Journal of Agricultural and Marine Sciences 2020, 25(2): 46–57
DOI: 10.24200/jams.vol25iss2pp46-57
Received 16 Mar 2020
Accepted 14 May 2020

Research Paper

Dynamics of Physical Capital in Artisanal Fisheries and Policy Implications

Shekar Bose[1], Hussein Samh Al-Masroori[2*], Salim Darwish Salim Al-Hasani[3]

ديناميات رأس المال المادي في مصايد الأسماك الحرفية والآثار المترتبة على السياسات

شيكار بوز١ وحسين سمح المسروري٢* وسالم درويش الحسني٣

Abstract. The dynamics of physical capital stock and net investment in artisanal fisheries of Al-Seeb, a coastal fishing town of Muscat Governorate, were examined covering the period 2004-2013. Data was gathered from two sources namely the Ministry of Agriculture and Fisheries and field survey. A hedonic regression model was used to examine the influence of boat characteristics on the boat acquisition prices and then to derive the growth rate of physical capital stock. Boat characteristics comprising of 'age', 'horsepower (hp)' and 'length (vl)' were found to be statistically significant at the 5% level and carry sign consistent with the economic theory of depreciation and cost respectively. While inter-annual fluctuation of net investment was observed, a positive trend in cumulative investment with an average growth rate of 7.63% was experienced in the fishery during 2004-2013. A crude assessment of the operating costs and the gross revenue of surveyed boat-owners in 2015 showed that on average monthly economic profit of 571±169 SD OMR was received by individual boat-owner, which complements the positive trend in cumulative investment. These findings have important management and policy implications in relation to the effective management of harvesting capacity as well as attract investment in the fishery. Finally, some limitations of the study are discussed along with the indication of potential future research.

Keywords: Sultanate of Oman, Al-Seeb, Capital Stock, Investment, Hedonic Model, Fishing Fleet.

المستخلص:تم في هذه الدراسة فحص ديناميات مخزون رأس المال المادي وصافي الاستثمار في المصايد الحرفية في ولاية السيب بمحافظة مسقط في الفترة ٢٠٠٤-٢٠١٣ وذلك بإستخدام بيانات جمعت من وزارة الزراعة والثروة السمكية وعن طريق المسح الميداني، وقد أستخدم نموذج إنحدار المنفعة لفحص تأثير خصائص القارب على أسعار اقتنائه ثم لإشتقاق معدل نمو رصيد رأس المال المادي. وقد وجد أن خصائص القارب التي تتكون من العمر والقوة والطول كانت ذات دلالة إحصائية عند مستوى ٥٪ وتحمل علامة تتوافق مع النظرية الاقتصادية للإهلاك والتكلفة على التوالي، وبينما وجد تذبذب سنوي في صافي الاستثمار لوحظ وجود اتجاه إيجابي في الاستثمار التراكمي بمتوسط معدل نمو ٧,٦٣٪ في مصايد الأسماك خلال الفترة ٢٠٠٤-٢٠١٣، وقد أظهر تقييم تكاليف التشغيل والإيرادات الإجمالية لمالكي القوارب الذين شملهم الاستطلاع في عام ٢٠١٥ أن مالك القارب الفردي حصل في المتوسط على أرباح اقتصادية شهرية تبلغ ٥٧١ ± ١٦٩ ريال عُماني، وهو ما يؤكد الاتجاه الإيجابي في الاستثمار التراكمي، ولهذه النتائج تداعيات إدارية وسياسية مهمة فيما يتعلق بالإدارة الفعالة لقدرة الحصاد وجذب الاستثمار في المصايد، وفي نهاية الورقة تمت مناقشة بعض قيود الدراسة مع الإشارة إلى البحوث المستقبلية المحتملة.

الكلمات المفتاحية: سلطنة عمان، السيب، رصيد رأس المال، الإستثمار، نموذج المنفعة، أسطول الصيد

Introduction

The twin problems of over-investment and excess harvesting capacity are of major concerns for fisheries in both developed (Zhang et al., 2018; Kirkley et al., 2002; Kirkley and Squires, 2003) and developing countries (Pomeroy, 2012; Purcell and Pomeroy, 2015). These problems are essentially linked to both physical and natural capital (Nøstbakken et al., 2011). The role of physical capital as a produced means of production is well established in economics in general (Hulten, 1991), and in natural resource industries like fisheries in particular (Clark et al., 1979). Frequent occurrence of conflicts in fisheries due to excess capacity (Ahmed et al., 2006), threats to long term sustainability due to capital stuffing (Kirkley and Squires, 1998), and poor economic returns associated with over-investment are some of the legitimate justifications for the need to address the concerns of over-investment and excess capacity in small- and/or large-scale fisheries. This calls for effective management of overcapitalization in fisheries which is crucial for ensuring sustainability in fisheries and the flow of benefits to the society in the long run (Kirkley and Squires, 1998). Furthermore, recognizing the role of small-scale fisheries in development (de Melo Alves Damasio et al., 2016), the financing of small-scale fisheries whether by public or private funds has received attention of policy-makers in recent years both locally (Diffey et al., 2009; Setlur and Arbuckle, 2015) and globally (Heck et al., 2007; Holmes et al., 2014). However, a lack of knowledge about the status of physical capital engaged in fishing will not only undermine effectiveness of management but also introduce uncertainty to the future investment planning for the sector. Hulten (1991) emphasized that an estimate of capital, however imperfect, is crucial to understand the

Hussein Samh Al-Masroori[2*] (✉) masroori@squ.edu.om, [2]Department of Marine Science and Fisheries, College of Agricultural and Marine Sciences, Sultan Qaboos University. [3]Ministry of Agriculture and Fisheries, Sultanate of Oman. [3]Gibbon Street, Woolloongabba Queensland, 4102, Australia.

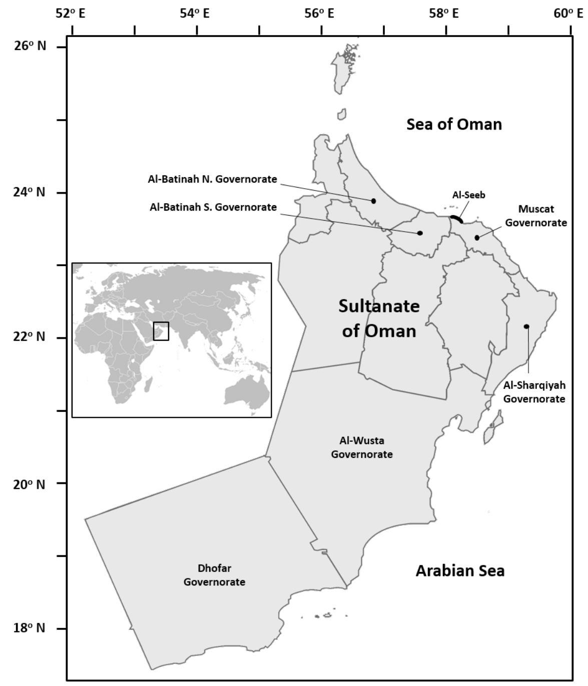

Figure 1. Map of Oman and study location

process of economic growth.

