

Transient Gear Shellfish Aquaculture

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Transient-gear aquaculture is a method of growing shellfish that is designed to minimize multiple-use conflicts and avoid the need for a conventional fixed lease

For the past three years, Spatco, Ltd. has been testing a novel method of oyster aquaculture that we call "Transient-Gear Aquaculture." The method involves placing hatchery-reared shellfish in cages resembling lobster pots on the pond bottom. The cages are marked by buoys and hauled every few weeks for cleaning and tending. The primary reason we became interested in this approach was to avoid conflicts with other user groups, principally the commercial shellfishermen and boaters. The buoyed "oyster pots" pose no more of a threat to navigation or shellfishing than do lobster pots or eel pots. Since the gear is periodically relocated, even the wild shellfish resource directly underneath the "oyster pots" becomes accessible to the wild-harvest digger periodically. In

short, this method of aquaculture no more requires the exclusivity of a lease than does lobster fishing with traditional traps.

In New England one of the primary obstacles to the growth of aquaculture is resistance to the leasing or privatization of public waters. Since transient gear does not require exclusive use of one area for more than a short period of time, it should not require a conventional exclusive-use lease. If transient-gear aquaculture proves to be an economical method of rearing shellfish, many areas that are closed to aquaculture because of resistance to leasing could become open to productive shellfish aquaculture. As wild harvests decline and per capita seafood consumption rises, aquaculture must make up the difference. The United States currently imports 60% of

its seafood, exacerbating a multibillion dollar trade deficit. We can either continue to increase our imports of seafood from other countries that have developed their aquaculture potential, or we can cultivate new approaches allowing us to develop our own natural resources to their full production potential.

Regulatory issues

To date no state or federal authorities have developed regulations to permit transient gear aquaculture, but pending applications by Spatco, Ltd. in Narragansett, Rhode Island, are likely to force regulators to examine the issue. Officials from Rhode Island's Department of Environmental Management (DEM) have stated that they prefer the transient gear approach to conventional fixed

leases as a way to avoid conflicts with the wild harvest fishermen. DEM has agreed to develop appropriate regulations in a timely fashion if Spatco's experimental transient-gear aquaculture permit is approved by the Coastal Resources Management Council (CRMC). Similarly, the US Army Corps of Engineers is aware of this permit application and may have to make some adjustments in their regulatory policies if this approach is permitted.

Since there is little difference between an oyster pot and a lobster pot, the regulations regarding their placement should be similar. Both growers and lobstermen must exercise the same common sense in placing their gear, avoiding the main navigational channels, areas where towed dredges would foul their gear, and shallow waters where their pots might be crushed by boats. In fact, since the investment in each pot is greater for a grower, the motivation to keep the gear out of harm's way is greater.

One regulatory approach being examined by DEM would allow the grower to operate within a "permitted area," but unless the applicant is given sufficient space to move his gear around to accommodate the wild-harvest fishermen, the advantages of the technique are lost. Other regulations would be essentially the same as for lobster fishing. In Rhode Island, lobstermen purchase commercial fishing licenses, attach identification tags on their pots, paint and brand their buoys, and place their pots wherever they think they will catch the most lobsters. Periodically, the pots are hauled and placed in a new location. The same regulations should apply for transient gear aquaculture.

The only real difference between lobster pots and oyster pots is that the former qualifies as a "fish attracting device" and the latter (while it does attract many fish and crustaceans) is designed primarily to hold and grow shellfish. From a regulatory point of view this is a very important distinction to the US Army Corps of Engineers (COE). "Fish attracting devices" (pots, traps and weirs) are covered under Nationwide Permit Number 4, giving individual states control over regulation of fishing gear. Aquaculture gear is not covered under Nationwide Permit Number 4 so it requires individual permits from the COE. This policy may change once the technique has been demonstrated, as it

is unlikely that the COE is going to want loran coordinates for a few hundred pots that move around every month.

Techniques

Fundamentally the transient gear approach is no different from many rack-and-bag shellfish aquaculture techniques that have been developed.⁽¹¹⁾ The only difference is that instead of placing the bags on fixed racks in the intertidal zone, the bags are held in buoyed cages that are mobile. This allows the grower to operate in deeper waters and to grow more shellfish in the same area by stacking in the vertical dimension. It also obligates the grower to haul the gear from a boat rather than tending it while standing on the shore.

