CONTRIBUTION TO THE INVESTIGATIONS ON THE OSMOREGULATION IN FISH EGGS.*

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SIX TEXT FIGURES

Some studies were made so as to understand the fate of some marine organisms that inhabit bodies of water, both very saline and brackish as it is between the North sea and the Baltic sea which have given rise to several physiological problems.

The physical properties studied were the specific gravity and diameter changes taking place on some fish egg species most common in the Baltic sea and the North sea. The spawning season of the species studied takes place from December (November) to July (August) of each year. The spawning period for each species lasts from 2 to 4 months, some of them overlapping each other.

Number of eggs of the different species in which the specific gravity and the diameter were examined:

Species	In original salinity determination		In different salinities determination	
	Specific gravity	Diameter	Specific gravity	Diameter
cod	279	1,603	375	562
onos	478	432	417	93
dab	208	185	142	74
plaice	63	89	62	27
flounder	21	22	20	----
mackerel	173	149	108	21
sprat	89	106	41	----

(By "original salinity" is meant, where the eggs themselves were fished (about 20 meters deep) by plankton egg net and "different salinity", when the eggs were transferred for definite length of time to other salinities except where they were originally found).

* A summary of the Thesis "Untersuchungen ueber die Osmoregulation pelagischer und demersaler Fischeier" performed and submitted at the Institute of Oceanography (Inst. f. Meereskunde) of the Christian Albrechts University in Kiel, Germany, in partial fulfillment of the degree of Doctor of Natural Science. The whole paper will be published in one of the European Journals.

Considering the chemical changes following the physiological behavior of the eggs the water, sodium, potassium, chloride and phosphorous contents and their changes with changing salinities of environment were examined. In this investigation not only pelagic eggs were investigated but also demersal marine and fresh water species. Like those in the examination of the physical characteristics the eggs were differentiated not only as to species but also according to the stage of embryonal development in the eggs and all investigations were performed at definite temperature.

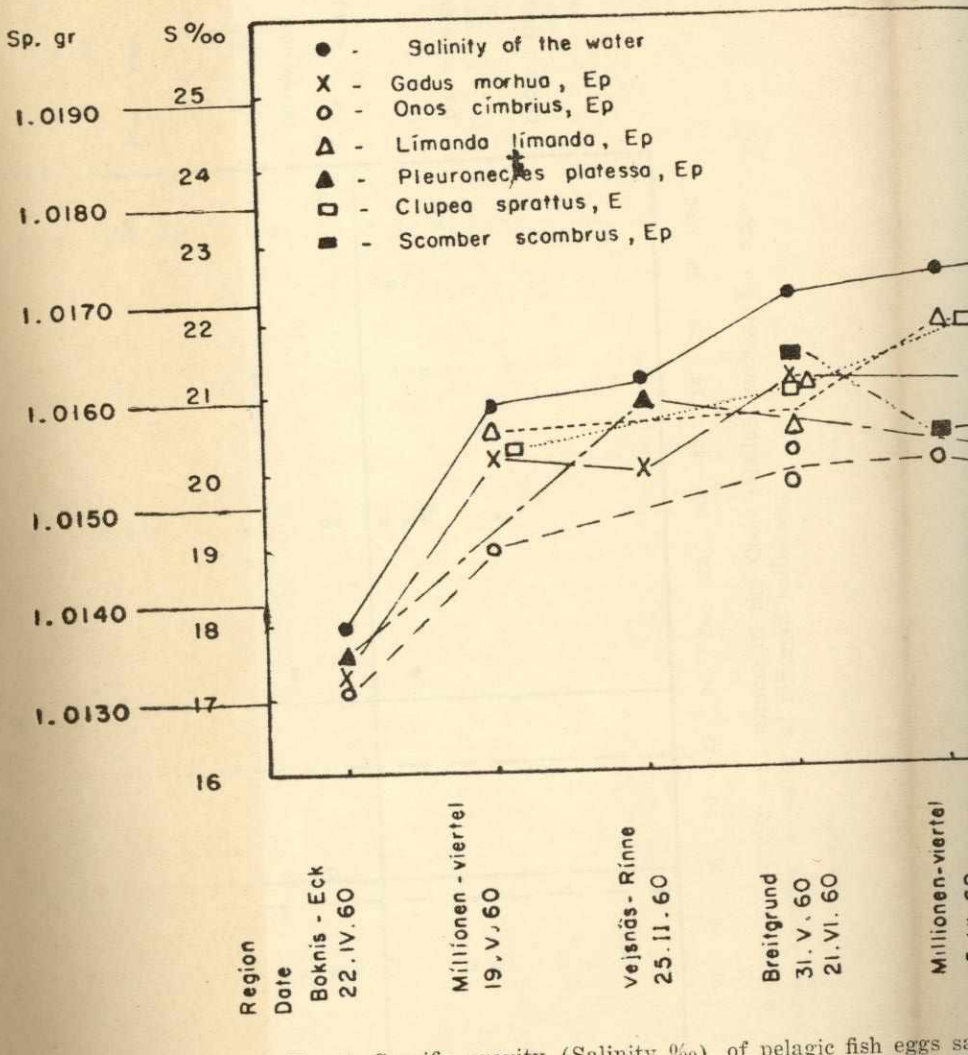
Number of analysis made:

Species	H_2O, Na, K, P, and ash	Chloride
cod:		
ovarian	12	12
fertilized	113	109
unfertilized	41	30
dab:		
fertilized	17	20
flounder:		
fertilized	16	9
cottus:		
ovarian	23	16
fertilized	75	72
pike:		
ovarian	4	4
fertilized	15	17
unfertilized	19	19

Sodium and potassium were analyzed by the Flamephotometric method, chloride, by the micrometric method of Rehberg and phosphorous, by colorimetric method using a spectral photometer.

Pelagic fish eggs of the different species vary in their specific gravity not only between species but also within the same species and even among individuals. According to the specific gravities, the fish eggs examined may be grouped into light, intermediate and heavy eggs. Under light eggs are seequabbe and plaice; intermediate: mackerel, cod and sprat; and heavy eggs: flounder followed by dab.

Specific gravity is related to some degree to the salinity of the surrounding water, (fig. 1) which may differ from the latter by minus 1 per cent to 3 per cent. The salinity of the water affects the specific gravity, volume and even the ion concentration of the eggs very early in its development or formation. This effect could already be traced from the ovarian eggs of



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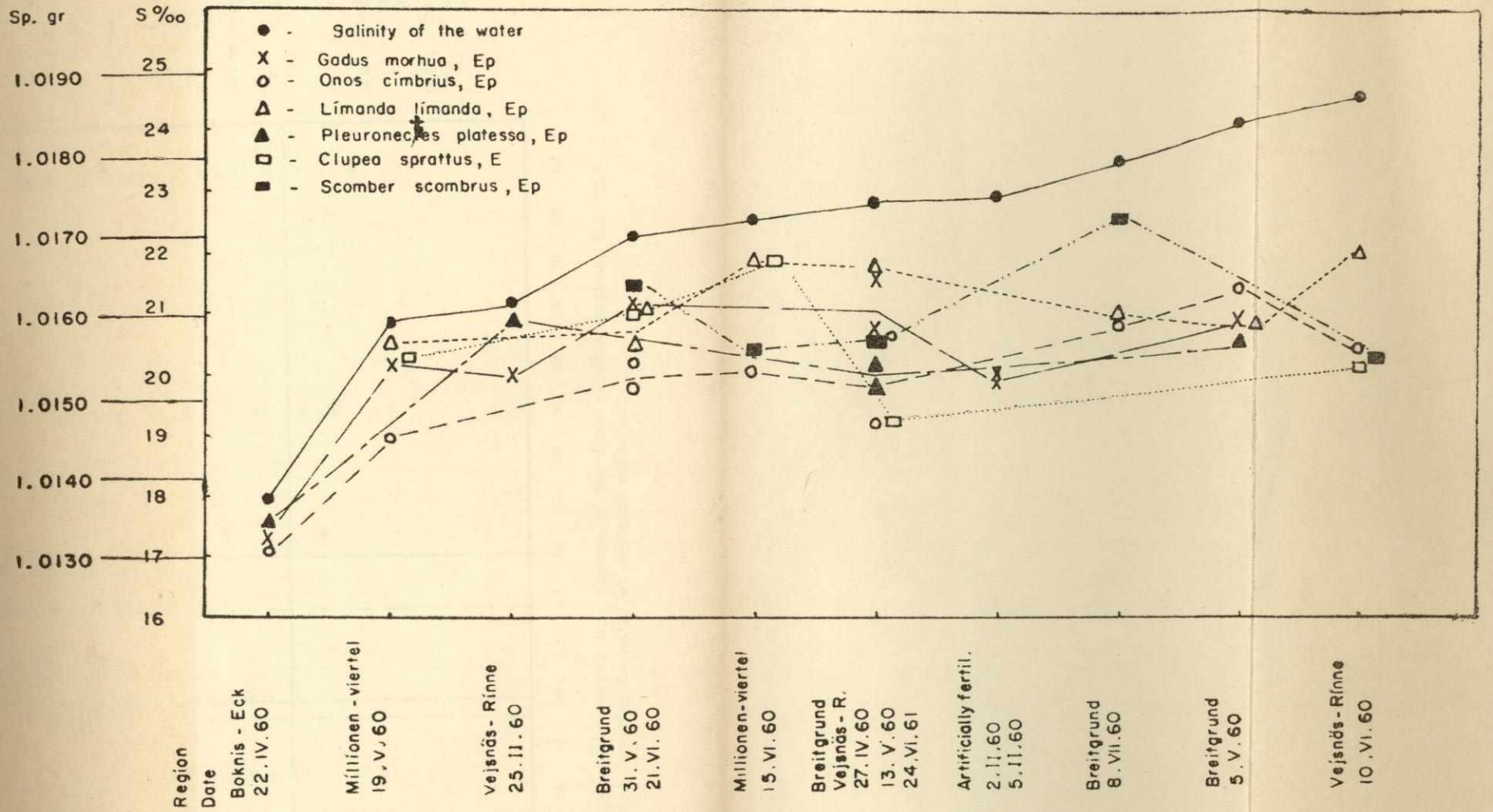
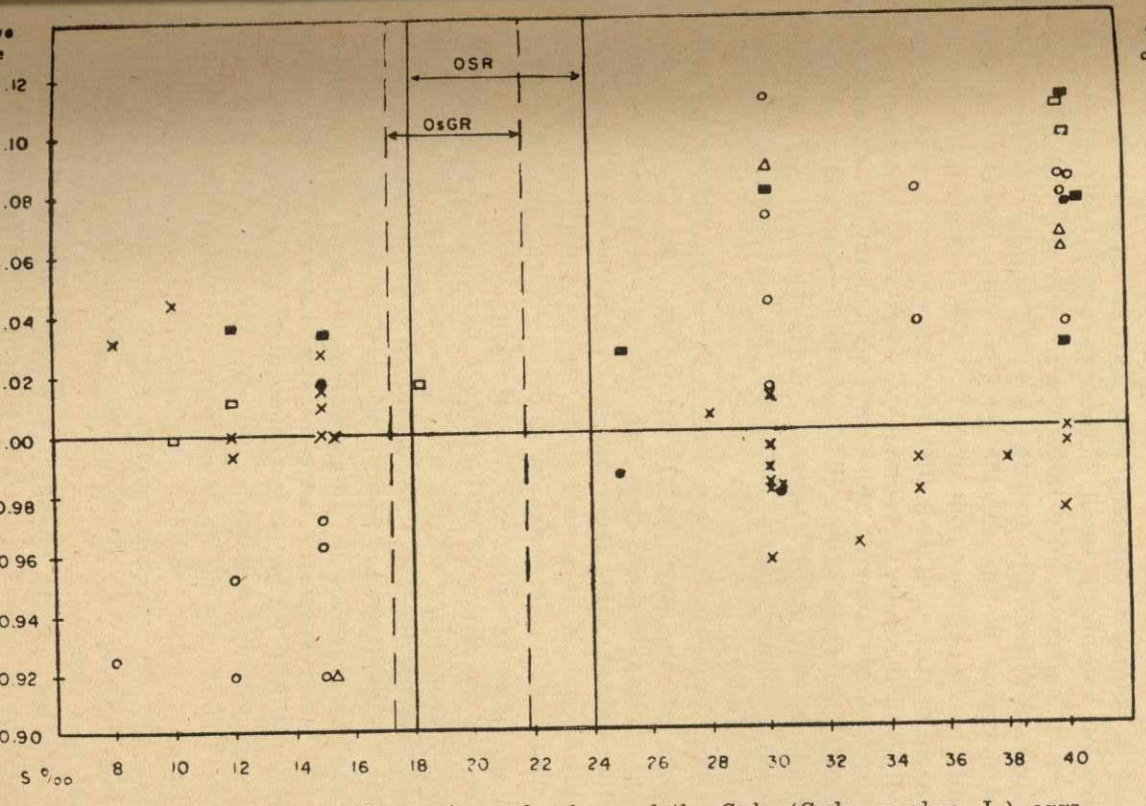


FIG. 1. Specific gravity (Salinity ‰) of pelagic fish eggs sampled from several localities with varied water salinities.