In economics, the description of the term capital has been conceived as deferred consumption, as a stock of durable goods, or as a flow of factor services (Hulten, 1991). In case of fisheries as argued by Squires (1988) that the quantity of capital measured as the flow of services from the number of boats (i.e. physical capital stock) operating in a fishery. The economic theory of capital in fisheries, differentiates three types of capital namely physical (e.g. boat, equipment), natural (fish stock), and human (crews, skills and expertise). The interdependencies of natural and physical capital (Boyce, 1995; Burt and Cummings, 1970) under various conditions such as functional form of investment costs (Boyce, 1995) and degree of malleability (Clark et al., 1979) were studied in fisheries. It was argued that favorable condition of growth in natural capital and other form of economic incentives (e.g. subsidy) leads to investment decisions by fishers and entry and exit behavior of fishers, other things being equal (Le Floc'h et al., 2011). However, it is important to note that exit from fisheries may be difficult due to lack of alternative employment opportunities (Bose et al., 2013; Ikiara and Odink, 1999). Eisenack et al. (2006) argued that for a developing fishery, a time gap existed between the growth of physical and natural capital, and due to partial substitutability between these two forms of capital the growth in physical capital continues even after decline of the natural capital. In general, while the conservation and management of natural capital are the primary objectives of management authorities, the regulatory environment is likely to exert influence on fishers' investment decisions relating to physical capital (Nøstbakken et al., 2011). The capital market imperfections in relation to the borrowing and lending constraint which has particular relevance to small-scale fisheries in Oman where collateral is needed by the financial institutions (Diffey et al., 2009). Other factors affecting investment decision include boat age and size, future revenues, operating costs (e.g. fuel, and labour), stock status of the main target species, and the impact of management measures (e.g. mesh size restrictions) and fleet size (Tidd et al., 2011).

The main objective of this case study were three-fold considering the above-mentioned strategic importance of small-scale fisheries sector in Oman. First, the extent of influence of basic boat characteristics on the acquisition price of boat. Second, an empirical assessment of the dynamics of physical capital stock and net investment in artisanal fisheries during 2004-2013. Third, ascribing importance to the view of 'fishing costs' as a key driver of fishers' investment decisions, among others, and the scarcity of such cost information (Lam et al.,

Table 1. Descriptive statistics of sample used for hedonic regression

Year	Boat	Boat Length (ft)			Boat Price (OMR)			Engine (hp)			Engine Price (OMR)		
	No.	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
2004	9	22.89	5.49	23.98	1614.53	971.31	60.16	102.78	92.4	89.90	1938.98	1383.32	71.34
2005	8	23.37	5.66	24.22	1537.87	839.75	54.60	109.37	96.49	88.22	2058.91	1382.51	67.15
2006	8	21.62	4.24	19.61	1361.36	704.28	51.73	88.12	86.89	98.60	2164.27	1842.41	85.13
2007	8	21.62	4.24	19.61	1474.83	803.87	54.51	88.12	86.89	98.60	1697.81	1056.14	62.21
2008	6	21.17	4.21	19.89	1429.34	772.88	54.07	70.83	76.77	108.39	1517.64	1101.61	72.59
2009	6	21.17	4.21	19.89	1676.81	784.26	46.77	70.83	76.77	108.39	1506.67	934.74	62.04
2010	4	22.75	4.57	20.09	1825.53	517.31	28.34	93.75	90.12	96.13	2194.17	1308.22	59.62
2011	4	24.50	4.51	18.41	2142.88	954.55	44.55	143.75	98.1	68.24	2882.25	1189.67	41.28
2012	2	27.00	2.83	10.48	NA	NA	NA	140	84.85	60.61	4053.75	1773.07	43.74

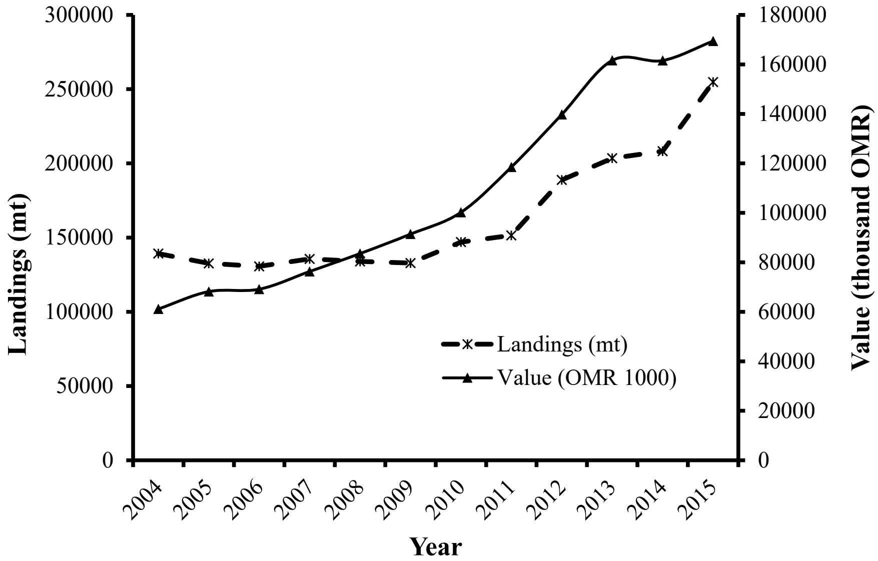

Figure 2. Landings and Value of Artisanal Fisheries, Oman

2011). This study aimed to provide a crude estimate of monthly average operating costs and revenue per boat experienced in 2015. Due to time and resource limitations, the cost estimate was produced using the logbook information obtained from ten owner-operators participated in the study.

From an academic perspective, this study can provide a wider relevance to artisanal fisheries sector in developing countries as this type of quantitative assessment is relatively limited in fisheries literature. In addition, the authors are unaware of any empirical work available or devoted explicitly to address the matter at hand in Oman. More importantly, the lack of knowledge about the existing fleet capacity and the extent of their utilization has been highlighted as major issues, among others, confronting the management of fisheries sector in Oman (Setlur and Arbuckle, 2015; Al-Siyabi and Bose, 2018). In the absence of such information fisheries managers may have the tendency to use the number of operating boats as a measure of capital stock and investment in the traditional fisheries sector. However, such measure would not be adequate as it ignores changes in the quality of such capital over time (Kirkley and Squires, 1998; Kendrick, 1961). So far, there is negligible attempt to collect and compile statistics on either the capital stock or the level of investment in the sector. This study also contributes to the practical realm, as it provides policy makers and investors with knowledge that has the potential to assist in designing effective strategic actions with regard to investment in fisheries. Therefore, this case study not only fills the existing knowledge gap but also complements the existing global literature by adding country-specific information.

