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Assessment of pond production of pacific white shrimp, *Litopenaeus vannamei* (Boone, 1931) culture in Gujarat state

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Abstract
Shrimp aquaculture industry has shown immense good growth in last decades. Black tiger shrimp (*Penaeus monodon*) and the white leg Pacific shrimp (*Litopenaeus vannamei*) are the main contributor in the shrimp culture production. India ranks first in shrimp products export due to great development in shrimp farming. Shrimp farming has been also developing actively in India and Gujarat. Presently Gujarat is producing 55,161 tons of high quality shrimp from 7542 ha. The present study was carried out at shrimp farms of six districts of Gujarat *viz*., Gir-somnath, Amreli, Bhavnagar, Surat, Navsari, Valsad during the year 2018 to assess the pond production of shrimp culture pond. Five ponds from each selected districts was randomly selected. The data were collected during March to September 2018. The growth parameters *viz*., weight gain, Feed Conversion Ratio (FCR), Average Daily Gain (ADG) and survival percentage were calculated. Stocking density, harvest size, FCR, culture period, ADG of selected district were significantly different (P<0.01) while pond production and survival percentage of selected district were not significantly different (P<0.01) Water parameters were significantly different (P<0.01) accept alkalinity which is not significantly different among all the ponds. To sustain the present culture practices in Gujarat, it is being recommended to adopt better management practices. The study has also provided essential information on which further studies can be carried out to evaluate impact of water parameters on growth & survival and also supports protection and decision making for sustainable development in the coastal districts of Gujarat.

Keywords: Pacific white shrimp, production, brackish water, earthen pond, Gujarat

1. Introduction
Worldwide, penaeid shrimp aquaculture ranks sixth in terms of quantity and second in terms of value among all the animals culture [1]. Around 80% of production is contributed from aquaculture which is dominated by two species i.e., black tiger shrimp (*Penaeus monodon*) and the pacific white shrimp (*Litopenaeus vannamei*) [2]. It is a native to the pacific coast of Central and South America and most widely cultivable species over the world because of the less risk of diseases and favorable environmental conditions [3, 4, 5]. The *L. vannamei* is cultured in around 38 countries of world [6]. In India, production of *L. vannamei* from culture is about 622,327 tons from 93,496 ha in 2017-18 [7]. Cultured shrimps, primarily the shrimp mainly *L. vannamei*, accounted for nearly 70% of the India's seafood exports worth Rs 30,868 crore in 2017-18 [7]. Most of the output has come from the states i.e., Andhra Pradesh, Odisha, West Bengal and Gujarat.

In India, majority of shrimp farming is done by traditional culture methods with ponds size 1.5 ha and bigger in Kerala and West Bengal or by semi-intensive methods with pond size below 0.5 ha, as in Andhra Pradesh, West Bengal, Gujarat and Odisha. Gujarat has longest coastline of 1600km with approximately 3.76 lakh hectare of brackish water area, which is ideal for shrimp culture. Out of this, only 7542 ha area is utilized for brackish water shrimp farming. Gujarat have 12 coastal districts and a union territory of Diu but only four of the districts *viz;* Valsad, Navsari, Surat and Bharuch are the major shrimp producer. The pacific white shrimp *L. vannamei* has become the major species produced through culture since 2009 [8].

Generally survival, growth and production of shrimp depend on the intensity of culture. In ponds usually high density exacerbates the problems with water quality and sediment deterioration. Many workers of shrimp farming have described about the growth in shrimp culture systems based on stocking density [9] and many researchers have reported an inverse

relationship between growth and stocking density [10-13]. Water quality management became the limiting factor because of higher feeding rates and greater stocking densities in the intensive farming. The pond water parameters and quality of supplementary feed as individual plays important role on the growth, survival and shrimp production, which together determine the final harvest. The ecosystem and biota of the culture pond may also influence the production performance of shrimp culture. The effect of water temperature, salinity, pH and dissolved oxygen on the shrimp growth and survival has been studied by many researchers across the world [14].

