3. Pre-spawning procedures

For ease of reference, technical guidance on how to manage health and maintain biosecurity in shrimp hatcheries is arranged according to the basic hatchery production process, starting from broodstock options through to transportation of PL out of the facility. This has been divided into two broad categories: the pre-spawning process and the post-spawning process. The pre-spawning process includes procedures for broodstock collection/production, landing and holding, selection, transport, utilization, quarantine, health screening, maturation and nutrition. Also covered are spawning, egg/nauplius hatching, selection, disinfection and washing, holding and disease testing of nauplii and their transportation. As these procedures require different facilities, the facility maintenance guidelines are described under the different specific facilities used in the hatchery production process.

Indian shrimp hatcheries are totally dependent upon wild broodstock, with the bulk of the production coming from gravid females. Although there appears to be sufficient supply of these broodstock in Indian waters to satisfy the current demand, future problems are expected. These include probable broodstock shortages from the wild, as the Indian shrimp aquaculture programme expands to meet the Indian Government's plan to double shrimp production by 2010 and a high infection rate of broodstock with pathogenic viruses and bacteria during peak demand periods, leading to poor quality broodstock, diseases and losses in the hatcheries and farms. Data exist to show that unhealthy and infected PL lead to frequent crop failures with estimated losses of US$ 110–220 million per annum (1US$=44.9 INR, 1 crore = 10 million). To date there is no existing broodstock programme to support production of high quality seed.

3.1 WILD BROODSTOCK

3.1.1 The broodstock capture fishery

Information on broodstock availability in India is difficult to find. As part of the FAO study that lead to this document, discussions were held with shrimp trawlers' associations, trawler crews and hatchery owners on different occasions to collect primary information. However, middlemen and deep-sea trawler operators could not be contacted. More information is needed to assess the current status of the sector before presenting suggestions for its improvement.

Presently broodstock is obtained as by-catch from shrimp trawling and by the use of specialized traps, except in seasons of peak demand and value, when exclusive fishing for gravid female broodstock is done by a small percentage of trawler operators for short duration. The broodstock capture fishery has been dominated by near-shore operators; the extent of involvement by offshore deep-sea operators was impossible to review as information was limited. Near-shore trawlers supplied about 90 percent of the broodstock requirement while the deep-sea trawlers may have fulfilled the rest.

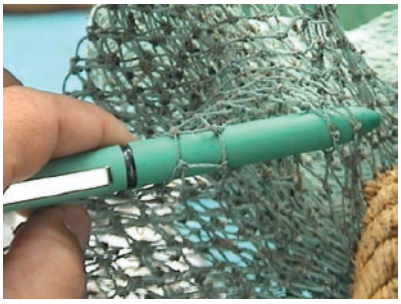
Sona baby trawlers at Vizag Fish Landing Complex

There are about 1 540 mechanized fishing vessels in Andhra Pradesh, of which 900 to 1 000 are 12–13 m "Sona baby trawlers," which mainly trawl for fish and shrimp. A survey of 26 Sona trawlers at Vishakapatnam (10), Kakinada (10) and Machilipatnam (6) indicated the availability of broodstock. Vishakapatnam has 500 trawlers which catch 21–28 percent shrimp, 3–5.8 percent of which is *P. monodon*, with an average

TABLE 8
Information on tiger shrimp broodstock as by-catch by mechanized trawlers in three districts of Andhra Pradesh

District	Fishing depth (m)	Vessel length (m)	Time (days/ fishing trip)	No. trawls/ day	Mean No. BS caught day/ boat	Transport time (h) (point of catch to jetty)	Total Mechanized Vessels (CMFRI/ DOF)	No. trawlers operating daily for BS
Vishakapatnam	30–50	12–13	1	3–5	2.5	8–14	500/600	375
Kakinada	20–36	12–13	3–7	5–6	1.6	4–7	600/500	200
Machilipatnam	18–28	12–13	5	4–7	2.6	9	200/238	170
	30–45	14.5	5	4–7	2-4	8		

Source: Broodstock fishery questionnaires, 2004



Small-mesh nets are used by most Sona trawlers to catch broodstock

daily harvest of 1–6 broodstock/boat; Kakinada has 600 trawlers catching 18.6–31.4 percent shrimp of which 1–2.3 percent is *P. monodon*, with a capture of 1–3 broodstock/d/boat; and Machilipatnam has 200 trawlers, catching an average of 4 broodstock/d/boat. If an estimated 25 percent of the Sona boats in Andhra Pradesh collected broodstock as by-catch, then about 500–700 could be made available to hatcheries every day.