The link between aggregate physical capital stock and the harvesting function is well established in fisheries literature, and the dynamic behaviour of physical capital stock is used for explaining the rate of investment associated with fisheries resource use. Therefore, research on capital-stuffing and investment behavior of fishers is valuable as it may provide necessary signal for investment incentives (or dis-incentives) to the private sector which is one of strategic objectives of the sector. The existence of capital market imperfections in relation to the borrowing and lending constraints (Diffey et al., 2009) further rationalizes the importance of the present research to identify market constraints and thereby, enhance the knowledge of the relevant actors to formulate appropriate marketing strategies to accommodate the market dynamics of foreign origin.

Case Study Profile

Fisheries are an integral part of Oman's economy and have occupied an important place in the national policy agenda as the 'Oman Vision 2020' - a long-term development plan, reflects the country's desire to achieve food security, enhance fishers' income, and maximize socio-economic benefits from the sector (Bose et al., 2010; MNE, 2007). The superior economic performance of the sector is a prerequisite for the achievement of these strategic objectives.

Small-scale artisanal fisheries in Oman have been the dominant both in terms of landings and value. During the past decade or so, the sector's contribution to Gross Domestic Product (GDP) has remained stable around 0.6% (at 2000 constant prices) (Bose et al., 2010; Al-Subhi et al., 2013). With the advent of economic diversification policy guided by 'the Vision for Oman's Economy-2020' the fisheries sector has attracted renewed

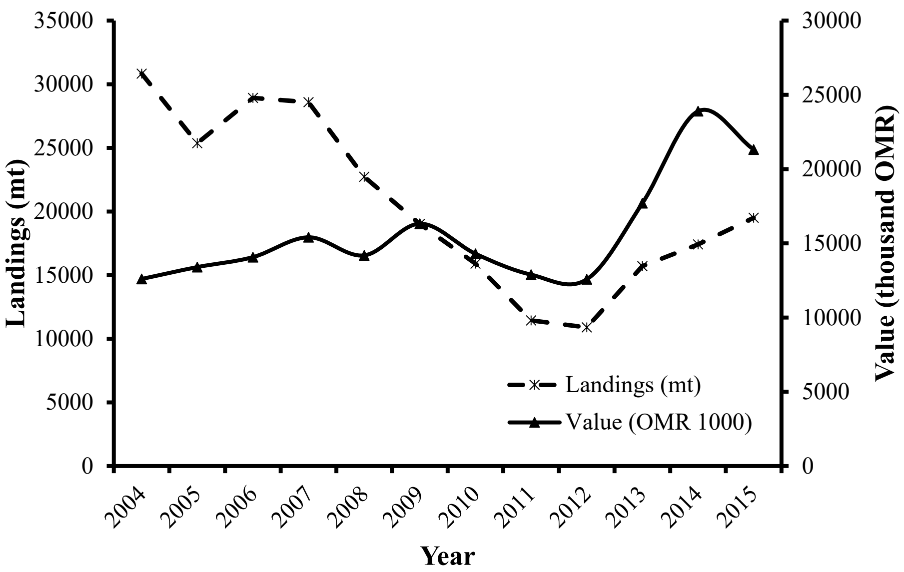

Figure 3. Landings and Value of Artisanal Fisheries, Muscat Governorate

interest and accordingly the authority has been promoting public-private partnerships to attract private investment in the sector. Recently, efforts have been directed to, amongst others, (i) modernize fishing operations and improve fleet performance, (ii) initiate effective fisheries governance mechanisms; (iii) ensure sustainable use of fisheries resources; and (iv) optimize socio-economic benefits from the sector.

The present study conducted in Al-Seeb area which is a coastal fishing town located in the northwest part of the Muscat Governorate. The selection of the study site is influenced by several factors, such as, time and costs, information availability and geographical proximity. It is envisaged that the replication of this study would be useful for generating insights into the pattern of fishery investment and subsequently the design of effective management policies in relation to the future investment in the fishery. Muscat Governorate is one of the seven coastal governorates of Oman (See Figure 1). Muscat Governorate has six Wilayah (Province) namely Muscat (capital city), Qurayyat and Al-Seeb, Bawshar, Al-Amrat and Mutrah.

Figures 2, 3, and 4 exhibit the performance of total fish landings and gross value at the national (Oman), governorate (Muscat) and Wilayah (Al-Seeb) level respectively covering the period 2004-2015. From these figures, it can be noted that at the national level showed a distinct positive trend during the study period, while the same pattern was not evident at the governorate and Wilayah level. However, a resemblance was observed in the behavioral pattern of landings and gross value at the governorate and Wilayah level. Further comparative analysis comprising landings, gross value, fishing boats, and number of fishers are provided in the results section.

Methodology

Data

Ideally, the economic value of capital services should be reflected in rental price. In the absence of such rental market the imputed price of capital services consists of two cost elements, namely the opportunity cost and the depreciation cost associated with the investment and the capital equipment respectively (Jorgenson, 1974; cited by Squires, 1988). There is negligible published database on actual transaction prices of new boats and, therefore, the factory quotation prices for new boats available for the period 2004-2013 were used in this analysis. In the absence of price information for other capital items, such as fishing gears, electrical equipment, and consistent price index series for heavy machinery, the nominal prices of tangible assets such as boats and engine along with the corresponding quality attributes age, boat length, and engine horsepower are considered in this study. Data were collected from two sources. First, the price quoted by Omani companies submitted to the Ministry of Agriculture and Fisheries during 2004-2013 for 53 boats of various sizes (ranging from 16ft to 33ft) and engine types were collected. The acquisition prices were not available. Second, data on registered fishing boats operating in Al-Seeb coastal water along with their characteristics, such as size, engine power, and boat age were collected from the local Ministry office. It was noted that the quoted prices for the same boat size and engine power from different companies differ in a given period due to different technical specification of boats and add-ons (such as warranty condition, and insurance period) coming with the deals. The average value was used to represent such cases. As mentioned earlier, a

