2012 surveys by sex and maturity stage as well the parameters of the relationship, number of specimens sampled and determination coefficient R^2.

References

Díaz, P., T. Patrocinio, and X. Paz. 2002. Increased Catches of Northern Shrimp (*Pandalus borealis*, Krøyer) in a 2002 Spanish Bottom Trawl Survey in NAFO Division 3N. *NAFO SCR Doc*., No. 143. Serial No.N4772, 11p.

McCRay, J.A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. *J. Fish. Res. Bd. Can.*, **28**: 98-100.

Orr, D. C. and D. J. Sullivan. 2012. Divisions 3LNO Northern Shrimp (*Pandalus borealis*) – Interim Monitoring Update. *NAFO SCR Doc.*, *No.* 43. Serial No. N6076, 17 p.

Paz, X., J. Martínez, and E. De Cárdenas. 1995. Preliminary results from the 95 Spanish bottom trawl survey in the NAFO Regulatory Area for Divisions 3NO. *NAFO SCR Doc*., No. 55. Serial No. N2568, 10 p.

Rasmussen, B. 1953. On the geographical variation in growth and sexual development of the Deep Sea Prawn (*Pandalus borealis*, Kr.) . *Norweg. Fish. And Mar. invest. Rep*., **10** (3):1-160.

Román, E., C. González-Iglesias, Á. Armesto, and D. González-Troncoso. 2008. Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2007. *NAFO SCR Doc*., No. 20. Serial No. N5514, 25p.

Shumway, S.E., H. C. Perkins, D. F. Schick, and A. P. Stikney. 1985. Synopsis of biological data on the Pink Shrimp (*Pandalus borealis*, Krøyer,1838). *NOAA Techn. Rep.* NMFS **30**, 57 p.

Vázquez, A. 2002. Catchability comparison between Lofoten and Campelen gears. *NAFO SCR. Doc.*, No.74. Serial No. N4688, 7p.

Walsh, S. J., X. Paz, and P. Durán. 2001. A preliminary investigation of the efficiency of Canadian and Spanish survey bottom trawls on the southern Grand Bank. *NAFO SCR. Doc*., No. 74. Serial No. N4453, 18 p.

Table 1.- Northern shrimp biomass estimated by swept area (t), standard error and catches (kg) from Spanish bottom trawl surveys in NAFO Div. 3NO, 1995-2012 and 3L 2003-2012.

3NO

Year	Biomass		Catch
	tons	Std. err.	(kg)
1995[1]	14	13	5
1996[1]	18	17	2
1997[1]	1	1	0
1998[1]	23	17	5
1999[1]	81	36	13
2000[1]	26	9	6
2001[2]	178	72	29
2002[2]	2043	814	408
2003[2]	1618	716	325
2004[2]	2654	1693	550
2005[2]	1627	590	368
2006[2]	1274	352	278
2007[2]	401	285	71
2008[2]	144	98	24
2009[2]	140	111	33
2010[2]	114	35	21
2011[2]	37	24	9
2012[2]	4	3	1

3L

Year	Biomass		Catch
	tons	Std. err	(kg)
1995			
1996			
1997			
1998			
1999			
2000			
2001			
2002			
2003[2]	63647	20105	5836
2004[2]	94270	40332	5093
2005		Not surveyed	
2006[2]	125850	12690	17805
2007[2]	113402	13445	18098
2008[2]	149265	48489	23720
2009[2]	74091	37999	12173
2010[2]	37803	9836	6103
2011[2]	24346	4449	4092
2012[2]	10784	3724	1838

[1] Pedreira codend 35 mm. mesh size.
[2] Campelen codend 44 mm. mesh size. (inner codend 20mm)

Table 2.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 1995-2012 in NAFO Div. 3NO.