A summary of information obtained from broodstock fishery personnel on broodstock fishing in Andhra Pradesh is shown in Table 8.

There are specific broodstock grounds, and trawlers usually do not cross to other waters of different districts for catching brooders. Most trawlers fished near shore at a depth of between 20 and 50 m. The impact of pollution below 50 m depth may be less, and a study is necessary to explore the availability and cost-efficiency of catching quality broodstock from the 50–100 m depth range.

Off the east coast of Andhra Pradesh fishing for broodstock is conducted 5 to 20 km from the shore where there is soft loam or sandy clay or clay-loam substrates with seaweed. Broodstock caught from the sandy coast of the Andaman Islands was reportedly of better quality than that from silty bottom areas.

Although trawling usually lasts from three to four hours, to reduce stress, broodstock-specific trawling lasted only 1 to 1.5 hours. The total catch per haul is spread on board, and any gravid female brooders are quickly collected and put into 50–100 litre containers. Battery-operated portable aerators are used to aerate the tanks.

As shrimp broodstock is largely by-catch, the fishermen need to modify present practice in order to reduce stress, improve general quality and minimize the time from capture to delivery of broodstock to the auction centres. There is a need for targeted short-duration trawling with nets having mesh size larger than the 1 cm mesh currently used (this should be discussed with trawlers and possibly incentives offered). Additionally the fishermen require training in selecting the right quality broodstock and in handling, storage and transportation techniques. The containers and aeration systems present on the Sona trawlers are often substandard and unreliable. After collection, the greatest risk to broodstock is thought to be due to bacterial-related mortality during transportation.

Broodstock-holding container and aerator on a Sona Trawler

Ideally individual animals should be transported in transparent plastic bags

filled with oxygen, sealed and placed on ice within insulated foam boxes to maintain a temperature of <29 °C. The use of bioreactor technology and/or anaesthetics to reduce metabolic activity during the holding and transportation of broodstock should be investigated. The literature indicates two possible anaesthetic compounds that could be used for the purpose: MS-222 (tricaine methane sulphanate at 150 ppm) and Aqui-(2-methoxy-4-propenolphenol – a major constituent of clove oil - at 20 ppm). MS-222 is the only anaesthetic agent licensed for use on fish intended for human consumption. A withdrawal period of 21 days is suggested following anesthetization of animals with MS-222 destined for human consumption; however, this does not apply to spawners destined for hatchery use only. Aqui-S™ is considered to be the safest anaesthetic since all ingredients are food grade and thus no withdrawal time is required. The use of these chemicals is not widespread and more research is required into their utility.

Shrimp fishing is a seasonal activity throughout India. The main season for fishing in Andhra Pradesh is June to February with the low (banned) season from March/April to May. In Vishakapatnam shrimp are landed throughout the year, but the main season is from July to December. The peak fishing seasons for Kakinada and Nellore are from September to December and from November to March, respectively.

Some trawler operators claim to have knowledge on locations where high quality broodstock can be caught. Through trial and error, some hatchery operators from Nellore also have a good knowledge of the seasonal and locational changes that affect broodstock quality; however, they tend to keep this information for their own use. In general large hatcheries with strong and diversified businesses tend to plan ahead to get good broodstock despite seasonal and locational changes in broodstock quality by closely coordinating with fishery operators and by paying at least 30 percent extra for high quality broodstock.

Fishing trip duration is about two to three days for the small trawlers; however when demand and price are high, a trawler will return to shore within a day with the broodstock gathered by all the trawlers to provide better quality.

Deep-sea trawlers tend to fish in depths of about 60 m where higher quality and larger broodstock is found. These trawlers usually spend around two to three weeks at sea and thus send their broodstock to port or landing centres via utility boats. According to some hatcheries, nauplii of better quality and quantity can be obtained from deep-sea gravid females but they are unable to use them for eyestalk ablation. However, some hatchery operators who also own fishing vessels have formed groups to get breeders from their deep-sea trawlers.

Due to the rapid expansion of the Sona trawler fleet in Andhra Pradesh since the early 1990s, there are concerns that over-fishing has occurred, and at least the artisanal fishery was clearly affected. For Vishakapatnam, Andhra Pradesh, the landings of *Penaeus monodon* have declined gradually from 5.8 percent in 1993–1994 to 3.0 percent in 1996–1997. For catch per hour, the decline was from 0.129 kg in 1994–1995 to 0.088 kg in 1996–1997. This indicates the importance of planning and management efforts aimed at improving the availability of tiger shrimp broodstock.

