MARINE REPORTS 1(2) (2022) : 99-109
DOI: 10.5281/zenodo.7393998

scopeScience

MARINE REPORTS

MARINE REPORTS
e-ISSN: 2822-5155
Journal homepage: https://scopesscience.com/index.php/marep/

Received: 10 October 2022; Received in revised form: 25 October 2022
Accepted: 01 November 2022; Available online: 03 December 2022
RESEARCH PAPER

Citation: Yigit, Ü., Kusku, H. (2022). Comparison of production trends in Japan with long history in aquaculture and challenging success of Türkiye as a fairly new country in fish farming. *Marine Reports*, *1*(2), 99-109. https://doi.org/10.5281/zenodo.7393998

COMPARISON OF PRODUCTION TRENDS IN JAPAN WITH LONG HISTORY IN AQUACULTURE AND CHALLENGING SUCCESS OF TÜRKİYE AS A FAIRLY NEW COUNTRY IN FISH FARMING

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Abstract
The struggle efforts and success of the Turkish aquaculture industry from past to present have been investigated with comparative evaluation of aquaculture trends in Japan, a country with significant infrastructure in fish farming. Despite its long history of fish farming, Japanese aquaculture production has stabilized over the last two decades, while Turkish aquaculture is in a rapid growth period, ranking among top producers in the world. The lower correlation between production and annual increase of population growth recorded for Japan (R= 0.795207) compared to the higher correlation for Türkiye (R= 0.930835), based on statistical data over the past 40 years, showed that population growth has influence on fish farming yields. The increasing number of younger adults in Türkiye provide advantageous conditions for the selection of qualified personnel from a wider range with higher opportunities in the employment of staff for the Turkish aquaculture sector. In Japan however, along with a variety of reasons, the industrialization has potentially shifted the interests towards technology-based businesses rather than marine works. Introducing high-tech aquaculture systems might reattract young generations, that may help restructuring Japanese aquaculture business. Hence, this study provides useful indications for decision makers in the management of securing the future of the aquaculture industry by reducing the so-called generation gap in aquaculture recruitments.

Keywords: Turkish aquaculture, Japanese aquaculture, population growth and aquaculture

Introduction

The world population is in an increasing trend with estimations of around 9 billion in year 2050 with further increase to 11.2 billion by 2100 according to the United Nations estimates (UN WPP, 2017). As a result, food demand for the increasing population is a serious challenge for the world and human beings need to search for new food sources. Considering the limitations of land and water resources in the world, it seems that the future will soon be a new era in which a struggle for water and land will be experienced. Aquaculture production has the potential to meet the growing demand of the human population (Naylor et al., 2021). Out of the total production of around 54 million tons in 2018, nearly 47 million tons were harvested from freshwater facilities, whereas about 7.3 million tons have been supplied by marine aquaculture production (FAO, 2020). Over the last 30 years, the rise in global aquaculture production from 1990 to 2018 has been recorded as 527%, and the increase in total food fish consumption in the world has been reported as 122% (FAO, 2020). The amount of fish consumption in developed countries showed an increase from 17.4 kg in 1961 to a peak of 26.4 kg per capita in 2007, while a gradual decline was recorded in the following years until 2017 with a consumption of 24.4 kg per capita in 2017. In developing countries however, a significant increase with an annual rate of 2.4 % was recorded and fish consumption increased from 5.2 kg per capita in 1961 to 19.4 kg in 2017. Considering the least developed countries, an increasing trend was reported from 6.1 kg in 1961 to 12.6 kg in 2017, with an average annual rate of 1.3 %. Also, in low-income countries with food-deficit conditions, fish consumption increased from 4.0 kg in 1961 to 9.3 kg in 2017 with a constant annual increase of 1.5 % (FAO, 2020). The increase in fish consumption in the world could be attributed to the expansion of fish farms and the developments in transportation and international trade.