Stratum	Area Mn^2	Depth range fth.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
375	271	0-30	0	0		0	0	0	3453	0	25	0	0	1989	0	0	0	0	0	0
376	1334	0-30	0	0		0	0	0	1270	0	0	0	341	4203	0	0	0	0	86	0
353	269	31-50	0	0		0	0	0	79	0	48	0	0	0	126	0	16	0	0	148
360	2783	31-50	0	0		0	0	0	26423	1457	3470	24	0	0	445	0	110	1317	33	0
374	214	31-50	0	0		0	0	0	178	0	0	0	0	0	62	0	0	0	29	0
354	246	51-100	0	0		0	0	0	87612	0	292	6917	0	0	14	0	0	55	196	0
359	421	51-100	0	0		0	1389	0	6348	847	1309	43	41	22	98	42	0	543	47	0
377	100	51-100	0	0		0	208	44	0	2020	751	1471	3742	3704	83	60	40	0	129	0
382	343	51-100		0		0	213	206		112695	302	297	825	944	191	4131	0	0	0	0
355	74	101-150		0		0	0	0	15170	147	7635	6146	6183	9179	262	204	0	961	0	0
358	225	101-150	0	0		0	30129	0	717	3261	3900	10289	32548	258	2357	2902	0	17220	34	0
378	139	101-150	0	0		8968	10998	1196	17004	680353	11429	772	3985	10066	1357	481	73	192	0	0
381	144	101-150		0		63	11205	122		84984	20648	225280	1486	75176	303300	114294	466	25403	0	0
356	47	151-200		0		0	0	0	137	0	1337	12937	8046	2683	213	635	39	409	19	28
357	164	151-200	0	18097		0	0	0	606	16414	425145	163606	38796	114178	9307	1249	959	14877	7269	3483
379	106	151-200	0	0	720	0	135	0	12511	70342	254080	7709	329867	116970	12146	2238	5079	15709	87	111
380	96	151-200		0		1024	9346	10240		1000960	698502	258603	120866	607392	6488	11379	125767	26518	0	0
721	65	201-300		0		0	0	0	2889	3282	1112	852	256	3054	0	257	318	6	6339	11
723	155	201-300		0		0	16872	0	0	12667	92831	44044	3333	53799	14615	90	0	916	0	0
725	105	201-300	14315	0		0	0	0	271	527	91803	1814540	748369	206794	47133	578	239	7745	335	0
727	96	201-300		0		13213	0	11429		28660	2119	98477	326841	62635	1248	3172	179	632	32	0
722	84	301-400		0		0	37	734	2890	60	156	0	36	0	0	0	0	0	0	0
724	124	301-400	0	0		0	0	0	0	55	628	58	165	53	213	0	0	0	0	0
726	72	301-400	0	0		0	0	0	0	7	54	2048	0	406	170	0	5351	146	22656	83
728	78	301-400		0		0	0	1671		7280	0	0	86	135	0	0	41	146	0	0
752	131	401-500		0		0	0	0		86	0	49	222	58	309	0	143	136	0	0
756	101	401-500		0		0	0	0	0	0	46	42	869	84	27	84	391	0	0	0
760	154	401-500		0		0	0	0	0	0	283	49	0	0	590	0	0	0	0	0
764	100	401-500		0		0	0	0	42	0	0	0	0	0	0	0	0	-	0	0
753	138	501-600		0		0	0	0		0	0	0	0	166	0	0	0	-	0	0
757	102	501-600		0		0	0	0		204	0	0	27	0	67	0	0	14	0	0
761	171	501-600		0		0	0	0	0	0	0	0	0	0	99	0	0	0	0	0
765	124	501-600		0		0	0	0	0	37	0	0	0	0	0	0	0	0	0	0
754	180	601-700				0	0	0		0	0	0	0	0	0	207	0	96	0	0
758	99	601-700				0	0	94		16302	0	19	88	0	0	0	0	0	0	0
762	212	601-700				0	0	0	0	85	0	0	0	0		0	0	0	0	0
766	144	601-700				0	0	0		19	58	0	0	0		0	0	32	0	0
755	385	701-800				0	0	89		0	174	0	68	0	0	1839	0	0	0	0
759	127	701-800				0	0	0		17	0	48	0	0		0	0	965	0	0
763	261	701-800				0	0	0		0	0	0	0	0		0	-	-	0	0
767	158	701-800				0	0	0		0	0	0	0	0		0	-	-	0	0
Biomass (t.)			14	18	1	23	81	26	178	2043	1618	2654	1627	1274	401	144	139	114	37	4
Std. Error (t.)			13	17	1	17	36	9	72	814	716	1693	590	352	285	98	111	35	24	3
Biomass % < 200fth			0	100	100	43	79	46	97	97	88	26	34	74	84	96	95	91	21	98

Table 3.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2003-2012 in NAFO Div. 3L.

