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Northern Shrimp (*Pandalus borealis*, Krøyer) in Spanish Bottom Trawl  
Survey 2004 and 2005 in NAFO Divisions 3LNO

by

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**Abstract**

The results on northern shrimp (*Pandalus borealis*) obtained from the Spanish bottom trawl surveys in the NAFO Regulatory Area (Divisions 3NO) in spring-summer 2004 and 2005, carried out by the Instituto Español de Oceanografía (Spanish Oceanographic Institute, Vigo Centre), are presented and compared with those from previous surveys from the same series. The catches 550 and 368 kg obtained in 2004 and 2005, respectively, confirmed the increase of shrimp importance in the last years in the Div. 3NO with an estimated biomass by swept area method around 2 000 tons.

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 being in the Northwest Atlantic at latitudes above 46°N. The stock of this species in Div. 3LNO, NAFO is distributed along the entire edge of the grand banks, at depths generally ranging from 180 to 550 metres, although the majority of the stock is found in Div. 3L. Temperature, salinity, depth and substratum determine the distribution pattern and abundance of this species, (Allen, 1959). This species is found in areas with temperatures generally ranging from 3°C to 8°C (Rasmussen, 1965).

Most of the scientific literature on the northern shrimp in the NAFO Regulatory Area corresponds to Div. 3M, where the most important fishery is conducted (Skuladottir *et al.*, 1999; Skuladottir, 2000; Bakanev, 2001; Nicolajsen and Brynjolfsson, 2001; Kristjansson, 2001; Skuladottir and Diaz, 2001; Casas *et al.*, 2004). Bibliography for shrimp from Div. 3N can be mainly found in works dealing with Div. 3NLO, (Orr *et al.*, 2002; Orr *et al.*, 2003; Colbourne and Orr, 2003).

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 0.5 and 9% of the total biomass in Div. 3LNO; over 82% of the biomass in Div. 3N is located beyond the 200-mile limit (Orr *et al.*, 2003). The biomass in Div. 3O accounts for less than 1% of the biomass in Div. 3LNO and only the 0.34% of the biomass in Div. 3O is beyond the 200-mile limit (Orr *et al.*, 2003).

The Vigo Centre of Instituto Español de Oceanografía is conducting research cruises since 1995 in the NAFO Regulatory Area in Div. 3NO beyond the 200 mile exclusive economic zone. 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 1995-2000, 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.*, 1993), used in those years.

During 2001 and 2002, 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. 28.8 kg.

From 2002 year a significant increase of the catches of northern shrimp was noted in Div. 3NO with catches bigger than 300 kg.

This work presents data on the geographical distribution in the NAFO Regulatory Area (Div. 3NO), on biomass, length frequencies, age structure and mean weight by length-class of catches of northern shrimp on Spanish bottom trawl survey 2004-2005.

### Materials and Methods

The 2004 and 2005 Spanish bottom trawl surveys were carried out from the 06<sup>th</sup> to 24<sup>th</sup> of June in 2004 and from 10<sup>th</sup> to 29<sup>th</sup> of June in 2005, following set guidelines previously established for the series of I.E.O. research surveys (Walsh *et al.*, 2001). These surveys took place in Div. 3NO, with a total of 122 and 121 valid hauls respectively, ranging depths between 40 and 1 400 m approximately.

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 endopodite of the first pleopod (Rasmussen, 1953). Following this criterion, individuals that were in the middle of a sex change were considered as males. 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 -OCL- (Shumway *et al.*, 1985). Such measurements were made to the lower half millimetre using electronic callipers.

Samples were taken from 21 hauls in 2004 and 19 hauls in 2005. Depths of the sampled hauls varied from 226-480 m. in 2004 and 300-500 in 2005. Data were used to obtain an estimate of the lengths distributions in the prospected area.

Furthermore, in 2005 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 1 802 individuals were selected, dried and weighed with a precision of 0.1g to calculate the length-weight relationship.

