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Best practice in live fish transport

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Abstract

The report is specifically directed towards live fish transport. It identifies seven phases in the transport value chain and it suggests best practise for issues assessed to most likely have an impact on welfare under these phases.

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Live fish transport and animal welfare

Best practise

European Animal Welfare Plattform

Preface

This report is put together on an assignment for the European Animal Welfare Plattform (EAWP). The issue about animal welfare is a wide and complicated theme, and this report is not attending to cover every aspect of this important subject, nor debate the many approaches that can be relevant in safeguarding fish's welfare. On the other hand this report is aiming to address the issues that the authors, after using extensive knowledge and relevant litterature, have found to be the best practise of what could have an impact on animal welfare in live fish transport. There are more complicating issues with live haul fish transport in a well boat than live fish transport in a truck. Most issues being discussed is anyhow relevant for truck transports. Our report has been focusing on transport of Atlantic salmon but is relevant for other species to a certain extent.

Markhytten, February 28th - 2011

Trond W. Rosten

Contents

Summary

This report addresses issues that are assessed to be relevant for animal welfare in live fish transport. The authors suggest to divide the transport process into seven phases; (1) the planning phase, (2) preparing fish, (3) preparing vessel, (4) the loading phase, (5) the transport phase, (6) the unloading phase, (7) wash and disinfection. Under each of these phases best best practise routines or topics are addressed. Relevant literature is also quoted, both litterture that is published in peer review journals and other reports that are found to be relevant to the topic are used. The following bulletpointed list sums up the suggested best practises under each phase:

The planning phase
- *to aim for full control of the biomass load in the fish haul.*
- *to ensure information about the health status of the fish prior to the transport*
- *to gather information about areas with higher bio-security risk along the route*
- *to check the expected weather conditions along the route*
- *to contact the sender of the fish and make sure preparations for transport and loading are made*
- *to contact the receiver of the fish and make sure preparations for unloading is made before arrival.*
- *to carry out a quality control prior to loading fish, making sure that all necessary information about the fish are given*

Preparing the fish
- *to restrict fish from feeding days before transport.*
- *to apply technology for checking the right numbers of fish prior to the transport.*

Preparing the vessel
- *to wash and disinfect the vessel before loading fish.*
- *to always calibrate water quality sensors before transport*
- *to avoid risk of supersaturation with nitrogen by degassing water in live haul before loading fish.*
- *to test that systems for improving water quality are functional and operating*
- *to carefully check all potential weak points in the transfer line of fish from the farm to the vessel.*

The loading phase
- *to apply and use technology to verify how much biomass is loaded into the vessel.*
- *to have trained personell available for observing fish during loading*
- *to dewater the used water (from fishtank on shore), before loading on to a vessel with closed system*
- *to ensure that the loading process is as quick and smooth as possible, bearing in mind that one should avoid damages on the fish and avoid unfavourable oxygen levels during and after loading*
- *to use siphon and/or low pressure loading systems*
- *to aim for 100 % oxygen saturation in all phases of the transport*
- *to apply continuous new water flowing through the fish haul during loading with open systems*
- *to ensure that all legal /biosecurity regulations are met when water is taken into the fish haul*

The transport phase
- *to choose a transport route that most likely do not to put the welfare of the fish into risk*
- *to choose a sailing route most unlikely to get close to other fish farms*
- *to avoid if possible rough sea conditions*
- *to find the safest sailing route through farming areas by using new hydrophysical models*
- *to remove CO_2 from transport water by using degassers during closed transport*

- *to keep some CO_2 present in the transport water during a closed haul transport to lower pH and keep more of the present ammonia/ammonium (TAN) on a less toxic form during closed transport*
- *since there is no efficient way to remove TAN from the transport water, best practise would be to limit the transport in length and biomass load, so that it could be kept within safe limits*
- *to use vessels equipped with CO_2 degassers, O_2 feedback control system, a moveable bulkhead (if it's a well boat), and water cooling system (or protection towards external heat through isolated tanks if it's a truck), a fish surveillance system (e.g. underwater cameras), and systems for water quality monitoring when using closed live haul transport*
- *to have knowledge about what causes these changes, how they can be counteracted and how they effects the welfare of the fish.*
- *to use a simulation model (e.g. transport calculator) to adapt fish load to wanted transport length so that neither CO_2 nor TAN would reach too high levels*
- *to always supply enough water to the haul during a open single pass flow-trough transport system to make sure that the water quality stays within safe limits*
- *to be aware of the chemical shifts in a closed haul and avoid raising pH in fish haul that contains high TAN levels*
- *to sample and monitor water from several areas in the haul, including the area most likely to represent the worst values in the fish haul (e.g. the outlet) and store these in an electronic file for later documentation or analysis.*
- *to keep water sampling bottles in the vessel for sampling, analyzing and evaluation in case of problems to ensure learning*
- *to have sufficient knowledge of fish behaviour in transport so that the personnell can judge if welfare problems are developing.*
- *to use visual observation through windows or hatches and underwater cameras to assess fish welfare*
- *to plan transport route and countermeasures according to the weather conditions expected along the sailing to apply countermeasures as lowering the biomass in the haul to lower risk for fish being scrubbed up against each other during lurching and to able to run pumps to secure circulation if propulsion of vessel is limited*