Japan, as a country with a remarkable infrastructure and knowledge of fish production historically faces some problems as its production is in a declining trend. Turkey, as a fairly new country in the aquaculture industry, has achieved significant success in aquaculture activities in a very short time. From this point of view, the growing success of the Turkish aquaculture sector has been evaluated in the present review with comparison to Japanese aquaculture in terms of their strong and weak aspects over the past 40 years.

Materials and Methods

Data collection and evaluation

In the present study measured variables have been recorded as means ± SD. The data for production quantity in tons for the main fish species from 1980 to 2020, dominating Japanese versus Turkish aquaculture industry have been collected from online statistical query panels of FAO (2020) based on yearly statistics of global aquaculture production quantities between years 1950 and 2020, and illustrated in tables and figures. Percent increase of production over years for each of the fish species have been assessed as “growth of harvest from aquaculture of a specific fish species, and calculated using the following equation:

$$AHG_{fish} = \frac{(\mathrm{FYH} - \mathrm{IYH})}{\mathrm{IYH}} \; x \; 100$$

where,
AHG: aquaculture harvest growth of specific fish species in tons
FYH: final year of harvest (tons)
IYH: initial year harvest (tons)

Statistical analyses

Data for annual growth of harvest for main fish species by countries were correlated with annual population increase in these countries. Correlation between annual increase of aquaculture production and annual population increases in Japan and Türkiye were evaluated using Microsoft Excel for MAC based on the following equation:

$$Correl\,(X,Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

where, $\bar{x}$ and $\bar{y}$ indicate sample mean values for series 1 and 2, which represent yearly increase in aquaculture production and annual population increase for each country, respectively.

Results and Discussion

In the past, Japan was one of the advanced countries in aquaculture around the world, but recently fish farming in Japan has been challenging difficulties recently. The quantity (tons) between 1980 and 2020 for the main fish species with over 4000 tons of production, dominating Japanese aquaculture sector has been illustrated in Table 1. Despite the 1.07-fold increase in total fish production from 1980 to 2020, the main fish species in Japanese aquaculture (Ayu Sweetfish, Japanese eel, and Japanese amberjack) showed a 0.51, 0.46, and 0.92-fold decline, respectively. In contrast however, Pacific Bluefin Tuna production increased by 1.25-fold from 2015 to 2020, whereas Silver salmon and Silver seabream harvest rates increased by 9.33 and 4.23-fold from 1980 to 2020, respectively. The highest production of Japanese eel was reached in 1985, for Silver salmon and Ayu Sweetfish in 1990, for Japanese amberjack in 1995, and for Silver seabream in 2000, which showed a gradual decline in the following years. Only the Pacific Bluefin Tuna production was highest in 2020 (Table 1).

On the other hand, with a rapid growth trend, Turkish aquaculture dominated European fish production with a total harvest of 417374 tons, and a share of 1.04% for Atlantic Bluefin Tuna (4338 tons), 1.78% for Meagre (7428 tons), 26.3% for gilthead seabream (109749 tons), 34.6% for rainbow trout (144283 tons), and 35.7% for European seabass (148907 tons) in 2020 (Table 2). The total production reported for rainbow trout in Turkish aquaculture comprises the total of both freshwater and seawater production. Rainbow trout farming in seawater is based in the Black Sea which shows a brackish water characteristic. Rainbow trout in the Black Sea is grown to a size of >2.5 kg and sold for domestic -but mainly international market as "Turkish Salmon" (TMAF, 2020). The quantity (tons) between years 1980 and 2020 for the main 5 fish species with an annual harvest yield of over 4000 tons has been illustrated in Table 2 (FAO, 2022).

In contrast to the Japanese fish production yields, Turkish aquaculture demonstrated a gradual increase over the years from 1980 to 2020, whereas Japanese aquaculture trends were negative for all main species with over 4000 tons of production, except for Pacific Bluefin Tuna that was introduced in cage farms in 2012 with harvest yield of 9639 tons in 2012, reaching 14825 tons in 2015 and 18500 tons in 2020 (Table 1, 2).