### Results and Discussion

The Table 1 shows the catches, biomass and standard errors estimated by swept area method of northern shrimp from the multi-species surveys, carried out by IEO Vigo, in the NAFO Div. 3NO in late spring from 1995-2005. In the year 2002 an abrupt increase with respect to earlier years occurred, 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 was confirmed, in terms of the period 1995-2001 and the catch levels are now close to those obtained in 2002 (Fig. 1).

The distribution of northern shrimp catches in the Spanish trawl survey 2004 and 2005 are shown in Fig. 2. The main catches in Div. 3NO were located to the Northeast of Div. 3N, in latitudes higher than 45°N, and in a small area on the central part of the bank with latitudes close to 43°30'N, and depths ranging between 200 and 500 meters.

Table 2 shows the shrimp biomass by depth strata as percentage of total biomass, from 2001 to 2005 surveys. In the last two years 2004-2005 a considerable amount of catches (>65%) were concentrated at depths between 200-300 fath. (367-550 m). Although it is considered that the shrimp Div. 3LNO stock is distributed along the entire edge of the grand banks, at depths generally ranging from 100 to 300 fathoms (180-550 m), the depth of the bulk of biomass in Div. 3NO has increased in the last years from lesser than 100 fath. in 2001 (68%) to depths greater than 200 fath. in 2004 and 2005 (74% and 66%, respectively).

The length distribution by sex and maturity stage estimated in the 2004 and 2005 are presented in table 3 and figure 3. Although the range of their length distributions where did not suffer important changes: male ranging between 11 and 24 mm; immature females between 19.5 and 26 mm and multiparous females between 21 and 28 mm., there was important differences between the two years. In the year 2005 the abundance decreased about 50%. This was mainly due to the fall in male abundance and the absence of the first modal group (around 13 mm), well defined in 2004.

A modal size analysis programme could not be used due the low number of sampled individuals. However according to the pattern showed in the length distribution of the last two years and observations made in adjacent waters (Nicolajsen, 2001; Skuladottir, 2001; Skuladottir and Diaz, 2001; Orr *et al.*, 2002; Orr *et al.*, 2003) a rough age-length key could be established.

Aged (years)	OCL (mm.)
0	<7.5
1	7.5-11.0
2	11.5-15.0
3	15.5-17.5
4	18.0-22.0
5	22.5-24.5
6	24.5-25.5
7	>25.5

According to the enclosed age-length key, in 2004 the males show three modal groups with lengths around 12.5 mm (age 2), 16.5 mm (age 3) and 21.0 mm (age 4). The sex change occurs at age 4 and the females both immature and mature females appear only represented by one modal group where several age groups are mixed: the immature females with lengths around 23.5 mm. and 5 year olds and mature females with more than one age group (age 5-7) and lengths mainly bigger than 23 mm. In 2005 the pattern was roughly similar with the exception of the absence of the first modal group.

The Table 4 and Fig. 4 shows the length-weight relationship estimated in 2005 survey by sex and maturity stage as well the parameters of the relationship, number of specimens sampled and determination coefficient  $R^2$ .

### References

Allen, J. A. 1959. On the biology of *Pandalus borealis* Krøyer, with reference to a population off the Northumberland coast. *J. Mar. Biol. Assoc. U. K.*, 38: 189-220.

