Hydrological Factors and Handling Effects on Fingerling Survival and Vitality of three Marine Fish Species

Nour S. Albahri[#1], Amir A. Ibrahim[#2], Mouina M. Badran[#3]
[#1], [#2], [#3], *High Institute of Marine Research-Tishreen University-Lattakia– Syria.*

Abstract — *This research deals with the effect of temperature, dissolved oxygen concentration, transportation period and oxygen injection on fingerlings vitality of some cultured marine fish species.*

Fingerlings were collected from shallow waters of three locations of Syrian coast during the period Mar. - November 2016. Fingerlings were transported in plastic containers and bags, and housed in aerated polyethylene tanks, then monitored for two weeks.

The results have shown that Liza aurata fingerlings taken from the two areas (Wadi Kandil: 75 minutes and Al Kabir Alshimali river: 40 minutes) were more tolerant to handling, transportation and farming conditions than Lithognathus mormyrus and Siganus rivulatus fingerlings.

Fingerlings of Siganus rivulatus caught from the laboratory nearby area (High Institute of Marine Research) had low mortality rate in the tanks, and those of Lithognathus mormyrus and Liza aurata did not show any death.

During transportation, the mortality rate was low at 19.5-28.5 ºC water temperatures and 3.3- 4.6 mg/l dissolved oxygen. However, at 28.6-31.9 °C water temperatures (with dissolved oxygen of 2.1mg/l) fish's survival and activity were negatively affected, causing high mortality. Injecting oxygen in the transporting bags kept the oxygen concentration level at 7.5 mg\l, which ceased fingerlings mortality.

Keywords - *Fish transportation, Fingerlings survival, Temperature effect, Dissolved oxygen effect, Syrian marine water.*

I. INTRODUCTION

Fish meat is an important source of animal protein for human [1] and the fish stocks available in seas and oceans nowadays do not meet the needs of the increased world population, especially in developing countries [2]. Therefore, the world finds its goal through improving the aquaculture [3] in order to ensure an additional source of cheap protein with high nutritional value [4]; Mari-culture industry is an important part of this practice.

One main purpose of Mari-culture is to obtain fingerlings from natural waters and transport them to suitable fattening farms in a short time at low cost [5]. Transporting fingerlings to fattening farms is considered as the most important part in fish culture [6].

Fish should be transported carefully in order to reduce mortality among fingerlings. Thus, fish should be protected, especially against temperature changes and oxygen depletion to avoid fish mortality [7]. During transportation, many problems arise such as: stress factors and change in the hydrological factors which cause loss of fingerlings [8].

Fish loss during fishing and transportation was previously considered as one of the main factors for development of fish culture industries. In fact, this loss should not exceed 10% when applying the optimal methods in fishing, handling and transportation. A study conducted in Malaysia showed that decreasing dissolved oxygen concentration (DO) down to 2 mg/l caused extremely high mortality among fingerlings of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* [9].

Marine fish farms in Syria extremely depend on collecting fingerlings from marine waters due to the technical and financial difficulties come upon artificial breeding or importing fingerlings from other countries. Despite these difficulties, no study on the subject had been so far conducted and, thus, urgent measure should be taken to improve the status of Mari-culture in Syria. In this research, we focus on the optimal ways to avoid fingerling loss and stress during transportation and handling of some marine fish species under local conditions.

II. RESEARCH AIMS

a. To find out the best conditions required to reduce mortality rate when handling and transporting fingerlings from the natural marine waters.

b. To determine the optimum values of some related hydrological factors (temperature, dissolved oxygen... etc.) required to reduce fingerlings mortality.

III. MATERIALS AND METHODS

Fishing sites and sample collection: Experiments have been conducted at the laboratory of the High Institute of Marine Research- HIMR (AlShatee Alazrak), Tishreen University-Lattakia, Syria (N35º 35 ˝ 29″ E 35º 44 ˝ 34″) on the basis of monthly samples during the period Mar. – November 2016. The period of Dec. - Feb. does not incorporate any Mari-culture activities in Syria and, thus, was not regarded in this work.