We have designed our oyster pots with four shelves to hold 12 mesh bags, four high by three wide. This design is a modification of enclosures previously designed for nursery culture of shellfish seed under floating docks in marinas.⁽¹⁷⁾ The pots are constructed of vinyl-coated galvanized wire identical to that used in lobster pots. We use a 2-inch mesh (5 cm), 10-gauge wire⁽¹⁹⁾ to construct a cage that is 183 cm wide x 61 cm deep x 61 cm high (6 x 2 x 2 feet) with shelves to hold the bags 15 cm (6 inches) apart vertically. The pots are fitted with 10-cm high (4-inch) metal or wood skids to

keep the bottom of the cage out of the mud (Figure 1). The mesh bags are made of plastic,⁽²⁰⁾ 61 cm x 61 cm x 5 cm deep (24 x 24 x 2 inches). The open end of the bag is closed with a slit piece of PVC pipe 1.9 cm in diameter (3/4 inch). Different mesh sizes are used at various stages of growth: 3 mm, 6 mm and 12 mm (1/8, 1/4 and 1/2 inch).

To facilitate management, we place our pots in trawls of 10, spaced 3 meters (9 feet) or more apart along the trawl line with buoys at each end. Management of the oysters involves removal of fouling organisms, restocking the bags, and harvesting the oysters. Most of the labor is devoted to keeping the gear clear of the various fouling organisms that settle on the cages or on the bags inhibiting the flow of water to the shellfish and competing for food. In dense assemblages shellfish growth is food-limited as their feeding will rapidly deplete the food available unless currents are swift enough to replenish the food.⁽⁹⁾ Shellfish growth is maximized under conditions of high seston flux—food-rich seawater and moderate or high current speed.^(10,13) The cages and bags are rapidly colonized by algae, tunicates, ascidians, sponges, polychaetes, barnacles, and even oysters. Removal of these fouling organisms is accomplished by jetting the gear with a 3000-psi pressure washer driven by an 11-hp gasoline-

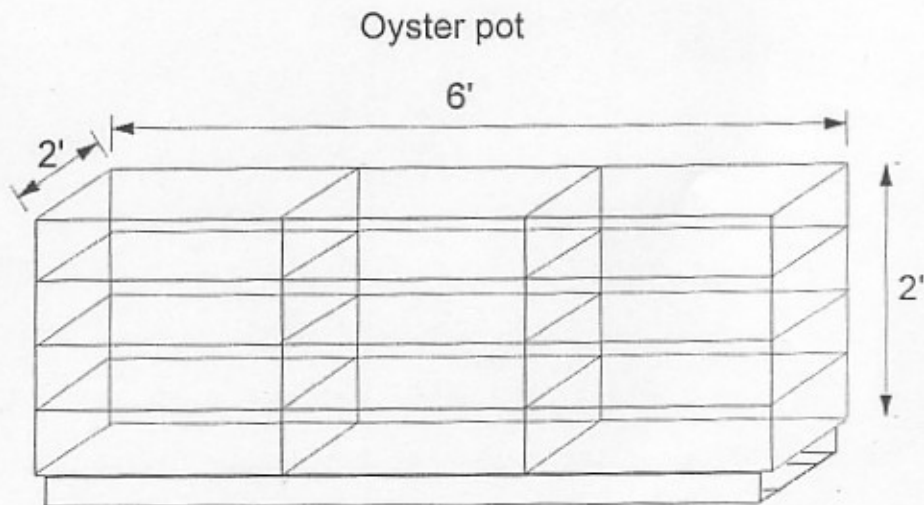


Figure 1. Schematic drawing showing the dimensions of an oyster pot. Each oyster pot has 12 shelves to accommodate plastic mesh shellfish bags. Typically the oyster pots rest on the estuary bottom and are marked by a small buoy.

powered engine. Growth of the fouling organisms varies seasonally with factors such as temperature, light and depth. During the summer we find it necessary to clean individual oyster pots every four to six weeks.