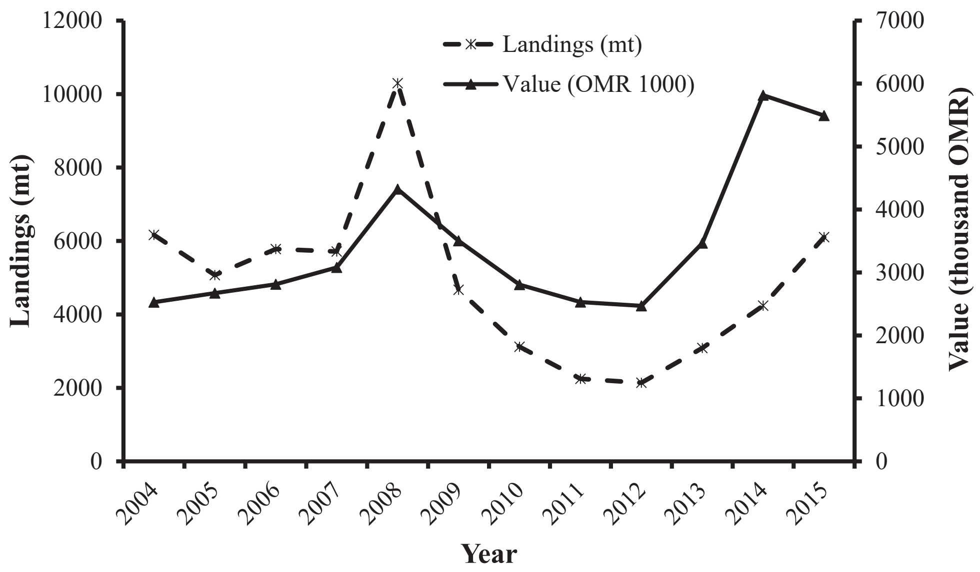

Figure 4. Landings and Value of Artisanal Fisheries, Al-Seeb

simple logbook was prepared (in Arabic) to collect information on basic operation costs. Ten owner-operators nominated by the local office of the Ministry were engaged during February-April 2015 to record costs per trip incurred by individual fisher for two weeks (14 trips per fisher).

In fisheries, boats are treated as a durable but depreciable asset. In estimating physical capital stock and net investment in the New England commercial fisheries (Kirkley and Squires, 1988) followed hedonic regression method and used data on boat characteristics, such as gross registered tonnage (GRT), length, and engine power. The basic idea behind the hedonic approach is to consider a fishing boat as a bundle of characteristics, such as length, age, engine horsepower (hp) and to generate estimate of the missing prices when quality changes.

Empirical Model

The basic model adopted in this study is mainly drawn from the study by Kirkley and Squires (1988). It involves two steps. First, a hedonic model was estimated, and second step growth rate of capital stock was derived by making use of the estimates of implicit price from the first step. Broadly speaking, the hedonic approach hypothesizes that the price of a commodity is influenced by its characteristics (Rosen, 1974). Kirkley and Squires (1988) have argued that the hedonic approach offers an attractive characteristic for estimating capital stock in fishing industries such that it incorporate changes in the quality of capital over time which should be reflected in boat acquisition prices. To represent this, the following Cobb-Douglas functional form was employed.

$$C=\text{constant}.(age)^{\alpha}.(vl)^{\beta}.(hp)^{\gamma}.(exp)^{u} \qquad \text{Eq.(1)}$$

where, C is the list price or acquisition price of boat, age is age of the boat, vl is boat length, hp is engine horsepower, and u is white noise error term. From a theoretical standpoint, the relationship expected between the price and the characteristics are as follows: $\alpha<0,\beta>0$,and $\gamma>0$. The hedonic approach is adopted because there is no market information available for used or rented boats. The application of hedonic regression on the available data provides implicit prices of the chosen quality dimensions which would also provide signal to the cost of fishing effort. The age of a boat, was counted from the year the boat was first registered in the boat registry of the Ministry. Size (measured as boat length) and capacity (measured as horsepower) are two important characteristics of fishing boats as they are routinely used for fishing effort measures. The stability of the estimated coefficients obtained from the hedonic regression model would not be tested due to lack of enough observation for each expected period.

In empirical analysis, a linear, semi-logarithmic, and log linear form of the model is frequently used. As there is no a priori reason to assume that price and quality behave in a particular fashion, a Box-Cox transformation was applied to decide whether linear or log-linear functional form of the model fit the data best as follows:

$$x_t^* = \frac{x_t^{\lambda}-1}{\lambda} \qquad \text{Eq.(2)}$$

Parameter 'λ' which was determined by the data defines the functional form as: if $\lambda=1$, it represents linear speci-

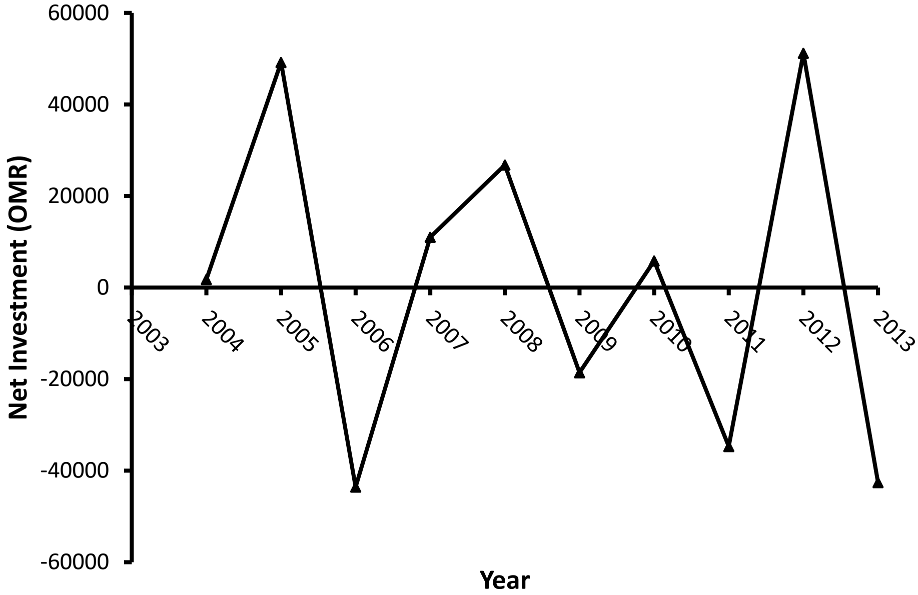

Figure 5. Net Investment in the Fishery during 2004-2013

fication, and if λ=0, it reduces to log-linear specification. Each observation of the dependent variable (i.e. boat price) was first divided by the geometric mean (GM = 3118.32) of the dependent variable and two versions (with and without taking log of the dependent variable) of the regression model (Equation 1) was run. The values of residual sum squares (RSS) were used to conduct a Chi-square test to decide between the linear and log-linear functional forms. The test result (see the result section) supported a log-linear version of the model. As the model is in log-linear form, the resulting regression coefficients can be interpreted as partial price elasticity with respect to the variable concerned, other things being equal. Following Grillches (1961), a semi-logarithmic form of the model (Equation 1) with respect to the age variable was also experimented to accommodate the possibility of geometric patterns of depreciation of boat value with age.