Many shrimp researchers has been worked for the increasing production through different stocking density, various fertilization method, artificial feeding [15]. Presently, Gujarat shrimp farmers are stocking the ponds based on their experience and information which is available in institutional guideline. Information on effect of stocking density on the shrimp performance during semi-intensive culture for Gujarat is limited and inconsistent. Although aquaculture activity is expanding throughout the Gujarat, there is lack of information on culture technique, pond management, stocking density and water quality of aquaculture ponds. If aquaculture industry has to sustain, proper management with high standards of environment quality maintenance should be practiced by the shrimp farmers. The work was carried out to estimate the production, growth rate and feed conversion ratio of *L. vannamei* cultures in the selected districts of Gujarat. The study will be also helpful to predict the suitable culture sites of Gujarat to obtain higher shrimp production

2. Materials and Methods

The present study was conducted at commercial shrimp farms of six districts of which three from Saurashtra and three from South-Gujarat (Gir-somnath, Amreli, Bhavnagar, Surat, Navsari, Valsad) during the crop year 2018. Total 30 shrimp ponds have been randomly selected from six districts. This districts were selected as there was extensive development in shrimp farming in all districts in last decade. All selected shrimp farms were visited on monthly interval for water sample and data collection. Details of stocking of shrimp seed, feed etc. were collected from shrimp farms during the month of March to September 2018. Growth performance of shrimp was measured based on mean individual weight at harvest, growth rate, feed conversion ratio (FCR) and survival rate were calculated by the formula as follows.

Total weight (kg) = sum of individual weight (kg)
Survival rate (%) = (Numbers of shrimps at harvest/ Number of stocked shrimps) x 100
Final harvest weight (gm) = Final harvest weight/Survived numbers
FCR = Total feed required (kg)/Total wet weight gain (kg)
Culture period (days) = Total culture days of crop
Growth rate (g day^{-1}) = (Final weight – Initial weight)/ Total days of culture

Water samples were collected monthly and analyzed for various physical and chemical parameters such as temperature, pH, dissolved oxygen, salinity and ammonia. Samples were collected by dipping the plastic bottles from 15 cm depth from water surface. Temperature (ºC) was measured by thermometer, the pH of the water by using a pH meter, salinity was measured by using refractometer the dissolved oxygen was measured by modified Winkler's method and alkalinity, total hardness & ammonia were analyzed by using standard methods [16]. All the results were statistically analyzed by one way analysis of variance (ANOVA) [17].

3. Results and Discussion

The main culture species of shrimp is *L. vannamei* which was started to culture in Gujarat and India from 2010. In 1991-92, shrimp culture was started in Gujarat in 4.5 ha area with an average production of 377.80 kg/ha and then increased to 7542 ha with an average production of 7.31 mt/ha in year 2017-18 [8]. Presently Gujarat is producing 55,161 tons of high quality shrimp from 7542 ha @ 7.31 mt/ha. Mostly semi-intensive culture system is followed for *L. vannamei* culture in Gujarat. Earthen ponds of 0.6 to 1.0 ha of size ponds are used by the shrimp farmers of selected districts of Gujarat (Figure 1). Stocking rate of post larvae in pond is mainly between 2-5 lakh per ha and it is according to Coastal Aquaculture Authority guideline for shrimp farming. Most shrimp farmers of selected districts were stocked their ponds with specific pathogen free (SPF) Pl-7 to PL-11. Stocking method were traditional or tank aeration method. Most farmers were using the artificial supplementary feed to fed shrimp. Feeding methods *viz.*, broadcasting, boat feeding or auto-feeder were used by the shrimp farmers of selected districts. Biosecurity measures were taken by the all the farmers of selected districts for prevention of diseases.

The mean total production of selected five ponds recorded 8252±200.23 kg/ha in Gir-somnath, 6217±480.80 kg/ha in Amreli, 7025±2603.80 kg/ha in Bhavnagar, 8021±1516.79 kg/ha in Surat, 7999±1887.85 kg/ha in Navsari and 5932±688.87 kg/ha in Valsad respectively (Figure 2). The results observed were similar to the shrimp aquaculture production data of Gujarat [6]. The highest production recorded was 11205 kg/ha in pond-5 of Navsari while lowest in 3490 kg/ha in pond-2 of Amreli. The results observed by Araneda *et al*., (2008) [18] and Zaki *et al*., (2010) [19] are found to be similar with reference to growth of this study.

