Socio-Economics and Cage Culture Practices of Red Tilapia (Tab Tim) at the Taasarn-Bangpla Canal, Nakhon Pathom Province, Thailand

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ABSTRACT

Taasarn-Bangpla is a natural canal in Nakhon Pathom province that has been used to divert water from Mae Klong river to Tha Chin river. The recent increase in fish cage culture raised concerns over its environmental impact. A study on fish cage culture in the canal carried out from 2013-2014 consisted of two interrelated aspects: socioeconomics and environmental. This paper reports the results of the study on socioeconomics which included the number of cages, distribution and production, and culture practices. The survey in 2013 found a total of 35 operators with 527 cages. The cages were mostly concentrated in Tung Kraphanghome sub-district of Kamphaeng Saen district with a small number found in Donthoom district. Red tilapia (Tab Tim) was the cultured species with an approximate production of 1,057 tonnes y^{-1} from 2 crops per year. Cage culture in the canal first emerged before 2002. The current popularity is a result of private sector promotion through contract farming. Profit margin obtained from successful cage culture has attracted more people to get involved in cage culture. Some farmers practice cage culture as their main occupation while others practiced it as a secondary occupation to earn additional income. The private sector provided technical guidance on how to raise fish, and supplied fingerlings for stocking as well as credit for the essential inputs such as feed and fingerlings. Operators would initially invest in cage construction mainly from their own savings, while other sources come from relatives who provided loans without interest, and/or commercial banks for loans with interest. A floating square metal frame net cage with a size of 5x5x2.5 m^3 was the typical cage structure used to stock 30-50 (30-100) g $fish^{-1}$ at the stocking rate of 25-30 (16-40) fish m^{-3}. Fish was raised for 4-5 (4-7) months with commercial pellet feed containing 0% (25-35%) protein, 3 (2-4) times d^{-1}. Production of 20-28 (10-28) kg m^{-3} was achieved from 80-90% (50-95%) survival rate of 700-1,000 (400-1,200) g $fish^{-1}$ at final harvest. FCR ranged between 1.2-1.9 (0.8-3.1). The concern on cage culture at the Taasarn-Bangpla canal is related with its sustainability. Low stocking rates, antibiotic use and aeration were evidences indicating environmental changes in the canal. The absence of strict control measures enabled unlimited proliferation of cages for fish farming, resulting in increased fish production. Thus, there is an issue of how current cage culture practices are affecting sustainability, both the environmental and socioeconomic aspects.

Keywords: Taasarn Bangpla, cage culture, red tilapia, Tab Tim, socioeconomics, contract farming, sustainability, environment

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INTRODUCTION

Country-wide tilapia culture practice has occurred resulting from success in mass seed production and mono-sex tilapia fry production techniques. Government policy and the private sector have also encouraged cage culture in Thailand. Tilapia has become the mainstay freshwater aquaculture species. Its annual production has been maintained above 200,000 tonnes since 2002 (DoF, 2013). The production mainly comes from pond culture; however, production from cage culture has become significant. The number of cage culture operators increased from 3-4 operators in 1999 (Hiranwat and Tavarutmaneegul, 1994) to 8,256 in 2011 (DoF, 2013). Cage culture gained popularity due to the abundance of water sources which can be easily accessed by people, often landless, who lived nearby (Hiranwat and Tavarutmaneegul, 1994; Lin and Kaewpaitoon, 2000). In addition, it provided an alternative opportunity for the jobless and/or those who needed additional income. Tilapia cage culture attracts investors to operate since it generates an attractive return within a short culture period of only 4 months. Therefore, the scale of operation ranges from small scale (few cages) to large commercial scale (>100 cages).

Taasarn-Bangpla canal is a tributary of the Tha Chin river. With a total length of 66 kilometers the canal originates from Tha-Krump-End sub-district in Kanchanaburi province, flows eastward through Kamphaeng Saen then Dontum districts, and combines with the Tha Chin river at Bangpla sub-district, Banglen district, Nakhon Pathom province. The canal has been used to divert water from the Mae Klong river in Kanchanaburi to the Tha Chin river in Nakhon Pathom to protect intrusion of saline water into the lower reach of the Tha Chin river during the dry season. Three sluice gates were constructed to regulate the water in the canal through 88 sub-tributaries on both sides of the canal and to support agricultural activities in the area.