The unloading phase
- *to check if the fish are relatively unstressed after the transport*
- *to use slightly elevated pressure system for unloading fish that is meant to stay in a net pen afterwards*
- *to use moving bulkhead to allow unloading with a full water volume in the haul*
- *to pay special attention that no fish is damaged or do escape trough the delivery pipe or hose*
- *to make sure that the intake of new water is balancing the outflow of fish and water (e.g. by a vacuum pump) so that stress during the loading period is minimised.*
- *to make sure that the process of unloading fish in the haul are being supervised by an experienced person so such good condtions can be obtained.*
- *to address welfare relvant indicators as viability, appetite, amount of scale loss, schooling pattern and mortality after the fish has been delivered.*

Wash and disinfections
- *to make sure that the vessel is clean and disinfected between every new group of fish that is being transported.*
- *to use approved chemicals and doses for washing and disinfection and to ensure that this is being documented by quality registrations.*

1. Introduction

The welfare of live animals during transport has been addressed by several reports by European Food Safety Authority (EFSA) Scahaw, 2002, EFSA, 2011. Assesment of risks for the welfare of transported animals are requested in the present Community legislation (Regulation (EC) No 1/2005. Welfare and health of farmed fish is addressed in the Council Directive 2006/88/EC (on animal health requirements for aquaculture animals) and the reccomentation from European Council /88/EF (June 5th. 2006).

The aim of this report is to address what can be considered as best practice during transport of live fish. An increasing number of fish produced in aquaculture are being transported up to several times during their life cycles (Rosten, 2010) and transport of live fish is a topic of welfare interests (Ashley, 2007, Farrell *et al.*, 2010, Rosten, submitted, RSPCA, 2010). We have found it natural to focus directly on the factors that are most likely to have a positive or a negative effect on the welfare of the fish. Keeping up the performance of a transport service is much about establishing a quality assurance system. In Norway as an example this has been addressed by quality assurance projects with the well-boat industry (Rosten and Maroni, 1996). To identify and highlight best practice is a way to achieve rapid progress in matters concerning fish welfare. Transport of fish is a complex process where there is a complicated interaction between the fish, the environment, the technical equipment and various human factors. We have chosen to present this by addressing best practices under each step throughout the transport value chain (Fig. 1).
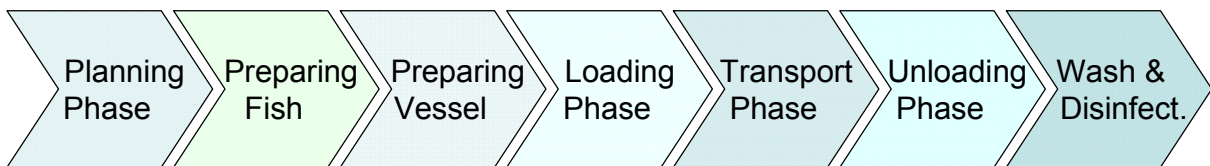
Figure 1. Value chain transport of live fish

2. The planning phase

This is the first phase we have identified. Good planning is essential to be able to carry out a transport with high welfare standards. During this phase we suggest to pay specific attention to plan; (1) the amount of fish, (2) the condition of the fish, (3) the transport route, (4) the loading phase, (5) the unloading phase. The best practise is given in the text in italics.

2.1 The amount of fish

A considerable amount of time must be directed towards the planning phase prior to a life fish transport. *The best practice approach would be to aim for information that give full control of the biomass load in the fish haul.* To be able to achieve this, the transporter must, as a minimum, know the average weight and the number of fish. Today there is equipment that ensures this with accuracy around 2 %. It is absolutely vital to know the biomass since it represents a limit to how much fish that can be loaded into that specific vessel. As an e.g. we can illustrate that there are large variations in size of well boats approved for live haul transport in Norway (See Table 1).

Table 1. The well boat fleet in Norway, adapted after Rosten (2010)

Size of live haul	Number of boats	% of fleet	Total capacity	% of live haul capacity
1300-2250	2	1,6	4 284	12,5
1000-1300	7	5,4	8 106	23,6
500-1000	7	5,4	4 889	14,2
400-500	6	4,7	2 740	8,0
300-400	15	11,6	5 020	14,6
200-300	19	14,7	4 247	12,4
100-200	29	55,5	4 252	12,4
50-100	8	6,2	571	1,7
<50	7	5,4	263	0,8
No data	29	22,5	0	0
Total	136	100	34 372	100

2.2 The condition of the fish

The fitness of the fish group can impact the welfare of the fish during transport (Hjeltnes *et al.*, 2008). A weakened fish group are less likely to handle the stress a transport procedure will cause. *The best practice approach would be to ensure information about the health status of the fish prior to the transport, so mitigations can be applied.* These actions can be lowering the biomass of the fish in the transport vessel and to be extra careful while handling the fish or forcing the transport to be carried out as a quarantine transport with closed haul. No sick or injured fish should be transported if it can be avoided.