—Average changes in the specific gravity and volume of the Code (Gadus morhua, L.) eggs following transfer to water of different salinities:

characteristics are lower to certain limits and on the other hand those living in more saline water have eggs which also have somewhat higher percentage of these traits, (Fig. 5).

In spite of this the specific gravity of the eggs and also the other characteristics after laying are not fixed. They vary still to a limited degree, with the stage of development of the egg and with the change of salinity of the surrounding. In relatively low salinity there is lowering of the specific gravity, increase in volume (diameter) (Fig. 2), and lowering of ion concentration and also a small increase in water content, and the reverse in higher salinity takes place. The different egg species behave differently, such as, seequabbe eggs which do not show lowering of the specific gravity with reduction of the salinity by 10 per cent, but upon transfer to higher salinity of the same degree as stated, they produce an increase in specific gravity and decrease in volume; cod eggs react almost symmetrically towards transfer to low and high salinities; sprat could tolerate to a certain extent, like seequabbe, reduction of salinity without showing much changes. Mackerel could well tolerate increase in salinity, just as the above species behave with lowering of salinity.

Critical stages in the egg's life are the stage during the early cleavage and the stage shortly before hatching. It seems that at these points or stage, eggs react very poorly towards changes in environment, aside from the environment where they were. It may be said that at this stage the eggs could not properly exercise their osmoregulatoric function, which at other intermediate stages could excellently be performed.

The ripe ovarian eggs of the pelagic type have large quantities of water from about 93 per cent to 95 per cent. Those of the non-pelagic marine type have about 80 per cent and the fresh water species have only approximately 70 per cent, (Fig. 3).

The initial increase of water content and ions after laying of the salt water species is large in comparison to the succeeding stages. Within 24 hours in the medium, the water content in the eggs remains constant, and the ions, also, to a certain degree. Then, during the stage before hatching, there is slight increase in water, sodium and potassium also to a limited extent, but the chloride remains either constant or decreases slightly, (Table 1). At this stage no change of salinity of water was made.

The water content changes only minimally with change of

TABLE 1.—*Water content and ion concentration of the Cottus Bubalis eggs of different stages of development in water of 15°/00 Salinity*

Egg stage	Number of analysis	% Water	In % Fresh weight					In dry weight		
			K	Na	P	Cl	Ash	K	Na	P
Ovarian	10	78.68 ± .30	0.151 ± .003	0.175 ± .004	0.129 ± .003	0.406 ± .016	0.79 ± .020	0.708 ± .017	0.821 ± .018	0.604 ± .013
1 hour	7	79.99 ± .19	0.155 ± .005	0.184 ± .007	0.114 ± .008	0.585 ± .018	1.00 ± .034	0.773 ± .026	0.919 ± .035	0.572 ± .012
6 hours	7	80.75 ± .11	0.185 ± .005	0.225 ± .005	0.109 ± .002	0.599 ± .014	1.13 ± .044	0.961 ± .029	1.170 ± .037	0.564 ± .010
24 hours	9	80.34 ± .22	0.134 ± .003	0.253 ± .009	0.114 ± .002	0.658 ± .012	1.18 ± .036	0.682 ± .016	1.285 ± .038	0.578 ± .007
Spawn [1]	5	79.80 ± .40	0.139 ± .004	0.264 ± .012	0.130 ± .011	0.649 ± .017	1.25 ± .055	0.687 ± .010	1.275 ± .041	0.657 ± .019
Lp	2	81.40 ± .61	0.108 ± .009	0.234 ± .032	0.105 ± .008		1.24 ± .055	0.578 ± .029	1.260 ± .054	0.561 ± .019
Ea	3	81.92 ± .17	0.124 ± .003	0.371 ± .011	0.107 ± .005	0.568 ± .012	1.64 ± .039	0.685 ± .015	2.055 ± .079	0.591 ± .003
Ea [2]	1	82.02	0.119	0.457	0.109		1.45	0.661	2.541	0.606

[1] Egg spawned naturally in the water, so that the exact length of time of its stay in the medium is not known, possibly between 20–27 hours after laying.