Stratum	Area miles^2	Depth range ft.	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
385	2356	51-100	420	175		2485867	2416545	8265541	140724	12046	975	4998
390	1481	51-100	1014	3780		2577958	5404325	317330	37466118	145874	15006844	6644446
389	821	101-150	14397492	41654297		53639329	49120205	74404070	25997291	21705956	8113071	2136050
391	282	101-150	1116135	1299793		3712072	12397477	24948041	28071	120096	979731	630153
387	718	151-200	17618619	21721973		29967360	11782827	14287154	6473372	7874303	2020	49686
388	361	151-200	25169595	24779540		32585066	26954928	21602795	2348269	5096163	11940	99221
392	145	151-200	2821419	1866379		193967	1199955	3675300	1564098	1608469	24550	118649
729	186	201-300	20371	1465049		88481	172095	16126	11533	95976	149	2618
731	216	201-300	2449416	1467221		177357	666240	1501056	54100	1083034	92	0
733	468	201-300		4077		390052	3281339	240647	6718	51397	2647	799077
730	170	301-400	0	876		1485	76	32	20	581	1349	596
732	231	301-400	34907	5643		14535	4723	1905	226	4266	194095	285343
734	228	301-400		408		10554	136	2144	69	129	4910	1553
741	223	401-500	0	56		1379	22	486	0	0	662	189
745	348	401-500	17642	0		1699	186	1950	0	2716	57	11202
748	159	401-500	292	696		366	499	66	0	49	2	20
742	206	501-600	0	0		462	0	0	0	1718	0	0
746	392	501-600	0	0		134	0	74	70	225	1911	250
749	126	501-600	0	23		99	0	0	0	0	381	0
743	211	601-700		0		1020	0	23	0	0	32	0
747	724	601-700		0		147	0	41	201	51	108	0
750	556	601-700		0		58	0	132	294	0	11	0
744	280	701-800		0		185	0	0	0	0	308	0
751	229	701-800				0	0	0	0	0	0	0
Biomasa (ton.)			63647	94270		125850	113402	149265	74091	37803	24346	10784
Std. Error (tons)			27126	54044		15484	13445	48489	37999	9836	4449	3724
Biomass % < 200 fth			96	97		99	96	99	100	97	99	90

Table 4.- Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2012 in NAFO Div. 3NO.

CL (mm)	Males	Females	Total
8	0	0	0
8.5	0	0	0
9	0	0	0
9.5	0	0	0
10	0	0	0
10.5	0	0	0
11	0	0	0
11.5	0	0	0
12	0	0	0
12.5	0	0	0
13	0	0	0
13.5	0	0	0
14	0	0	0
14.5	0	0	0
15	11	0	11
15.5	11	0	11
16	0	0	0
16.5	33	0	33
17	0	0	0
17.5	11	0	11
18	11	0	11
18.5	11	0	11
19	47	0	47
19.5	44	0	44
20	71	0	71
20.5	33	0	33
21	73	6	79
21.5	11	22	33
22	0	14	14
22.5	0	36	36
23	0	18	18
23.5	0	55	55
24	0	22	22
24.5	0	22	22
25	0	22	22
25.5	0	11	11
26	0	22	22
26.5	0	0	0
27	0	0	0
27.5	0	0	0
28	0	0	0
28.5	0	0	0
29	0	0	0
29.5	0	0	0
30	0	0	0
30.5	0	0	0
31	0	0	0
31.5	0	0	0
32	0	0	0
Total	368	251	620
	59%	41%	

Table 5.- Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2012 in NAFO Div. 3L.