2.3 The transport route

To plan the transport route is a highly valid point. The length of the transport might influence the water quality in the haul, depending on if it is an open or a closed haul transport. The accumulation of metabolites in a closed haul is a product of the metabolism rate of the fish and it varies with temperature, fish size and swimming speed (Grottum and Sigholt, 1998). In a well boat this can be measured as bulk oxygen consumption (Farrell, 2006). The call for a closed transport are often related to passing areas with risk of contamination with fish pathogens (as decribed in e.g. Norwegian regulations (FOR - 2008-06-17 nr 820). *It is to be considered to be a best practice to gather information about areas with higher bio-security risk.* Passing such areas might call for the use of closed fish haul, and therefore it is important for the transporter know how long it will take to sail through these zones. *In addition it is best practice to check the expected weather conditions along the route* (see chapter 6.8) and clarifify the distance and expected length of time of the journey

2.4 The loading phase

It is vital that the necessary numbers of people are present to make sure that the loading process runs as smoothly as possible. An e.g.of this might be the skills and number of people necessary to present a good brail net catch in a net pen prior to loading. *It must be considered as best practice for the transporter to contact the owner of the fish and make sure preparations for transport and loading are* made before the vessel arrives and co-ordinate to make sure fish are not held/crowded too long before loading.

2.5 The unloading phase

There might be several operations that have to be prepared before the fish comes to the delivery point. In some cases the fish might be unloaded into a harvesting – slaughter system, in other cases it might be unloaded into a new farming system for further growth. There are often specific arrangements that have to be in place at site before unloading can take place and lack of such might influence the effectiveness and smoothness of the process. *It must be considered as best practice for the transporter to contact the receiver of the fish and make sure preparations for unloading is made before arrival of the vessel.*

3. Preparing fish

This is the second phase we have identified. The preparation of the fish can be highly valid for being able carry out a transport with high welfare standards. During this phase we suggest to pay specific attention to; (1) the papers, (2) feed restriction, (3) counting and sorting. The best practise is given in the text in italics.

3.1 Documentation

Health and origin certificates for the fish group are examples of papers the transporter need to get from the shipper (fish owner). Likewise, a consignment note with the correct number and size of fish is obligatory to bring. *It is regarded as best practise to carry out a quality control prior to loading fish making sure that all necessary information about the fish group is available.* An example of such a scheme is shown in appendix 1.

3.2 Feed withdrawal pre transport

The water quality in a closed haul is significantly affected by accumulation of potential toxic metabolites (Murray, 1986, Grottum *et al.*, 1997, King, 2009, Tang *et al.*, 2009). Ammonia (NH_3) is highly toxic to salmon (Knoph and Olsen, 1994, Knoph and Masoval, 1996), and carbon dioxide (CO_2) can cause large physiological disturbances (Fivelstad, 1997, Ishimatsu, 2004 and, 2005, Farrell *et al.*, 2010). The excretion rates of these metabolites are highly influenced by feeding status , with up to 90 % decrease in ammonia and 50 % decrease in CO_2 in feed restricted adult salmon (Forsberg, 1997) . *Due to this mechanism, feed withdrawal, for 2-4 days before transport, is a way to improve the water quality (Murray, 1986, Hjeltnes et al., 2008) in the transport haul and must be regarded as a best practice.*

3.3 Counting and sorting

There are different procedures in use for preparing the right numbers of fish in the transport. *Doing so is to be seen as a best practice.* Some might count the fish in advance, grading out the right sizes and leaving the prepared in delivery tank/cage. Such procedures might allow removal of individual fishes, not fit for transport. The other option is an inline fish counting system onboard the vessel.

4. Preparing the vessel

This is the third phase we have identified. The preparation of the vessel is important for the delivery of a welfare sustainable environment for the fish. During this phase we suggest to pay specific attention to (1) bio security, (2) calibration of sensors, (3) avoiding nitrogen supersaturation, (4) test the life sustaining equipment. The best practise is given in the text in italics.

4.1 Bio security

In order to reduce risk for spreading of, and exposure to, fish pathogens, the vessel must be washed and disinfected before transport. In particular this is important for the haul and circulation systems (pipes and pumps).Wash and disinfection must be documented. An example of such documentation is given in appendix 2. Approved wash and disinfection chemicals must be used in the correct concentration and time (FOR - 2008-06-17 nr 820, Kyrkjebø, 1989). *In transport of live fish this is one of the most vital best practise procedures*.