[2] Ea stage eggs in which the heart beats of embryo is strong and very clearly seen.

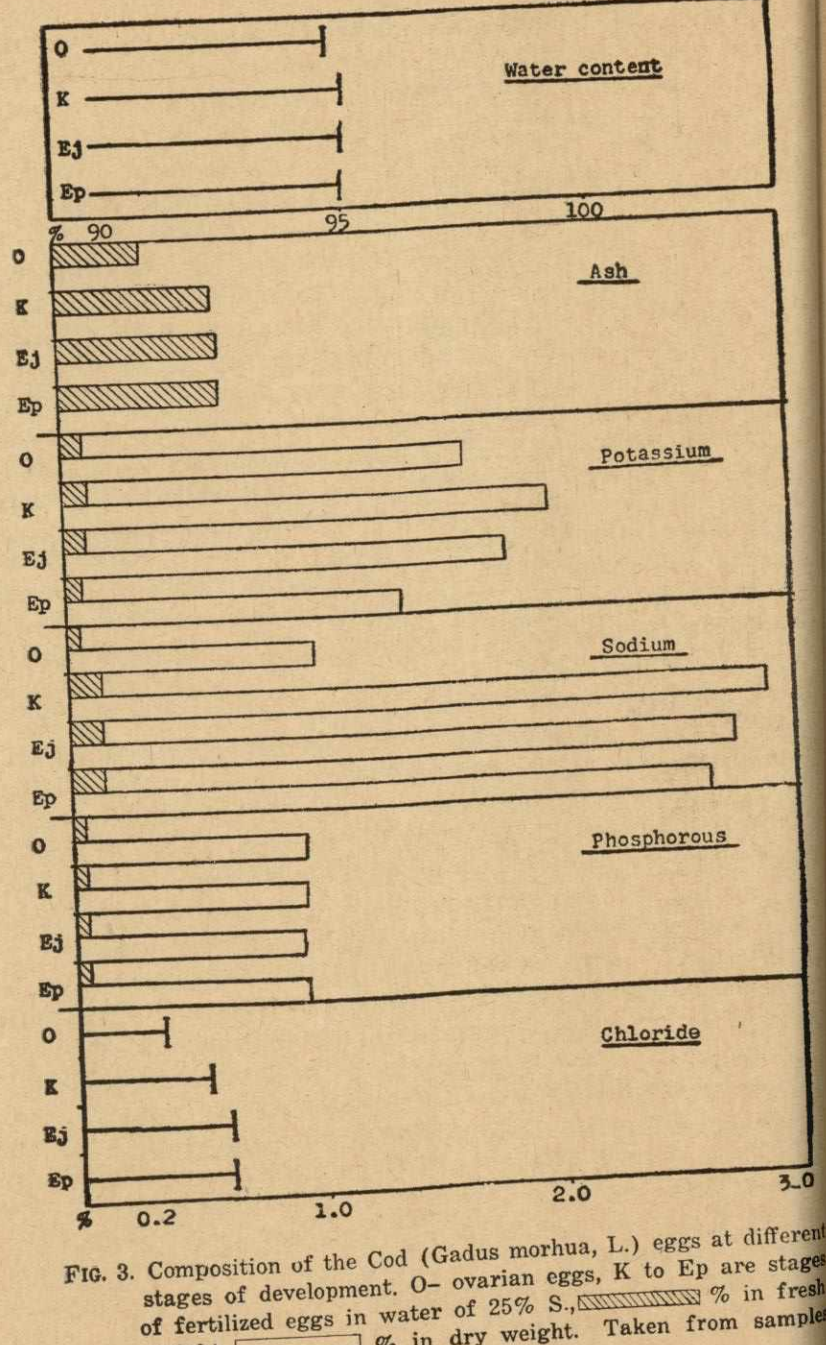


FIG. 3. Composition of the Cod (Gadus morhua, L.) eggs at different stages of development. O– ovarian eggs, K to Ep are stages of fertilized eggs in water of 25% S., ▨ % in fresh weight, □ % in dry weight. Taken from samples D–3,–3a,–4,–5 and –5a.

smaller degree potassium changes exceedingly during all stages accompanying change of salinity (Fig. 4). The changes found for the ions were all significant changes.