Table 1. Production of main aquaculture fishes in Japan (only species with over 4.000 tons production by 2022, only; according to FAO, 2022)

Year	Total Fishes*	Pacific Bluefin Tuna	Coho (silver) salmon	Ayu sweetfish	Silver seabream	Japanese eel	Japanese amberjack
1980	269297	0	1855	7898	14757	36618	149311
1985	298607	0	6990	10967	28430	**39568**	150961
1990	359261	0	**23608**	**12978**	51636	38855	161106
1995	**361652**	0	13524	10896	72185	29131	**169765**
2000	327063	0	13107	8603	**82183**	24118	136834
2005	319868	0	12729	6527	76082	19495	159741
2010	295919	0	14766	5676	67607	20543	138936
2015	291110	14825	13937	5084	63605	20119	140292
2020	287881	**18500**	17300	4044	62400	16887	137100
Growth 1980-2020	*x 1.07 increase*	*x 1.25 increase 2015-2020*	*x 9.33 increase*	*x 0.51* ***decrease***	*x 4.23 increase*	*x 0.46* ***decrease***	*x 0.92* ***decrease***

Maximum production for main species indicated with grey background color and bold characters
** Total production,* all fish species included

Table 2. Production of main aquaculture fishes in Türkiye (only species with over 4.000 tons production by 2022, only; according to FAO, 2022)

Year	Total Fishes*	Atlantic Bluefin Tuna	Meagre	Gilthead seabream	Rainbow trout	European seabass
1980	1370	0	0	0	190	0
1985	2700	0	0	0	900	0
1990	5782	0	0	1031	3212	102
1995	21387	0	0	4847	12689	2773
2000	78683	0	0	15460	44533	17877
2005	118067	390	0	28334	49282	37490
2010	167381	580	0	28157	85244	50796
2015	240331	1710	2801	51844	106598	75164
2020	**417374**	**4338**	**7428**	**109749**	**144283**	**148907**
Growth over years	*x 304.65 increase 1980-2020*	*x 11.12 increase 2005-2020*	*x 2.65 increase 2015-2020*	*x 106.45 increase 1990-2020*	*x 759.38 increase 1980-2020*	*x 1459.87 increase 1990-2020*

Maximum production for main species indicated with grey background color and bold characters
** Total production,* all fish species included

Pacific bluefin tuna, coho (silver) salmon, Ayu Sweetfish, Silver seabream, Japanese eel, and Japanese amberjack are the primary six fish species dominating Japanese aquaculture, almost stabilized production over the last decade. Even decreased harvest between 2010 and 2020 was recorded for Japanese eel from 20543 tons to 16887 tons, and for silver seabream from 67607 tons to 62400 tons, increasing trends were recorded meanwhile for silver salmon that reached from 14766 tons to 17300 tons. A growth trend was also noted between 2012-2020 for Pacific bluefin tuna, which gradually reached a from 9639 tons to 18500 tons. Despite the sudden drop in silver salmon production to 116 tons in 2011, the production was increased again to 9728 tons in 2012, to 12215 tons in the following year, and reached 17300 tons in 2020. Overall, a remarkable decline in fish production has been recorded in the Japanese aquaculture business from its highest rate of 371473 tons in 1991 to 287881 tons in 2020 (Table 3).

The Turkish aquaculture sector in contrast to the Japanese aquaculture industry, showed a 304.65-fold increase from only 1370 tons in 1980 to 417374 tons in 2020, being the fastest-growing aquaculture industry in Europe (Table 4). Today, Turkish aquaculture is the main producer of gilthead seabream, European seabass and Rainbow trout in Europe, and World's second-biggest trout producer after Iran (FAO, 2022). With its dynamic growth over the past years, Turkish aquaculture today exceeded Japanese aquaculture in 2018 (Figure 1).