The first data set was used to estimate the parameters from the two versions of Equation 1. At the second-stage, the parameter estimates from Equation 1 were used to generate estimate of capital stock per boat per year based on the second data set that include physical characteristics of the registered boats that have been operating in the Al-Seeb fisheries. The estimated capital stock per boat was then summed for all boats in a year to obtain the estimate of total capital stock. It was assumed that the value of all capital services was the sum of the values of individual capital services (Squires, 1988). Net investment was then calculated as the change in total capital stock per unit of time (i.e. year).

Results

Some relevant comparative statistics are also calculated from the data presented in the Figures 1-3. During 2004-2015, the average growth rate of total landings in Oman was about 5.65% per annum whereas Muscat governorate and Al-Seeb were witnessed negative growth rate of -4.08% and -0.09% respectively. However, during the same period, the positive trends in total value were observed for Oman, Muscat governorate and Al-Seeb, was observed the average growth rate of 9.71%, 4.90% and 7.31%, respectively. Furthermore, for Muscat and Al-Seeb, a downward trend was observed for total landings around mid 2000-2012 and then a positive trend after 2012. The sharpest decline in landings appeared to take place in 2008. With reference to number of fishers and boats positive trends were observed for Oman, Muscat and Al-Seeb but differed in extent, with the average growth rates of 3.40%, 1.60% and 2.41% for number of fishers and 2.03%, 1.61%, and 2.11%, respectively.

The variation in total landings as measured by the coefficient of variation (CV) for Al-Seeb was the highest (45.47%) followed by Muscat governorate (32.94%) and Oman (24.92%). On the other hand, the variation observed in total value was the highest for Oman (37.18%) followed by Al-Seeb (33.49%) and the governorate (22.91%).

The descriptive statistics of the sample used for hedonic regression model are presented in Table 1. It was mentioned earlier that a Box-Cox transformation was followed to decide between the two conventional versions namely the linear and the log-linear models. The estimated χ^2 test value (38.25, 8 df) supported the log-linear specification of the model. Table 2 provides the empirical results of the hedonic regression mod-

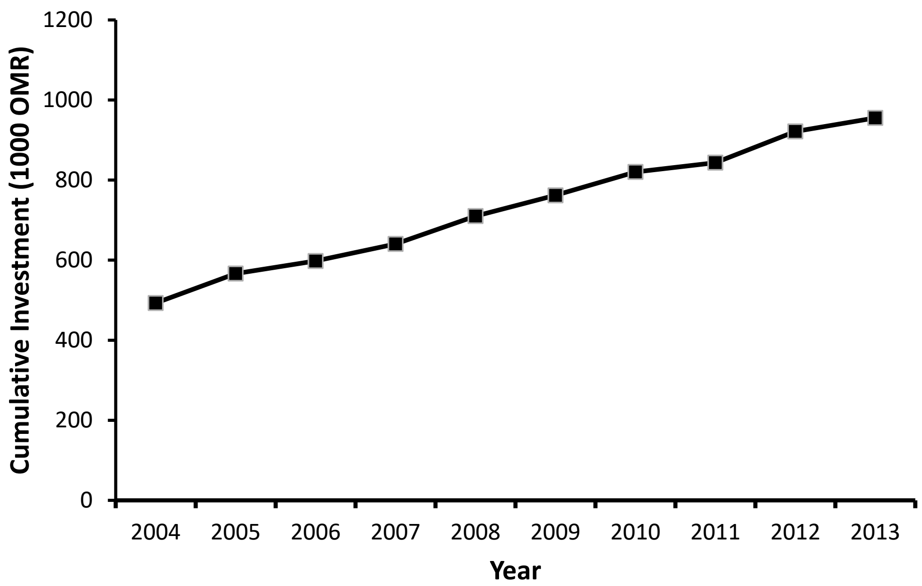

Figure 6. Cumulative Investment in the Fishery: 2004-2013

el specified in Equation 1 in two forms (log linear and semi-log with respect to age) along with the summary statistics and diagnostics. The potential 'non-linearity' in variable was also experimented by including square root term for each variable in to the model but failed to generate any theoretically convincing results.

Some important results can be noted from Table 1. The average boat length was more or less similar across the years, which indicated the degree of homogeneity in small-scale fisheries with respect to boat size. However, the results of boat power exhibited relatively greater degree of heterogeneity in the sample as reflected in the coefficient of variation (CV) estimate. This was because of the fact that some boats were using twin-engine. This was also reflected by the fact that the average price of engine is higher than that of boat except for 2009. Furthermore, the variability (as indicated by CV estimates) of average boat price was lower than engine power and engine price which to some extent consistent with the homogeneity in boat size as mentioned earlier. Apart from higher capital cost (i.e. fixed cost), the use of twin-engine also exerted influence on variable costs due to recent rise in fuel price.

It is noted that a limited number of quality dimensions explain a very large fraction of the total variability of the list price as measured by R^2 value. The coefficient of the variable 'age' carries an expected sign as expected from the economic theory of depreciation and the associated t-value suggests that the variable is statistically significant at the 5% level. The coefficient of age in Model 1 is the elasticity, which is the predicted average proportionate change in boat list price due to proportionate change in boat age, holding other qualities constant. On the other hand, semi-log form the coefficient of age can be interpreted as the percentage change in the boat list price due to a unit change in age, other things being equal.

The variables 'horsepower (hp)'and 'length (vl)' are statistically significant at the 5% level with expected sign that is consistent with the theory of cost which predicted that the boat cost should increase with the increase in the characteristics of power and size. These results are in line with Kirkley and Squires (1998). Furthermore, it is important to note that boats engine power and length have the highest influence on the acquisition price of boats, which is consistent with the descriptive statistics presented in Table 1.