CL (mm)	Males	Females	Total
8	15	0	15
8.5	0	0	0
9	0	0	0
9.5	0	0	0
10	0	0	0
10.5	0	0	0
11	0	0	0
11.5	0	0	0
12	406	0	406
12.5	1227	0	1227
13	1135	0	1135
13.5	2433	0	2433
14	12948	0	12948
14.5	18735	0	18735
15	30723	543	31266
15.5	25863	0	25863
16	14173	285	14457
16.5	19310	0	19310
17	24436	497	24933
17.5	39607	220	39828
18	57193	3515	60709
18.5	55161	558	55719
19	63749	2944	66693
19.5	85409	2639	88048
20	93029	1915	94945
20.5	96179	5248	101428
21	105480	13279	118759
21.5	97879	14180	112059
22	64730	26722	91451
22.5	49248	46043	95292
23	8053	60472	68524
23.5	10482	84981	95463
24	3587	107611	111198
24.5	0	98703	98703
25	0	82379	82379
25.5	0	57625	57625
26	0	37398	37398
26.5	0	17173	17173
27	0	17068	17068
27.5	0	8632	8632
28	0	2220	2220
28.5	0	1063	1063
29	0	1204	1204
29.5	0	1173	1173
30	0	92	92
30.5	0	61	61
31	0	0	0
31.5	0	0	0
32	0	61	61
Total	981192	696502	1677695
	58%	42%	

Table 6. Results of the modal analysis (MIX) by sex and maturity stage Spanish bottom trawl survey 3L 2012.

	Males		***Females***	
Age	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***
1				
2	0.114	0.000		
3	0.254	0.001	0.014	0.000
4	0.632	0.001	0.093	0.001
5			0.807	0.001
6			0.085	0.001
7				
Age	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***
1				
2	15.30	0.003		
3	18.49	0.005	18.91	0.013
4	21.11	0.003	22.15	0.013
5			24.44	0.004
6			26.65	0.014
7				
Age	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***
1				
2	0.833	0.001		
3	1.007	Cons. C.V	0.851	Fixed C.V
4	1.149	Cons. C.V	0.997	Fixed C.V
5			1.100	Fixed C.V
6			1.199	Fixed C.V
7				

Table 7.-Northern shrimp length-weight relationship by sex, maturity stage and all combined from Spanish bottom trawl survey 2012 in NAFO Div. 3NO and 3L.

	a	b	R^2	N
Division 3NO				
Males	0.00935	2.104	0.81383	37
Inmature females	0.06142	1.50702	0.64781	5
Mature females	0.00376	2.39997	0.81981	21
Ovigerous females				
All combined	0.00707	2.19877	0.91237	63
Division 3L				
Males	0.00154	2.68261	0.94743	3835
Inmature females	0.00041	3.11615	0.86594	494
Mature females	0.00075	2.91638	0.87123	722
Ovigerous females	0.02621	1.79992	0.50915	202
All combined	0.00119	2.77255	0.96611	5253