Türkiye however, with its growing economic development shows an increasing trend of the population with a significant share of young people. The population in Türkiye has increased continuously, and doubled from 1950 and 1980 from 21.408.399 to 43.975.971, and showed a 4-fold increase in 2020, reaching 84.339.067 tons (Figure 2). Therefore, the proportion of young generation is a great advantage for the employment of young people with strength in working under harsh sea conditions, that in turn keeps the aquaculture sector alive and provides dynamic progress.

Qualified personnel is of great importance for the success of the business in the aquaculture sector. Considering that high physical and mental strength are compulsory for the employment in aquaculture business, especially in offshore marine farms, there is a need for a young population to work in harsh conditions of aquaculture operations. Figure 2 provides data for the population growth of Japan and Türkiye from 1950 to 2020. Population growth in Japan increased from 82.802.084 in 1950 to 124.505.240 in 1990, thereafter almost stabilized. A peak in population was recorded in the year 2010 with 128.542.353 people, but then the downtrend started, declining to 126.476.461 (Figure 2).

It can be noted that elder generations are not interested or even not capable to work in harsh conditions at the sea, and it is well known that young generations all over the world are rather interested in innovative areas such as technology and computing. This might also be the case among the young Japanese generation, linking to possible reasons for the long-term stagnation of Japanese fish farming sector in contrast to the rapid growth of the Turkish aquaculture over the last decades. Combining aquaculture technologies with computing can be a beneficial step to attract younger adults in the Japanese society into the aquaculture business. Therefore, it is encouraged to support new projects in order to introduce computing with high technology in aquaculture operations for the future of the Japanese fish farming industry. Further, financial support is also needed for new projects and initiatives.

DOI: 10.5281/zenodo.7393998

Table 3. Aquaculture Production of Japan over the last decade (2010-2020; FAO, 2022). Main aquaculture species with >4.000 tons by 2020 indicated with green highlight.

Fish species (tons, live weight)	**Years**										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Freshwater fishes nei	129	112	275	98	175	168	171	152	154	127	107
Japanese jack mackerel *Trachurus japonicus*	1471	1094	1093	957	836	811	740	810	848	839	600
Common carp *Cyprinus carpio*	3692	3133	2964	3019	3273	3256	3131	3015	2932	2741	2247
Bastard halibut *Paralichthys olivaceus*	3977	3475	3125	2501	2607	2545	2309	2250	2186	2006	2600
Trouts nei	3261	2815	2999	2934	2847	2873	2852	2908	2610	2537	2042
Marine fishes nei	11751	12689	2709	2234	2607	2709	2659	2859	2868	2869	3200
Tiger pufferfish *Takifugu rubripes*	4410	3724	4179	4965	4902	4012	3491	3924	4166	3824	3200
White trevally *Pseudocaranx dentex*	2795	3082	3131	3155	3186	3352	3941	4435	4763	4409	4000
Rainbow trout *Oncorhynchus mykiss*	6102	5406	5147	4962	4786	4836	4954	4731	4732	4651	3854
Ayu Sweetfish *Plecoglossus altivelis*	5676	5420	5195	5279	5163	5084	5183	5053	4310	4089	4044
Coho (Silver) salmon *Oncorhynchus kisutch*	14766	116	9728	12215	12802	13937	13208	15648	18053	15938	17300
Japanese eel *Anguilla japonica*	20543	22006	17377	14204	17627	20119	18907	20979	15111	17071	16887
Pacific bluefin tuna *Thunnus orientalis*	-	-	9639	10396	14713	14825	13413	15858	17641	19587	18500
Silver seabream *Pagrus auratus*	67607	61186	56653	56861	61702	63605	66965	62850	60736	62301	62400
Japanese amberjack *Seriola quinqueradiata*	138936	146240	160215	150387	134608	140292	140868	138999	138229	136367	137100
TOTAL	**295919**	**271688**	**285537**	**275530**	**277626**	**291110**	**301469**	**304547**	**291669**	**292216**	**287881**

nei: not elsewhere included species

Table 4. Aquaculture Production in Türkiye over the last decade (2010-2020; FAO, 2022). Main aquaculture species with >4.000 tons by 2020 indicated with green highlight.