To demonstrate the empirical validity of the model a series of diagnostics has been applied and the results are presented in Table 2. It can be seen that in all cases, the results from the econometric diagnostics do not exhibit any deviations from the classical linear regression properties. The J-B LM test was used to examine the normality of the residuals at the 5% level (Jarque and Bera, 1980). The test statistic follows a χ^2 (with 2 df) distribution and the value of the test statistic indicates that the null hypothesis of normality cannot be rejected. The B-P-G test was used to test the null hypothesis of homoscedasticity of the residuals at the 5% level (Breusch and Pagan, 1979; Godfrey, 1978). The test statistic follows a χ^2 (with 2 df) distribution and the test value was insignificant at the 5% level thereby the null hypothesis of homoscedastic error variances cannot be rejected. The Lagrange Multiplier (LM) test statistic with two lags was used to test the null hypothesis of no autocorrelation at the 5% level. The test result supported the null hypothesis of no autocorrelation. Comparing the output of summary statistics, forecast performance, and model selection criteria, it can be

Table 2. Empirical results of the hedonic regression model

Model 1 (log-log)			Model 2 (Semi-log w.r.t. age)		
Variable	Coeffi-cient	t-value	Variable	Coefficient	t-value
ln(age)	-0.23	-4.61	age	-0.03	-4.50
ln(hp)	0.49	9.97	ln(hp)	0.49	9.85
ln(l)	0.47	2.26	ln(l)	0.49	2.37
Constant	4.98	10.49	Constant	4.71	10.12
Summary Statistics:					
R^2		0.95	0.94		
Residual Sum Square (RSS)		0.78	0.81		
Log likelihood		37.20	36.82		
F statistics (Joint test)		287.50	283.16		
(p = 0.00)			(p = 0.00)		
Regression Diagnostics:					
Normality: LM test($\chi^2$2 df)		2.23 (p = 0.33)	2.27 (p = 0.32)		
Serial correlation: Durbin Watson (D-W)		2.06	2.05		
LM Test ($\chi^2$2 df)		1.52 (p = 0.47)	0.98 (p = 0.38)		
Heteroscedasticity: B-P-G test ($\chi^2$3 df)		0.10 (p = 0.96)	0.11(p = 0.95)		
Forecast Performance:					
RMSE		0.121	0.122		
MAE		0.102	0.103		
MAPE		1.274	1.288		
Model Selection Criteria					
AIC		-1.23	-1.22		
SC		-1.08	-1.07		
H-Q		-1.17	-1.16		

seen that Model 1 performs only marginally better than Model 2. Therefore, it was decided to use the parameter estimates of Model 1 in the second stage.

At the second-stage the parameter estimates from Equation 1 were used to generate estimate of capital stock per boat per year based on the second data set that include physical characteristics of the registered boats that have been operating in Al-Seeb water. The net investment was calculated as the change in total capital stock per unit of time (i.e. year) for the period 2004-2013 and it is presented in Figure 5, which exhibits inter-annual fluctuation in net investment in the fishery. Despite this year-to-year fluctuation, the cumulative of net investment in the fishery experienced a positive

Table 3. Descriptive statistics of boat operation costs, Al-Seeb

Item	Min	Max	Mean	SD
Boat size (feet)	22	25	23.9	1.2
Engine Power (hp)	60	200	103.5	43.5
Engine Price (OMR)	1500	5000	2604.1	1240.6
Fishing Gear (units)	10	83	38.7	25.4
Fishing Gear Price (OMR)	525	5350	2215.9	1471.7
Maintenance Cost (OMR)	150	1250	517.8	332.6
Fishing Trip (hours)	2	19	8.1	3.8
Cost/trip/boat (OMR)				
Fuel	1	67	8.1	9.6
Oil	0.7	23.5	2.4	2.5
Food	0.2	33.5	2.7	3.4
Bait	0.5	15	4.3	3.2
Ice	0.5	8	1.5	1.1
Total	4	75.9	15.4	14.3

Source: Field survey

trend during 2004-2013 as depicted in Figure 6. Table 3 presents the descriptive statistics of boat characteristics, engine and gear price, maintenance costs, and operating costs per trip per boat gathered from the logbook survey data.

It is noted that the boats involved in cost analysis ranging in length from 22 feet to 25 feet with an average horsepower of about 104 hp. These figures are within the range presented in Table 1. Furthermore, the largest variability with regard to engine price is consistent with the result presented in Table 1. On average, the fishing trip lasted for about 8 hours. The operating costs include fuel, oil, food bait and ice, and the average cost per trip for individual fisher was estimated to be about 15 OMR. On average, fuel cost has the highest share (about 53%) followed by the bait cost (28%) in the total trip cost. This information is of important use for future research in this area. The highest share of fuel cost has important cost implication for boats that are using twine-engine as stated earlier.

To get an idea about the extent of economic benefits generated from fishing activities, crude estimates of the average monthly net value earned per boat are presented in Table 4 based on the survey data and the data from the statistical yearbook. The gross value is evaluated at farm gate prices of fish species. In the calculation of monthly operational costs per boat, it was assumed that individual boat makes 20 trips per month. Therefore, the estimate was conservative in nature.

Fishers' physical access to market can improve their

Table 4. Crude estimates of the average monthly net value earned per boat in Al-Seeb

Number of boats		521	
Number of fishers		1201	
Cost (OMR)/trip/boat		15.366	
Cost (OMR)/boat/month *		307.320	
Month	Value (OMR)	Value (OMR)/boat	Income (OMR)/boat
January	593000	1138.2	830.9
February	599000	1149.7	842.4
March	448000	859.9	552.6
April	321000	616.1	308.8
May	447000	858.0	550.6
June	370000	710.2	402.9
July	315000	604.6	297.3
August	439000	842.6	535.3
September	467000	896.4	589.0
October	535000	1026.9	719.6
November	500000	959.7	652.4
December	457000	877.2	569.8
Total	5491000	10539.3	6851.5

* assuming that a boat will make 1 trip per day and work for 20 working days a month.
Source: Field survey and MAF data.

profitability, as the prevailing market price was higher than that of farm gate. One of the reasons for the establishment of the central wholesale market in Oman in April 2014 was to give fishers access to market and address pricing inefficiency (Al-Busaidi et al., 2016; Al-Jabri et al., 2015). Furthermore, the extent of profitability was also influenced by the economic value of species caught, which differed from species to species. The monthly net revenue figures ranged from 297 in July (summer month) to 842 in February (winter month). On average, the monthly net revenue per boat was about 571 ± 169 OMR. The findings indicates the fact that fishing has been a profitable profession and this is reflected in the estimates of cumulative net investment. Personal discussion with fishers also revealed the same. However, up-to-date, comprehensive, and quality economic data are required to convey precise assessment of the economic situation of the sector. Expenditure figures presented in Table 4 are only a part of the costs involved in fishing operations. The cost of the boat in the form of depreciation allowance needs to be accounted. In addition, the opportunity costs of capital and the owner's labor and management have to be accounted for in order to arrive at the results of this economic activity.