The mean stocking density was 41±1.37 nos/sq.mt in Gir-somnath, 24±2.26 nos/sq.mt in Amreli, 31±6.43 nos/sq.mt in Bhavnagar, 30±5.89 nos/sq.mt in Surat, 34±9.92 nos/sq.mt in Navsari and 29±6.57 nos/sq.mt in Valsad respectively (Figure 3). All the selected ponds were stocked according to the guideline of Coastal Aquaculture Authority of India. Several workers have reported on the survival and growth of *L. vannamei* in different densities [20-24]. The optimum stocking density is decided on the basis of pond water area, desired shrimp size at harvest and numbers of crops per year with good returns [25]. The stocking density is depended on culture system followed and shrimp species to be culture [26]. Reduced growth of shrimp at higher densities attributes mainly to reducing grading activity in ponds [7, 26]. Lee and Shelser (1984) [27], reported that the effect of live weight and growth curves by the stocking density. The data in present study showed that with higher density, the production also increased at certain level and it was similar the other researchers [9, 11, 28, 29] who stated that with increase in density, yield also increase but growth declined in penaeid shrimps. Maguire and Leedow (1983) [9] and Allan and Maguire (1992) [26] reported that the growth reduction in shrimp at higher densities attributed to reduction in grazing activity of a pond. However, in present investigation all ponds of Gir-somnath, pond-3 of Bhavanagar and pond-5 of Navsari showed higher growth rate with higher stocking density.

The mean harvest size was 21.99±2.18 gm in Gir-somnath,

32.07±1.47 gm in Amreli, 23.87±6.78 gm in Bhavnagar, 31.00±5.15 gm in Surat, 26.94±1.47 gm in Navsari and 24.98±6.10 gm in Valsad respectively (Figure 4). The harvest sizes of shrimps showing variation as the culture period varied for all the selected ponds. The highest mean value of individual harvest size of shrimp was 32 gm in Amreli while lowest 23 gm was in Bhavnagar district. The culture period were different for all the ponds of selected districts as harvested based on the pond conditions and desirable harvest size of shrimp. The maximum culture period was recorded 198 days for pond-1 in Surat while minimum was 117 days in pond-1 & 2 in Valsad district (Figure 5).

The growth rate was maximum 0.22 gm/day in Amreli while minimum 0.16 gm/day in Gir-somnath district (Figure 6). Growth performance of *L. vannamei* cultured in ground water and brackish water fed ponds and found that ADG was ranged between 0.05 and 0.38 gm in the ground water will fed pond and in the brackish water fed pond the ADG was between 0.11 gm and 0.33 gm [30]. In present study, all the ponds of all the districts were used creek water for culture and ADG was ranged from 0.16 gm/day to 0.22 gm/day which shown confirmatory ranged given by Singh *et al.* (2013) [30].

Mean FCR values recorded was 1.21±0.13 in Gir-somnath, 1.56±0.05 in Amreli, 1.35±0.10 in Bhavnagar, 1.73±0.13 in Surat, 1.59±0.07 in Navsari and 1.56±0.12 in Valsad respectively (Figure 7). The average value of FCR was higher in Surat followed by Navsari, Valsad, Amreli, and Bhavnagar and lowest was recorded in Gir-somnath. Increasing stocking density reduces feed conversion efficiency [11]. The results of the present study agreed with the literature under the same conditions studied by [19, 26, 31]. Bharthi *et al*., 2017 [32] also observed the same range of FCR during their study in coastal districts of Andhra Pradesh.

Survival percentage recorded was 91±10.11 in Gir-somnath, 81±2.88 in Amreli, 92±6.60 in Bhavnagar, 88±9.08 in Surat 87±1.56 in Navsari and 86±3.65 in Valsad respectively (Figure 8). The average survival rate was observed maximum 92% in Bhavnagar district, while minimum 81% was Amreli district. The survival decreased with the increased in stocking densities. Similar results observed by Nunes and Parsons (1998) [33] for semi intensive culture system. Nunes and Parsons (1998) [33] observed that 69 -71.9% of survival rate for semi intensive culture system. Wyban *et al*. (1987) [29] stated the suitable stocking densities for *L. vannamei* were 5 to 21 nos/sq.mt. In present study, the survival rate ranged from 81-92%, which shows little higher with comparison to above researchers. It may be because of the culture of shrimps at all the districts are maintained well with proper disease management.