The rapid increase in the number of fish cages in the canal has recently raised a concern over the issue of environmental impacts. Failure to recognize the impact of cage culture on the environment has often led to a problem of over-carrying capacity (Beveridge *et al*., 1998). Lack of data and information of cage culture in the canal makes it difficult to assess the current status as well as the linkage of the practices with socioeconomic and environmental aspects. Therefore a study was carried out focusing on these two interrelated aspects, i.e. socioeconomic and environmental aspects. This paper reports on the results of the socioeconomic study, whose objectives were to determine the number, distribution and production levels of cage fish culture in the canal, investigate the socioeconomic status of the cage culture operators, and, look into the cage culture practices of the operators.

MATERIALS AND METHODS

Data/information gathering was primarily performed by communicating with provincial line agencies such as fisheries officers and irrigation officers for primary data and information. Search from Google Earth was conducted to determine the number and distribution of fish cages in the canal. Ground truth was subsequently conducted to enumerate the actual number of cages, location verification and interview for information. A set of questionnaires was designed and used as guidelines for data/information gathering. Essential elements included in the questionnaires were: background information on cage culture start-up operations, fish culture techniques, and socioeconomic information of operators. Data/information gathering was carried out during October-December 2013. Collected data was entered, analyzed and categorized by Excel program.

RESULTS

Number and distribution of cages, and production levels

The survey in 2013 found a total of 35 cage culture operators with 527 cages distributed in Kamphaeng Saen and Donthoom districts. Out of the 35 operators, 34 (97%) were in Kamphaeng Saen district and only one (3%) in Donthoom district. Wang Namkhiew and Tung Kraphanghome sub-districts have an equal number of operators (13 or 37% each).

The remaining 26% (9 operators) were distributed at Kamphaeng Saen, Wang Tagu, Rarng Phikul, Don Koi sub-districts, and Sam Ngam sub-district of Donthoom (Table 1). Tung Kraphanghome sub-district had the highest number of fish cages (Table 1 and Figure 1). The number of fish cages operated by one operator ranged from 3 to 65 cages. The fewest (7) and most numerous (33) fish cages per operator were found in Wang Tagu and Rarng Phikul, respectively (Table 1).

Red tilapia (Tab Tim) was the species of choice to be cultured in fish cages. One cage with a size of 5x5x2.5 m^3 could produce an average of 985 kg $cage^{-1}$ $crop^{-1}$. Based on the average fish production $cage.^{-1}$ $crop^{-1}$, the approximated annual production in the canal could reach 1,057 tonnes at in 2 crops per year.

Socio-economic information

Operators' ages ranged between 22 and 75 years old but the majority were between the ages of 40 and 49 (34.3%) (Table 2). Education levels varied widely from primary school to university, but the majority (51.4%) have graduated from primary school. The number of family members ranged from 1 to 10, but 3 to 4 was the average including a couple with 1 to 2 children. Cage culture activity could either be the main or supplementary occupation. Forty percent (40%) practiced cage culture as their main activity while the rest (60%) had other main activities and practiced cage culture as a supplementary activity. These main occupation included agriculture (22.9%), being an employee (14.3%), government service (11.4%) and trading (11.4%) (Table 2).

Table 1. Distribution of cage culture operations in Taasarn-Bangpla canal by administrative boundary

District	Sub-district	No. of operators	No. of fish cages	Average no. of fish cages per operator
Khamphangsaen	Wang Namkhiew	13	167	13
	Tung Kraphanghome	13	206	16
	Kamphaengsaen	3	34	11
	Wang Tagu	2	13	7
	Rarng Phikul	2	66	33
	Don Koi	1	11	11
Donthoom	Sarm Ngarm	1	30	30