- Bakanev, S. V. 2001. Russian Fishery for Northern Shrimp (*Pandalus borealis*) on Flemish Cap Bank, NAFO Division 3M and Grand Bank, Division 3L, in 2000 and January-September 2001. *NAFO SCR Doc.*, No. 184, Serial No. N4574, 9 p.
- Casas, J. M., J. L. del Rio, and D. González Troncoso. 2004. Northern Shrimp (*Pandalus borealis*) on Flemish Cap surveys 2003 and 2004. *NAFO SCR Doc.*, No. 77, Serial No. N5047, 25 p.
- Colbourne, E. B., and D. C. Orr. 2002. The Distribution and Abundance of Northern Shrimp (*Pandalus borealis*) in relation to bottom temperatures in NAFO Divisions 3LNO Based on Multi-Species Surveys from 1995-2002. *NAFO SCR Doc.*, No. 153, Serial No. N4782, 14 p.
- Colbourne, E. B., and D.C. Orr. 2002. The Distribution and Abundance of Northern Shrimp (*Pandalus borealis*) in relation to bottom temperatures in NAFO Divisions 3LNO based on Multi-Species Surveys from 1995-2003. *NAFO SCR Doc.*, No. 81, Serial No. N4922, 18 p.
- 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, 11 p.
- Kristjansson, J. 2001a. Short-time variation in Catch-per-Unit-Effort (CPUE) of Shrimp (*Pandalus borealis*) at the Flemish Cap. *NAFO SCR Doc.*, No. 170, Serial No. N4515, 4 p.
- Kristjansson, J. 2001b. Changes in Population Structure of the Shrimp (*Pandalus borealis*) Stock at Flemish Cap, 1995-2000. *NAFO SCR Doc.* 01/171, Serial No. N4516, 5 p.
- McRay, J. A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. *J. Fish. Res. Board. Can.*, **28**: 98-100.
- Patrocinio T., P. Díaz, and X. Paz. 2004. Northern Shrimp (*Pandalus borealis*, Krøyer) in Spanish Bottom Trawl Survey 2003 in NAFO Divisions 3LNO. *NAFO SCR Doc.*, No. 79, Serial No. N5049, 16 p.
- Orr, D. C., P. Veitch, and D. Sullivan. 2002. Information pertaining to the distribution of Northern Shrimp (*Pandalus borealis*, Krøyer) in NAFO Divisions 3LNO. *NAFO SCR Doc.*, No. 61, Serial No. N4673, 72 p.
- Orr, D. C., P. Veitch, and D. Sullivan. 2002. An Update of Information Pertaining to Northern Shrimp (*Pandalus borealis*, Krøyer) and Groundfish in NAFO Divisions 3LNO. *NAFO SCR Doc.*, No. 160, Serial No. N4789, 54 p.
- Orr, D. C., P. Veitch, and D. Sullivan. 2003. An Update of Information Pertaining to Northern Shrimp (*Pandalus borealis*, Krøyer) and Groundfish in NAFO Divisions 3LNO. *NAFO SCR Doc.*, No. 82, Serial No. N4924, 51 p.
- Paz, J., J. M. Casas, and G. Perez –Gandaras. 1993. The feeding of cod (*Gadus morhua* L) on Flemish Cap, 1989-90. *NAFO Sci. Coun. Studies*, 19:41-50.
- 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.
- Rasmussen, B. 1965. The fishery for deep sea prawn in Norway. *In: Proceedings of the Symposium on Crustacea*, p. 1437-1441. Symposium Series 2, Marine Biological Association of India.
- 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.
- Skuladottir, U., D. G. Parsons, and D. Orr 1999. The International Fishery for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap), 1993-1999. *NAFO SCR Doc.*, No. 112, Serial No. N4192, 21 p.

- Skuladóttir, U. 2000. The Icelandic shrimp fishery (*Pandalus borealis*, Kr.) at Flemish Cap in 1993-2000. *NAFO SCR Doc.*, No. 74, Serial No. N4331, 34 p.
- Skuladóttir, U., and P. Díaz. 2001. Age assessment of northern shrimp (*Pandalus borealis*) in EU surveys on Flemish Cap in 1988-2001. *NAFO SCR Doc.*, No. 01/189, Serial No. N4579, 8 p.
- Nicolajsen, A, and S. Brynjolfsson. 2001. Young northern shrimp (*Pandalus borealis*) index for Flemish Cap (Division 3M), 1998-2001. *NAFO SCR Doc.*, No. 187, Serial No. N4577. 7p.
- Vázquez, A. 2002. Catchability comparison between Lofoten and Campelen gears. *NAFO SCR. Doc.* 02/74. 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, standard error and catches (kg.) on Spanish bottom trawl survey in NAFO Div. 3NO, 1995-2003.

