THE GOAL AND THE GOLD MINE: Constraints Management and the Dutch Herring Fishing Industry, 1400-1700

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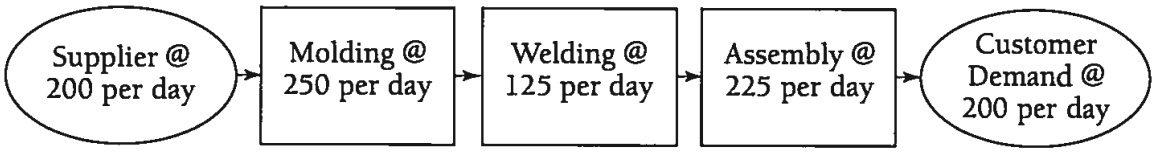
In many ways, the Netherlands set the pace for European economic growth in the fifteenth through the eighteenth centuries. The Dutch herring fishing industry was critical to this modern economic progress. A comparative study of this enterprise to the lean manufacturing tool of constraints management provides insight into how the Dutch dominated this lucrative industry. Improvements by Dutch fishing interests in technology, practice, procedures and quality control were consistent with the constraints management model. English and Scottish competitors failed to identify these constraints and thus, failed to challenge Dutch operators. The Dutch fishing industry practiced and understood constraints management and used it to monopolize the export herring market for three centuries.

The Netherlands was at the vanguard of modern economic development from 1400 to 1700. Dominating this growth and sophistication was the herring fishery, and the Dutch were clearly cognizant of the importance of this industry. A proclamation in 1615 declared, "The great fishing and catching of herrings is the chiefest trade and principal gold-mine of these United Countries."[1] The market for herring was enormous and it was monopolized by the Dutch for nearly 300 years. The Baltic and Catholic countries provided huge demand for salted fish. In addition to the consumption of fish because of religious guidelines, a sixteenth-century workman's lunch typically consisted of "a chunk of bread, a herring, and a head of garlic."[2] Fishermen from the Netherlands supplied this market completely and almost exclusively; during the 16th and 17th centuries, 82 percent of all herring shipped into the Baltic was provided by the Dutch.[3] Before they achieved

this market dominance, commercial fishing had always been a coastal enterprise. Small boats would depart daily, return with their catch and either take the fresh fish to market or preserve them on shore by drying or salting. Unfortunately for the coastal fishermen, the herring began to move out to sea around 1400, migrating from the coasts of Sweden to the North Sea and British waters, out of reach to traditional fishing vessels and techniques. The North Sea was far too violent for small fishing boats and far too remote for daily expeditions: supply had been separated from demand.

The Dutch filled this gap. Fishermen from the United Provinces exploited the fishing grounds in the North Sea and British waters and satisfied the export market for salted herring with a superior product. How did a country with no proximity to the supply, no proximity to the demand, and seemingly no inherent internal advantages dominate this lucrative trade? Since some believe the Netherlands to be the first modern economy, a modern economic tool may help in evaluating the history of the herring fishing industry.

Constraints management has been one of the most important techniques for improvement in lean manufacturing since the 1980s. The process, outlined and clearly described in the extremely popular mass-market book, *The Goal*, by Eliahu Goldratt,[4] is here applied to the Dutch herring fishing industry, which was an extraordinarily successful commercial enterprise. First, it is critical to outline the constraints management model. Goldratt emphasized that a chain is only as strong as its weakest link. Constraints management is a collection of concepts and practices to help determine the "weakest link" and to improve upon it. A constraint can simply be thought of as a bottleneck in any system, which is defined as any resource whose capacity is equal to or less than the demand placed on it. Naturally, a non-bottleneck is any resource whose capacity is greater than the demand placed on it. Consider the following simple example of a modern manufacturing process:



The maximum daily throughput is 125 pieces per day. The system can only produce as much as the welding operation can process. Therefore, the welding operation is the bottleneck in the system. The only way to increase throughput is to increase the productive capacity of the welding station. Improvements to any other portions of the system are irrelevant. For example, an increase in molding capacity will only serve to increase inventory before the welding station and does nothing to increase throughput on the system. Increasing molding capacity has now raised the carrying cost of inventory and only created waste. No matter what other improvements are made, if the welding process is not changed, maximum daily sales remain at 125 pieces. Therefore, improving the capacity of the bottleneck is a critical step to improving the throughput of any process.

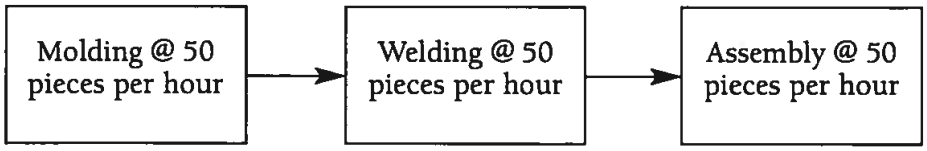
Methods to improve the performance of a bottleneck resource fall into three categories: minimizing downtime, off-loading, and working only on necessary items. Minimizing downtime is fairly straightforward. The time that a constraint should be

operating needs to be maximized. As conveyed in the previous example, it would be wise to make sure that the welding process is running during breaks, lunches and weekends. All available time should be utilized.