The salinity of the water where the fish, (*Cottus bubalis*), is cultured affects the properties of the eggs to be laid. In relatively low salinity the ripe ovarian eggs have higher precentage of water and in relatively saline water, smaller and the ions vary more or less in the reverse way, (Fig. 5). The chloride content in the three different salinities, 5, 15 and 30 parts per thousand differ significantly. In the 15 and 30 parts per thousand bracket, the concentration of ion sodium does not vary significantly. In 5 parts per thousand the variation is significant. This is also true with potassium. Whether the fish lived or were cultured in low or highly saline waters, the eggs upon contact with the medium shows increase water content in the cell and sudden changes in ion content occur (Fig. 6).

The fresh water pike eggs exhibited an impermeable stage during development of the embryo. After the first initial increase of water after laying and very minimal decrease in some of the ions, the concentration of these substances remained constant till shortly before hatching.

Therefore it may be concluded that fresh water fish eggs are practically independent of their hypotonic surrounding and the same independence is true for marine eggs with regard to their strongly hypertonic environment.

Potassium is higher than sodium in the ovarian eggs of most fishes. The latter upon contact with sea water becomes higher than the former. With fresh water species the relation remains the same before and after laying. But with Seeskorpion the relation of the two ions is almost 1: 1.2 (K: Na).

The quantity of phosphorus in the egg remains more or less constant after a small lose immediately after laying, which is true for all species.

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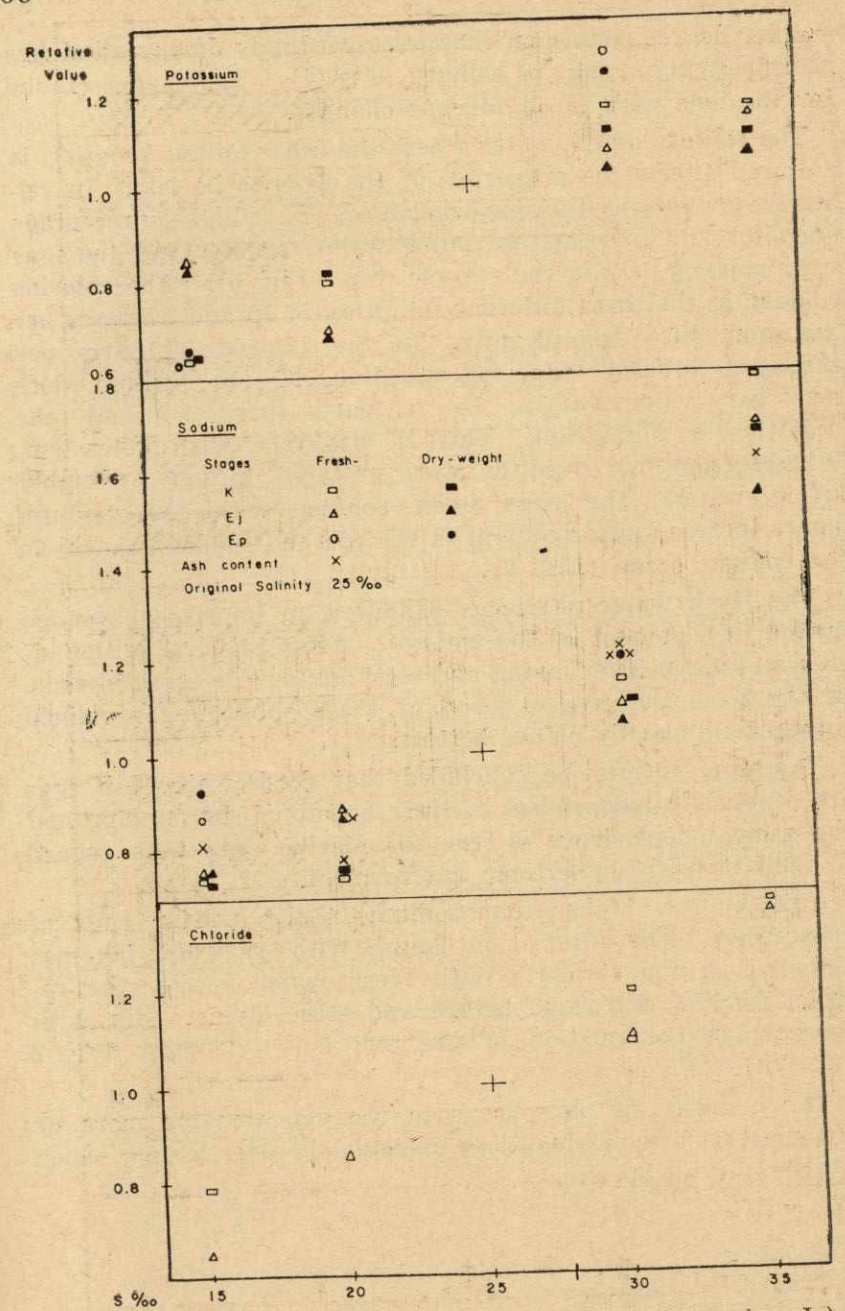