Year	Biomass (tons)	Std. err.	Catch (kg.)
1995 <sup>1</sup>	14	1.9	5
1996 <sup>1</sup>	18	2.0	2
1997 <sup>1</sup>	1	0.1	0
1998 <sup>1</sup>	23	1.6	5
1999 <sup>1</sup>	80	3.5	13
2000 <sup>1</sup>	26	0.8	6
2001 <sup>2</sup>	178	9.2	29
2002 <sup>2</sup>	2043	78.7	408
2003 <sup>2</sup>	1618	69.2	325
2004 <sup>2</sup>	2654	163.7	550
2005 <sup>2</sup>	1627	57.1	368

<sup>1</sup> Pedreira codend 35 mm. mesh size.

<sup>2</sup> Campelen codend 20 mm. mesh size.

**Table 2.** Northern shrimp biomass by strata (as percentage % of total biomass) on Spanish bottom trawl survey 2001-2005 in NAFO Div. 3NO.

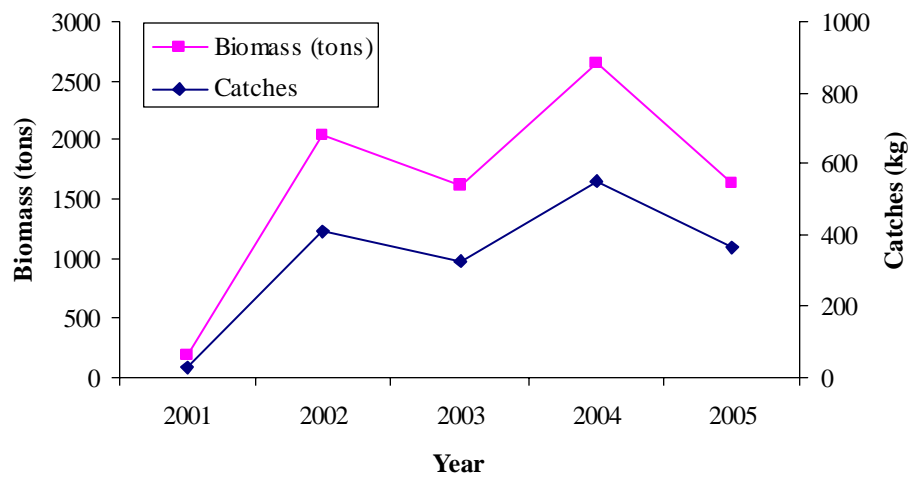
Depth strata (fath.)	2001	2002	2003	2004	2005
0-30	2.7%		0.0%		0.0%
31-50	15.0%	0.1%	0.2%	0.0%	
51-100	52.9%	5.7%	0.2%	0.3%	0.3%
101-150	18.5%	37.6%	2.7%	9.1%	2.7%
151-200	7.5%	53.2%	85.2%	16.7%	30.6%
201-300	1.8%	2.2%	11.6%	73.8%	66.3%
301-400	1.6%	0.4%	0.1%	0.1%	0.0%
401-500	0.0%	0.0%	0.0%	0.0%	0.1%
501-600		0.0%			0.0%
601-700		0.8%	0.0%	0.0%	0.0%
701-800		0.0%	0.0%	0.0%	0.0%
Total Biomass (tons)	178	2043	1618	2654	1627

**Table 3.** Northern shrimp size distribution ('000) by sex and maturity stage in Spanish bottom trawl survey 2004 and 2005 in NAFO Div. 3NO.