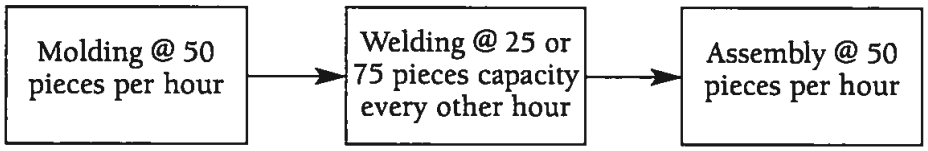
Off-loading is simply equated to outsourcing. The bottleneck process could be improved if an outside resource was utilized. If a suitable welding subcontractor were used to add additional production, then the total welding output would be increased, raising throughput.

Working only on necessary items is the third method of expanding the constraint, which is identifying the critical parts of the process and removing any unnecessary steps. If analysis reveals that the welder is spending half of the workday sorting through molded parts to find those suitable for welding, then the welding output can be doubled by having others (e.g. the molding department) provide quality control. The welder spends the day welding not sorting; the bottleneck capacity is increased.

One final factor remains in the construction of the model: statistical fluctuations. Variances from average production impact total production. The greater the variances of a production process, the lower the total production. Consider the following simple example.

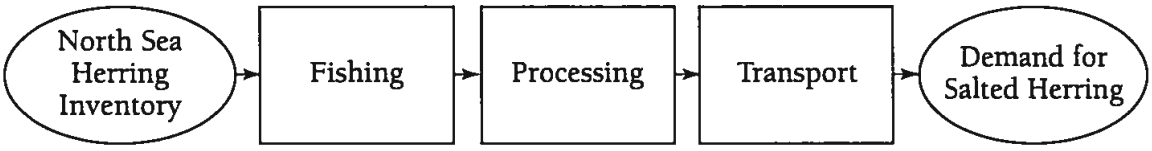


Assuming that each station produces 50 pieces each and every hour, with no statistical fluctuations, the total production in four hours is 200 pieces. What happens if some fluctuation is introduced at one workstation?



In this example, in the first cycle, molding, produces 50, welding 25, but assembly only has 25 to work with so total production is 25. In the next cycle, molding produces 50, welding 75 (25 pieces in inventory from the previous cycle), assembly 50. The total is now 75 pieces. In the third cycle, molding produces 50, welding 25, assembly 50 (25 in inventory from previous). The total production is now 125. The fourth cycle is molding 50, welding 75 (25 inventory from previous), assembly 50. The total production for four hours is 175 pieces. The introduction of fluctuation in the process (average capacity remained the same) decreased the total output twelve and a half percent from 200 to 175; the greater any statistical fluctuation, the greater the impact (decrease) on total throughput. Statistical fluctuations can create bottlenecks in a system.

This simple constraints management model can be easily applied to the herring fishery. The first step is to outline the process then identify the constraint or bottleneck.



The constraint of any system is determined by finding the point where inventory is building up prior to an operation and shortages are found immediately after. In this simple model, the bottleneck in the process was fishing: the time spent hauling fish from the North Sea into the ship was the constraint. The evidence supporting this premise will be discussed in greater detail, but maximizing the amount of herring netted was critical to the industry. For example, boats returning to land to dry or salt their daily catch were missing out on valuable fishing time. Fishing vessels needed to be over the fishing grounds catching fish. With few exceptions, every other process or factor was subordinate.

One can think of the petroleum industry as an analogous modern example. The inventory of crude oil remains underground. Under most circumstances, extraction would be the bottleneck. The herring schools were the inventory under the surface awaiting extraction by European fishermen.

After 1400, the fertile herring fishing grounds were in the North Sea and British waters, far out of reach from the coastal fishing vessels. Even if one could get to the fish, time spent fishing was extremely short since there had to be frequent trips to shore to preserve the catch before it spoiled. To increase the capacity of the constraint and maximize the time spent fishing in the North Sea, three things needed to be addressed. First, fishing vessels had to get to the fishing grounds and survive in the open ocean. Second, the time at sea must be extended. Daily returns to land would not be realistic. Finally, the quality of the product must somehow be maintained.[5]