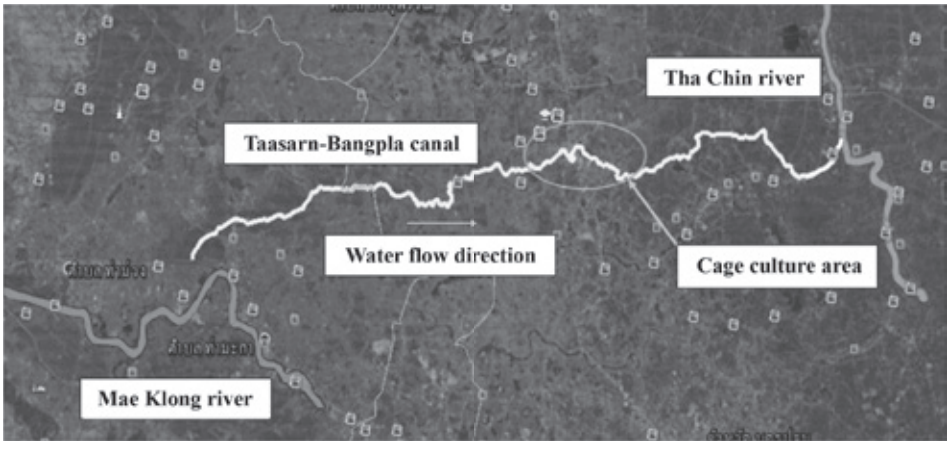

Figure 1. Distribution of cage fish culture operations along the Taasarn Bangpla canal (green circle), between 13°59' 47.26"N, 99°57'45.01"E and 13°59'22.10"N, 100°3'38.15"E.

Table 2. Socio-economic information of fish cage operators at the Taasarn-Bangpla canal, Nakhon Pathom province

Socio-economic Parameters	Details	% (Frequency)
Age (years)	<30	8.6% (n=3)
	30-39	20.0% (n=7)
	40-49	34.3% (n=12
	50-59	25.7% (n=9)
	>60	11.4% (n=4)
		100% (n= 35)
Educational attainment	primary school	51.4% (n=18)
	high school	31.4% (n=11)
	vocational school	2.9% (n=1)
	University	14.3% (n=5)
		100% (n= 35)
Main occupation	government service	11.4% (n=4)
	employee	14.3% (n=5)
	trading	11.4% (n=4)
	agriculture	22.9% (n=8)
	cage culture	40.0% (n=14)
		100% (n= 35)
Alternative occupation	government service	0% (n=0)
	employee	14.3% (n=5)
	trading	2.9% (n=1)
	agriculture	17.1% (n=6)
	cage culture	48.6% (n=17)
	none	17.1% (n=6)
		100% (n= 35)
Reason to start cage fish farming	follow another	74.3% (n=26)
	sales representative promotion	8.6% (n=3)
	government extension	8.6% (n=3)
	Others	8.6% (n=3)
		100% (n= 35)
Source of investment	own savings	68.6% (n=24)
	loan without interest	11.4% (n=4)
	loan with interest	20.0% (n=7)
		100% (n= 35)
Ownership of canal front area	owned by operator	91.4% (n=32)
	rented from another	8.6% (n=3)
		100% (n= 35)
Culture fish species	all male red tilapia (Tab Tim)	91.4% (n=32)
	all male red tilapia (Tab Tim) +other species	8.6% (n=3)
		100% (n= 35)

Cage culture in the canal commenced sometime before 2002 by following the practices from other areas. The number of operators increased by 32.4% during 2002-2006, 23.5% during 2007-2010, and 41.2% from 2010 onwards. The decision to practice cage culture was due to a number of reasons such as attractive income, unemployment and living near the canal, promotion by sales representatives of feedmill companies, and extension activities by the Tambon (Sub-District) Administration Organization and the Thai Department of Fisheries. The majority (74.3%) started cage culture by following others who were already operating cages. Another 8.6% were persuaded by promotion through sale representatives, agency extension work and other reasons.

Fish cage operators gained knowledge through many channels but the majority (54.3%) learned cage culture techniques from sales representatives, with 37.1% learning from others such as relatives or employers, 5.7% learned from their own cage culture experiences, and 2.9% learned from district fisheries officers. The majority (68.6%) invested in cage culture using their own savings, while 20% loaned with interest from banks and 11.4% loaned without interest from relatives.

People living on banks along the canal took advantage of using the canal for cage culture. Up to 91.4% of operators set up fish cages just in front of their residence, with only 8.6% living some distance from the canal. The latter rented the water-frontage areas from others at a considerably low rental fee of 12,000 baht/year to culture fish in cages.

Tab Tim (Red tilapia) was the main cultured species. A large majority of operators (up to 91.4%) raised only sex reversed red tilapia while the rest raised mixed sex red tilapia as the main species, although some also tried stocking with a smaller number of catfish. Up to 62.9% of the cage operators preferred to stock large fingerlings (30-50 grams/individual), while the rest (37.1%) stocked small fries (1.0-1.5 cm in total length) which they would further nurse, then raise to marketable size.