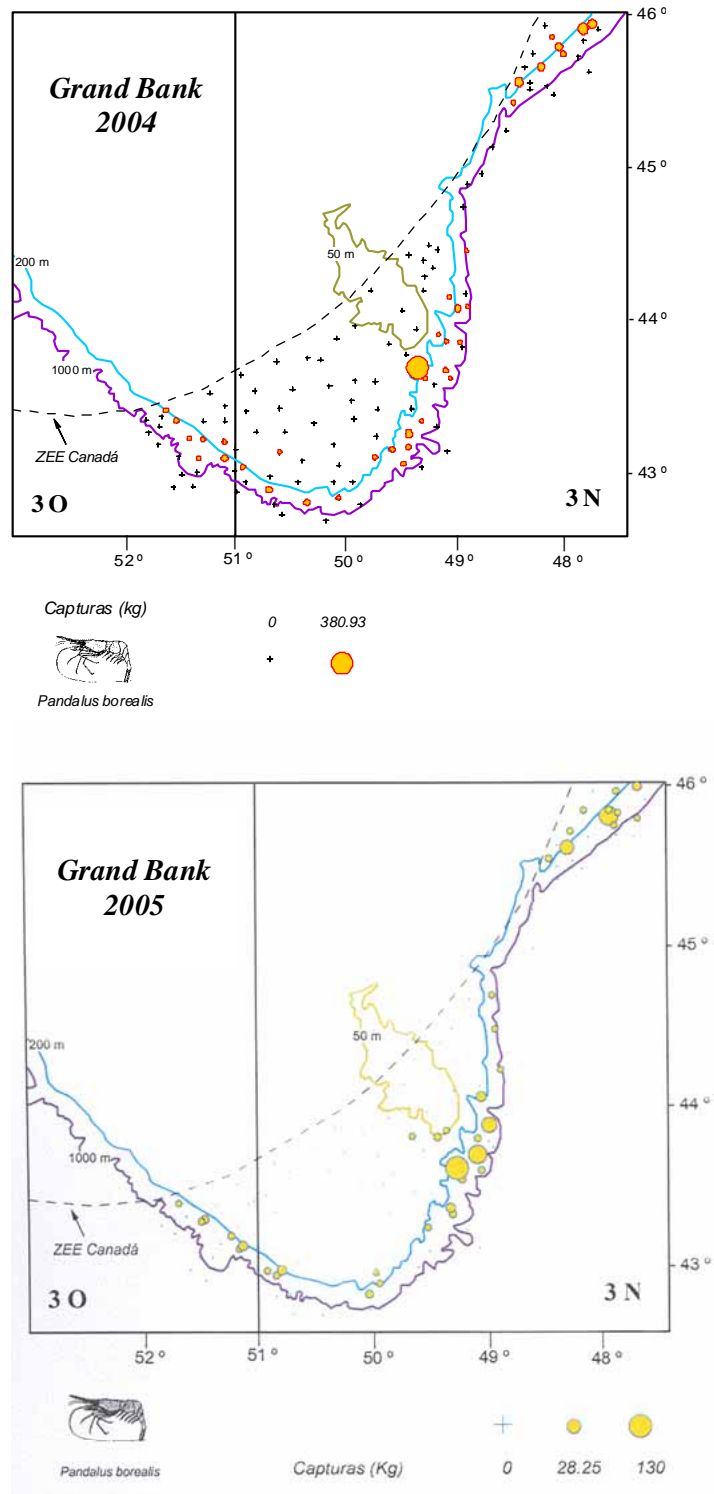
OCL(mm)	2004				2005				
	Males	Inmat. female	Mat. females	Total	Males	Inmat. female	Mat. females	Ovig.	Total
8									
8.5									
9	7			7					
9.5									
10									
10.5	7			7					
11	838			838	15				15
11.5	893			893	31				31
12	1992			1992	55				55
12.5	14383			14383	172				172
13	10963			10963	345				345
13.5	13750			13750	521				521
14	11905			11905	550				550
14.5	5965			5965	1228				1228
15	6628			6628	1417				1417
15.5	4768			4768	1834				1834
16	5220			5220	2820				2820
16.5	10371			10371	5493				5493
17	6282			6282	5653				5653
17.5	8159			8159	5943				5943
18	4269	87		4356	5620				5620
18.5	6389	87		6477	4419	4			4424
19	7496	50	87	7634	5526		62		5588
19.5	10917	826		11744	4327	63			4390
20	11615	471		12086	8886	56			8942
20.5	14653	1657	103	16414	6756	721	24		7500
21	21815	3028	392	25235	8326	2623	11		10959
21.5	12911	8218	267	21396	5126	2345	326	3	7800
22	18826	14160	2097	35082	4551	6737	428		11715
22.5	11365	19087	2883	33336	1986	13372	1256		16615
23	2615	23517	5560	31691	1497	19313	2421		23231
23.5	1707	32441	9578	43726	210	16527	4138		20876
24	6	23966	9299	33271	312	13926	5267		19505
24.5		17418	13224	30642	4	16294	9353		25651
25	33	7440	7336	14809		7640	8130		15770
25.5		4315	4523	8838		2128	9693		11821
26		790	1373	2162		1504	4454		5958
26.5	43	776	2573	3391		543	2898		3441
27			20	20			1033		1033
27.5			864	864			436		436
28							308		308
Total	226790	158333	60178	445302	83624	103797	50236	3	237661
	50.9%	35.6%	13.5%	2	35.2%	43.7%	21.1%	0.0%	