Low Countries shipbuilders provided the solution around 1400 with the development of the herring buss. The buss was a vessel specifically suited for use in the deep-sea fishery. In addition to being much larger than coastal fishing vessels, the buss incorporated unique design features; the length-to-beam ratio along with round beam and stern enhanced maneuverability without sacrificing seaworthiness. Removable masts and a large deck area enabled the buss to accommodate the increased on-board activity. The first herring buss appeared at the port of Hoorn in West Friesland in 1415 and then, in 1427, in the ports of Groedereede and Domburg in Zeeland.[6] The herring buss was revolutionary and resolved multiple issues at once. Accompanying the introduction of the buss, the first large herring net in the northern Low Countries also appeared at Hoorn in 1416, and was made by connecting many small drag nets. Small coastal vessels were completely unsuitable to utilize this new technology, but the buss was perfect both for storing and controlling the massive nets.[7] Herring busses were large ships, capable of long voyages and surviving storms in the open seas. The first two constraints were addressed, getting to and remaining on the lucrative fishing grounds. However, it would not matter if the fish rotted in the hold.

William Beukesz of Biervliet in Northern Zeeland, a Dutch Herring skipper, might be credited with identifying and improving the processing and preserving constraint. His fellow countrymen recognized him for developing the process of gutting, curing and packaging the herring catch immediately on ship. With this new process, there was no need to return frequently to shore to preserve or sell the catch. The Dutch were well aware

of the magnitude of this breakthrough. A monument was erected in honor of Beukesz in Biervliet, and Emperor Charles V was documented as visiting his tomb.[8]

The herring buss was the first factory ship. It optimized yield by remaining at sea, maximizing fishing time, and minimizing waste by quick processing. An important benefit gained by the introduction of the buss was the increase in product quality. Herring were gutted and cured immediately after they were pulled on board. This was a marked improvement in freshness and quality when compared to coastal fisheries, where the catch was not processed until the vessel had returned to shore. Dutch shipbuilders used further innovations to enhance the freshness of the herring catch. After 1400, it became more and more common for busses to be built with a "bun," a compartment mid-ship, with small holes, and therefore open to seawater. When the nets were emptied, the herring were placed in the "bun" where a continuous over wash of seawater would keep them fresh while they awaited, gutting and salting.[9] The buss and its efficiency gave Dutch fisherman an overwhelming advantage in quality (as well as productivity) over any other European fishermen. The Dutch government did not miss the critical importance of herring busses on the country's fishing industry, and consistently prohibited the export of those vital vessels.[10]

The magnitude of the advantage that the Dutch herring fishermen enjoyed over others was difficult to comprehend. In order to give depth to this analysis, it is necessary to view the industry through the eyes not only of the Dutch themselves but also of their competitors, primarily the English and Scottish, whose coasts were nearest to the herring buss fleets. The English and Scottish pamphleteers were well aware and somewhat embarrassed by the overwhelming dominance by the Dutch, as described in the below example:

> The Hollanders busses are great and strong, and able to brook foul weather, whereas our cobbies, crayers and boats being small and thin-sided, are easily swallowed by a rough sea, not daring to adventure far in fair weather, by reason of their weakness, for fear of storms.[11]

The English were clearly impressed if not intimidated by the commanding position the Dutch herring busses held in the North Sea fishing grounds. The development and utilization of the herring buss clearly and dramatically expanded the capacity of the fishing bottleneck. Not only was the constraint capacity increased, the improvements fell into multiple areas.

Downtime was primarily minimized by increasing the ability to reach the fishing ground, to remain at sea when encountering foul weather, and to carry enough provisions for the crew for extended voyages. Secondly, by eliminating the need for daily return trips to land for preserving, the time spent catching fish was exponentially expanded.

Along with decreasing downtime, the buss reduced statistical variations in two meaningful ways. First, the variances in weather were largely eliminated. Busses endured very foul weather, unlike small coastal vessels. Second, by processing the catch immediately on board, the variable of spoilage was removed. Thus, the Dutch herring buss minimized downtime and reduced statistical variations.

With respect to the development and implementation of the herring buss, it appeared as though Dutch shipbuilders and fisherman had an intuitive understanding of constraints management. Was there a conscious decision to identify and increase the capacity of a bottleneck? Presumably a shipbuilder built the first buss with the goal of resolving the constraints of coastal fishing; there is, however, no explicit evidence of that decision.

Evidence of a constraints management decision can be found in the person of William Beukesz. Both the Dutch and the English identified him as the person who developed the process for gutting, salting and barreling herring on board ship, a clear decision (or process) to increase the capacity of a constraint. Beukesz identified a bottleneck and increased the capacity.

Dutch success in the herring fishery cannot be attributed only to the relative technological superiority of the herring buss. These vessels would have been of little advantage if their introduction was not accompanied by procedural improvements, as well. How the voyages were conducted was critical to optimizing herring yield. Fishing season began June 24, and nets could be dropped on that day. The goal was simple: catch as many fish as possible in the available time. The Dutch prepared early: "about mid-May they made ready their busses, and fisher-fleets, and by the first of June were seen to sail."[12] The herring buss fleet was consistently on the fishing grounds off the Shetland Islands prior to opening day.