Fingerlings were caught from three fishing sites differing in their distances from the laboratory:

a. Kandil river estuary site (Wadi Kandil) (N 35º 43˝11″ E 35º 50˝01″), which is 25km distance from the laboratory. The estuary location varies from year to year due to the thick and broad sandy beach layer and to the topography of the area [10]. This estuary is rich with fish fauna community. Fingerlings were caught using cast net and transported into the laboratory within 75 minutes.

b. Al Kabir Alshimali river estuary site (N 35º 29 ˝ 53″ E 35º 48 ˝ 37″), distanced 13km from the laboratory and characterized by gravelly bottom and sandy shore. It is well known for its richness with euryhaline fishes like *Liza aurata* and other similar species. Fishing was done using cast net and fingerlings were transported into the laboratory within 40 minutes.

c. HIMR site (N 35º 35˝32″ E 35º 44˝27″) which is a shallow rocky area neighboring the laboratory. Fingerlings were collected using metal sieve device [11].

Hydrological parameters of the natural seawater and the transporting water were recorded.

Fish species: Three marine fish species were studied; they were chosen for their familiarity as Mari-cultured species, their high abundance in the wild and the ease to capture:

a. *Liza aurata* (Risso, 1810) (Mugilidae) Fig.1: It is a euryhaline species that usually enters coastal rivers for feeding above substrates of varying structures. It resists variations in many hydrological factors [12].

Fig. 1: ***Liza aurata***

b. *Siganus rivulatus* (Forsskal and Nebuhr, 1775) (Siganidae) Fig. 2: It can be found in shallow water on depths less than 15m. It is also tolerant to variations in many hydrological factors [13].

Fig. 2: ***Siganus rivulatus***

c. *Lithognathus mormyrus* (Linnaeus, 1758) (Sparidae) Fig. 3: It can be found above substrates of sandy, muddy or grass meadows structures [14].

Fig. 3: ***Lithognathus mormyrus***

Fish classification was verified according to [15]. Standard length and weight of the studied fingerlings were presented in Table I.

Fingerlings of all species had been transported in polyethylene containers (25 L. each: 15-20 fingerling/container), filled with seawater for testing the effect of transportation period, water temperature and dissolved oxygen on mortality rate and behavior.

Fingerlings were monitored from the moment of catching along the transportation stage until placing them in the test polypropylene tanks (250L. each: with aeration: 20-30 fingerling/tank) at the laboratory of HIMR. Fingerlings had been transported by a truck at low speed for 2 reasons: to reduce stress and to extend the period of transportation; making it long enough for testing. The resulting periods, in fact, reflect the periods usually required for transporting fish from near, moderate and long distances along the coastline of Syria (which is only 183km long) [16], [17].

Fingerlings in the test tanks were fed a diet of 32.5% protein and monitored daily for two weeks, for their behavior and death. During this period, fish waste was removed and the water was changed frequently.

The effect of oxygen injection on fingerlings has been tested (in a separate test) by transporting the fingerlings in transparent plastic bags (55*80 cm, with 25% water volume: 5 fingerlings/bag); one bag was left as a control bag (without oxygen injection). DO was measured before and after transportation and fingerling activity and death were registered.

Table I: Standard length (cm) and weight (g) of fingerlings (± SD) from the three studied areas

Species / Area	*Liza aurata*		*Siganus rivulatus*		*Lithognathus mormyrus*	
	Weight	length	Weight	length	Weight	length
Wadi Kandil river estuary	2.9±0.6	5.8±0.9	1.6±0.6	2.9±0.6	7.4±1.2	7.8±2
AlKabir Alshimali river estuary	4.7±2.1	6.4±2.3	2.1±0.8	4.2±0.7	5.9±1.5	6.1±0.8
HIMR	5.8±3.6	5.8±1.8	5.7±2.2	4.9±1.3	5.0±1.1	5.5±1

Correlation between temperature, DO and mortality rate during transportation had been calculated. Statistical differences in the behavior and mortality between the control site (HIMR) and the other 2 sites were tested using t-test. The significance level had been set at 0.05. Data was manipulated using Microsoft Excel application.