4.2 Calibration of sensors

Case studies have shown that wrong calibration of sensors can cause problems in a live haul fish transport (Rosten *et al.*, 2007). *It is considered as a best practice to always calibrate water quality sensors before a life fish transport*. Expected sensors to available on vessel are: oxygen, temperature, pH, CO_2, total gas pressure (TGP) and salinity. Calibration must for most sensors take water temperature and salinity into account. One should expect to find quality registrations from maintenance and calibration of the sensors.

4.3 Avoid super saturation with nitrogen

Supersaturation with gaseous nitrogen (N_2) can be detrimental to the health of fish and must be reflected in the design and operation of aquatic systems (Colt, 1986). It is shown that supersaturation can occur during filling water into an empty haul and starting circulation pumps (Rosten *et al.*, 2007). This could in particular be a problem during transport with closed system. *To avoid this it is considered best practise to degas water before loading fish*. This was also included in the new transport regulations in Norway (FOR - 2008-06-17 nr 820).

4.4 Test the life-sustaining equipment

Oxygenation systems and CO_2 degassing systems are to be seen as life sustaining equipment in a transport vessel. *Prior to transport it is considered best practise to test that these systems are functional and operating*. This might be documented by a checklist prior to transport (se example appendix 2). Such a checklist should be included in a quality assurance system onboard the vessel. If oxygen is supplied from cannisters, one should check that there is sufficient supply left for the whole transport. *Best practice (RSPCA Std.) would recommend enough O_2 available for 150 % of journey requirement.*

5. Loading fish

This is the fourth phase we have identified. The loading of fish is a crucial phase with high possibility to have an impact of the welfare of the fish. During this phase we suggest to pay specific attention to (1) prevent fish escapes, (2) prevent fish damage, (3) verify correct biomass, (4) observation of fish welfare, (5) dewater used water, (6) ensure capacity and swiftness of the process, (7) supply and control of oxygen, (8) special water quality considerations. The best practise is given in the text in italics.

5.1 Prevent fish escapes

Escapees of farmed fish represent an environmental problem (Skaala *et al.*, 2006, Walker *et al.*, 2006) and should be avoided. Critical points where escapes are reported are from loading juveniles and salmon smolts onto a vessel (Fjellheim et al., 2010). *Best practice would be to carefully check all potential weak points in the transfer line of fish from the farm to the vessel. Known critical points are joints and bends and attachment to vessel.*

5.2 Prevent fish damage

When fish is to be moved it is best to do this while it is enclosed in water to avoid damage (Lekang, 1991). Damages to the fish might also occur if water is lacking, or if speed and g-force is to high, causing fish to hit walls, misfit joints or sharp edges in the transport hose/pipe. *The best practise approach would be to control the loading hose/pipe for any problematic issues prior to loading and loading stopped if sign of problems appear. The use of siphon and or low pressure system for loading fish is also considered as best practise.*

5.3 Verify correct biomass

Exceeding the capacity of the vessel in terms of fish load and fish density can have negative effect on welfare of fish in transport (Hjeltnes *et al.*, 2008). *Best practice is to ensure to verify how much biomass is loaded on the vessel.* Biomass estimating equipment are available and applied to many large well boats, allowing calculation of the size, distribution and numbers of fish brought into the hull (e.g. from a few suppliers can be found).

5.4 Observations of fish welfare

There is no sensor which can compete with the eyes of an experienced person observing the fish during loading. *Best practice is to have such personell present during this critical phase* (Hjeltnes et al., 2008). Use of underwater cameras in the fish haul is obligatory. The five top recommended parameters are suggested to be;

1. Absence of panic and flight responses
2. Absence of damaged fish and scale loss
3. Normal gill opercula movements (high frequency indicate hypoxia and stress, too low frequency might indicate hyperoxia)
4. Normal swimming pattern
5. Absence of mortality

5.5 Dewater used water

Loading fish and used water into a vessel, before a transport start, means that the transport would start with high levels of CO_2 and TAN (Rosten, 2006). This could be critical if the loading and transport is to be carried out as a closed one where these metabolites are likely to increase (Hjeltnes et al., 2008). *Best practise would therefore be to dewater the used water before loading on to a vessel with closed system.* It is also know that the bioavailability of potential fish harming metals as aluminium and iron might increase when mixing freshwater with high metal concentration with seawater (Bjerknes, 2007). This could also be avoided by using dewatering systems.

5.6 Time and capacity conciderations

Loading time of smolt can vary. From a study in Norway, Rosten et al, (2007) found that the average loading time for Atlantic salmon smolt was 3,5 hours. Depending of whether or not the loading is carried out on an open system (single pass flow-through system), this time might be considered as transport time, where water quality is worsening due to accumulation of metabolites (Rosten, 2006). Loading of fish on the vessel generates a large stress response (Erikson *et al.*, 1997, Iversen *et al.*, 2005) in which the oxygen consumption increases (Murray, 1986, Farrell, 2006). This can partly be counteracted by oxygen supply and CO_2 degassing. *It is however best practice to ensure that the loading process is as quick and smooth as possible, baring in mind that one should avoid damages on the fish (se above 5.2.). Unfavourable oxygen levels must be avoided.*