The fleet placed itself in the best position for success. It was not every man or boat for himself. The English observed that while their fishermen had little direction and organization, "the Hollanders, two of the best experienced fishermen are appointed to guide the rest of the fleet, and the others are bound to follow them and cast their lines according to their direction."[13] They were going to spend time catching fish not looking for fish.

Most, if not all, of the fishing season was spent within reasonable proximity of the English and Scottish coasts. The British offer some incredibly telling observations not only of how effectively the Dutch conducted their fishing voyages, but within a context that illustrated their own fisherman's performance. The following two descriptions from 1601 and 1674 were clear and consistent:

> They [The Dutch] go forth in June to seek the shoals of herring, and having found them, do dwell amongst them, coming along with them until November, taking them in great abundance; and we stay till the herrings come home to our own coast, and sometime suffer them to pass by us before we look out, and so loose God's blessing.[14]

> Herring fishing in his majesties seas, begins in June and goes out in November: and for the first four moneths, (which is the best time both for profit and fair weather) we never so much as look after it, but fall in upon the winter fishing, from September, to the end of November, which is the most tempestuous season the whole year.[15]

In contrast, the Dutch practices furnish a splendid example of a technique or procedure

of minimizing downtime in any industry or time period. The Netherlands herring fishermen drop nets on opening day, the most experienced fishermen locate schools of fish for the entire fleet, and the fleet follows the schools for six months and 500 miles.

According to the simple model outlined earlier, the bottleneck was keeping the fishing vessels over the fishing grounds catching fish. Everything else was subordinate. While the busses could remain at sea longer and even in poor weather, they would eventually either run out of supplies or provisions, or would reach their capacity of barrels of herring. The vessel would have to experience downtime while it returned to port to unload and resupply. The Dutch improved this constraint by the techniques of offloading and only working on necessary items. Fleets of service vessels were utilized to relieve the busses of tasks that were not directly related to fishing. Most contemporary accounts agree with the estimate that each buss "employed three ships besides herself, one to fetch home salt in their own country, another to carry forth barrels and salt to her at sea, and to bring her herrings back into her own country; and the third to transport her herrings beyond the seas."[16]

The key vessel in the process was the *yagar*. These relatively swift sailing vessels brought supplies to the herring buss fleet and removed the processed herring. After unloading and reloading at sea, the herring busses would simply continue fishing without any delay, thus, helping to maximize yield. The following account of a ship owner-operator and his family perfectly illustrated the enormous effect that the yagars had in maintaining the uptime of the fishing vessels.

> Having a gallant great new busse of his owne, and having a daughter married unto one which was his mate in the busse, and the owner that was master of this busse did take his wife with him aboard, and his mate his wife, and so did set saile for the north-seas, with two women with them, the mother and the daughter, where having a fair wind, and being fishing in the North-seas, they soon filled their busse with herrings, and a herring yager commeth unto them, and brings them gold and fresh supplies, and copeth with them, and taketh in their herrings for ready mony and delivereth them more barrels and salt, and away goeth the yager for the first market in Sprucia, and still is the busse fishing at sea, and soone after again, was full laden, and boone home, but then another yager commeth unto them as did the former, and delivering them more provisions and salt, and ready mony and bid them farewell, and still lyeth a sea with mother and daughter so long and not very long, before they had againe all their barrels full, and then they sailed home into-Holland, with the two women, and a busse laden with herrings, and a thousand pounds of ready mony.[17]

The effect on production was dramatic. From the above example, the time spent fishing and the total production tripled due to the utilization of a yagar, which removed all transportation responsibilities from the herring buss. The buss was able to focus time and efforts on fishing or working only on necessary items as outlined in the constraints management model.

Servicing the fishing ships was a critical factor in expanding the capacity of the bottleneck on the fishing grounds. The Dutch government had a clear understanding of

this constraint and took specific actions to maximize it. The yagars were strictly controlled and regulated. The government required that the operators take a detailed oath to ensure compliance.[18] The government's goals of the yagar oath were clear, to ensure that yagars were to service Dutch vessels only, thus, maximizing and stabilizing production. The prohibition of any kind of trade with foreign entities made sure that the Dutch would have optimal resources to maximize the fishing yield. Decision-makers were maximizing constraints.

The Dutch did not come to dominate the market exclusively, or even primarily, because of low cost, high volume production. The *quality* of salted and pickled herring from Netherlands producers was markedly superior to that of other European fishermen. This competitive edge was meticulously cultivated and protected by the national government. A contemporary English pamphleteer illustrated the significance of the Dutch quality advantage, noting that "the excellency and reputation of curing and packing their fish, proceeds from the careful inspection of the states of the United Netherlands, above any other place, and their curing on shipboard and then repacking."[19] Quality and product standardization in the herring fishing industry was a passion of the Dutch government.