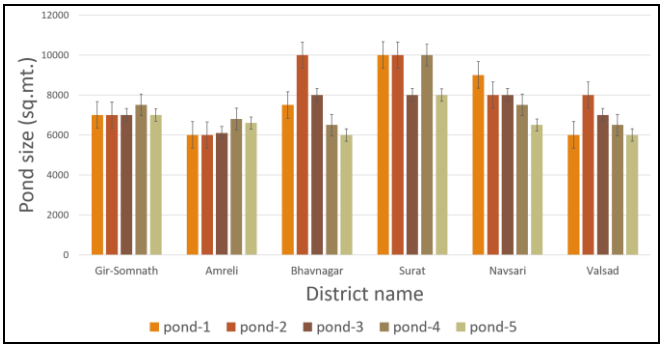

Fig 1: Culture pond sizes (sq.mt.) of *L. vannamei* from selected coastal districts of Gujarat

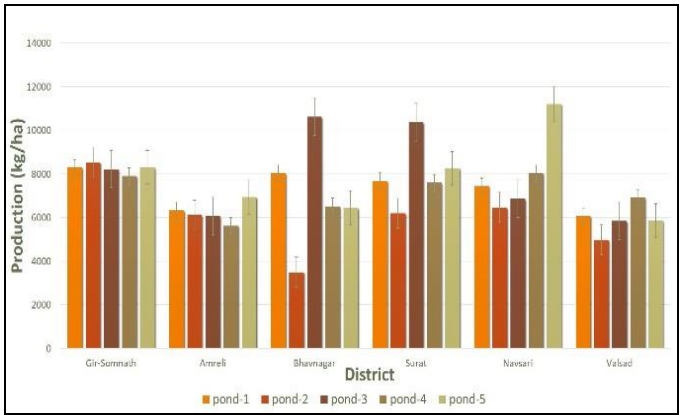

Fig 2: Pond production (kg/ha) of *L. vannamei* from selected coastal districts of Gujarat

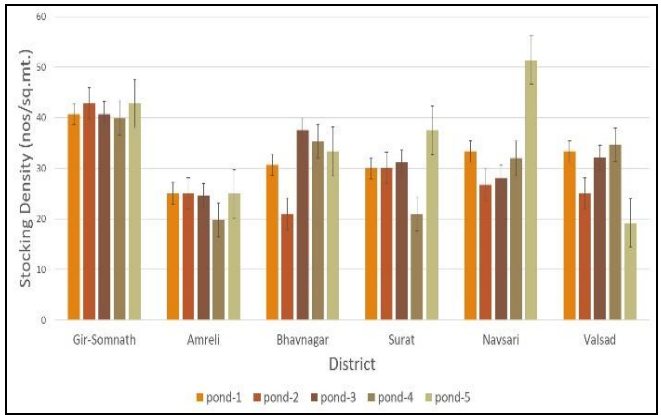

Fig 3: Stocking density (nos/sq.mt.) in culture pond of *L. vannamei* from selected coastal districts of Gujarat

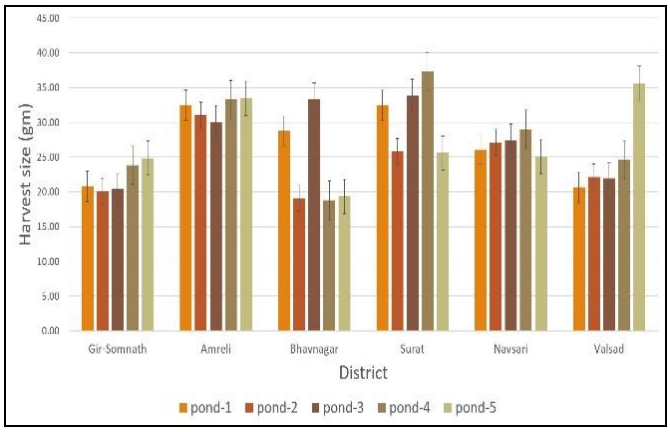

Fig 4: Harvest Size (gm) of *L. vannamei* from selected coastal districts of Gujarat