**Table 4.** Northern shrimp length-weight relationship by sex and combined from Spanish bottom trawl survey 2005 in NAFO Div. 3NO.

	a	b	$R^2$	N
Males	0.0016	2.6865	0.93	679
Inmature females	0.0011	2.8013	0.78	646
Mature females	0.0011	2.7999	0.74	477
All combined	0.0012	2.7893	0.96	1802

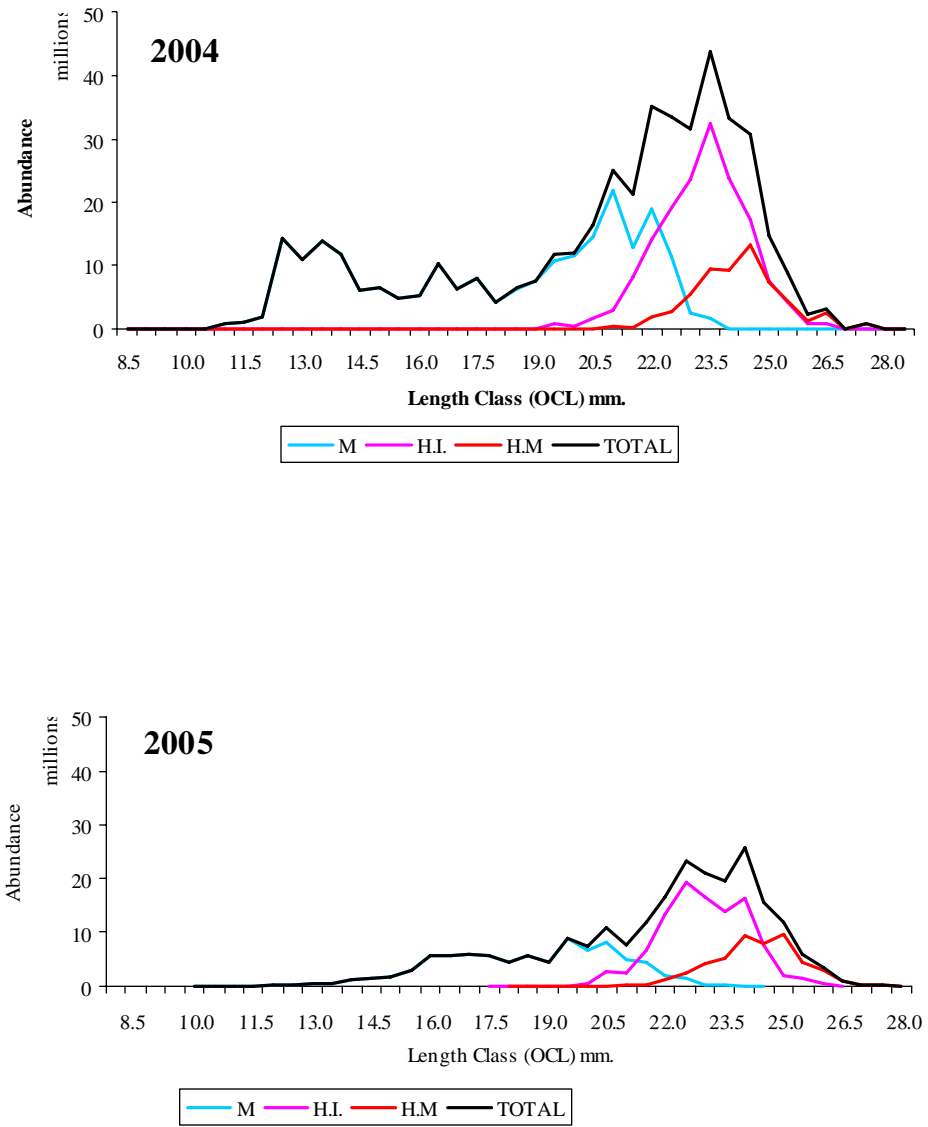


**Fig. 1.** Northern shrimp biomass (tons) and catch (kg) on Spanish research surveys in NAFO Div. 3NO 2001-2005



**Fig. 2.