5.7 Supply and control of oxygen

Oxygen is the most critical parameter to control in aquaculture , both too little (hypoxia) and to high (hyperoxia) can create welfare problems for fish (Brauner, 1998, Brauner *et al.*, 2000, Espmark *et al.*, 2010). *Best practice would be to aim for 100 % saturation* (Rosten, 2009). But variations between 80-120 % saturation might be acceptable for limited periods of time. Both high and low oxygen level is particularly dangerous in combination with high levels of metabolites in the transport water (Rosten *et al.*, 2007) The toxicity of ammonia increases with low oxygen levels (Alabaster et al., 1979). Hyperoxic water causes increased internal oxygen concentrations (Kristensen *et al.*, 2010), and might cause oxidative damage (Lygren. *et al.*, 2000, Olsvik *et al.*, 2006). Hyperoxia may cause damage to osmoregulation (Brauner, 1998), and negative effects of hyperoxia during transport has been demonstrated to increase in combination with hypercapnia (Brauner *et al.*, 2000).

5.8 Special water quality considerations

5.8.1 Filling of water into the transport haul

Loading a vessel with continuous new water flowing through the fish haul is regarded as best practise. The water should be supplied from a source not containing high levels of metabolites or metals. This source could be the surrounding seawater or it could be fresh water supplied from the hatchery / smolt farm. This water might have a high variation of quality as shown by Kristensen et al., (2009). *It can be considered as best practice to take a sample of the raw-water quality at the hatchery / smolt farm, and have it analysed by an acreditated lab.* As previously described, the used water, should be dewatered during the loading process. There are a few special considerations one must be aware of. One would like to avoid the problems known to occur in estuarine mixing zones (Bjerknes et al., 2003). The problem with unstable and bio-reactive chemistry arises when freshwater with low pH and high aluminium content mixes into water with high pH and high salinity. If the loading point is located in an estuarine mixing zone, intake of such water to the haul, must be avoided. Same type of

problem is described to occur for freshwater containing high proportion of total organic material (TOC) after a this has been is mixed into seawater (Bjerknes, 2007). In any case bringing in water to the fish haul from an external source also has to take bio-security into account. In some cases the fish health authorities have put limitations on what type of water can be used fill into a vessel for life fish transport. This will be implemented due to the fish health situation in the area, e.g. Norwegian transport regulations (FOR - 2008-06-17 nr 820). *Best practise is to check that no such regulations are being violated when water is taken into the fish haul.*

5.8.2 Freshwater to Freshwater Movements

There will be cases where seawater could not be used as transport water. An example of this would be when juvenile, non smoltified salmonides are transferred from one hatchery to another. These transports can be challenging since no water exchange is possible (closed haul system is needed) or at least limited to specific water exchange stations. Such transports would always be limited in possible transport time and fish load. *Best practise would be to use mathematical models derived from empirical datasets* (Tang *et al.*, 2009, Rosten, 2010) *to estimate the possible fish load and transport distance in closed haul*

6. Transport phase

This is the fifth phase we have identified. The transport phase is the moving of fish from the sender to the reciever and it can be challenging and unpredictable. It is of highest importance to decide if or when the transport is to be carried out as a closed haul transport or open haul transport. During this phase we suggest to pay specific attention to; (1) the route, (2) open or closed haul system, (3) choice of vessel, (4) water quality changes, (5) dewater used water, (6) renewal of water in the haul, (7) water quality documentation, (7) monitor and understand fish welfare indicators, (8) weather impacts. The best practise is given in the text in italics.

6.1 The route

Best practise would be to choose a transport route that most likely will not compromise fish welfare. What type of dangers this might be would vary. As an example we can think of a situation with a well boat with open system sailing through an area contaminated with fish pathogens, or vice versa when a well boat loaded with sick fish is sailing through an area with healthy fish with open system. In both cases there might be a risk for contamination one way or the other. *Choosing a sailing route most unlikely to get close to other fish farms is regarded as best practice. In some cases this needs to be balanced with the risks of damaging fish due to rough sea conditions* (Iversen et al., 2005). A more off-shore sailing route would sometimes be more risky than a inshore sailing route. In addition one would like to avoid areas with risk of estuarine mixing zone problems. The analysis of risk for contamination and contact between salmon farms in sea areas can be carried out with a 3D hydrodynamic model. Such a model is presented by Viljugrein er al., (2009) and are ready for use. This new tool makes it possible to find the safest sailing route in farming areas avoiding water with potential pathogens or sealice larvae. *Establishing sailing routes with such new dynamic tools would be considered as best practise.* For trucks the route should be the fastest way form loading to delivery point, avoiding critical points that could cause delays. If water exchange is to happen, a safe and approved place for doing this needs to be planned into the route. *As long as information is available, the risks along the transport route can be avoided. Aiming for that is best practise.*