The second most labor intensive aspect of bag culture involves restocking the bags to maintain a proper density for optimal growth. Typically at this time the shellfish are also passed through a sieve to separate them by size. Within a given bag it is desirable to minimize variability in size because the larger shellfish will filter most of the water available, further slowing the growth among the smaller animals. Shellfish have inherently high variability in growth rates and should be sieved periodically for ease of management and maximal growth. It is usually desirable to use the largest mesh size possible that will effectively retain the shellfish since the larger mesh size material has a greater percentage of open area permitting better flow of water to the shellfish.

Restocking the bags is necessary to accommodate the geometric increase in volume resulting from the growth of the shellfish. Our experience in Rhode Island is that 200 mL of 1-mm seed in May will grow to 500 L in July, and about 10000 L by the end of the growing season (Figure 2). We attempt to stock each bag so that the shellfish form a layer no more than one animal deep. Juvenile shellfish can be stocked at great densities in terms of numbers per bag; however, juveniles are stocked at much lower volumes per bag than adults (Table 1). At each location optimal stocking densities must be determined experimentally as this figure varies with temperature, current speed and food concentration.

When sieving and restocking the bags a considerable amount of time may be spent breaking apart clumps of oysters that have grown together. This is imperative if one is targeting the high-end halfshell market. Clumps of oysters, sold for their meats alone, are worth about one quarter what they would bring as singles. We also take this opportunity to dip the oysters in a saturated brine solution. This eliminates the parasites *Polydora websteri* (a polychaete that causes mud blisters) and *Cliona* spp. (boring sponges) as well as controlling barnacles and oyster overset.^(7,12)

When shellfish are cultured at commercial densities, growth is almost in-

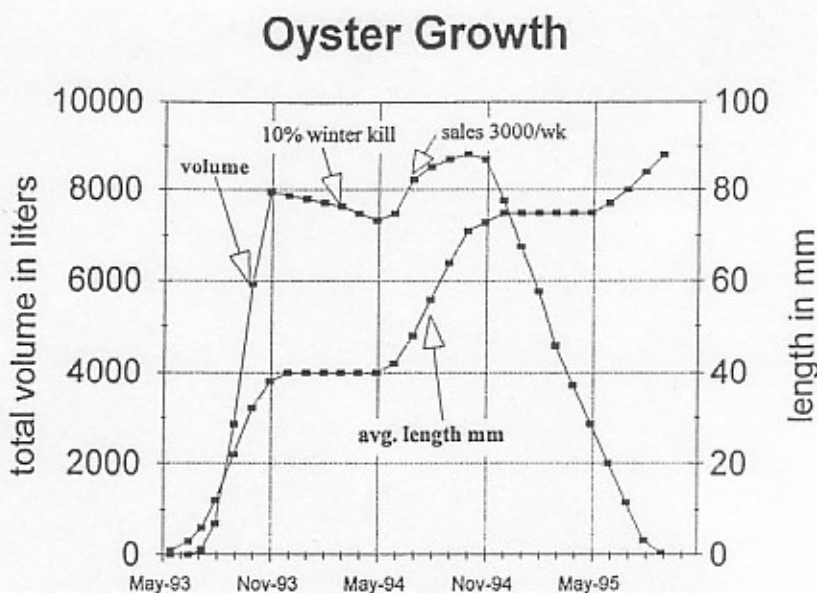


Figure 2 Typical oyster growth during a two year cycle in oyster pots. Oysters reach market size of about 65mm shell height in about two growth seasons. Once oysters reach market size, total volume of the oyster pots is limited by the weekly sales of product.

variably food limited.^(5,18) Locations with high seston flux can sustain good growth rates at higher stocking densities than comparable sites with less current or phytoplankton. Optimal stocking density can be defined in terms of maximizing growth, minimizing gear and labor, or some combination of the two. Lower stocking densities will always result in faster growth, but at some point additional thinning becomes uneconomical because the gear and labor costs increase as the number of individuals per bag declines. Seasonal variations in growth rate or market demand may also dictate that densities should be varied. In our location we have found that for good growth, 6-mm oysters in 3-mm mesh bags should be stocked at 1.5 liters/bag, whereas 40-mm oysters in 12-mm mesh bags can be stocked at 6 liters/bag or more (Table 1).

Optimal stocking densities will vary with the organism in culture as well. The bay scallop, *Argopecten irradians*, filters far more water than a similar sized oyster.⁽¹⁵⁾ To achieve economically optimal growth with scallops we use initial stocking densities that are one-third those that we use for oysters.