** Geographic distribution of Northern shrimp catches on Spanish bottom trawl surveys 2004 and 2005.





**Fig. 3.** Northern shrimp size distribution, by sex and maturity stage on Spanish bottom trawl survey 2004 and 2005 in Div. 3NO.

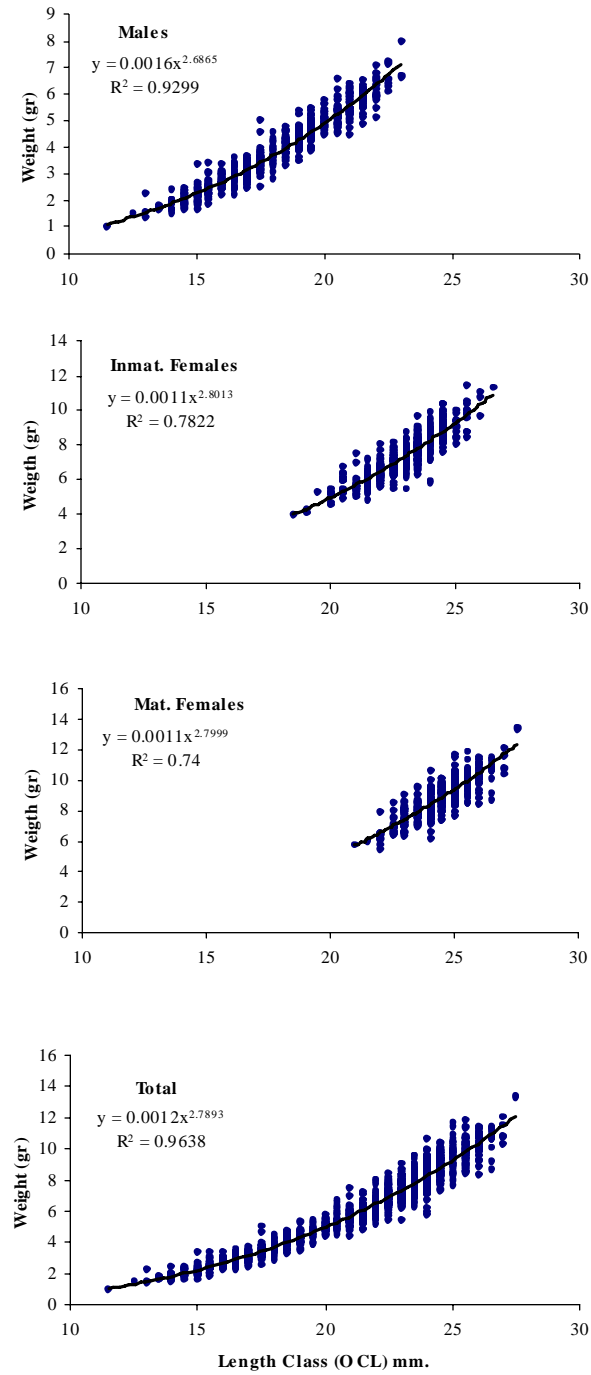


Fig. 4. Northern shrimp Length-weight relationship on Spanish bottom trawl survey 2005 in Div. 3NO.