Effects of electro-fishing on galvano-taxis and carcass quality characteristics in sea bass (Dicentrarchus labrax)

Edo D'Agaro, Antonella Stravisi

Dipartimento di Scienze Animali, Università di Udine, Italy

Corresponding author: Edo D'Agaro. Dipartimento di Scienze Animali, Università di Udine. Via s. Mauro 2, Pagnacco (UD), Italy - Tel. +39 0432 650110 - Fax: +39 0432 660614 - Email: edo.dagaro@uniud.it

ABSTRACT - The aim of this study was to investigate the effects of electro-fishing in sea water. We evaluated the feasibility of an electro-fishing system using numerical simulations for laboratory tanks and the open sea and performing a laboratory experiment. A non-homogeneous bi-dimensional electric-field model for marine water and fish based on discrete formulation of electro-magnetic field equations was developed using GAME (geometric approach for Maxwell equations) software. Voltage gradients inside the fish and close to the body were determined. Results showed that fish in the open sea and in groups had greater internal voltage differences than did fish in tanks and single fish. Sea bass (length:10 and 30 cm) were exposed in laboratory tanks to pulsed direct current (PDC), 25-125 Hz and duty cycle (5-40%). We measured the electro-taxis and tetanus thresholds after electrical exposure. It is significant that these values decreased with increasing the size of fish. No differences were found after electro-fishing on overall appearance, internal and external haemorrhage, standard freshness scoring techniques and carcass quality characteristics

Key words: Elecro-fishing, Sea water, Quality, Sea bass.

Introduction - Electric fishing is widely used to monitor freshwater species without harmful effects (Bahlin *et al.,* 1989). The principle of electric fishing is based on the introduction of an electric potential gradient in water between one or more cathodes and one anode. Continuous current (*DC*), alternating current (*AC*) or pulsed current (*PDC*) are used, depending on environmental conditions (conductivity and temperature) and the fish to be sampled (species and size). The various types of current differ in their effects on fish. Only *DC* and *PDC* induce galvano-taxis in fish, i.e., active movement of fish towards the anode. The fish swims towards the anode because of muscle contractions induced by the electric impulses (electro-taxis) until tetanus occurs (Beaumont *et al.*, 2002). Understanding the effects of electric fields on fish health and carcass quality characteristics is important for an efficient electro-fishing and for avoiding injuries induced by this method (Henry and Grizzle, 2006; Roh *et al.*, 2006). The aim of this study was to evaluate the feasibility of electric fishing in the tanks and open sea by using numerical simulations and a laboratory experiments. This method could improve the efficacy and selectivity of fishing, which currently involves light attraction and net capture.

Material and methods - Electric field simulations were conducted using a bi-dimensional, non-homogenous electric system for fish in seawater, which was developed specifically for this purpose. The model calculates the head–tail potential difference of fish and the mean electric field in both fish and water for a given electrode geometry. The output values of the model are: electrode current density (*I),* µA/cm²; fish head–tail voltage gradient, V/m; mean voltage gradient (*E*) inside the fish (V/m) and in the surrounding water (V/m) and values for arbitrary sampling points (mean voltage gradient (*E*), V/m and current density (*J*), A/m²). In the Gulf of Trieste (Northern Adriatic Sea), the

average monthly salinity ranges from 32.29 to 38.12 psu and the temperature ranges from 6.60 to 24.20°C (Stravisi, 1983; Stravisi, 1986). In this study, we used ranges of 30–40 psu for salinity and 6–25°C for temperature. Numerical simulations were carried out for water conductivity of 3.0, 4.0, 5.0 and 6.0 S/m. The laboratory experiment was carried out at the Animal Science Department using sea bass of 10 and 30 cm of length. Electric fields (PDC) were generated by a specifically designed equipment. The apparatus provided PDC waves with frequencies of 25, 75 and 125 Hz. The duty cycle for each frequency was set to 5, 20 and 40%. The exposure chambers were plastic troughs (30x100x30 cm deep). Electrodes were steel plates separated by 100 cm. After electric exposure five fish for each treatment were analysed for colour, rigor mortis, texture shear force, pH, cooking loss, overall appearance (QIM), internal and external haemorrhage.