IV. RESULTS AND DISCUSSION

A. Hydrological factors of Seawater in the study areas

1) **Wadi Kandil site**: As presented in Fig. 4, the range of seawater temperature values was 17.1-28.5 °C during the study period. The highest value was in Jul. (29.9 °C) and the lowest was in January (15.8 °C). Seawater DO values range was 4.4-4.8 mg/l; the highest value was in May (5.1 mg/l) and the lowest was in January (4.1 mg/l). Seawater salinity values range was 37.0-38.4‰; the highest value was in Aug. (38.8‰) and the lowest was in February (36.1‰). Finally, the range of seawater pH values was 7.1-8.4; the highest value was in Aug. (8.8) and the lowest was in February (7.0).

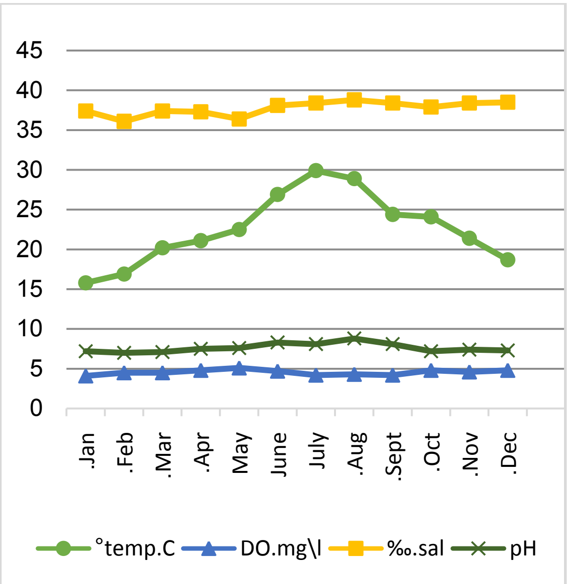

Fig. 4: **Values of the hydrological factors of seawater in Wadi Kandil area**

2) **Al Kabir Alshimali river estuary site:** As presented in Fig. 5, the range of seawater temperature values was 16.7-27.9 °C during the study period; The highest value was in Aug. (30.9 °C) and the lowest was in January (15.5 °C). The range of DO values of seawater was 3.5-4.5 mg/l; the highest value was in Dec. (4.8 mg/l) and the lowest was in Aug. and September (3.1mg/l). The range of seawater salinity values was 34.9-37.7‰; the highest value was in Sep. (38.1‰) and the lowest was in May (32.8‰). Finally, the range of pH values was 7.0-8.2; the highest value was in Aug. (8.6) and the lowest was in February (6.8).

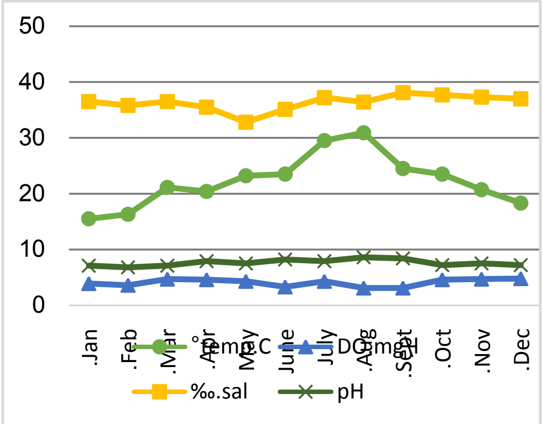

Fig. 5: **Values of the hydrological factors of seawater in AlKabir Alshimali river estuary**

3) **HIMR site:** As presented in Fig. 6, the range of seawater temperature values was 16.6 – 28.3 °C during the study period; the highest value was in Jul. (31.6 °C) and the lowest was in February (15.8 °C). The range of seawater DO values was 3.9-4.5 mg/l; the highest value was in Feb. (5.2 mg/l) and the lowest was in August (3.2 mg/l). The range of seawater salinity values was 37.6-38.7‰; the highest value was in Aug. (39.5‰) and the lowest was in March (37.3‰). The seawater pH values range was 7.3-8.2, the highest value was in Aug. (8.6) and the lowest was in March (7.1).