6.2 Open or closed haul system?

Transport of live fish in a well-boat, gives as earlier stated, the choice of carrying out the transport with open single pass flow through system or closed haul system. Unlike this, a transport with a truck is only possible with a closed system, and this could be problematic in terms of high CO_2 (King, 2009) and TAN. Selecting an open or a closed system is depending upon if there are bio-security issues associated with the fish group it self, local regulations (e.g. coming into an slaughtery) or risks of contamination with fish pathogens along the transport route. One could not tell by a general rule what is considered best practise out of choosing an open or a closed system. It will depend upon the current situation. Many times there is no choice between open and closed system, since regulations may make closed systems obligatory. If it can be found that an open transport is bio- security viable, this is preferable in terms of water quality in the fish haul. A single pass flow-through system is more likely to be able to remove metabolites as CO_2 and TAN which might cause welfare problems for the fish. It has been argued by studies that such transport of Atlantic salmon smolt reflected good welfare (Nomura *et al.*, 2009) The new water will also provide a substantial amount of the necessary oxygen needed for the fish. Unlike this, i*n a closed system, CO_2 can be partly removed by using degassers and it must be considered as best practice to have degassing systems implemented on the vessels. In fact there is evidence that keeping some CO_2 present in the water during a closed haul transport is beneficial, since it lower pH and keep more of the TAN as less toxic NH_4^+* (Hjeltnes et al., 2008)*.* Systems including zeolittes for removing ammonia have been tested (Johnson, 1974, Bruin, 1981) but not found in commercial or large-scale practical use. Oxygen that is consumed by the fish must be added to the water in same rate as the consumption, e.g. through an oxygen injection system. *Since there is no effective way to remove TAN from the transport water, best practise would be to limit the transport in length and biomass load so that it could be kept within safe limits.* Another important adaptation to improve the water quality during transport with closed system would be to lower the metabolism of the fish. This can be achieved by reducing the water temperature and by reducing the swimming speed of the fish in the haul (Hjeltnes et al., 2008). Current recommendation for lowering the temperature is to do so gradually, (1.5 C^0 h^{-1}) and not further that 4-6 C^0 as endpoint (Hjeltnes et al., 2008). It is also important to have sufficient equipment for monitoring water quality changes during closed transport.

6.3 Choice of vessel

The vessels used for transport fish are of different, age, size (see Table 1) and equipment. Not all are suitable for closed transport. *Best practise would call for the use of vessels equipped with CO_2 degassers, O_2 feedback control system, a moveable bulkhead (if it's a well boat), and water cooling system (or protection towards external heat through isolated tanks if it's a truck), a fish surveillance system (e.g. underwater cameras), and systems for water quality monitoring.*

6.4 Water quality changes

There are several water quality changes occurring in a live transport vessel when the haul is closed. The water quality of an open haul system is determined upon the rate of water exchange and the fish load as in a fish tank on shore and is much more likely to be low with regards to toxic metabolites (Rosten, 2006). Closed transport will lead to accumulation of CO_2 (Grottum *et al.*, 1997, King, 2009, Farrell *et al.*, 2010), drop in pH (Grottum et al., 1997), accumulation of TAN (Grottum et al., 1997), accumulation of TOC (Bjerknes, 2007) and these could lead to a water quality environment not associable with good welfare (Ashley, 2007, Hjeltnes *et al.*, 2008). These factors need to be considered and counteracted (Hjeltnes *et al.*, 2008, Farrell *et al.*, 2010). *Best practice will be to have knowledge about what causes these changes, how they can be counteracted and how they effects the welfare of the fish. Best practice would also be to use a simulation model to adapt fish load and*

transport length so that neither CO_2 nor TAN would reach to problematical levels (Farrell et al., 2010).

6.5 Renewal of water in the well or tank (haul)

It is complicated to explain best practice regarding changing the water in fish haul during transport. To start with a simple situation, an open single pass flow through system will generate a constant exchange of the water in the fish haul. The residence time of the water inside the haul is dependant on the flow rate and size of the haul. *Best practice in such cases would be to always supply enough water to the haul to make sure that the water quality stays within safe limits.* In a well boat the water exchange would depend upon the speed of the boat and the opening of the valves bringing water through the haul system. When the boat is slowing down or laying still for some reason, the water exchange is depended upon using pumps with sufficient capacity.