Discussion

The degree of homogeneity in relation to boat length and the degree of heterogeneity to engine power are consistent with the findings by Al-Siyabi and Bose (2018). At least two important implications of these findings are as follows: (i) the homogeneity aspect may help reduce the conflicts, which arise from unequal catch share between large and small boats, and (ii)) the apparent heterogeneity to engine power along with the highest share of fuel cost (on average 53%) has important economic implications as the use of twin-engine exerts influence on operating costs. In addition, the recent rise in fuel price as noted by Al-Siyabi and Bose (2018) exerted upward pressure on the operation costs.

Higher fuel costs may discourage fishers' future investment decisions in the sector as it could reduce net gain unless it is compensated by the revenue earned through either increase in fish price or increase in total landings, or a combination of both (Tidd et al., 2011). Tidd et al. (2011) found a statistically significant influence of fuel prices on vessel entry and suggested that the vessels would enter at lower costs of subsidized fuel.

The highest degree of variation in total landings measured by the coefficient of variation (CV) and its sharpest decline experienced in 2008 for the study area signal the level of uncertainty in generating revenue from fishing. This is reflected by the variability in fishers' income as shown in Table 3. The authority may promote diversification rather than specialization of fishing portfolio through fishers' participation in additional or more diverse fisheries to mitigate seasonal variation in their income. This approach is common in fisheries. Anderson et al. (2017) proposed such strategy to buffer against income variability due to seasonality in fisheries. In a local context, alternative strategic initiatives such as aquaculture development (Al-Siyabi and Bose, 2018) and fishing tourism (Al-Busaidi et al., 2016) are also suggested to enable fishers to choose related but alternative profession. This type of approach would also help reducing fishing pressure and if economically viable would encourage relatively inefficient fishers to exit from harvesting operations.

The results of the hedonic model in relation to boat age, length and horsepower are consistent with the theoretical predictions and have important management implications. The statistical significance of the variable boat 'age' can be related to operational efficiency of the fleet as older vessels are expected to be less efficient than the newer one. Tidd et al. (2011) argued that older vessels are more likely to exit the fishery. The statistical significance of the variables 'horsepower (hp)' and 'length (vl)' predicted that the boat cost would increase with the increase in the characteristics of power and size. The results are also consistent with other empirical studies (Tidd et al., 2011). The implication of these results is that boat size and horsepower together with the high fuel costs may affect stock status and the economic viability of fishers, which in turn discourage future investment in fisheries.

With regard to the parameter estimates of the model, one may argue that the use of list prices of boats and engines introduces bias in estimates depending on the extent to which they deviate from the actual acquisition price. Furthermore, prices of used boats or rental market were not available. Due to a lack of sales data (new or used), validity of parameter estimates with specific reference to boat age could not be checked. It should also be noted that the boat acquisition price series were not inflation adjusted due to a lack of suitable (e.g., price index for equipment) and consistent price index for the study period. However, this may not undermine the results. It is argued that available machinery and durable equipment price index failed to incorporate quality changes adequately (Griliches, 1961), and therefore the process of deflation can introduce errors in measurement of price variable (Hulten, 1991). Usher (1980) mentioned the choice of price index reflects the equivalent performance of the old and new capital goods which is contrary to the real situation. The estimated parameters may be upward bias due to the use of quoted price rather than the acquisition price. However, this upward bias may be partly compensated as other components of capital costs, which are not included in the present analysis.

While inter-annual fluctuation in net investment in the fishery is observed, the cumulative investment trend was positive. The negative net investment could be influenced by various factors. For example, disinvestment in 2011 may be due to negative growth in landings as depicted in Figure 4 and social upheaval experienced in the country (Valeri, 2015). On the other hand, the positive net investment was influenced by the influx of new entrant. For instance, 25 new boats added to the registry in 2005. The positive trend in cumulative net investment for the period 2004-2013 reflects the overall dynamics of physical capital. Therefore, a convincing case can be made to support government investments and develop infrastructure. The positive trends in relation to number of fishers and boats were observed for Oman, Muscat and Al-Seeb signal economic potential of fisheries. In a recent case study, Al-Siyabi and Bose (2018) noted the existence of under-utilized fishing capacity and the presence of technical inefficiency in the utilization variable inputs (i.e. crews and fishing time) in small-scale fisheries. Based on these findings, Al-Siyabi and Bose (2018) argued that there was potential for improving production without having to incur any additional physical capital costs. Therefore, this signal of economic potential can be used as a tool to attract private investment in the sector, which is one of the strategic goals of the sector as mentioned earlier. However, a precautionary approach needs to be adopted and any effort to increase investment must strike a balance with the stock status. Otherwise, the call for public-private partnership can inevitably be limited.

While the findings in this study have important strategic implications with regard to future course of actions in the context of investment in small-scale fisheries, there are a number of limitations of this paper that need to be mentioned. First, a variety of potential variables such as fishing gear and equipment, and shore-based tangible assets like cars and buildings, are not considered as the data for such variable are not readily available. Second, the estimate of capital stock is based on the registered fishing boats in the local office, which is different from the number of boats as published in the yearbook. This discrepancy is due to the time lag in license renewal requirements. Third, estimates generated in this study used registered boats of Al-Seeb fisheries only, therefore, it should not be treated as an indication of net investment in the overall fisheries sector of Oman.

Conclusion

This case study uses a hedonic approach for examining the dynamics of physical capital stock and net investment in Al-Seeb artisanal fisheries. In spite of the above-mentioned limitations, the study has identified important information gaps in this area of research, set the groundwork for a more complete research study in the future, and form the basis for generating insights into the pattern of fishery investment and subsequently the design of effective management policies in relation to the future investment in the fishery. While the present case study has provided useful information, the robustness of empirical data and conclusions needs to be verified with further studies to a point where generalization of results can be accomplished. There is a great deal of room for further research particularly in the area of inclusion of physical assets other than boat and engine, inclusion of add-on characteristics in the quoted price, larger samples covering the whole sector, and improved method of inferring depreciation rates of boats. They could provide the authority with essential indicators/estimates which could be used in promoting and making investment decisions. Furthermore, it could motivate the data collection agencies to create a database and provide a better basis for making informed decisions.

References

Ahmed M, Salayo ND, Viswanathan KK, Garces LR, Pido MD. (2006). Management of fishing capacity and resource use conflicts in Southeast Asia: A policy brief. TWF Center, Malaysia.

Al-Busaidi MA, Jukes DJ, Bose S. (2016). Seafood safety and quality: An analysis of the supply chain in the Sultanate of Oman. Food Control 59: 651–662.

Al-Jabri O, Collins R, Sun X, Bose S, Belwal R. (2015). Measuring relationship marketing effect in small-scale fishing in Oman and enhancing efficiency and economic gains for traditional fishermen. Marine Fisheries Review 77(4):20-28.