High and consistent product quality is a somewhat less intuitive, but not a less important component of constraints management. A poor product has devastating effects on throughput. Primarily, statistical fluctuations increase. Variability of total production increases when the uncertainty of an unacceptable product is introduced. Production levels can only drop. Furthermore, any existing bottlenecks will be reduced in capacity by poor product quality. The result is that the bottleneck resource will be expended on items that cannot ultimately be sold. It will, in effect, be working on unnecessary items. For instance, as seen in the previous welding example, if the constraint is welding at 50 pieces per hour, and the assembly station can produce 75 pieces but damages 15 pieces every hour, then throughput is only 35 pieces an hour. To maximize capacity of a bottleneck and throughput of the system, it is critical that quality and precision is of the highest importance at every process downstream from the bottleneck. The Dutch used intense regulation to insure product integrity.

Regulation began around the time of the first herring buss. In 1424, regulation of the herring catch, salting, packing, and cask size began in the province of Holland. The catalyst to greater governmental control was complaints from the consumers of the export market. Charles V, in 1519, issued the first general law that encompassed the entire Low Countries herring fishery, which continued in force with only minor changes into the nineteenth century. The most significant action relating to the Dutch herring industry, with the exception of the development of the buss, happened in 1567 with the creation of the College van Commissarissen van de Groote Visscherij, or College of Commissioners of the Great Fishery. It was originally a board of advisors, with representatives from the major herring producing towns, but by 1600, it had acquired law-making power. The College was primarily concerned with everything relating to the fishery except sales price, such as fishing season, prevention of inferior materials and packaging, organizing convoys, licenses, and inspection and branding. Producers were independent, but as a result of this regulation, the industry behaved like a consortium. This degree of control

and regulation was invaluable to the industry, as the export herring market was much more sensitive to quality than price. The College insured the standardization and quality.[20] From the competitors' viewpoint, the importance of sound governmental support and direction was not missed, as when an anonymous Englishmen proposed "that a constant councel of trade be erected by Parliament, which may inspect this trade: and during the intervals (with his majesties approbation) may make by-law."[21]

One of the most significant areas of attention by the College was the prevention of the use of inferior materials. The most important material for curing and preserving herring was salt. The regulations on the kind and use of salt were complete and meticulous, as seen in the following summary of a portion of a placard of Dutch laws concerning the herring trade from April, 1632.

1. No salt permitted in chests or barrels before being appraised by the rate-master.
2. Spanish or Portuguese salt only and it must be verified as such.
3. Must open salt barrels on demand by the rate-master.
4. Fines for any deceit or fraud.
5. French salt is prohibited.
6. Steeresman responsible for any fines.
7. Salt on salt must be used where required.
8. White salt or small salt must be certified of the place of manufacture and of the quality.[22]

The intention of the Dutch government's salt regulations was clear: the widespread use of inferior salt was not going to compromise the commercial viability of the herring catch. This was an unmistakable and documented example of the College of Commissioners of the Great Fishery practicing a constraints management methodology. A bottleneck was identified and that bottleneck was improved.

Protecting the integrity of the herring trade was the explicit goal of the College as this passage from a 1615 proclamation indicates:

> And we are informed, that a newe device is put into practice to the prejudice of the trade, to transport out of the United Countries into other countryes, staves for herring barrels made heere...whereby this chiefe trade should be decayed heere, and the inhabitants of these countryes damnified, if we make not provision in time against such practices.[23]

Product quality would be held at the highest level with a minimum of variation. Not only was the government going to insure a premium product, they were going to virtually eliminate any possibility of fraud or adulteration. The level of detail in the regulation was extraordinary.[24] These laws were exceptionally specific, and each one carried a unique fine. The College was making absolutely certain that the integrity of the product was being maintained at every possible point downstream from the bottleneck of the fishing grounds, a perfect example of prudent constraints management decision making. Dutch salted and pickled herring was a standardized product that enjoyed an outstanding

reputation in the export marketplace as a result of sound regulation.

Englishmen coveting the Dutch herring market provide insight into the importance of the actions taken by the College of Commissioners of the Great Fishery. The impact of the lack of English regulation was "the negligent and corrupt curing of fish by the English, (except Red-herrings) whereby their reputation is far less than those cured by the Dutch."[25] The outcome of this negligence was predictable: the English were completely unable to compete with the Dutch in the foreign, and sometimes domestic, markets. English pamphleteer Tobias Gentleman understood the consequences of misunderstanding the bottleneck of product quality when he wrote that English fishermen "have not yet the right use of making barreled fish, where with they might serve France, as do the Hollanders; they be now constrained to sell in England [...] the French will not buy it."[26]

Fisheries regulation in the Netherlands was not limited to product quality and integrity. The government took an active role in making laws to outline and control labor and hiring practices on board ships. Once again, it was a measured response to a constraints management issue; the College of Commissioners clearly identified the bottleneck and described the intention of the actions as, "many faults and misdemeanors are happened in the hiring of mariners, hiring themselves for the fishing voyage, and that it is needful to provide there in by all due means and remedies."[27]