After some time with transport in a closed haul system, renewal of water can be a risky operation. This is related to ammonia toxification (Hjeltnes *et al.*, 2008) induced by a pH rise. What actually causes this is that a rise in pH will shift the equation of TAN from rather non-toxic NH_4^+ to highly toxic NH_3. Renewal of water can be beneficial but one must consider the ammonia risk and counteract it either with avoiding renewal with water of higher pH or add enough water at high volume so dilution counteracts the formation of NH_3. *Best practice would be to be aware of these chemical shifts and avoid raising pH in a fish haul that contains a lot of TAN. This is being implemented in the Norwegian regulations for transport (FOR - 2008-06-17 nr 820).*

6.6 Water quality documentation

Actual levels and changes in water quality in the fish haul during transport can be monitored or measured, and it is to be considered best practise to do so and to keep quality registration for documentation. *The best practise solution would be to sample and monitor water from several areas in the haul, including the area most likely to represent the worst values in the fish haul (e.g. the outlet) and store these in an electronical file for later documentation or analysis. We also would also highlight the benefit to keep water sampling bottles in the vessel in case of an instant problem, e.g. now being included in the Norwegian transport regulations (FOR - 2008-06-17 nr 820).*

6.7 Monitor and understand fish welfare indicators

The welfare of the fish during transport must be monitored and understood. Welfare indicators during transport are described by Rosten et al (submitted) and include changes in behaviour and schooling pattern. Fish reflexes such as body posture, coughing and gill opercula movements amongst others, might be useful as welfare indicators (Davis, 2010). *Best practise would be that the skipper or transporter, have sufficient knowledge of fish behaviour in transport so he / she can judge if problems are developing. To be able to do so it is necessary to use both visual observation through windows or hatches and underwater cameras.*

6.8 Weather impacts

The weather conditions can have effects on the stress level of fish in a well boat (Iversen et al., 2005). What causes the stress effect is not described, but we know that bad weather causes more lurching because of the waves and limits the propulsion and the amount of water flowing trough the haul in an open system. *It is therefore to be considered as best practise to plan transport route and*

countermeasures according to the weather conditions expected along the sailing. Countermeasures would be to lower the biomass in the haul to lower risk for fish being scrubbed up against each other during lurching, and to able to run pumps to secure circulation if propulsion is limited. Likewise a Contingency Plan must be in place in case the wellboat is not able to arrive at destination due to bad weather, eg some sheltered moorings should be identified during the planning phase

7. Unloading fish

The sixth phase is ending the part of the transport value chain where the fish are involved. It can be a critical phase and there are some procedures to be considered as best practise. It is e.g. expected to find that the fish are relatively unstressed after the transport (Erikson et al., 1997), given that no specific problems have occurred during the transport, but it is also demonatrated that the stress increases significantly during the unloading phase (Erikson *et al.*, 1997, Hjeltnes *et al.*, 2008). It is therefore of high welfare importance to ensure that this procedure is carried out as smooth as possible. During this phase we suggest to pay specific attention to (1) unloading with an open or closed system, (2) open or closed haul system, (3) renewal of water, (4) observing fish welfare. The best practise is given in the text in italics.

7.1 Unloading with an open or a closed system?

In a well-boat with modern technology unloading the fish to a net pen would involve raising the pressure by about 0.1 - 0.2 atm inside the haul by adding water. The pressure difference would drive fish and water through a pipe / hose into the net pen. *This is generally considered as best practise for unloading fish that is meant to stay in a net pen for some time (e.g. smolts).* There are limitations to the lifting height, due to the pressure, so a vacuum pump or water filled dip net are the other options to unload fish. Best practise for higher lifting heights are to use a vacuum pump. Some well boats have a moving bulkhead installed. *This feature allows unloading with full water volume in the haul and that is seen as best practise.* It is an important technical construction to have on a well boat when unloading is to be done with a closed system (e.g. no water spillage) and it is also a way of avoiding water quality related problems related to a rise in pH and TAN as described earlier.

Unloading from a truck normally involves using gravity head from the fish hauls on the truck and a hose / pipeline. *Best practice would be to pay special attention that no fish is damaged or escapes through the delivery pipe or hose.*

7.2 Renewal of water

Unloading fish from an open system in a well boat haul might involve intake of water from the surroundings. *It must be considered as best practise to make sure that the intake of new water is balancing the outflow of fish and water (e.g. by a vacuum pump) so that stress during the loading period is minimised.* Lowering the water level is a procedure that normally generate a large stress response in salmon (Rosten, 1991).

7.3 Observing fish welfare

It is important to observe and judge if the fish seems calm and are provided with sufficient amounts of oxygen and water to move in during the unloading phase. *Best practise is to make sure that the fish in the haul are being supervised by an experienced person so such conditions can be obtained.*

Unloading fish generate a high stress response (Erikson *et al.*, 1997, Erikson *et al.*, 1998, Iversen *et al.*, 2005) and the stress might have an impact on meat quality (Erikson *et al.*, 1998). There is considered to be a link between good welfare and good meat quality (Hjeltnes *et al.*, 2008). The stress associated with unloading fish can be increased tremendously by a bad stunning and bleeding procedure (Poli *et al.*, 2005).

Unloading the fish into a net pen gives the opportunity to observe the welfare of the fish after transport. Viability, appetite, amount of scale loss, schooling pattern and mortality are factors that can serve as operational welfare indicators (Rosten, submitted). Best practise would be to carry out welfare registrations based on these indicators after the fish has been delivered.

8. Wash and disinfection

This is the seventh phase we have identified. This phase is relevant to fish welfare because of its potential to effect the welfare of the next fish group in the transport. During this phase we suggest to pay specific attention to removal of pathogens. The best practise is given in the text in italics.