Fish species (tons, live weight)	Years										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Marine fishes nei	2201	1442	0	0	0	0	0	0	0	0	0
Porgies, seabreams nei	0	0	409	475.3	0	0	0	0	0	0	0
Sciaenas nei	0	0	955	1100	0	0	0	0	0	0	0
Sharpsnout seabream *Diplodus puntazzo*	0	0	0	0	8	59	2	0	0	0	0
Redbanded seabream *Pagrus auriga*	0	0	0	0	0	0	0	66	1	0	0
Sturgeons nei	0	0	0	0	17	28	6	13	2	0	0
Red porgy *Pagrus pagrus*	0	0	0	0	106	143	225	20	2	5	1
Tilapias nei	0	0	0	0	32	12	58	8	12	6	13
Common dentex *Dentex dentex*	0	0	0	0	113	132	43	51	24	27	0
Shi drum *Umbrina cirrosa*	0	0	0	0	39	61	20	125	30	47	26
Pink dentex *Dentex gibbosus*	0	0	0	0	75	90	61	107	70	66	0
Bluespotted seabream *Pagrus caeruleostictus*	0	0	0	0	0	0	0	122	74	74	0
Wels catfish *Silurus glanis*	0	0	0	0	0	0	0	8	5	121	92
Common carp *Cyprinus carpio*	403	207	222	145,5	157	206	196	233	212	203	173
Atlantic bluefin tuna *Thunnus thynnus*	580	100	395	470	1136	1710	3834	3834	3571	2327	4338
Meagre *Argyrosomus regius*	0	0	0	0	3281	2801	2463	697	1486	3375	7428
Gilthead seabream *Sparus aurata*	28157	32187	30743	35701.1	41873	51844	58254	61090	76680	99730	109749

Rainbow trout *Oncorhynchus mykiss*	85244	107936	114569	128059.2	112345	106598	104355	106733	112427	123089	144283
European seabass *Dicentrarchus labrax*	50796	47013	65512	67912.5	74653	75164	80847	99971	116915	137419	148907
TOTAL	**167381**	**188885**	**212805**	**233863,6**	**235133**	**240331**	**253066**	**276013**	**313630**	**369188**	**417374**