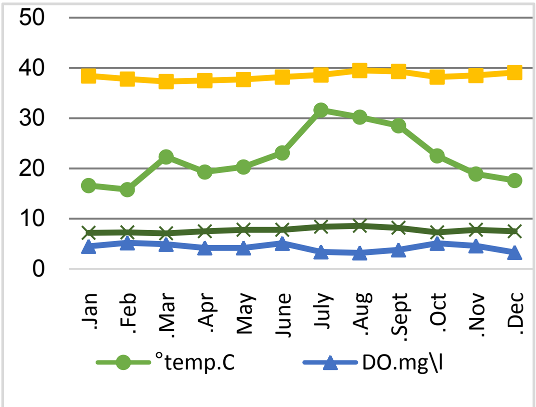

Fig. 6: **Values of the hydrological factors of seawater in HIMR**

Sea water temperature values recorded during this study were somehow close to the usual temperature of Syrian marine water [16] and [18]. Even so, an increase in the maximum seawater temperatures (up to 31.6 °C) and a decrease in the minimum seawater temperatures (down to 15.5 °C) was noticed comparing to [19], [20].

Salinity values recorded in this study signify the low contribution of fresh river-waters to the overall volume of water in the studied estuaries.

The recorded DO values (3.1-5.2 mg/l) match those of [21] but was lower than those recorded by [19] (5.9-7.6 mg/l) or by [22] (5.3-8.1 mg/l). Again, the maximum salinity value was 39.5‰ (in the HIMR area) which closely matches that of [19] 39.6‰.

pH values in some months are somehow lower than the normal seawater pH value due to, even low, freshwater mixing.

B. Hydrological factors changes during transportation

The results have revealed clear changes in temperature and DO values during transportation. DO seemed to be the governing factor affecting fingerling's life during transportation due to the continuous increase in oxygen consumption. Salinity and pH values did not change during transportation because such period was not long enough to create such changes. Measurements were as follows:

1) Wadi Kandil area

In spring, water temperature decreased by ~2 °C at the end of the transportation period, because the containers were in the shade inside the vehicle. DO decreased from 5.1 down to 3.9 mg/l, due to consumption. In summer, only minor decrease in temperature was recorded at the end of the transportation period, but DO decreased from 4.5 down to 2.7 mg/l due to high ambient temperature and to consumption. Similarly, in autumn, the rise in temperature during transportation led to a decrease in DO down to 2.8 mg/l (Table II).

Table II Seasonal changes in the hydrological factors during transportation from Wadi Kandil area

Season	Transport. stage	Temp. C°	DO mg\l	Salinity ‰	pH
Spring	Beginning	22.5	5.1	37	7.4
	During	20.2	4.6	37.1	7.3
	End	20.8	3.9	37.1	7.3
Summer	Beginning	28.9	4.5	38.4	8.2
	During	29.2	3.4	38.5	7.7
	End	29.7	2.7	38.8	7.4
Autumn	Beginning	24.6	3.6	38.3	7.5
	During	25.1	3.1	38.5	7.4
	End	25.2	2.8	38.8	7.3

2) AlKabir Alshimali river estuary area

In spring, water temperature has changed only slightly, which helped in DO preservation in the transporting water and enhancing oxygen solubility from air to water: DO decreased from 4.5 only to 4.3 mg/l. In summer, DO noticeably decreased during transportation from 4.1 down to 2.8 mg/l, because of temperature rise. Similarly, in autumn, DO decreased during transportation down to 2.9 mg/l (Table III).

Table III Hydrological factors changes during transportation from AlKabir Alshimali river estuary

Season	Transportation stage	Temperature °C	DO mg\l	Salinity ‰	pH
Spring	Beginning	20.4	4.5	34.9	7.5
	During	18.4	4.4	35.0	7.4
	End	18.5	4.3	35.2	7.4
Summer	Beginning	28.9	4.1	36.2	8.2
	During	29.7	3.2	36.7	7.7
	End	29.6	2.8	36.8	7.7
Autumn	Beginning	23.5	3.9	37.7	7.7
	During	24.6	3.4	37.8	7.5
	End	24.5	2.9	37.8	7.3

Measurements in HIMR area were not taken because such area was very close to the laboratory and no changes in seawater quality is expected.