FIG. 4. Changes in the ion content of cod. (Cadus morhua, L.) eggs 24 hours following transfer to other salinity. The

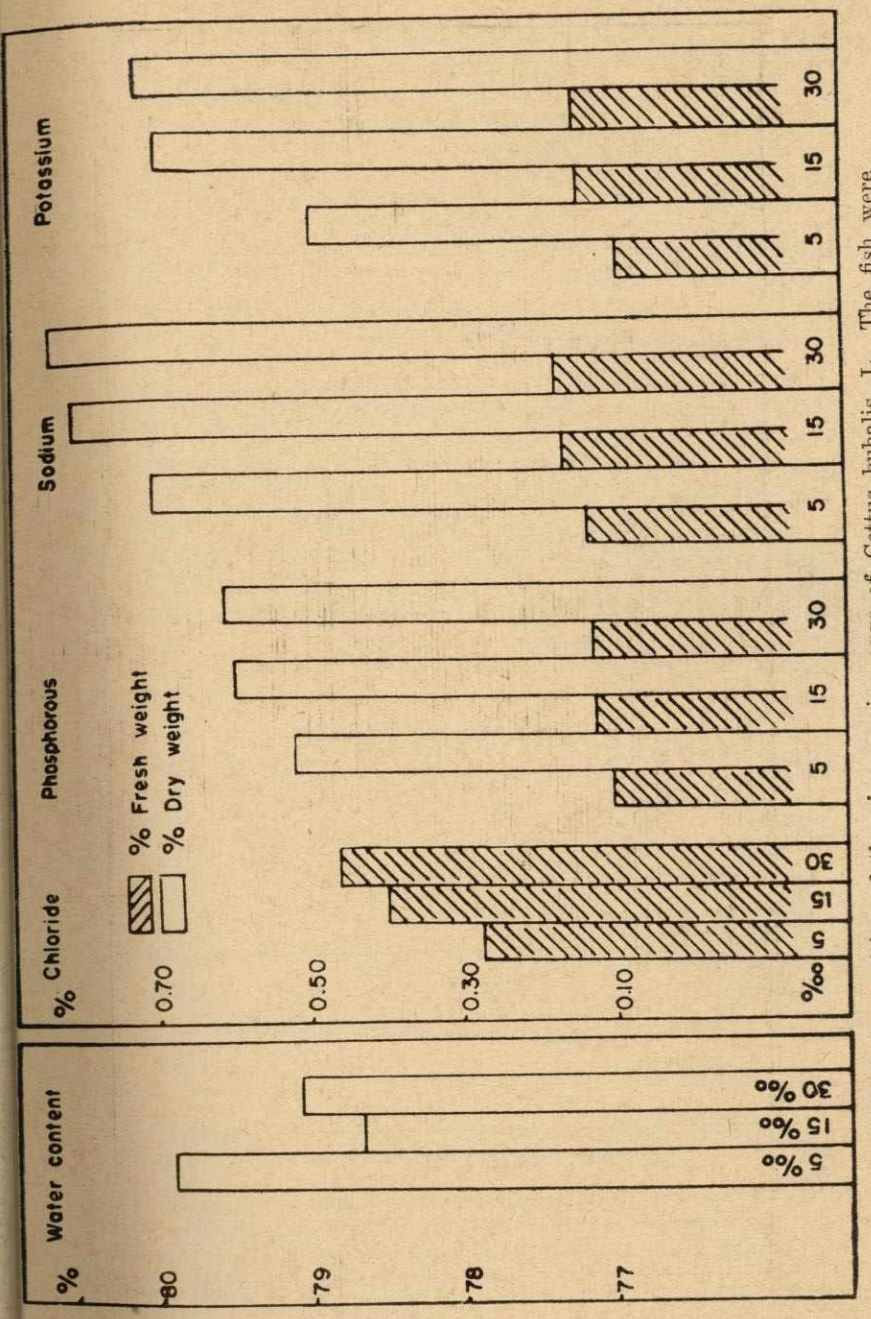

FIG. 5. Composition of the ripe ovarian eggs of Cottus bubalis, L. The fish were cultural in water with salinities of 5‰, 15‰ and 30‰.