nei: not elsewhere included species

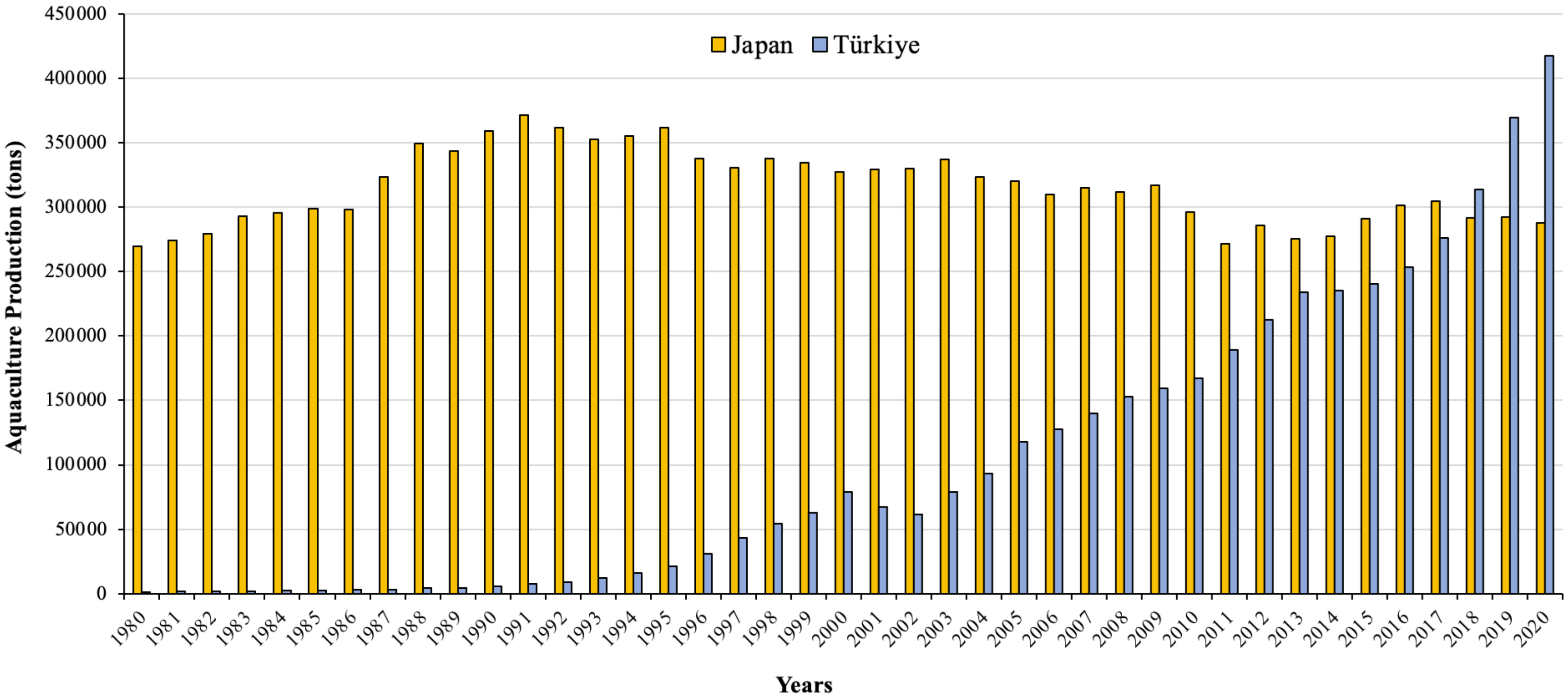

Figure 1. Growth trend of Japanese versus Turkish aquaculture industry from 1980 to 2020 (graphic produced by statistical data of UN-FAO (FAO, 2022).