In terms of catch per hour by Sona boats of Vishakapatnam for 12 month periods, penaeid shrimp landings increased from 1.70 kg in 1993–1994 to 2.96 in 1996–1997. Overfishing tendencies were reported for *P. monodon* and *Metapenaeus affinis*, while stocks of other penaeid species appeared healthy.

In the Kakinada region from 1995 to 2002–2003, while there was an increase in total landings for all six varieties of shrimp, the catch composition percentage varied for different species. Discussions with trawler operators indicated that catches of tiger shrimp and Indian white shrimp (*Fenneropenaeus indicus*) have declined drastically, the catch per boat decreasing significantly because of the increase in the number of fishing vessels over the period. Currently (before the tsunami) there are 600 mechanized boats involved in fishing activity in Kakinada region. The lowest percentage composition in

the catch is for *P. monodon* (1.0–2.6 percent), followed by *F. indicus* (3.3–9.5 percent), and the highest is for *Metapenaeus dobsoni* (16.1–37.9 percent).

In other discussions, catches of *P. monodon* broodstock were reported to be consistent but comprising only a small percentage of the total landings. More information is required to predict future availability of the broodstock, which may be a crucial factor in the sustainability of the hatchery sector.

Tables 9, 10 and 11 give some historical data on the catches of shrimp from around India.

TABLE 9
Penaeid shrimp landings in Vishakapatnam by Sona boats from 1993–1994 to 1996–1997

Species	1993–1994	1994–1995	1995–1996	1996–1997	Mean
Shrimp (tonnes)	1 224	1 165	980	1 220	1 147
Metapenaeus monoceros (%)	27.0	25.3	30.3	23.6	26.6
M. dobsoni (%)	12.2	34.5	20.4	33.0	25.0
M. affinis (%)	12.4	7.9	3.0	3.0	6.6
Fenneropenaeus indicus (%)	14.5	8.2	14.1	11.7	12.1
Penaeus monodon (%)	5.8	5.7	5.1	3.0	4.9
P. monodon (tonnes)	70.6	67.0	49.7	36.1	55.9
P. semisulcatus (%)	1.0	1.0	0.7	0.7	0.9
Other penaeids (%)	27.0	17.3	26.3	25.0	23.9

TABLE 10
Marine shrimp landings by all mechanized boats in Kakinada between 1995 and 2002–2003

Species	1995	1996	1997	1998	1999	2000–2001	2001–2002	2002–2003
Marine shrimp (tonnes) [all boats total]	1 537	1 433	1 723	1 790	2 490	5 647	10 111	10 631
Sona boats (tonnes)	-	-	-	-	-	1 828	3 842	5 226
Sorrah boats (tonnes)	-	-	-	-	-	2 720	4 448	4 048
Penaeus monodon (%)	2.3	2.3	1.1	1.0	2.0	1.1	2.6	2.5
P. monodon (tonnes)	35.1	33.5	19.4	17.7	49.7	61.7	267.5	267.5
Fenneropenaeus indicus (%)	5.2	5.3	5.2	4.3	3.3	3.5	9.5	8.7
Parapenaeopsis stylifera (%)	12.6	15.3	12.0	9.6	10.6	15.1	17.1	20.3
Metapenaeus monoceros (%)	16.7	15.0	17.0	16.1	9.3	6.2	10.4	9.1
M. dobsoni (%)	31.6	30.1	37.9	32.0	25.5	16.1	18.4	19.5
M. brevicornis (%)	3.9	4.4	7.3	9.9	5.0	10.4	10.0	7.3
Others (%)	27.7	27.6	19.5	27.1	44.3	47.6	31.9	32.6

Source: Department of Fisheries, Kakinada, 2004

TABLE 11
Landings (tonnes) of penaeid shrimp on Indian coasts over the ten-year period from 1991 to 2000

Coastal States	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
West Bengal	1 233	2 677	2 754	1 247	3 352	3 799	3 030	3 123	2 704	4 272
Orissa	1 972	2 738	2 986	2 520	5 350	3 557	2 966	2 276	4 323	6 911
Andhra Pradesh	10 759	10 797	16 200	15 513	13 863	15 138	14 193	19 011	24 967	22 573
Tamil Nadu	18 523	20 286	19 833	30 176	28 038	27 528	27 284	28 348	23 443	21 868
Pondicherry	654	400	146	785	458	361	104	702	368	437
Kerala	60 318	51 068	47 988	71 871	43 224	46 143	56 131	58 523	42 133	56 462
Goa	3 231	2 997	2 202	2 617	1 853	3 178	2 914	1 726	986	1 668
Maharashtra	57 976	58 055	56 416	52 413	40 450	52 984	49 819	45 832	31 840	47 611
Gujarat	26 376	29 980	20 151	39 061	34 533	27 935	42 621	48 630	34 414	38 354
Total	190 202	189 819	173 204	224 621	178 874	187 791	208 532	214 679	174 071	206 729