C. Mortality rate during transportation:

For the three species (*L. aurata*, *L. mormyrus* and *S. rivulatus*), mortality rate decreased when temperature decreased down till 15.9 °C: at this point, DO increased and fingerlings recovered faster. The minimal mortality rate was reached when transporting water temperature was 15.9-24.5 °C, where DO was 4.0-5.1mg/l. This proves that, these ranges of temperature and DO are the optimal ranges for transporting fingerlings (Table IV).

Table IV: Mortality rate during transportation at different levels of DO.

DO (mg\l.)	Total Number	Dead fish Number	Mortality rate %
2.1-2.3	48	45	93.75
2.4-3.1	50	38	76.00
3.1-3.9	123	33	26.80
4.0-5.1	152	21	13.80
5.2-6.5	118	27	22.80

Temperature increase from 28.6 up to 31.9 °C negatively affected fish survival and vitality during transportation, which caused death at a rate of 60-90%. This associated with a decrease in DO down to 2.1 mg/l. These ranges of temperature and DO outline the vital thresholds of fish life. These results agree with [7], where the best temperature range during transportation was 14-28 °C for many marine and freshwater species (Groupers and Tilapias); the best range for DO was ≥5 mg/l. Similarly, in the study of [23], DO during transportation was found to be ≥6 mg/l. According to [24], the best water temperature range was 10-12 °C where DO was ≥5 mg/l. In general, it can be said that water temperature and DO, and not any of the salinity or pH, were the most important factors affecting mortality during transportation.

Mortality rate had been strongly and positively affected by water temperature (r=0.82) and strongly and negatively affected by DO (r=-0.95). Anyway, temperature rise causes a decrease in DO (r=-95) and consequently fingerling death.

D. Effect of oxygen injection on vitality

The result (Table V) showed that, oxygen injection inside the bags transported from Wadi Kandil area (75 minutes) had stopped fingerling mortality of the three species, and increased their activity and vitality. In the control bag (with no oxygen injection), the mortality rate increased up to

40% at a DO of 2.7 mg/l, and the signs of stress were clear on the fingerlings; they were swaying in swimming and moving towards water surface with open mouths.

Similarly, for the fingerlings transported from AlKabir Alshimali river estuary area (40 minutes), mortality rate in the control bag upon arrival reached 33.3%, at DO 2.7 mg/l, and the signs of oxygen deficiency appeared clearly. On contrast, in the bags that were injected with oxygen, the fingerlings were very active and no death had occurred (Table V).

Table V: Mortality rate when transporting fish inside oxygen-injected bags

Factor	Sea water	After oxygen injection	Without oxygen injection
Wadi Kandil			
DO mg\l	4.5	7.4	2.7
Temperature °C	28.9	28.2	28.3
Mortality rate %		0	40
AlKabir Alshimali river estuary			
DO mg\l	4.3	7.6	2.7
Temperature °C	29.9	31.7	32.9
Mortality rate %		0	33.3

E. Effect of transportation on vitality

The ability of fingerlings to tolerate changes in the environmental factors was species-dependent. Mortality rate was the greatest in *S. rivulatus* followed by *L. mormyrus* and then by *L. aurata*: the latter showed a great tolerance to changes in the hydrological factors (high temperature and low DO; 32 °C and 2.3mg/l respectively). The results agree with [11] who stated that *L. aurata* cultured in tanks had high tolerance to hydrological changes of water (especially temperature and salinity) and to stresses from fishing and handling. In the study of [12], the thermo tolerance range for *L. aurata* was 3-35 °C and the salinity tolerance range was ~0-38‰.

Similarly, studies indicated that *L. mormyrus* fingerlings tolerate changes in the hydrological factors where the temperature tolerance range is 15.9-29.3 °C [13]. *S. rivulatus*, in general, is considered as a tolerant species to transportation conditions [25] but, in this study, it showed less tolerance to stress resulted from transportation. Reference [26] stated that fingerlings of this species has a temperature range of 17-32 °C, and reference [27] had described this species as a tolerant one to salinity and temperature.