DOI: 10.5281/zenodo.7393998

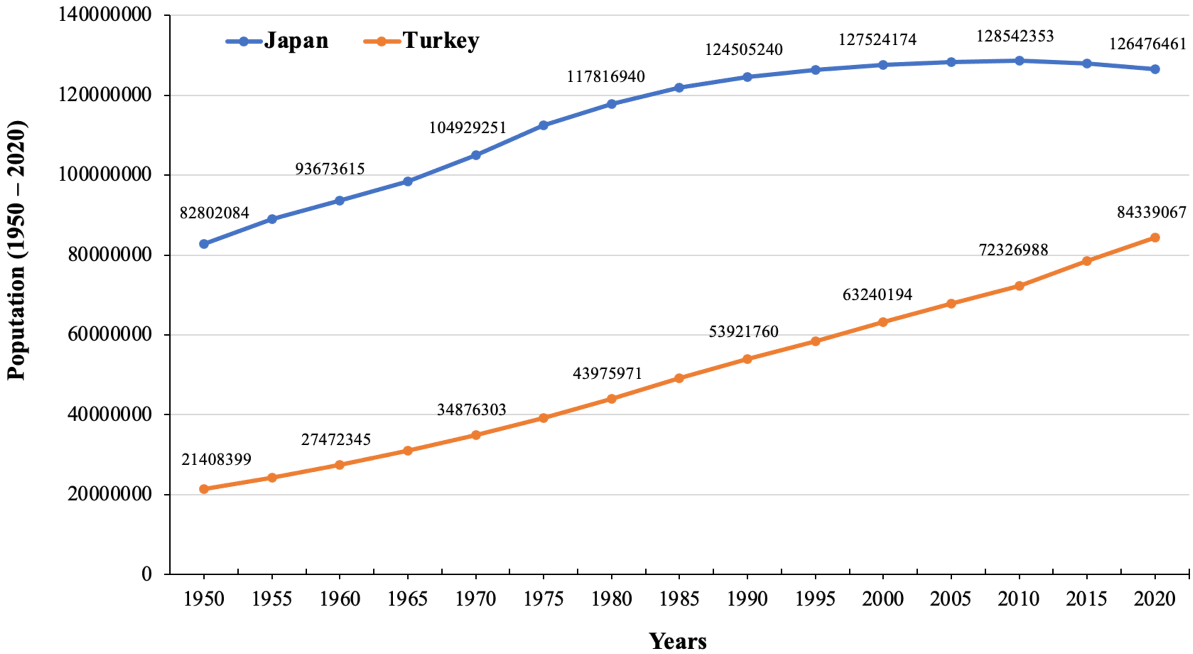

Figure 2. Changes of population in Japan versus Türkiye from 1950 to 2020 (produced with data provided by Worldometer, 2022a, b)

Beyond these views, findings in this study revealed that population growth has effect on aquaculture production yields. Instead of direct interaction, this situation can be evaluated as an advantage of selecting qualified personnel from a large population or the increase in opportunities in the recruitment of necessary personnel.

Despite the fact that some other trend variables such as industrialization or shift of interests of young population towards computing and intelligent technologies, the mathematical correlation between harvest yields of aquaculture over the years coupled with the population growth trend of both countries showed strong correlation between the series analyzed in the present study. The positive and strong correlation provides evidence that the growth in aquaculture harvest is remarkably dependent on population growth.

The lower correlation between aquaculture -and population growth in Japan (R= 0.795207) compared to the correlation found for Türkiye (R= 0.930835), could be attributed to several reasons, among which industrialization stands out and draws attention for Japan. A population with less young adults in a highly industrialized country may lose excitement and desire to benefit from natural systems and nature-related working-areas (Erwin et al., 2002). In contrast however, countries with growing population and modest industrialization, as in the case of Türkiye, still have the opportunities in reaching the manpower for natural work environments such as aquaculture facilities. As a consequence, it is feasible to imagine that people in industrialized countries like Japan, get more and more involved in different work environments distancing from marine related works such as aquaculture. Additionally, there is an increasing trend in the interest for technology over the past decade, strongly linked to the unprecedented growth in innovation of computing Technologies (Anderson & Perrin, 2017; Standard Eurobarometer, 2019; Freeman et al., 2020). Earlier investigations on use of technology among age groups suggest that older adults may be technophobic (Heinz et al., 2013; Nimrod, 2018) with less ability in using technology, as they accept new technological developments in more cautious way compared to younger adults (Berry et al., 2011; Duggan, 2015), which can be described as the generation gap.

Conclusions

Trained and qualified personnel are essential for the development of the aquaculture industry in the world. It is of great importance to increase the quality of education by updating the education system and course curriculum in higher education institutions, especially in the field of aquaculture, according to the necessities of the sector. Representatives from companies and universities should come together more often, and common views should be set forward in determining the needs in the field. In particular, more support could be encouraged for projects carried out with university-industry cooperation so that developing technologies can be used in production. In addition, students taking part in these projects may gain knowledge in using new technologies in fish farming, that in turn may increase the number of highly skilled employees who can use advanced technologies. Developed infrastructure and establishment of technology-based facilities, may pave more interests for younger adults towards aquaculture. Finally, the combination of aquaculture technologies with computer-based high-tech systems may attract young generations in both the Turkish and Japanese aquaculture industries, that in turn may trigger restructuring of the Japanese aquaculture sector and ensuring further growth of the Turkish aquaculture model, which may benefit the entire world aquaculture sector in future.

Ethical approval

No ethical approval needed for this study since no living organisms were used.

Informed consent

Informed consent has been obtained from all individual participants involved in the study.

Data availability statement

The authors declare that data can be provided by corresponding author upon reasonable request.

Conflicts of interest

There is no conflict of interests for publishing this study.

Funding organizations

No funding available for this study.

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