Results and conclusions - The results of simulations of electric fields for fish reared in a tank are presented in Table 1. In these simulations, a specific voltage was applied at the electrodes to produce voltage gradients identical to those obtained in simulations of open sea conditions without fish. As for the open sea, the mean current density inside the tank fish was greater than in the water close to the fish one, and internal voltage differences for groups of fish were greater than of single fish ones.
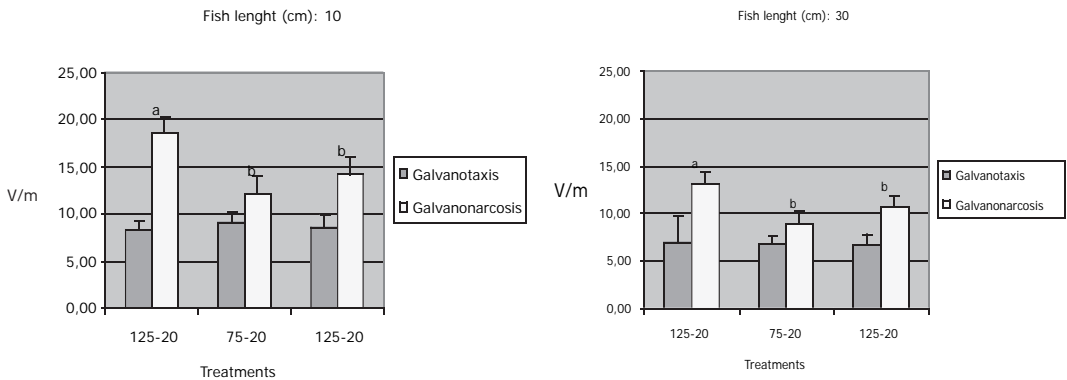
Table 1. Numerical simulations in a tank using different fish configurations. Values of first column (E water) were obtained from the open sea simulations without fish.

E water V/m	Voltage V	N. of fish	Length m	Water Conductivity S/m	Current density A	Head /Tail gradient V	E_{mean} int V/m	$E_{mean—}$ est V/m
15.1	36.24	1	0.10	3	19.10	1.76	18.05	17.11
				6	38.20	1.76	18.06	17.11
			0.30	3	18.89	5.34	18.25	17.40
				6	37.79	5.34	18.26	17.41
		30	0.10	3	17.59	1.18	44.29	15.62
				6	35.15	1.18	44.56	15.66
13.3	31.92	1	0.10	3	16.82	1.55	15.90	15.07
				6	33.65	1.55	15.90	15.07
			0.30	3	16.64	4.70	16.07	15.33
				6	33.28	4.70	16.08	15.33
		30	0.10	3	15.49	1.04	39.01	13.76
				6	30.96	1.04	39.25	13.79
9.4	22.56	1	0.10	3	11.89	1.09	11.24	10.65
				6	23.78	1.09	11.24	10.65
			0.30	3	11.76	3.32	11.36	10.83
				6	23.53	3.33	11.36	10.84
		30	0.10	3	10.95	0.74	27.57	9.72
				6	21.88	0.74	27.74	9.75

Experimental results of sea bass after exposure to elecro-fishing in laboratory tanks are presented in Figure 1 and 2. These figures illustrate differences in terms of galvano-taxis and tetanus threshold values in fish of two sizes (10 and 30 cm). Tetanus threshold values decreased significantly (P<0.05) for higher frequencies in both sizes while galvano-taxis was not influenced by treatments. It is worth noting that these values decreased with increasing the size of fish. All fish were immobilized during the electrical exposure and they recovered opercular movements and swimming ability within 5 min.

Results of electro-fishing exposure on carcass quality characteristics are reported in Table 2. No carcass quality problems were identified in any of the fish from either treatment group. Fish were inspected for haemorrhage in the skin, external damage, internal haemorrhaging, blood spotting and damage of the spine. No differences were found after electrofishing on carcass quality characteristics (QIM, colour, shear force, rigor mortis).

Figure 1-2. Electric-induced galvano-taxis and tetanus of sea bass after electro-fishing (frequency:25-75-125; duty cycle: 20) exposure.

a, b<P<0.05.

Table 2. Results of electro-fishing exposure on carcass quality characteristics.

	Treatments									
	25-5	25-20	25-40	75-5	75-20	75-40	125-5	125-20	125-40	Rse df 18
pH	6.4	6.1	6.4	6.1	6.4	6.2	6.1	6.2	6.3	0.19
Colour:										
L*	34.8	36.4	35.5	36.5	36.1	36.1	35.5	35.8	36.0	2.65
a*	-1.9	-1.6	-1.7	-2.7	-1.5	-1.5	-1.5	-2.5	-1.8	0.16
b*	6.0	7.6	6.3	5.4	5.1	5.1	6.4	6.1	6.5	1.74
Croma	6.3	7.8	7.3	6.7	5.3	5.3	6.6	6	6.7	1.63
Hue angle	107.3	102.2	109.6	107.4	106.9	106.9	105.1	109.8	106.2	15.98
Cooking yield (%)	98.76	98.00	97.96	98.62	99.02	98.93	97.66	97.78	98.10	0.96
Maximum force (N)	9.0	8.5	8.7	9.2	8.3	7.5	8.5	8.9	9.0	4.34
Total amount of work (J)	0.125	0.095	0.122	0.104	0.090	0.088	0.103	0.100	0.101	0.0001

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