Production Model

The following model incorporates four years of data using transient gear to grow oysters and scallops. This model can be used as a general guide to estimate start-up gear costs and to generate estimates of expenses and income. Actual production using this system will vary greatly from location to location depending on temperature, current speed, phytoplankton concentration, and the source of the seed.

Mortality

In the four years that Spatco has been working with bag culture we have run the gamut of possible mortalities from negligible to total losses. Two crops have been victims of Unidentified Juvenile Oyster Mortality^(3,5,8) and one crop was wiped out by an undescribed pathogen. Since it is impossible to predict losses to disease, this model has been constructed to assume realistic mortality due to breakage and handling of 1-2 percent per month and winter kill of 10 percent.

Oyster Volume three crops

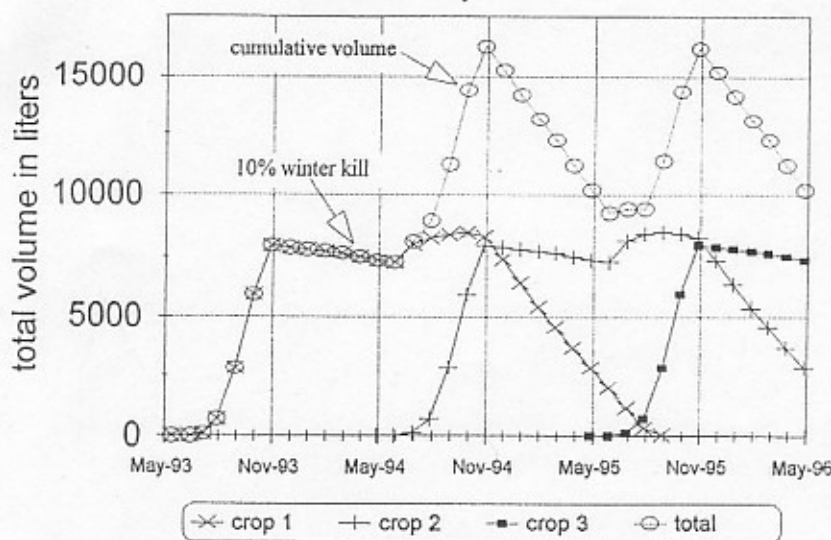


Figure 3 A multi-year production model showing the disposition of three crop years. Cumulative volume totals determine the number of oyster pots to be deployed at any time.

Growth

Based on an annual crop planting of 200 thousand 1-mm seed in May, the model projects that the average oyster will grow to 40 mm in the first season while the entire crop will grow to a total volume of 8000 liters (Figure 3), held in 1300 bags in 110 of our 2-m (6 foot) pots. Growth drops to zero when temperatures drop below 10°C. (November to May). Oysters begin to reach market size by the middle of their second growing season and are picked out and sold year-round at a rate of 3000 oysters per week. Cumulative mortality over the 25-month period for one crop is 25%. By the end of the third summer the first crop has been harvested, the second crop is just reaching market size and the third crop is averaging 35 mm (1.5 inches) long (Table 1).

Economics:

Depending on how the product is marketed, one can expect to receive 20-55 cents apiece. This model projects sales of 150 thousand oysters and gross revenues of US\$30 thousand to US\$82 thousand per year. To maintain an annual crop planting of 200 thousand requires a maximum of 220 of the 2-meter pots at roughly US\$110 per pot, representing

an expenditure of US\$24 thousand for pots and bags alone.

Labor costs are highly variable regionally and will also vary with the season and the fouling rate at each site. Aquaculture is labor intensive and many person-hours are devoted to growout, cleaning, sorting, marketing, sales, deliveries, maintenance, and constructing new gear. During the peak of summer we employ four people full time, but during the winter months labor is limited to 20 person-hours per week for harvesting and shipping and maintenance.

Depending on the source and size of seed purchased, seed costs will vary tremendously. Oyster seed cost will triple if 10-mm seed are purchased instead of 2-mm seed, however seed costs tend to be a minor expense in the overall budget. Seed costs for this model are US\$1500/yr. Seasonal availability of larger sized seed may also change the projections of this model. Other variable costs include a boat, permits, insurance, testing, legal fees, and expendables such as gas, ice, and salt. We estimate our profit margin (in the absence of disease-related mortality) to be around 20%, but we foresee several areas where automation, economies of scale, and aggressive marketing should improve this margin. Substantial savings could be realized by

a fisherman who already has a boat and much of the equipment needed for this work.