The result has shown that, in Wadi Kandil area (75 minutes) and in AlKabir Alshimali river estuary area (40 minutes), fingerling stresses (mechanical scratches, swaying in swimming, signs of DO deficiency… etc.) caused by fishing, transportation and handling were greater at *L. mormyrus* and *S. rivulatus* compared to *L. aurata* where the highest mortality rates of the former 2 species were recorded during the first hour of fishing. On contrast, *L. aurata* fingerlings showed good tolerance to transportation and to other factors where mortality occurred mostly after few days of fishing; as a consequence of wounds and hemorrhage. *S. rivulatus* has sharp spines, which cause injuries to other fishes, so it is preferable not to place this species in one container with other sensitive species.

In the HIMR area (the control area), mortality rate was very low for *S. rivulatus* and even was zero for *L. mormyrus* and *L. aurata*. The difference in mortality rate between this control area and the other 2 areas was significant ($P<0.05$) which clearly indicates the effect of fishing, handling, transportation and changes in the hydrological parameters on mortality (Table VI).

Table VI: Number of dead fish and mortality rate: from fishing throughout two weeks in the test tanks

Area	Species	Total Number	Number of dead fish after: 1 h. of transport	2 h of arrival	1 day	2 days	1 week	2 weeks	Mortality rate%
AlKabir Alshimali river estuary	*S.rivulatus*	26	33	1	0	1	1	0	23.07
	L.mormyrus	22	2	1	1	0	0	0	18.1
	L.aurata	32	0	0	0	1	0	0	3.1
Wadi Kandil	*S.rivulatus*	29	2	2	1	0	1	0	20.6
	L.mormyrus	19	2	1	0	1	0	0	21
	L.aurata	35	0	0	1	1	0	0	5.7

V. CONCLUSIONS AND RECOMMENDATIONS

1. The best temperature range for fingerling transportation was 15.9-24.5 ºC and the best range of DO was 4.5-5.2 mg\l.
2. Mortality rate is strongly affected; positively by transportation time & water temperature and negatively by DO concentration.
3. *L. aurata* was the most tolerant species for transportation and handling stresses, followed by *L. mormyrus* and then by *S. rivulatus*.
4. Even for short transporting periods, plastic bags injected with oxygen were the best for fingerlings transportation, where DO was the most governing factor of fingerling's life.
5. *S. rivulatus* fingerlings should not be placed in one container with other fingerlings, because their spines cause injuries to them.

6. In addition to other species, fingerlings of *L. mormyrus* can be collected from the wild for Mari-culture: they are tolerant and resistant to transportation, culturing conditions and changes in the hydrological factors.

REFERENCES

[1] Salman H; Lahlah M; Shaaban Q, “Study of Endo-Parasitic Nematoda in Sargocentron Rubrum Fish at the Syrian Coastal Water”, International Journal of Agriculture & Environmental Science (SSRG – IJAES), 5, 96, 2018.

[2] Msangi S, Kobayashi M, Batka M, Vannuccini S, Dey M, Anderson J, “Fish to 2030: prospects for fisheries and aquaculture”, World Bank Report, p. 102, 2013.

[3] Håstein T; Hjeltnes B; Lillehaug A; Skåre JU; Berntssen M; Lundebye AK, “Food safety hazards that occur during the production stage: challenges for fish farming and the fishing industry”. Rev sci tech Off int Epiz, 25, 607, 2006.

[4] FAO. “The State of World Fisheries and Aquaculture 2018. Meeting the sustainable development goals”, Rome, 2018.

[5] Murnyak D. Fish Farming: Basics of Raising Tilapia & Implementing Aquaculture Projects. North Fort Myers: Echo Technical Note 2010.

[6] Bocek A, “Water harvesting and aquaculture for rural development”, International Center for Aquaculture and Aquatic Environments, Swingle Hall Auburn University, Alabama, 2009.

[7] Tucker JW, Marine Fish Culture, Harbor Branch Oceanographic Institution and Florida Institute of Technology, Springer Science+Business Media Dordrecht, 1998.

[8] Sopinka NM; Donaldson MR; O’Connor CM; Suski CD; Cooke SJ, “Stress indicators in fish. Fish Physiology”, Elsevier, p. 405, 2016.