3.1.2 Broodstock quality

When considering the availability *of Penaeus monodon* broodstock, it is important to think in terms of quality as well as quantity. Sufficient numbers of gravid female broodstock appear to be consistently available to meet the current demand. However, measurements of broodstock quality remain somewhat elusive because of the lack of standardization and monitoring. Currently there is no precise information available on the percentage of broodstock infected with pathogens in the different areas (hatcheries, landing centres or catching sites). Additionally there are no quality criteria available, only morphological parameters being used currently.

Although there are 30 shrimp hatcheries in Andhra Pradesh equipped with PCR laboratories, only a few screen the broodstock for white spot syndrome virus (WSSV) infection. Random checking is performed by selecting one or two individuals from a batch of 50–60 broodstock. Moreover, quality appears to vary with season, and there are some indications that average size has become smaller and quality poorer in recent years.

In Andhra Pradesh at least, although the number of trawlers has increased and the catch per unit effort has declined, the total landings for at least one district remain unchanged. During the last three years the fishing crews have reported that they often caught broodstock with black spots on their heads and pleopods, necrosis and reddish colouration. These substandard broodstock are rejected by hatchery technicians except for the gravid females that are at stage IV.

As wild-caught broodstock from different trawlers are held in one container at the fish landing, they are marked by tieing a knot to their antenna to indicate their source. Such practices should be discouraged by proper training

The availability and supply of high quality broodstock is vital in successful shrimp hatchery operations and the production of high quality PL that can support the grow-out farming sector. With the emergence of several serious pathogens of cultured shrimp in recent years, disease-free wild broodstock have become rare around Indian coasts, as in all other Asian countries. Therefore extreme care must be given to the collection, transportation, handling and maintenance of broodstock free from such pathogens and to the biosecurity of hatcheries producing larvae from them. New areas for the capture of broodstock are required.

Most hatcheries in Vizag and some from other districts such as Kakinada have reported that broodstock quality has declined since 1995 and that the females are unable to undergo the maturation process. Mortality occurring during maturation, before or after performing eyestalk ablation, has caused the hatcheries to suspend their maturation operations and obtain nauplii from the two functioning maturation systems in Vizag or to obtain gravid females to satisfy their demands for PL production.

Highly stressed broodstock like this one could still be sold to hatcheries when there is a supply shortage. This situation poses a danger to the production of healthy shrimp seed

During the visits to hatcheries in Nellore some problems with a reduction in egg production from the female spawners were reported (this was disputed by others), but most of the hatcheries there have maturation programmes and have become centres for the production of nauplii, supplying them to hatcheries in other districts. Analysis of field information from Andhra Pradesh suggests that there has been a decline in broodstock quality since the year 2000 (see Table 12). Average data for both eyestalk-ablated and gravid females show a trend towards decreasing quality. However, this has yet to be scientifically documented and confusion remains.

TABLE 12
Performance of gravid and non-gravid female broodstock used at hatcheries in Andhra Pradesh

	Before 2000			After 2000		
	100–150 g	150–200 g	Mean	100–150 g	150–200 g	Mean
Eyestalk ablated (EA)						
Mean fecundity (millions)	0.50	0.59	0.55	0.43	0.49	0.46
Mean hatching rate (%)	80	78	79	76	78	77
Mean survival to PL20 (%)	43	41	42	42	43	43
No. spawners required to produce 1 million PL20	5.8	5.3	5.5	7.3	6.1	6.6
Gravid female (GF)						
Mean fecundity (millions)	0.42	0.65	0.54	0.40	0.57	0.49
Mean hatching rate (%)	80	81	81	77	83	80
Mean survival to PL20 (%)	40	34	37	35	39	37
No. spawners required to produce 1 million PL20	7.4	5.6	6.2	9.3	5.4	6.9

Field survey data, 2004

In order to solve their broodstock problems, some hatcheries have looked into the possibility of importing broodstock from sources outside mainland India such as the Andaman Islands, where more and better *P. monodon* broodstock have recently been reported to be available.