Al-Siyabi M, Bose S. (2018). Capacity utilization in small-Scale fisheries: A case of the Sultanate of Oman. Sri Lanka Journal of Aquatic Sciences 23(2):163-172

Al-Subhi KKN, Bose S, Al-Masroori HS. (2013). Fishers' compliance motivations: A case study of the Sultanate of Oman. Marine Policy 37: 141–148.

Anderson SC, Ward EJ, Shelton AO, Adkison MD, Beaudreau AH, Brenner RE, Haynie AC, Shriver JC, Watson JT, Williams BC. (2017). Benefits and risks of diversification for individual fishers. PNAS 114(40): 10797–10802.

Bose S, Al-Kindy F, Al-Balushi A, Rajab MM. (2013). Accounting the unaccounted: Case of women's participation in shellfish harvesting in the Sultanate of Oman. Gender, Technology and Development. 17(1):31–53.

Bose S, Al-Mazrouai A, Al-Habsi S, Al-Busaidi I, Al-Nahdi A. (2010). Fisheries and food security: The case of the Sultanate of Oman. In: Proceedings of the International Conference on Food Security in the Arab Countries: New Challenges and Opportunities in the Context of Global Price Volatility. p. 2–4.

Boyce JR. (1995). Optimal capital accumulation in a fishery: A nonlinear irreversible investment model. Journal of Environmental Economics and Management 28(3): 324–339.

Breusch TS, Pagan AR. (1979). A simple test for heteroscedasticity and random coefficient variation. Econometrica: Journal of the Econometric Society. p.1287–1294.

Burt OR, Cummings RG. (1970). Production and investment in natural resource industries. The American Economic Review 60(4): 576–590.

Clark CW, Clarke FH, Munro GR. (1979). The optimal exploitation of renewable resource stocks: problems of irreversible investment. Econometrica: Journal of the Econometric Society 47(1): 25–47.

de Melo Alves Damasio L, Lopes PFM, Pennino MG, Carvalho AR, Sumaila UR. (2016). Size matters: fishing less and yielding more in smaller-scale fisheries. ICES Journal of Marine Science 73(6): 1494–1502.

Diffey S, Barnes C, Palfreman A. (2009). Code of practice for financing investment in the small-scale fisheries sector. Sultanate of Oman: Ministry of Agriculture and Fisheries.

Eisenack K, Welsch H, Kropp JP. (2006). A qualitative dynamical modelling approach to capital accumulation in unregulated fisheries. Journal of Economic Dynamics and Control 30(12): 2613–2636.

Godfrey LG. (1978). Testing for multiplicative heteroskedasticity. Journal of Econometrics 8(2): 227–236.

Griliches Z. (1961). Hedonic price indexes for automobiles: An econometric of quality change. In: The Price Statistics of the Federal Goverment. NBER. p. 173–196.

Heck S, Béné C, Reyes-Gaskin R. (2007). Investing in African fisheries: building links to the millennium development goals. Fish and Fisheries 8(3): 211–226.

Holmes L, Strauss CK, de Vos K, Bonzon K. (2014). Towards investment in sustainable fisheries: A framework for financing the transition. Environmental Defense Fund and The Prince of Wale's International Sustainability Unit, UK.

Hulten CR. (1991). The Measurement of Capital. Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth, 1 January 1991, p. 119–158.

Ikiara MM, Odink JG. (1999). Fishermen resistance to exit fisheries. Marine resource economics. 14(3):199–213.

Jarque CM, Bera AK. (1980). Efficient tests for normality, homoscedasticity and serial independence of regression residuals. Economics Letters 6(3): 255–259.

Jorgenson DW. (1974). The economic theory of replacement and depreciation. In: Econometrics and economic theory. Springer, New York. p. 189–221.

Kendrick JW. (1961). Some theoretical aspects of capital measurement. The American Economic Review 51(2): 102–111.

Kirkley J, Squires D. (1988). A limited information approach for determining capital stock and investment in a fishery. Fishery Bulletin 86(2): 339-349

Kirkley J, Paul CJM, Squires D. (2002). Capacity and capacity utilization in common-pool resource industries. Environmental and Resource Economics 22(1–2): 71–97.

Kirkley J, Squires D. (1998). Measuring capacity and capacity utilization in fisheries. Background paper Prepared for FAO Technical Working Group on the Management of Fishing Capacity, La Jolla, USA, 15-18 April 1998, 160 pp.

Kirkley J, Squires D. (2003). Capacity and capacity utilization in fishing industries. Measuring Capacity in Fisheries Report No.: 445.

Lam VW, Sumaila UR, Dyck A, Pauly D, Watson R. (2011). Construction and first applications of a global cost of fishing database. ICES Journal of Marine Science 68(9): 1996–2004.

Le Floc'h P, Daurès F, Nourry M, Thébaud O, Travers M, Van Iseghem S. (2011). The influence of fiscal regulations on investment in marine fisheries: A French case study. Fisheries Research 109(2–3): 257–264.

MNE. (2007). Long-term development strategy (1996-2020): Vision for Oman's economy (Oman 2020).

Ministry of National Economy, National Center for Statistics and Information.

Nøstbakken L, Thebaud O, Sørensen L-C. (2011). Investment behaviour and capacity adjustment in fisheries: a survey of the literature. Marine Resource Economics 26(2): 95–117.

Pomeroy RS. (2012). Managing overcapacity in small-scale fisheries in Southeast Asia. Marine Policy 36(2): 520–527.

Purcell SW, Pomeroy RS. (2015). Driving small-scale fisheries in developing countries. Frontiers in Marine Science 2: 1-7 (Article 44).

Rosen S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. Journal of Political Economy 82(1): 34–55.

Setlur B, Arbuckle MW. (2015). Sustainable management of the fisheries sector in Oman : a vision for shared prosperity. The World Bank Report No.: 110678. 44 pp.

Squires D. (1988). Index numbers and productivity measurement in multispecies Fisheries: an application to the pacific coast trawl fleet. NOAA Technical Report NMFS 67, NOAA/National Marine Fisheries Service, USA.

Tidd AN, Hutton T, Kell LT, Padda G. (2011). Exit and entry of fishing vessels: an evaluation of factors affecting investment decisions in the North Sea English beam trawl fleet. ICES Journal of Marine Science 68(5): 961–971.

Usher D. (1980). Introduction to “The Measurement of Capital.” In: The Measurement of Capital. National Bureau of Economic Research. NBER Book Series Studies in Income and Wealth. p. 1–22.

Valeri M. (2015). Simmering unrest and succession challenges in Oman. Carnegie Endowment for International Peace, Washington DC, USA.

Zhang D, Sikveland M, Hermansen Ø. (2018). Fishing fleet capacity and profitability. Marine Policy 88: 116–121.