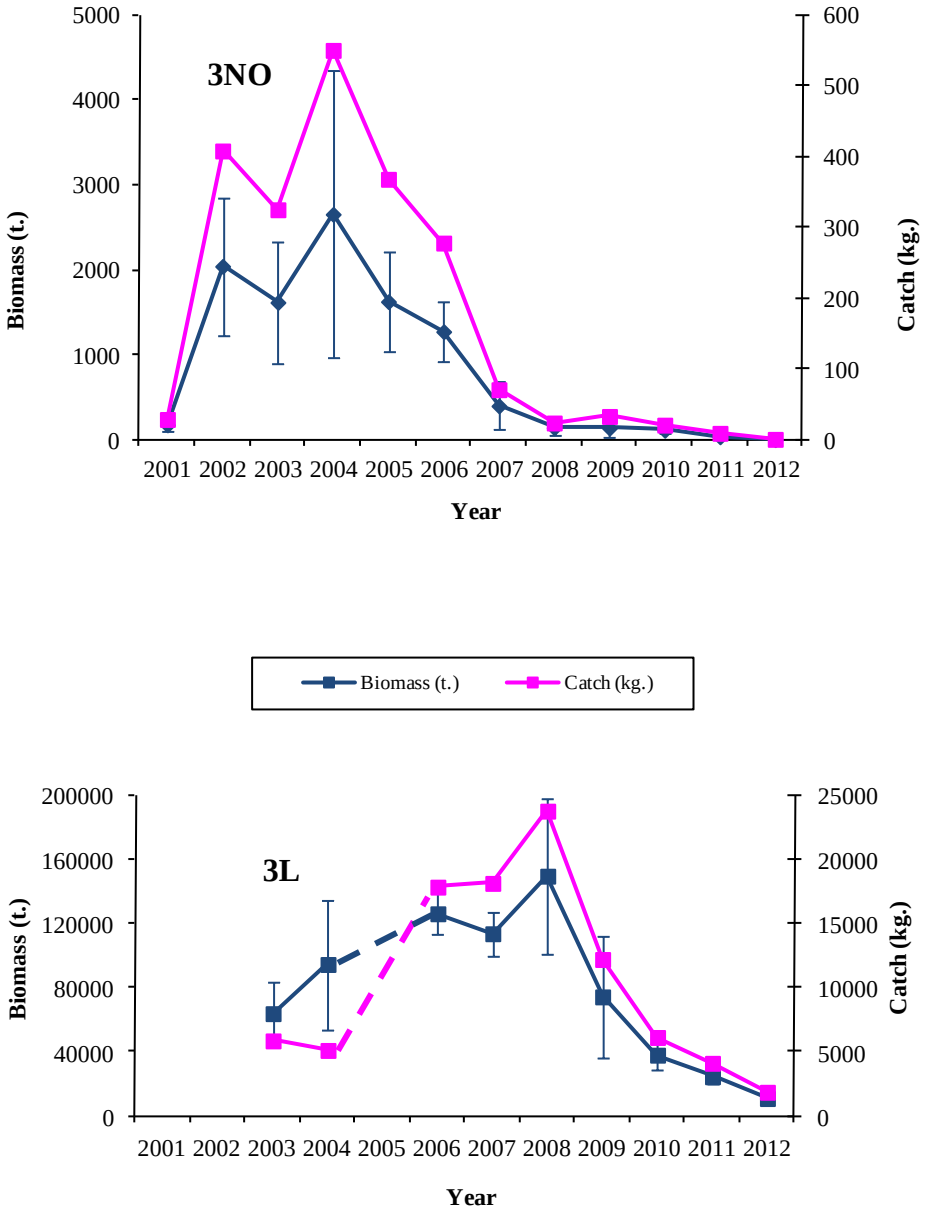

Figure 1.- Northern shrimp biomass (tons) and catch (kg) from Spanish research surveys in NAFO Div. 3NO 2001-2012 and 3L 2003-2012.