[9] Nyanti L; Soo C-L; Ahmad-Tarmizi N-N; Abu-Rashid N-N-K; Ling T-Y; Sim S-F; et al, “Effects of water temperature, dissolved oxygen and total suspended solids on juvenile Barbonymus schwanenfeldii (Bleeker, 1854) and Oreochromis niloticus (Linnaeus, 1758)”, Aquaculture, Aquarium, Conservation & Legislation, International Journal of the Bioflux Society (AACL Bioflux), 11, 394, 2018.

[10] Salhab S, “effect of kandil river on the distribution of local and alien fish species in the estuary and its surroundings”, marine biology, High Institute of Marine Research, Tishreen university journal, lattakia-syria, p. 87, 2018.

[11] Badran M, “Dietary requirements (protein-lipid) for liza aurata fry in different water salinities”. High Institute of Marine Research, Tishreen university journal, p. 92, 2013.

[12] Fazli H; Ghaninejad D; Janbaz AA; Daryanabard R, “Population ecology parameters and biomass of golden grey mullet (Liza aurata) in Iranian waters of the Caspian Sea”, Fisheries Research, 93,9, 2008.

[13] Vlachogianni T; Vogrin M; Scoullos M, “Aliens in the Mediterranean”. Athens, Greece, MIO-ECSDE, 2013.

[14] Sumer C; Ozdemir G; Ertekin H, “Age, growth and reproduction of the striped seabream, Lithognathus mormyrus (Pisces: Sparidae), in the Beymelek Lagoon (southwestern coast of Turkey)”. Cahiers de Biologie Marine, 55, 37, 2014.

[15] Whitehead PJP; Bauchot M; Hureau J; Nielsen J; Tortonese E, Fishes of the north-eastern Atlantic and the Mediterranean, ED. UNESCO, vol 1-3, 1984.

[16] Ibrahim A, “Vulnerability Assessment and Possible Adaptation Measures of the Syrian Coastal Areas to Climate Changes”, In: UNFCCC tNCRt, editor: UNDP, 2008.

[17] Ibrahim A, “Field study on vulnerability and adaptation of Syria marine & coastal habitats & vertebrates to climate changes”, In: research CbTUAHCfS, editor, Damascus, 2011.

[18] Al-Hanoun K; Mayya W, “A New Species of Labidocera acuta (Copepoda, Calanoida, Pontellidae) Collected from the Coast Water of Tartous City (the Eastern Mediterranean Sea)”, International journal of Agriculture & Environmental Science (SSRG-IJAES), 4, 2017.

[19] Mtawej A, “Selectivity of some Fishing Gears to Fish Species and Sizes in the Syrian Marine Waters”, High Institute of Marine Research, Tishreen university journal, p. 101,2012.

[20] Ghanem W, “Contribution to the biological study (environment and multiplication) for some economic Syrian fish”, Faculty of Science, Tishreen university journal, p. 143, 2006.

[21] Qazzaz M, “Contribution to the study of the dynamics of Chelon labrosus(Mugilidae) in the coastal waters of Lattakia”. High Institute of Marine Research, Tishreen university, p. 87, 2012.

[22] Arabia I, “A study of changing of Marine Benthic communities along the Syrian Coast Using Classical and Newly Developed Benthic Indices”, High Institute of Marine Research, Tishreen University, p. 185, 2011.

[23] Jensen GL, “Transportation of Warmwater Fish”, Stoneville, Mississippi, Southern Regional Aquaculture Center, p. 4, 1990,

[24] Berka R, “The transport of live fish: a review”, Food and Agriculture Organization of the United Nations, Rome, 1986.

[25] Badran M, “Culture of two Syrian Marine Economical Fingerlings”, High Institute of Marine Research, Tishreen University, p. 89, 2008.

[26] Saoud IP; Mohanna C; Ghanawi J, “Effects of temperature on survival and growth of juvenile spinefoot rabbitfish (Siganus rivulatus)”, Aquaculture Research, 39, 491, 2008.

[27] Abdel-Aziz MFA, “Effect of Different Salinity Levels of Lake Qaroun Water on Growth Performance, Feed Utilization and Histological Changes on Liver and Gills of Rabbitfish Juvenile”, International Journal of ChemTech Research, 10,479, 2017.