Labor was a critical factor in maximizing the fishing bottleneck. It was impossible to catch herring without sailors. In order to maximize production, a fishing vessel required a complete, competent, and stable crew. Incompetence and unreliability at the very least reduced production, but when voyaging in the North Sea, it could easily be deadly. Therefore, to maximize the productive capacity of the fishing constraint, human resource issues had to be kept to a minimum. The Dutch government resolved this by clearly defining hiring, working and discipline expectations and requirements for both sailors and the vessel owners. Once again Dutch laws were explicit and detailed.[28] The interesting aspect of these labor laws is that they appear to address problems of both parties in the labor contract. For example, regulations that wages must be paid in money were to protect sailors from less than honorable ship owners, who may try to pay the crew with left over supplies. Obviously, the government was attempting to stabilize the workforce, not serve any one interest group. Sound labor laws clarified expectations and thus, reduced statistical fluctuations for ship crews. Crews and skippers had a better understanding of what was expected of them, and therefore, they could spend more time catching fish and less time addressing labor problems. The reduction of labor issues increased the capacity of the fishing bottleneck.

The constraints management model had worked well for the Dutch herring industry. They had effectively maximized capacity on the bottleneck and protected product quality and integrity downstream. The fishery was extremely profitable. To fully appreciate the accomplishments of the fishermen, merchants, and government of the Netherlands, the actions and results of a competitor would be helpful. English and Scottish coveted the Dutch herring fishery. Fleets of 1000-2000 herring busses off shore were a source of aggravation and a reminder of the shortcomings of their own fishery. The level of irritation can be seen when an English fishing industry advocate complained that "the

Dutch have 400 vessels, at least, that take herring at Yarmouth, and there, for the honour of the English nation, sell them for ready money, which is, as if the Dutch should come and mow our fields, and then sell us the hay."[29] The English and Scottish believed that the herring fishery was rightly theirs, and they had seen what it had meant to the growth of the Netherlands. The advocate added: "The foundation of the Dutch grandeur has been laid in our own seas, particularly by fishing for herrings upon our own coasts."[30] Considering that the fishing grounds were so close, why did the English or Scottish not dominate, or even compete effectively, in the export herring trade? What was the implication of the constraints management model for English and Scottish fishermen?

The bottleneck was maximizing fishing time on the fishing grounds, and then protecting the quality of the herring afterwards. The overwhelming advantage trumpeted by contemporary English writers was the British proximity to the fertile fishing areas. It was incomprehensible to them that domestic fishermen could not dominate the trade simply by being the closest. In this respect, the British had a complete misunderstanding of the constraint, as ease of transportation had little to do with maximizing fishing time. Some even argued that fishing from shore would be a viable option: "by setting netts on the sands, at low water, great quantities of fish are taken next tide of ebb; and provisions and labor are so cheap in those parts...our herrings will not stand us in half so much as the Dutch."[31] Any such operation would be of little importance to the industry. Processing on shore frequently appeared as a competitive advantage, and most reasoning was consistent with the following statement.

> If I have hands always ready on shore for gutting, cleaning, and curing of my fish for small wages; and paying them only whilst they work, and who working on land can perform it much better, than when crowded in the buss; and the fish cured on the spot, where they will be repack'd; then, I have a great advantage over those who must carry the workmen on board; who must pay them dear wages, and that as well when they have no work as when they work; who must clean and cure, pack and repack the same fishes, in several times and places.[32]

This was a clear indication of the misunderstanding of the fishery constraint, and how the Dutch exploited it. Netherlands fishermen were forbidden to process fish on shore in order to maintain product quality. Furthermore, labor would be much more variable in the above scenario as compared to the Dutch process. The catch would almost continuously be at risk of spoilage in the English scenario outlined above.

The English never seemed to grasp the importance of keeping fishing vessels on the fishing grounds continuously. The one consistent component of every British fisheries pamphlet was the inclusion of the advantage of ease of returning to port quickly. The use of Dutch yagars was never seen as an advantage but an unneeded cost. For example, "the great expense of dogger-boats, which the Dutch are oblig'd to make use of to take off their fish at sea, and refurbish their fishermen with cask, and other necessaries, is saved to the English, who bear no such expense, nor any such risque."[33] The English just could not identify the bottleneck.