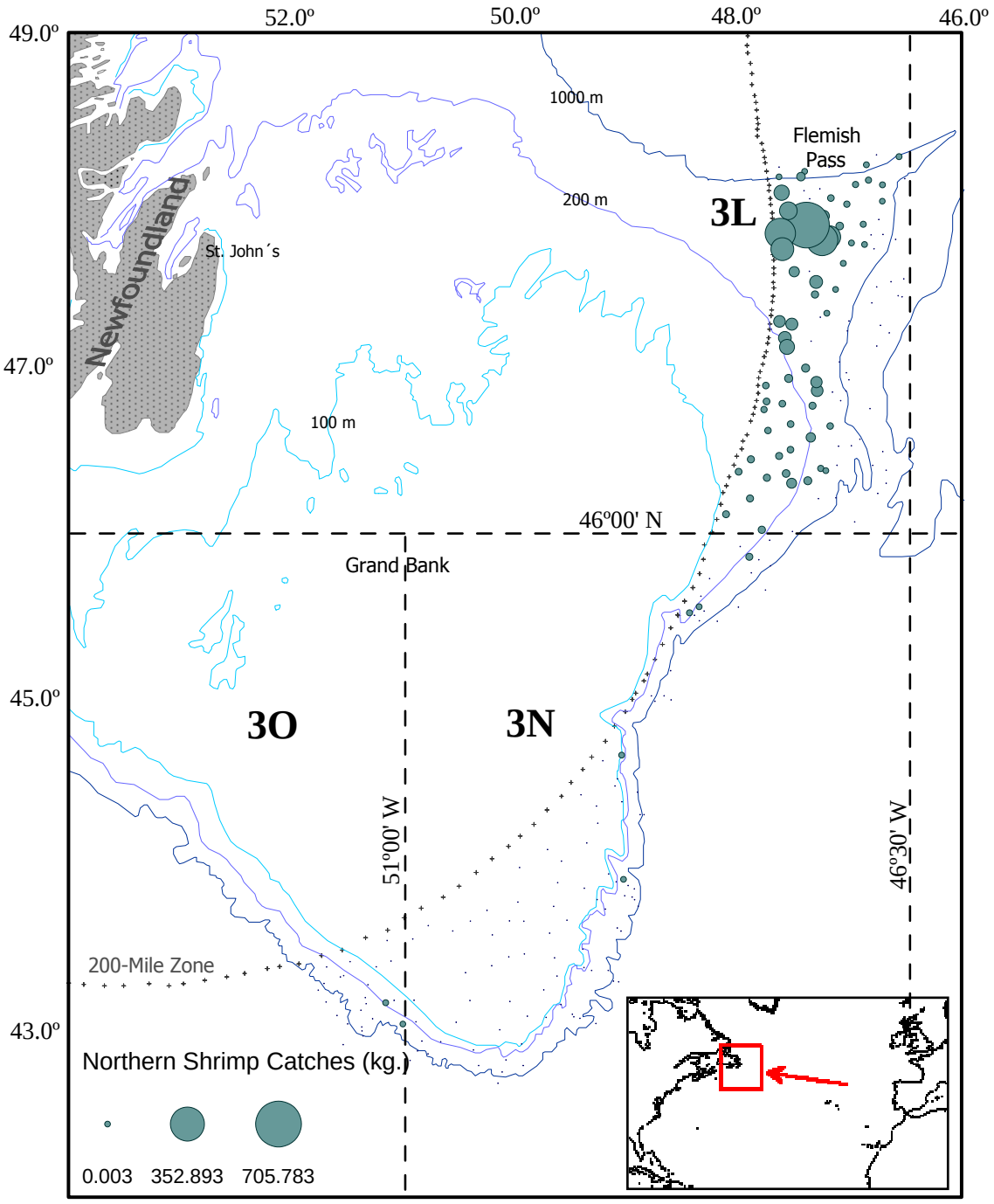

Figure 2.- Geographic distribution of Northern shrimp catches from Spanish bottom trawls surveys 2012.

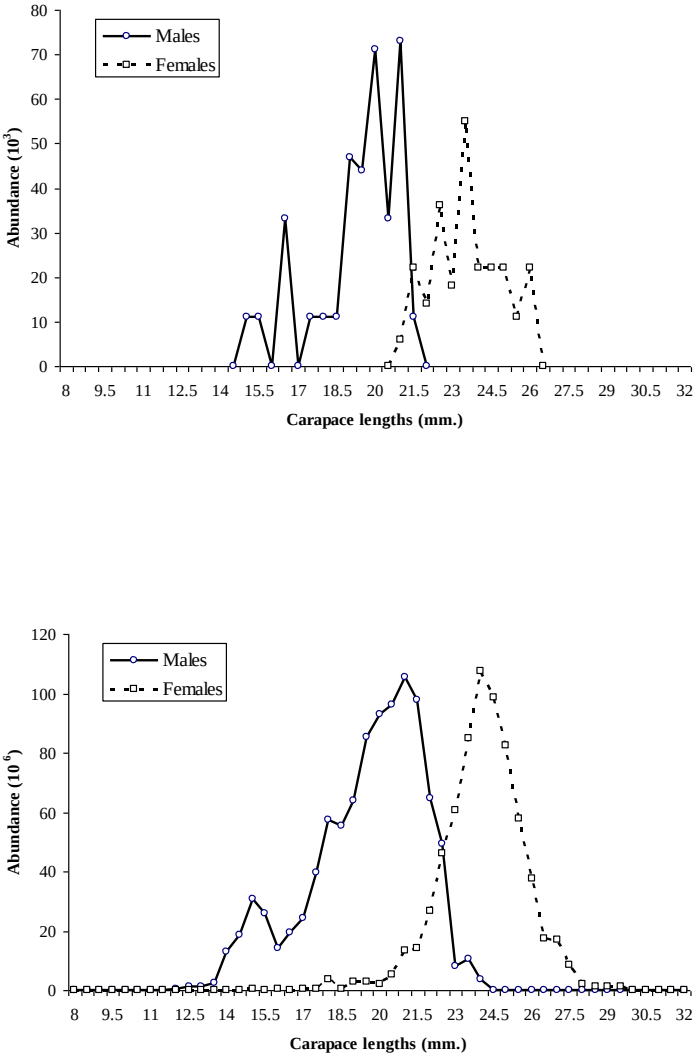

Figure 3.- Northern shrimp size distribution, by sex from Spanish bottom trawl surveys (2012) in Div. 3NO and 3L.