Technical practices

A typical cuboid net cage with 5x5x2.5 m^3 square metal frame was used by 82.8% operators (Figure 2 and Table 3). The net cage was suspended with a square iron frame and buoyed up by barrel tanks to keep it afloat (Figure 2). Four lower corners of the net were stretched with brick to maintain maximum space of cubic feature. One square metal frame (5x5x2.5 m^3) was divided into 4 small cages for ease of management. The cages were connected to each other in a series along the canal or also expanded in parallel when width of canal increased. The cages move vertically according to changes in water level but were fixed at a specific area by tying them onto poles or big trees on the bank.

Figure 2. Feature of net cages used to raise red tilapia (Tab Tim)

Table 3. Technical information on cage fish culture operations at Taasarn-Bangpla canal, Nakhon Pathom province

Technical Parameters	Technical Data	% (Frequency)
Size of cages (m^3)	5x5x2.5	82.8% (n=29)
	4.5x4.5x2.5	2.8% (n=1)
	6x6x2	2.8% (n=1)
	4x5x1.8	2.8% (n=1)
	5x5x2	8.6% (n=3)
		100% (n=35)
Size at stocking (g $fish^{-1}$)	30-50	85.7% (n=30)
	60-70	5.7% (n=2)
	80-100	8.6% (n=3)
		100% (n=35)
Stocking rate (fish m^{-3})	16-24	8.5% (n=3)
	25-30	57.1% (n=20)
	31-36	28.5% (n=10)
	18-30	2.8% (n=1)
	34-40	2.8% (n=1)
		100% (n=35)
Culture period (months)	4-5	76% (n=25)
	6-7	24% (n=8)
		100% (n=33)
Survival rate (%)	50-70	27% (n=9)
	80-90	69% (n=23)
	50-95	3% (n=1)
		100% (n=33)
Production (kg m^{-3})	10-18	39% (n=13)
	20-28	60% (n=20)
		100% (n=33)
FCR	0.8-1.0	6% (n=2)
	1.2-1.5	39% (n=13)
	1.6-1.9	39% (n=13)
	2.0-3.1	15% (n=5)
		100% (n=33)
Crops $year^{-1}$	1	6% (n=2)
	1.5-1.8	13% (n=4)
	2	75% (n=24)
	3	6% (n=2)
		100% (n=32)
Harvest size (g $fish^{-1}$)	400-650	18% (n=6)
	700-1,000	78% (n=26)
	1,200	3% (n=1)
		100% (n=33)
Feeding frequency (time day^{-1})	2	2.8% (n=1)
	3	86.8% (n=31)
	4	8.6% (n=3)
		100% (n=35)
Feed protein content (%)	25	3% (n=1)
	30	38% (n=12)
	25, 30	3% (n=1)
	28, 30	12.5% (n=4)
	30, 32	12.5% (n=4)
	30, 35	31% (n=10)
		100% (n=32)
Use of antibiotic and premixed	antibiotic	43% (n=15)
	antibiotic + premixed	57% (n=20)
		100% (n=35)

All male red tilapia (Tab Tim) was the species raised in cages. The majority of operators (85.7%) stocked 30-50 g fish^{-1} at various stocking rates (from 16-40 fish m^{-3}). However, 25-30 fish m^{-3} was the most popular stocking rate practiced by up to 57.1% of the operators. Scarcity and high price of large fingerlings have forced some operators to purchase small size fry (length of about 1.5 cm) to nurse for another 1-2 months to reach 30-50 grams fish^{-1}, then raising them further to marketable sized fish.

The culture cycle lasted for 4-7 months but the majority (76%) could raise fish for 4-5 months crop^{-1}. Considerably higher survival rates (80-90%) were reported by 69% of the operators. Production varied from 10-28 kgs m^{-3}, with 60% of the operators able to reach 20-28 kgs m^{-3}. Harvest size ranged from 400-1,200 g fish^{-1}, with 78% of the operators had fish sizes ranging from 700 to 1,000 g fish^{-1}. Feed conversion ratio ranged from 0.8-3.1, with 78% of the operators reporting FCRs of 1.2-1.9. Feed was manually applied 2-4 times day^{-1} with 86.8% of the operators giving feed 3 times day^{-1} (morning, noon and evening). Protein content of feed varied from 25-35%. Less than half of the operators (41%) used only one protein content, either 25 or 28% throughout the culture period. The majority (59%) used a combination of feeds with two protein content levels such as 30 and 25%, 30 and 28%, 32 and 30%, and, 35 and 30%.