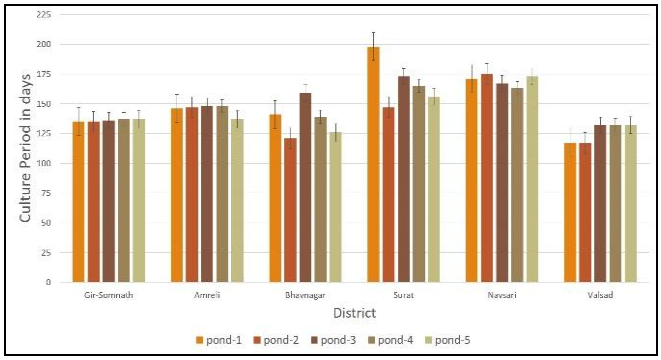

Fig 5: Culture period (days) of *L. vannamei* in selected coastal districts of Gujarat

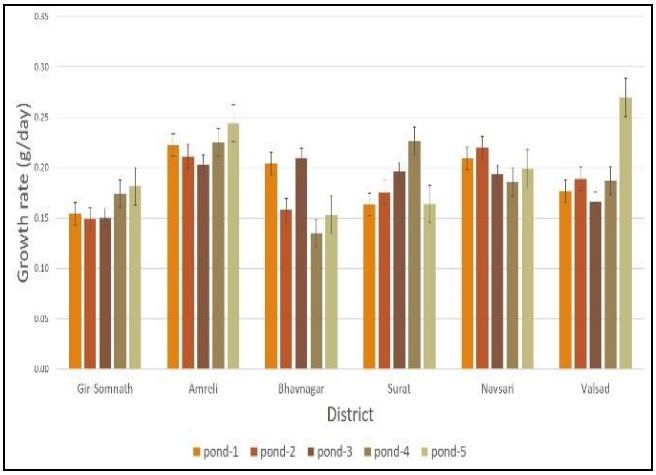

Fig 6: Growth rate (gm/day) of *L. vannamei* in culture pond in selected coastal districts of Gujarat

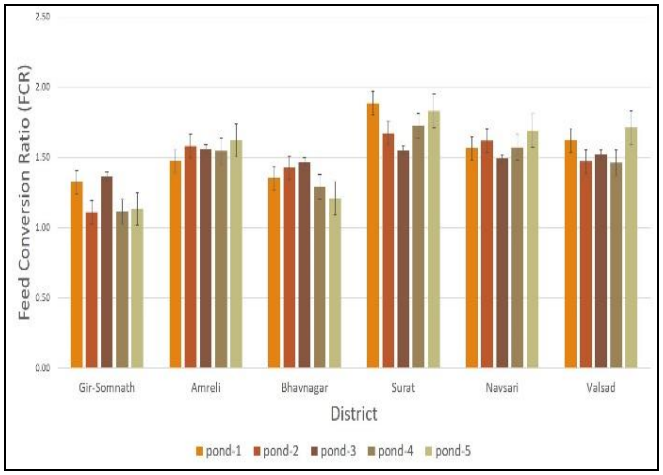

Fig 7: FCR of culture pond of *L. vannamei* from selected coastal districts of Gujarat

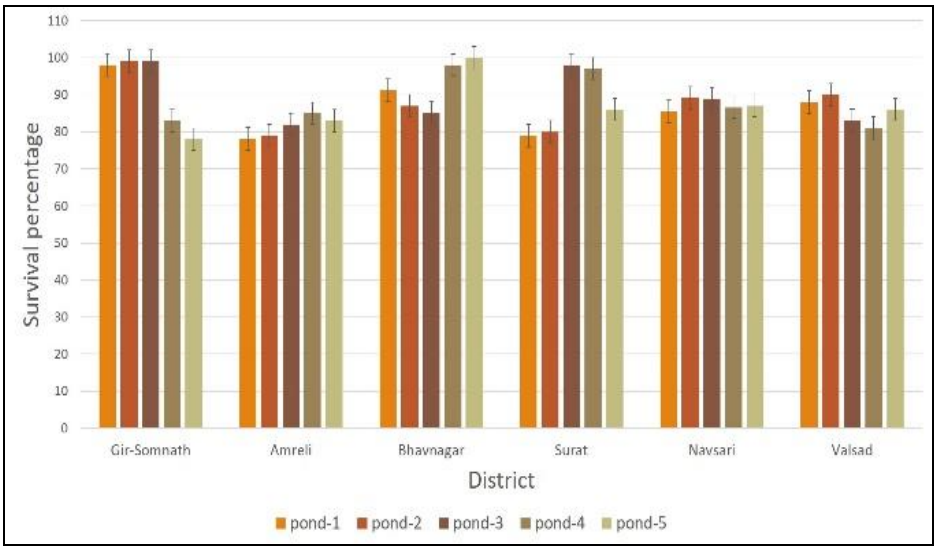

Fig 8: Survival rate (%) of *L. vannamei* in culture pond in selected coastal districts of Gujarat

The water quality parameters recorded during study is presented in Table-1. Maintenance of water quality is very important for optimum growth and survival of shrimp. Water quality of shrimp farm is greatly influenced by excess feed, fecal matter and metabolites [34].