8.1 Removal of pathogens

It is a best practise to make sure that the vessel is not carrying any fish pathogens. Presence of fish pathogens in the haul or circulations system might cause spreading of fish diseases (Kyrkjebø, 1989, Midtlyng, 1989). Removal of pathogens involves both a cleaning and washing phase where all organic material are visually removed, followed by a disinfection phase where remaining pathogens are killed. *It is best practise to make sure that the vessel is clean and disinfected between every new group of fish is being transported. Only approved chemicals and dosages must be used, and that it is best practise to ensure that this is being documented by quality registrations* (e.g. format appendix 2). Removal and disinfection of transport water is considered a special case when sick fish is being transported e.g. Norwegian regulation (FOR - 2008-06-17 nr 820). If such quarantine regulation is set on the transport, a system for collection all water from the haul must be set up on land. Alternatively a system for leading the water back into the haul of the vessel for further disinfection must be in place.

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4.10 PROSEDYRE FOR PLANLEGGING AV OPPDRAG OG KLARGJØRING AV BÅT

1. HENSIKT

Å sikre at viktige momenter av betydning for kvaliteten av transporten blir vurdert og eventuelt justert før transporten gjennomføres.

2. GJENNOMFØRING

Når en lasteordre foreligger skal skipper / styrmann sørge for at klargjøring av båt blir gjennomgått. Sjekklisten bør fylles ut for hvert transportoppdrag eller eventuelt fungere som et oppslag som er hengt opp i styrhuset. Ved bruk av liste som oppslag må det kvitteres i dekksdagboka for gjennomført prosedyre, samt eventuelt noteres viktig informasjon knyttet til det enkelte sjekkpunkt. Eventuelt problemstillinger som avdekkes må korrigeres før oppstart.

3. VEDLEGG

Planskjema - Ordremottak, planlegging og klargjøring for transport

Prosedyrehåndbok for Brønnbåteiernes Forening
Prosedyre
Dato : 8.5.02

Dokument nr: 4.10
Fil: Planlegging av transport og klargjøring av båt-4.10
Godkjent av :
Side 1 av 3

SJEKKLISTE
ORDREMOTTAK, PLANLEGGING AV TRANSPORT, KLARGJØRING AV BÅT

Før iverksettelse av oppdrag gjennomgå følgende punkter. Gjennomgått OK sjekkliste kvitteres med signatur fra brovakt i dekksdagboka.

nr	Sjekkpunkt
1.	Sjekke kunde/ oppdragsgivernavn
2.	Avtalt lastelokalitet og lastetid
3.	Avtalt lossetid
4.	Sjekket navn på lokalitet og merdnr.
5.	Ordre bekreftet (send ordrebekreftelsesskjema)
6.	Beregnet transporttid
7.	Gjennomgått transportrute
8.	Sjekket sjøtemperatur og oksygenfølere
9.	Sjekket båndlegging
10.	Sykdomsstatus på fisk/ veterinærattester smolt
11.	Avtalt inntak av transportvann
12.	Vask & desinfeksjon i hht vaskeplan
13.	Sjekket om det er nødvendig med veterinærattest
14.	Instrumentering (batteri, kalibrering)
15.	Oksygenanlegg (flasketrykk, koblinger etc.)
16.	Fiskepumpe
17.	Håver (håvlås, tauverk, presenning)
18.	Fiskepumper, Vakuumpumpe m/aggregat
19.	Sorteringsanlegg
20.	Veie/Telle system
21.	Kvittert i dekksdagbok for gjennomgått sjekkliste

Prosedyrehåndbok for Brønnbåteiernes Forening
Prosedyre
Dato : 8.5.02

Dokument nr. 4.10
Fil: Planlegging av transport og klargjøring av båt-4.10
Godkjent av :

Side 3 av 3

Brønnbåteiernes Forening

Sjekkpunktliste – Renhold /Desinfeksjon

UKE .... ÅR......

Uke dag	VASK				DESINFISERING					
	Ryddet dekk kran, håver	Brønnsyst. med ristplater	Ventiler pumper rørsystem	Brønn tak, dørk vegger	Ryddet dekk kran, håver	Brønnsyst. med ristplater	Ventiler pumper rørsystem	Brønn tak, dørk vegger	SIGN Utførende	SIGN Godkjent
Mandag										
Tirsdag										
Onsdag										
Torsdag										
Fredag										
Lørdag										
Søndag										

Som vaskemiddel benyttes (................) sammen med steam
Som desinfeksjon nyttes (navn på desinfeksjonsmiddel)
Når skumanlegg benyttes brukes (navn på såpe / desinfeksjonsmiddel)

Prosedyrehåndbok for Brønnbåteiernes Forening
Skjema
Dato : 8.5.02   Godkjent av :

Dokument nr: 5.11.1
Fil: Alternativ sjekkliste vask og desinfeksjon-5.11.1
Side 1 av 1

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