All the operators (100%) reported using antibiotics (43% used only antibiotics while 57% used antibiotics together with premix) depending on the stage of culture, normally with the newly stocked fish, and before and after transferring. The use of antibiotics was necessary to protect from disease and mortality caused by stress, weakness, and infectious wounds from transportation/transferring. The 58% of the operators used premixed regularly or at least at certain times during the culture period.

Aeration either by paddle wheel or blower was applied in some areas to improve dissolved oxygen during the low flow period or when water reached hypoxia conditions.

DISCUSSION

Cage culture farming in the canal emerged sometime before 2002. The success of a few pioneers coupled with the promotion of the contract farming scheme inspired a number of people to get involved in fish case farming. Hence, the number of operators and cage increased. A survey in 2013 found a total number of 35 cage culture operators with 527 cages distributed in Kamphang Saen and Donthoom districts. Dense cage culture was practiced in Kamphaeng Saen districts possibly associated with dense population in such the district.

Alternative employment and the promotion of alternative livelihoods have recently become a common feature of many policies in ASEAN member countries. But alternative employment was not an easy matter, it depends strongly on differences in cultural, social, economic and natural conditions and potentials (FAO, 2006). Cage culture promotion by the Thai government was aimed to alleviate poverty of the rural poor as well as enhance fish production from natural waters. Therefore the rural poor living near or have access to water bodies gained benefit from the policy. Proximity to water front was an influential factor for cage culture operations (Belton *et al*., 2006, Phimphakan *et al*., 2014).

Aquaculture benefits the poor in many ways and it is perceived very positively by poor and non-poor alike. The poor derive a relatively larger share of their income from it than the rich. Extensive or semi-intensive aquaculture production systems are usually thought to be relatively more pro-poor than intensive systems because the lack of access to credit prevents poor fish farmers from purchasing inputs in large quantities as required by intensive systems (Irz *et al*., 2007). Cage culture is an intensive fish culture system. It is attractive because there is no expenditure needed for land, pond construction, water supply systems and management skills (Beveridge and Stewart, 1998, Hortle *et al*., 2011). Cage culture attracted not only the rural poor but also the rich businessmen. In addition, contract farming scheme supports more people to be able to operate cage culture. The current increase in the number of fish

cage operators in the Taasarn-Bangpla canal are mostly from the contract farming scheme promoted by the private sector. People whose houses face a water body and wanted to practice cage culture had to invest primarily for cage construction cost. The initial investment came from their own savings, were borrowed from their relatives without interest, or loaned from banks with interest. Starting with a few cages and subsequently expanding to more cages using their profits to reinvest was a general strategy employed since cage culture had a quick return to investment of only 4-5 months.

Cage culture was practiced in the Taasarn-Bangpla canal either as a main or alternative occupation. Fish farming is usually a component of a portfolio of household activities, but as farm size increases, it may become a core business (Lebel *et al*. 2013). Some operators abandoned their previous occupation such as rice or shrimp farming because of the attractive returns to effort which cage culture offers (Belton *et al*., 2006).

Under the contract farming scheme, the inputs supplier principally provided fingerlings and feed to the contracted dealership in credit. Technical advice such as stocking strategies, application of feed, drug and chemical use, and buying back the harvested fish was the portfolio of the contract farming scheme. It seemed to support well those who lived near the water front and wanted to practice cage culture but they lack the budget, technical knowledge and marketing ability. This fact finding was consistent with what was stated by Prowse (n.d.) that smallholders often suffer from capital constraints, and they lack capacity to adopt technological innovations. Contract farming scheme provided solutions to overcome these constraints. However many operators claimed that only a small profit could be derived from the scheme since the inputs provided by the supplier-contractor were always costly. Delay in obtaining fingerlings for stocking and fish harvesting were other disadvantages. Operators also took risk from the current degraded environment that often caused fish disease and massive mortality. Many operators stopped dealing with the scheme but the majority still continued with it. Principally, contract farming has both advantages and disadvantages. It is workable if the advantages outweigh the disadvantages for both supplier and cage fish operator, and both feel better off with contract than without it (Birthal, 2008).

Similar to other water bodies in the country, the Taasarn-Bangpla canal has been used for cage culture since the last few decades or when tilapia culture became popular. The canal connecting between the Mae Klong river and the Tha Chin river flows in eastward direction. Water flow in the canal was not natural but manipulated. Water diversion from the Mae Klong river to the Tha Chin river aimed to maintain the freshwater ecosystem of the lower reach of the Tha Chin river from intrusion of saline water during the dry season. The canal also supplied water for agricultural activities in the watershed through its 88 tributaries. On the other hand, these tributaries returned poor quality (contaminated) water back to the canal. Water quality of the canal varied seasonally according to water management scheme. Good water quality was observed during high flow period from December to July and poor water quality occurred during low flow period from October to November.