Table 1: Water quality parameters of culture ponds of *L. vannamei* from selected coastal districts of Gujarat

Particular	Gir-somnath	Amreli	Bhavnagar	Surat	Navsari	Valsad
Temperature (ºC)	27-31	26-32	26-33	25-33	24-32	26-32
pH	7.9-8.5	7.1-8.6	7.2-8.2	7.5-8.5	7.3-8.4	7.3-8.5
Salinity (ppt)	40-51	35-53	25-52	15-45	10-54	16-54
Dissolved Oxygen (ppm)	3.9-5.0	3.7-4.2	3.5-4.2	3.8-5.3	3.9-4.9	3.8-4.3
Alkalinity (ppm)	180-240	140-280	180-240	180-280	160-270	160-300
Total hardness (ppm)	8950-12100	6710-10700	1990-10800	2850-11300	2080-10450	2610-9800
Total ammonia (ppm)	0-0.1	0.1-0.3	0-0.25	0-0.3	0-0.1	0-0.3

Temperature has pervasive controlling effect on growth [35]. Temperature in the present study ranged 24 to 33 ºC. Temperature can affect shrimp growth directly controlled by food consumption and nutrients availability in the food. Shrimp grows faster in a temperature range from 24-34 ºC in culture conditions [36]. The pH ranges from 7.6-8.6 is favorable for *L. vannamei* [37]. Water pH recorded from *L. vannamei* culture pond was ranging between 7.9-8.5 in Gir-somnath, 7.1-8.6 in Amreli, 7.2-8.2 in Bhavnagar, 7.5-8.5 in Surat, 7.3-8.4 in Navsari and 7.3-8.5 in Valsad district and values reported were in the permissible range and were same as reported by other workers. Salinity was recorded ranged from 10-54 ppt in all experimental ponds. It was ranging between 40-51 ppt in Gir-somnath, 35-53 ppt in Amreli, 25-52 ppt in Bhavnagar, 15-45 ppt in Surat, 10-54 ppt in Navsari and 16-54 ppt in Valsad district. Water having salinity 10-35 ppt supports the good growth and survival of *L. vannamei* [24]. DO recorded from *L. vannamei* culture pond was ranging between 3.9-5.0 ppm in Gir-somnath, 3.7-4.2 ppm in Amreli, 3.5-4.2 ppm in Bhavnagar, 3.8-5.3 ppm in Surat, 3.9-4.9 ppm in Navsari and 3.8-4.3 ppm in Valsad district. It was lies between 3.5-5.3 ppm which is within the desirable limit in

most of the ponds. In the present study the total alkalinity of ponds lies between 140-300 ppm which is within the desirable limit in most of the ponds. Total hardness of ponds of selected districts were ranged between 1990-12100 ppm and values reported were higher than permissible range though the farmers are successfully culturing the *L. vannamei* in Gujarat as they were using water softener to reduce hardness. Ammonia level in the cultured pond was varied from 0.0 ppm to 0.3 ppm that is favorable for the shrimp's growth.

4. Conclusions

So, present study finds that average production of *L. vannamei* was observed higher in district Gir-somnath followed by Surat and Navsari. Seed stocking rate was also accordance to guideline of Coastal Aquaculture Authority of India is up to 60 nos/sq.mt. FCR was observed between lower in culture ponds of Gir-somnath which showed good feed management. The culture period was recorded longer in Surat and Navsari districts. Water quality parameters was very well managed in selected culture ponds of all districts. Though, total hardness observed was above limit but farmers were managed by using softener. Water salinity was somewhat higher than the optimum range in Gir-somnath and Amreli district. The information generated from this work will be helpful in designing scientific shrimp farming projects in future. Present work also supports the expansion of shrimp farming in all districts especially Gir-somnath, Amreli and Bhavnagar.

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