Natural resources were a popular argument for English advantage. Most writing on

the subject believed that the British Isles were far superior to the Netherlands in supplying the necessary material to support the fishing industry. The actual situation was exactly the opposite; the Netherlands was much more effective in obtaining raw materials, mostly because of political action taken by the English. The navigation acts restricted the importation of timber, pitch, tar, hemp and iron, all critical to shipbuilding. The Dutch, however, were relatively free to trade and could acquire the needed items at a much lower cost.[34]

Not only did the British fail to recognize the existing constraints, politics often created bottlenecks. Salt was an essential element for the herring industry. Both the English and the Scottish constrained the supply of quality salt by restricting importation from foreign sources. The goal was to protect the domestic salt industry; the herring fishermen, however, were required to use an inferior grade of salt, which resulted in a substandard final product.[35]

The English focused on everything except the actual constraint of the system, namely, maximizing the fishing time and protecting the product once caught. The consequences were unmistakable. The country whose fishery understood constraints management grew the industry and dominated, while the one that did not was a marginal factor in the market at best. The English continued to envy the Dutch.

The herring fishing industry in the Netherlands from 1400 to 1700 fits nicely into the model of improvement as outlined by the concepts of constraints management. The bottleneck improvement was clearly maximizing the catch from the fishing grounds. Dutch actions indicate that they recognized this and were focused on raising the fish catching capacity, as well as the meticulous protection of product integrity downstream from the bottleneck. The improvements made were consistent with the model, and the results from those improvements further demonstrate that the Dutch had at least an intuitive understanding of constraints management.

The question remains of whether or not the level understanding went beyond intuition. Was constraints management part of the conscious and active decision making process? The answer must be yes. The critical pieces of evidence to support that conclusion are the unbelievably thorough and precise Dutch laws to regulate the industry. Three factors confirm conscious practice of constraints management. First, the intentions were clearly stated that the laws were to protect and promote the industry. Second, the laws were, almost without exception, focused on maximizing the capacity of the bottleneck or protecting the quality of the product at all steps following the bottleneck. Lastly, the laws worked. The constraint was improved. The quality was superior and the industry was extraordinarily successful.

The English may not have understood how the Dutch were able to do it, but they were able to admire what was happening off shore:

> They seldom or never depart the coast before they are brimful, and really (to give them their due) they are the best fishermen in the world, for they are not only ingenious, in every article of their tackling, or material, but also diligent, industrious, and endure the great fatigue to admiration.[36]

The Dutch herring industry from 1400-1700 had an effective monopoly in the European herring export market. It was an astounding success and set a standard for excellence in commercial endeavors as Western Europe was emerging as the world's economic leader. Little did the decision-makers of the time know that they were also setting a standard to be followed in modern lean manufacturing.

NOTES

1. E. S. (Edward Sharpe) ...*Britaines Busse.* London. 1615, 697.
2. Carlo M. Cipolla, *The Fontana Economic History of Europe, Vol 2.* (New York, HarvesterPress/Barnes & Noble, 1977), 121.
3. Richard W. Unger, "Dutch Herring, Technology, and International Trade in the Seventeenth Century," *The Journal of Economic History* 40 (June 1980): 263.
4. Eliyahu M. Goldratt and Jeff Cox, *The Goal: A Process of Ongoing Improvement* (Great Barrington: North River Press, 1992).
5. Jan De Vries and Ad Van Der Woude, *The First Modern Economy* (New York: Cambridge University Press, 1997), 244.
6. Richard W. Unger, *Dutch Shipbuilding Before 1800* (Amsterdam: Van Gorcum & Company. 1978), 29.
7. Richard W. Unger, *Dutch Shipbuilding Before 1800* (Amsterdam: Van Gorcum & Company. 1978), 29.
8. John R. Elder, *The Royal Fishery Companies of the Seventeenth Century* (Glasgow: John Maclehose and Sons, 1912), 3.
9. Richard W. Unger, *Dutch Shipbuilding Before 1800* (Amsterdam: Van Gorcum & Company, 1978), 31.
10. Richard W. Unger, "Dutch Herring, Technology, and International Trade in the Seventeenth Century," *The Journal of Economic History* 40 (June 1980): 260.
11. Thomas Jenner, *Londons Blame* (Printed for T.J. at the South Entrance of the Royal Exchange, 1651), 11.
12. Gerard Malynes, *Consuetudo, Vel Lex Mercatoria* (London, 1622), 242.
13. Thomas Jenner, *Londons Blame* (Printed for T.J. at the South Entrance of the Royal Exchange, 1651), 11.
14. John Keymor, *Observations Made Upon Dutch Fishing, about the Year 1601* (London, 1664), 9.
15. Sir Roger L'Estrange, *A Discourse of the Fishery* (London, 1674), 5.
16. John Keymor, *Observations Made Upon Dutch Fishing, about the Year 1601* (London, 1664), 7.
17. Tobias Gentleman, *Englands Way to Win Wealth, and to Employ Ships and Marriners* (London, 1614), 39.
18. *Anonymous: A Translation of the Dutch Placart and Ordinance for the Government of the Great Fishery* (London, 1750), 17-18.
19. *Anonymous: The Royal Fishing Revived* (London, 1670), 3.
20. Richard W. Unger, "Dutch Herring, Technology, and International Trade in the

Seventeenth Century," *The Journal of Economic History* 40 (June 1980): 261-262.