Other considerations

In our location, oysters take two to three years to reach market size. During this period the entire crop is susceptible to disease-related mortalities such as Unidentified Juvenile Oyster Mortality, MSX, or Dermo.⁽¹⁶⁾ Each of these diseases has at one time ravaged American oyster populations and has the potential to kill a large percentage of the crop. The shellfish also can be lost to storm damage and theft; however the motivation to steal from a grower is slight because at any given time 90% of the stock is typically of sublegal size. We have also attempted to minimize theft by making the pots large enough to deter lifting by the casual boater. Each of our 2-m pots can weigh up to 180 kg (400 pounds) when fully loaded and fouled.

Species

We have used this method to culture northern quahogs, (*Mercenaria mercenaria*), bay scallops, (*Argopecten irradians*), American oysters, (*Crassostrea virginica*), and European flat oysters, (*Ostrea edulis*). Bag culture works well for bay scallops if the seed are made available early enough in the season. There is an emerging market for whole bay scallops, live in-shell, at 5-8 cm for 15 to 25 cents each. This size can be achieved in 4 to 5 months at proper stocking densities. Unfortunately, bay scallops cultured at commercial densities will suffer very high winter mortalities (50 - 95%) if they do not make it to market size in their first season. In spring and summer the adductor tissue glycogen levels are low, making them less palatable.⁽²⁾ We have found that this system is inappropriate for quahog culture. The labor and gear costs are too high for an animal that takes 2-3 years to reach market size and brings only 15 to 20 cents each. Clams will also suffer high winter mortalities unless they are permitted to bury themselves in the sediment. *Ostrea edulis* is attractive because of its fast growth and high market price, but *O. edulis* has a short shelf life, is vulnerable to low winter temperatures, and may be considered an undesirable exotic species in some states.

Table 1. An economic model for oyster production using a transient-gear aquaculture system. Estimates of mortality, growth, and sales are based on data collected in the 1990 to 1994 growing seasons in Point Judith Pond, Narragansett, Rhode Island. For optimum growth, oysters are held to a maximum biovolume of 6 liters per bag. See text for details of gear and discussion of model assumptions.

Date	Mean size (mm)	Volume (liters)	Liters/bag	Number of bags	Number of cages	Sales	Number of oysters	Mortality (%)	Revenue @ \$0.50 ea	
15 May 93	1	0.2	0.05	4			200 000	2%		
15 Jun 93	3	2.5	0.25	10			196 000	2%		
07 Jul 93	6	120	1	120			192 080	2%		
30 Jul 93	12	695	2	347	29		190 159	1%		
30 Aug 93	22	2842	3	947	79		188 258	1%		
30 Sep 93	32	5940	5	1188	99		186 375	1%		
30 Oct 93	38	7960	6	1327	111		184 511	1%		
30 Nov 93	40	7880	6	1327	111		182 666	1%		
30 Dec 93	40	7801	6	1327	111		180 840	1%		
30 Jan 94	40	7723	6	1327	111		179 031	1%		
28 Feb 94	40	7646	6	1327	111		177 241	1%		
30 Mar 94	40	7943	6	1327	111		173 696	2%		
30 Apr 94	40	7343	6	1224	102		170 222	2%		
30 May 94	42	7490	6	1248	104		168 520	1%		
30 Jun 94	48	8239	6	1373	114		166 835	1%		
30 Jul 94	56	8530	6	1422	118	8 000	157 166	1%	\$4000	
30 Aug 94	64	8699	6	1450	121	10 000	145 595	1%	\$5000	
30 Sep 94	71	8820	6	1470	123	12 000	132 139	1%	\$6000	
30 Oct 94	73	8691	6	1448	121	12 000	118 817	1%	\$6000	
30 Nov 94	75	7768	6	1295	108	12 000	105 629	1%	\$6000	
30 Dec 94	75	6767	6	1128	94	12 000	92 573	1%	\$6000	
30 Jan 95	75	5776	6	963	80	12 000	79 647	1%	\$6000	
28 Feb 95	75	4579	6	763	64	12 000	66 851	1%	\$6000	
30 Mar 95	75	3711	6	619	52	12 000	54 182	1%	\$6000	
30 Apr 95	75	2852	6	475	40	12 000	41 640	1%	\$6000	
30 May 95	77	2002	6	334	28	12 000	29 224	1%	\$6000	
30 Jun 95	80	1160	6	193	16	12 000	16 932	1%	\$6000	
30 Jul 95	84	326	6	54	5	12 000	4 762	1%	\$6000	
30 Aug 95	88	49	6	8	1	4 000	715	1%	\$2000	
TOTALS								154 000		\$77 000