Good water quality during high flow period is favorable to cage culture. However, operating two crops per year in combination with uncontrollable availability of large size fingerlings during high demand period, including delays in harvesting caused difficulty in controlling the culture period to be confined within the high flow period. These constraints are consistent with Belton *et al*. (2006) which reported that disruption of cage culture production cycles occurred by inconsistent availability of fingerlings and delayed harvesting at times of oversupply. Cage culture operators acknowledged the annual change of water flow and its related water quality, hence avoided negative impact by reducing the number of cages and reducing stocking rates during unfavorable periods. It was found that the stocking rate of 30-50 g fish^{-1} at the Taasarn Bangpla canal cage culture varied between 25-30 fish m^{-3} and this was apparently lower than the 50 fish m^{-3} stocked in Saiburi river in the south (Jesoh *et al*., n.d.) and 49 ± 16 fish•m^{-3} in the upper Ping river in the North (Lebel *et al*., 2013). The other evidence was the installation of water pump and paddle wheel in some cage culture areas to maintain dissolved oxygen at a favorable level from hypoxia condition.

Tilapia is an easy species to culture due to its high adaptability to eat a wide range of food and organic matter, resistance to diseases and environmental changes, and ease of culture in various aquaculture systems (Hortle *et al*., 2011). Tilapia cage culture could be practiced by employing simple techniques but the production largely depends on its surrounding environment. Surface water was generally polluted to some extent. Access to suitable areas to suspend cages may be restricted by both physical conditions such as flow or depth as well as social or legal limits to use of riverbanks or water surface (Phimphakan *et al*., 2014). Moreover, cage culture has been facing a number of challenges, including high feed costs, lack of capital, diseases, and natural disasters such as flood and drought (Hortle *et al*., 2011). In worse situations, fish farmed under deteriorated environment encountered severe problems of fish disease and mass mortality.

The concern for cage culture at the Taasarn-Bangpla canal was related to its sustainability associated with environmental conditions particularly water quality in the canal. Presumably the current number of cages and their production as well as other activities in the river basin caused severe water quality alteration. Cage culture in the canal continues to be alive because of good water quality diverted from the Mae Klong river to the Tha Chin river via the canal. Without water diversion to maintain good water quality during high flow period, cage culture will completely cease. The use of antibiotics and aeration were good evidences indicating environmental alteration of the canal.

Increasing population, and economic, agricultural and industrial expansion are the major causes of water quality deterioration in many water bodies. Rivers in populated areas were polluted due to the discharges of wastewater from various point sources. High loading of pollutants beyond the water resource carrying capacity can contribute to degradation of water quality. On the average water quality is acceptable, the official data suggests that more than half of the rivers have acceptable water quality, while about one-third, included the Tha Chin river is under degraded or polluted condition (Thailand, 2013).

Lack of strict control has allowed the number of cages to increase freely, without official records on number and production. This finding was consistent with Belton (2006) in that the true extent of tilapia culture and production were severely under-reported. Approximately 1,057 tonnes of the annual cage fish production indicated cage culture practice in the canal were involved in waste generation to some extent. Legally, cage culture practice in public waters must be approved by the local authority to control the number so as not to exceed the water carrying capacity. However, this was not the case at the Taasarn-Bangpla canal. Therefore there is a need to question whether current cage culture practices would affect the sustainability of environmental and social aspects.

CONCLUSION

Cage culture practice in the Taasarn-Bangpla canal is supporting the livelihood of those living along the canal to some extent. Benefits obtained from cage culture either as main or supplementary occupation depend largely on the diversified background of operators. Contract farming scheme was an important driving force enhancing number of operators and production. Thirty-five operators with an approximate annual production of 1,057 tonnes were recorded during the study period from 2013-2014. Cage culture is facing risks from poor water quality during the low flow period hence the number of cages and stocking rates are adjusted accordingly. Culturing fish during the low flow period resulted in slow growth and vulnerability to disease and mortality. Antibiotics and aerators were applied in some areas to cope with such risks. However, antibiotics were widely applied without sufficient control measures. The association of the current cage culture practice and sustainability of environmental and social aspect is questionable.

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