It is also possible that it is not broodstock quality that is causing this problem but rather poor water quality. Poor water quality may cause deficiencies in reproduction, maturation, spawning, fertilization, egg quality, hatching and survival of larvae and PL. This idea is lent support by the fact that the hatcheries in Nellore (where there is little other industry) are currently fulfilling the majority of the seed demand to the Indian industry, while the water supplying hatcheries in the Vizag and Kakinada areas is known to be contaminated with heavy metals. This could explain the difficulties that hatcheries in these areas are having with maturation, but further investigation is required, since some hatcheries are still able to conduct maturation, often with foreign technicians.

A further problem with broodstock quality is that there has been a high seasonal and spatial prevalence of viral and bacterial pathogens in wild shrimp broodstock. During 2001–2004 the broodstock tested by state and private laboratories confirmed varying degree of WSSV infections, although the exact source of these infections still requires further investigation.

Currently there is a certain degree of hatchery accreditation available in the form of a code of practice (COP) by MPEDA, while guidelines are in preparation by the Coastal Aquaculture Authority of India (CAA). Close coordination among stakeholders to establish an accreditation scheme for broodstock quality as an alternative may improve the broodstock supply business networks. Applying such accreditation schemes to seed production centres would indirectly improve the supply of quality broodstock, thereby reducing the risk of vertical transmission of pathogens.

Industrial pollution may be a major cause of poor water quality in broodstock fishing grounds close to Kakinada, as an industrial complex is located on the coast

3.1.3 Pollution

Increasing industrial pollution (and a lack of information about its extent) is a potential threat to the marine environment, including the availability and quality of shrimp broodstock and the hatchery and farm-culture operations. The expansion of chemical and oil industries in Andhra Pradesh State,

especially in Vizag and Kakinada, has caused pollution along the east coast. Information on the industrial growth occurring in the coastal zone of Andhra Pradesh can be summarized as follows:

- paper mills and tanneries in Srikakulam, and Vizianagaram districts;
- steel, fertilizer, metal alloy and shipping industries in Vishakapatnam District causing hydrocarbon and heavy metal pollution with cadmium, lead, mercury, nickel, zinc and iron (See Table 13) (a detailed investigation is needed to determine the risks of sourcing shrimp broodstock from this area);
- fertilizer plants near Kakinada;
- a paper mill at Bhadrachalam;
- agricultural pesticides in the Godavari-Krishna River Delta; and
- lead and zinc mining and agricultural pesticides in Guntur.

TABLE 13
Concentrations of lead and cadmium in the seawater around India[1]

Sampling station	Sampling date	Lead (µg/litre)	Cadmium (µg/litre)
Vishakapatnam	28-01-98	164	3.38
Coringa	24-01-98	47.1	2.65
Kakinada	11-01-98	64.2	1.34
Godavari	10-01-98	72.6	3.28

[1] Source: Coastal Ocean Monitoring and Prediction System (COMAPS), Annual Report, 1997–98

The Nellore and Prakasam coast is relatively free from pollution and the possibly of sourcing more broodstock from this coast should be explored.

3.2 DOMESTICATED AND SPF/SPR/SPT BROODSTOCK

Specific Pathogen Free (SPF) shrimp are those that are maintained in highly biosecure facilities and have been routinely checked and found to be free of specified pathogens. There is no single internationally recognized SPF list although it is generally agreed that SPF shrimp must be regularly tested for and be declared free from the following pathogens:

- infectious hypodermal and haematopoietic necrosis virus (IHHNV)
- white spot syndrome virus (WSSV)
- hepatopancreatic parvo-like virus (HPV)
- Taura syndrome virus (TSV)
- yellow head virus (YHV)
- monodon baculovirus (MBV)
- microsporidians
- gregarines
- haplosporidians
- other protozoans
- metazoan parasites

Specific Pathogen Resistant (SPR) shrimp are those that are not (or are less) susceptible to infection by one or several specific pathogens, and Specific Pathogen Tolerant (SPT) shrimp are those that are intentionally bred to develop tolerance to disease caused by one or several specific pathogens. For example there are lines of commercially available *Litopenaeus vannamei* in the United States of America that are SPF and SPR, but only to Taura syndrome virus (TSV), and often only to certain strains of that virus. These shrimp are not necessarily any more resistant to other viruses (or strains of TSV) than any other shrimp. Lines of *L. stylirostris* that are resistant to IHHNV are also available.

Research in Thailand aimed at identifying the cause of the slow growth syndrome of *P. monodon* (monodon slow growth syndrome, MSGS) has indicated an increase in the viral load of apparently healthy wild spawners. It was shown that a significant number carry multiple viral infections, some of which could be passed on to their offspring and result in mortality and/or the reduced growth rate seen recently during on-growing. Recent research has also identified a new lymphoid organ virus that may be carried