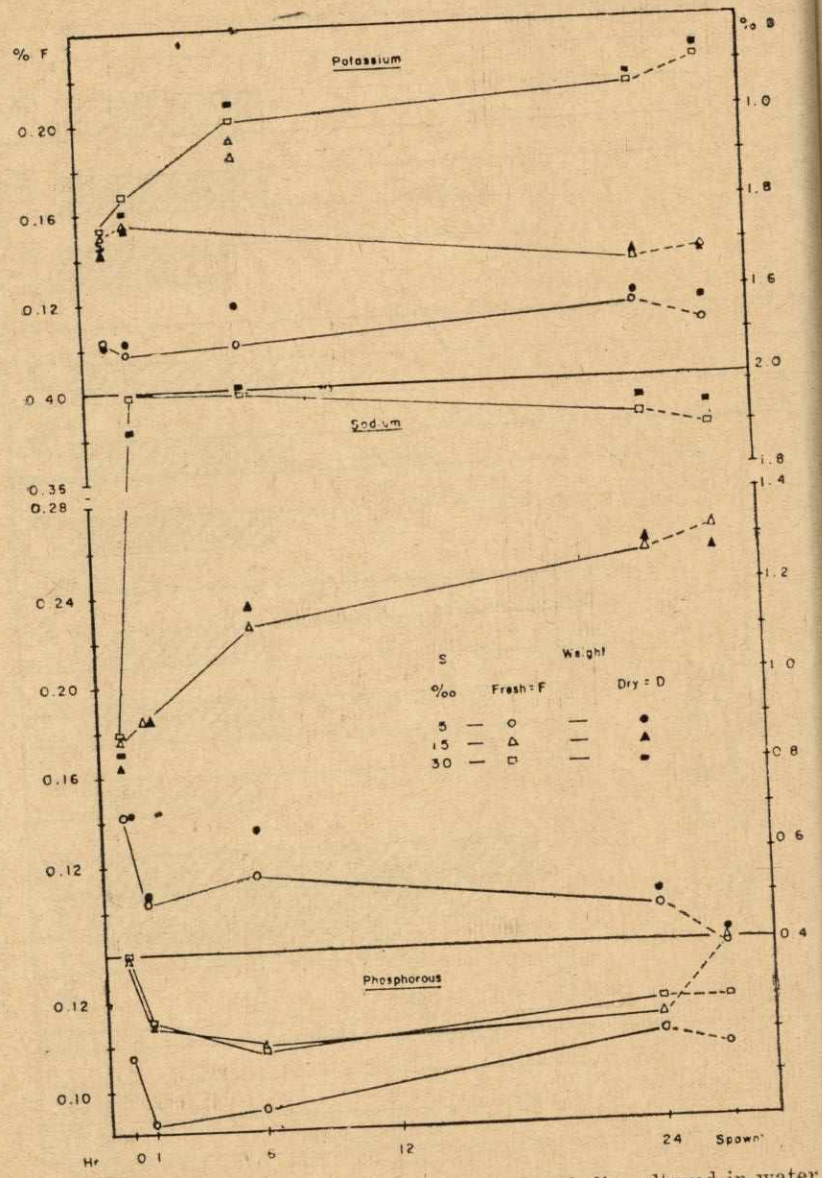

Fig. 6. Ion content of the eggs from Cottus bubalis cultured in water of different salinities and after their eggs had stayed in these salinities for definite length of time.

ILLUSTRATIONS

SIX TEXT FIGURES