21. *Anonymous: The Royal Fishing Revived* (London, 1670), 8.
22. Simon Smith, *The Herring-Busse Trade Expressed in Sundry Particular* (London, 1641), 28 34.
23. E. S. (Edward Sharpe), *Britaines Busse* (London, 1615), 698.
24. The following summary of the laws from the 1632 placard pertaining to regulation of product integrity was amazing in the level of thoroughness and detail:
    1. Fresh or baskets of fish could not be packed on shore in the Netherlands.
    2. May not engage in trade of herrings at sea with anyone other than authorized agents of Holland and West Friezeland.
    3. No vessel may service busses without an act of consent and the required oath.
    4. No one can bring herrings anywhere but Holland or West Friezeland.
    5. No resident may have a stake in any ship that has been banned from Holland or West Friezeland.
    6. The first herrings of the season must be in the first pickle at least 10 days before repacking.
    7. Each barrel must have a unique mark identifying the ship.
    8. Once in port ships must register with the secretary's office.
    9. Herrings must be laid four in length in a barrel and not thrown into the barrel.
    10. No adulteration of herrings.
    11. Barrels must be marked indicating the kind of herring inside.
    12. Must disclose what kind of herring is being sold.
    13. Herrings must be salted according to standards.
    14. Herrings must be appraised within three weeks of arrival from sea.
    15. Repacking must be done in the open for inspection purposes.
    16. No unfit herrings may be packed with pure herrings.
    17. Barrel makers are accountable for barrel quality.
    18. Barrels must have suitable hoops.
    19. Minimum 14 hoops for binding barrels.
    20. Herring may be packed only in herring barrels; other barrels may not be reused.
    21. No packing into unfit barrels.
    22. Herring for France and Flanders must be Roan Brandt herring caught and packed after Crux-Tyde (September 14).
    23. No packing or salting in any other country.
    24. No burning of marks on the herring barrel.
    25. No reuse of barrels of sea that have been once exported.
    26. No processing of foreign caught herring of any kind.
    27. Fine distribution is a third to the informer, a third to the officer and a third to the poor.
    28. Must take a copy of the ordinance at sea so as to not be able to plead ignorance.
    29. Publication and posting of the ordinance so no one can plead ignorance.

    Simon Smith, *The Herring-Busse Trade Expressed in Sundry Particular* (London, 1641), 18-34.
25. *Anonymous: The Royal Fishing Revived* (London, 1670), 4.

26. Tobias Gentleman, *The Best Way to Make England the Richest and Wealthiest Kingdome in Europe* (London, 1660), 9.
27. Simon Smith, *The Herring-Busse Trade Expressed in Sundry Particular* (London, 1641), 34.
28. Dutch laws pertaining to labor were explicit and detailed as can be seen in the following summary:
    1. Persons hired to a steeresman must discharge duties or be fined a specific amount.
    2. If a person cannot or will not discharge duties then the steeresman may discarge them.
    3. Mariners may not hire to more than one steeresman, and steeresmen may not knowingly hire a mariner already hired to another.
    4. Mariners must come aboard ship at the appointed time to go to sea.
    5. May keep up to 14 days wages, to insure mariner returns to ship when it is time to put to sea if appropriate.
    6. Provisions for the payment of the mariners in various uncertain circumstances.
    7. In case of loss of ship, the mariners must be paid for time of service.
    8. No herrings may be carried off ship by anyone.
    9. No beer may be carried off ship and no one from off ship may consume beer.
    10. Mariners that receive money or herrings and run away are liable for both and a fine.
    11. In case of injury due to war, mariner shall receive wages but the ship owner is not liable for anything else.
    12. If person is hired in the time of war, and will not fight when needed, he shall be punished according to a judge from the port from which the ship sailed.
    13. Wages must be paid in money
    14. May not pick herrings out of barrels when at sea.

Simon Smith, *The Herring-Busse Trade Expressed in Sundry Particular* (London, 1641), 34-41.

29. Henry Elking, *The Interest of Great Britain Consider'd* (London, 1723), 13.
30. Henry Elking, *The Interest of Great Britain Consider'd* (London, 1723), 11.
31. *Anonymous: The Importance and Management of the British Fishery consider'd* (London, 1720), 21.
32. *Anonymous: Proposals Relating to the Fishery* (London, 1709), 3.
33. *Anonymous: The Importance and Management of the British Fishery consider'd* (London, 1720), 21.
34. *Anonymous: The Royal Fishing Revived* (London, 1670), 4.
35. *A Proclamation, Anent the Salt* (Edinburgh, 1671), 1.
36. John Campbell, *A True and Exact Description of the Island of Shetland* (London, 1753), 28 29.