Advantages

The primary advantage of this approach is that it allows growers flexibility in the placement of their gear so that user conflicts can be minimized. Gear can also be moved to take advantage of seasonal blooms, to avoid red tides, or to minimize winter kill. Since the product is all contained in bags there are no losses to predators. Oysters grown off-bottom reach market size in two to three years, a full year faster than those cultured on the bottom. Bags also afford growers easy access to the shellfish for sorting and inspection, giving the grower greater control over the quality and uniformity of the product while facilitating harvest. Single oysters for the halfshell trade bring a high price premium over wild-harvest product. Cultured shellfish are exempt from many of the regulations designed to protect the wild resource (eg. seasonal harvest restrictions). Most states permit cultured shellfish to be sold year-round and several have relaxed their minimum size regulations for cultured shellfish.

Disadvantages

Transient-gear aquaculture also has disadvantages when compared to other more extensive methods of shellfish aquaculture. The method is extremely gear- and labor-intensive. During the peak of summer our company employs four people full time and labor costs can reach US\$1000 a week. This is a very expensive method of culturing shellfish, justified only by the quality of the product and the ability to avoid user conflicts.

Benefits

- Shellfish are filter feeders and will improve water quality and clarity by filtering the water. The shellfish in each of our cages will clear an estimated 70-300 m³/d (17,500-75,000 gal/d). These "biological filters" are highly efficient at removing phytoplankton from the water column, incorporating nitrogen and phosphorus into oyster tissue, thereby improving sunlight penetration and slowing eutrophication.⁽¹⁴⁾
- Cultured shellfish will spawn and release millions of larvae to the wild-harvest fishery. For every oyster in culture an estimated 1 million

eggs are released each year. Of these a minute fraction will survive to be recruited into the wild-harvest fishery, but we estimate conservatively that 200 thousand oysters should bring US\$50 thousand to the wild harvest each year.

- The oyster pots provide an excellent refuge and foraging site for myriads of juvenile fish. The cages become small portable artificial reefs, enhancing the juvenile survival of many commercially important fish species.

Transient-gear aquaculture is a novel approach designed primarily to resolve multiple-use conflicts currently hampering the expansion of shellfish aquaculture in the Northeast. Our work has demonstrated that the method works well in rich, coastal salt ponds where oysters can reach market size in two to three years. It remains to be proven whether or not this approach is viable in deeper waters. Since there is insufficient space in the salt ponds for the technique to have any real economic significance in terms of regional production, future studies are aimed measuring growth rates in deeper, colder, more oligotrophic waters. It is likely that growth rates will be slower, meaning that gear will be tied up for longer periods, making labor and gear costs per oyster proportionately higher. It is equally plausible that fouling growth will also be less of a problem in deeper waters. The question remains whether or not this technique can be economically viable outside of the salt pond environment.

Transient-gear aquaculture has the potential to alleviate traditional user conflicts while allowing aquaculture to develop without the need for conventional, exclusionary fixed leases. If the aquaculturist can operate without a conventional lease then the potential exists for aquaculture to proliferate in areas where leasing is not a viable option. Landings of the wild-harvest shellfishery in Rhode Island are down about 60% from five years ago. If the state wants to maintain its position as a major shellfish producer it must look to aquaculture to fill the void.

The technique also has great potential as a supplementary income source for wild-harvest fishermen without significantly altering their way of life, since

transient gear aquaculture requires a minimal capital investment for gear and uses the traditional tools and skills of the waterman. An investment of US\$15 thousand in gear can be sufficient to raise 100 thousand oysters a year, potentially worth over US\$40 thousand if marketed properly. Many fishermen already have the skills and equipment necessary to get started in transient-gear aquaculture.

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