Project summary - Autonomous Scallop Harvesting Platform (ASHP)

General

The Autonomous Scallop Harvesting Platform (ASHP) is envisaged to be a self-contained automatic shellfish harvesting system. The concept is of a vehicle which moves underwater over a pre-determined search area and identifies and collects specified shellfish with minimal impact on the surrounding environment.

Requirements

The initial requirements for such a platform are detailed below. The system should:

- Be easily deployed from a (small fishing) surface vessel.
- Cover a predetermined area systematically.
- Travel at a constant altitude and a measurable velocity.
- Be a stable platform.
- Detect and identify scallops on all types of seabed, including undulating, rocky and sandy.
- Avoid any underwater obstacles.
- Collect a number of scallops weighing an average of 20g each
- Have the ability to unload scallops into a parent crate at set intervals if required.
- Be completely autonomous.
- Have high endurance
- Be relatively low cost, durable and easy to maintain and operate.

Key Issues

The key problems that must be solved so that an autonomous platform can meet these requirements include the following:

- Scallop detection – the system must be able to identify scallops from the seabed and amongst debris on the sea floor. Assuming that a conventional sensor such as a sonar or camera is used then successful image recognition software will need to be developed.
- Scallop collection – methods of retrieving scallops from the seabed and storing them for recovery to the surface.
- Autonomy –to make the platform fully autonomous it must be able to navigate a course and collect scallops with no assistance.
- Additional to these are the vehicle endurance issues. Power is required for propulsion, camera/sonar, software and the collection method for the duration of a mission.

(Continued)

Conclusions and Recommendations

It is concluded that an autonomous scallop harvesting platform has the potential to be a viable shellfish collector causing little or no damage to the seabed.

The ability for the vehicle to observe the seabed and identify likely scallop ground is fundamental to a successful system. It is possible that this scallop detection phase could be developed initially as a stand-alone system, which could help divers and fishermen identify likely scallop habitats. Indeed, the detection technology could be utilised as a standalone (autonomous) system providing valuable environmental data and survey capabilities for existing fishery activities.

The key problems that must be solved so that an autonomous platform can meet the requirements outlined in the main report can be divided into the following areas – scallop detection, scallop collection, autonomy and vehicle endurance.

It is proposed that further development of the ASHP can be divided into nine stages covering detection, collection, software development, control and depth autonomy, platform design and build and final integration and testing.

The scallop detection and collection methods are vital to the success of the platform and further development is required to confirm the feasibility of these options and their likely performance.

The cost of the prototype ASHP cannot be clearly defined at this stage but is likely to be in the region of £75k-£100k.

It would be expected that commercial variants of the initial build would be available for considerably less.

Autonomous Shellfish Harvesting Platform: Design Concepts

Anna Bent, Andrew Moody
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Principal author	
Enter author	Anna Bent/Andrew Moody
Enter author address	QinetiQ, Bincleaves Technology Park, Newtons Road, WEYMOUTH, Dorset, DT4 8UR
Enter additional author	
Enter additional author address	

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Executive Summary

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The key problems that must be solved so that an autonomous platform can meet these requirements include the following.

Scallop detection – the system must be able to identify scallops from the seabed and amongst debris on the sea floor. Assuming that a conventional sensor such as a sonar or camera is used then successful **image recognition** software will need to be developed.

Scallop collection – methods of retrieving scallops from the seabed and storing them for recovery to the surface.

Autonomy –to make the platform fully autonomous it must be able to navigate a course and collect scallops with no assistance.

Additional to these are the **vehicle endurance** issues. Power is required for propulsion, camera/sonar, software and the collection method for the duration of a mission.

Conclusions and Recommendations

It is concluded that an autonomous scallop harvesting platform has the potential to be a viable shellfish collector causing little or no damage to the seabed.

The ability for the vehicle to observe the seabed and identify likely scallop ground is fundamental to a successful system. It is possible that this scallop detection phase could be developed initially as a stand-alone system, which could help divers and fishermen identify likely scallop habitats. Indeed, the detection technology could be utilised as a standalone (autonomous) system providing valuable environmental data and survey capabilities for existing fishery activities.

The key problems that must be solved so that an autonomous platform can meet the requirements stated in section 2 can be divided into the following areas – scallop detection, scallop collection, autonomy and vehicle endurance.

It is proposed that further development of the ASHP can be divided into nine stages covering detection, collection, software development, control and depth autonomy, platform design and build and final integration and testing.

The scallop detection and collection methods are vital to the success of the platform and further development is required to confirm the feasibility of these options and their likely performance.

The cost of the prototype ASHP cannot be clearly defined at this stage but is likely to be in the region of £75k-£100k.

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1 Introduction

1.1 General

The Autonomous Scallop Harvesting Platform (ASHP) is envisaged to be a self-contained automatic shellfish harvesting system. The concept is of a vehicle that moves underwater over a pre-determined search area and identifies and collects specified shellfish with minimal impact on the surrounding environment.

This report discusses a number of issues covering existing technology and new ideas; it details the problems and benefits of each and concludes by providing suggestions for a possible solution. It presents recommendations for the future development of such a platform and the issues and constraints that must be considered.

1.2 Background

Both Great (*Pecten maximus*) and Queen (*Clamys opercalaris)* scallops are fished in the UK and are found around all British and Irish coasts. They live mainly in sand or gravel and up to depths of 100m. The Great scallop grows up to 15cm whereas the Queen scallop only reaches 9cm.

Dredging is currently the main method of fishing for scallops, however, a small number are gathered by divers. Dredging for scallops involves scouring the seabed with a plough-like apparatus, and the damage has been likened to digging up a meadow for the odd turnip. It is probably the most destructive type of fishing. Diving for scallops has little impact on the environment, but is labour-intensive and unlikely to fully meet demand. Scallop farming is increasing in productivity but is also unlikely and arguably undesirable to completely meet demand.

The demand for scallops is increasing and 9719 tonnes were collected in 2001 with a value of £12 649 788 [1]. The introduction of an autonomous harvesting platform would provide an environmentally friendly option to dredging and aid or replace divers as required in both the wild and farming sectors.

1.3 Structure of Report

The report is divided into the following sections:

- Introduction
- Requirements
- Key Issues
- Platform Design
- Discussion
- Conclusions

2 Requirements

2.1 The ASHP mission

The following list provides an overview of the requirements for an autonomous scallop harvesting platform. The system should:

- Be easily deployed from a (small fishing) surface vessel.
- Cover a predetermined area systematically.
- Travel at a constant altitude and a measurable velocity.
- Be a stable platform.
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- Be relatively low cost, durable and easy to maintain and operate.

3 Key Issues

3.1 General

The key problems that must be solved so that an autonomous platform can meet the requirements stated in the previous section include the following.

Scallop detection – the system must be able to identify scallops from the seabed and amongst debris on the sea floor. Assuming that a conventional sensor such as a sonar or camera is used then successful **image recognition** software will need to be developed.

Scallop collection – methods of retrieving scallops from the seabed and storing them for recovery to the surface.

Autonomy –to make the platform fully autonomous it must be able to navigate a course and collect scallops with no assistance.

Additional to these are the **vehicle endurance** issues. Power is required for propulsion, camera/sonar, software and the collection method for the duration of a mission.

3.2 Scallop detection

The ability for the vehicle to observe the seabed and identify likely scallop ground is fundamental to a successful system. It is possible that this scallop detection phase could be developed initially as a stand-alone system, which could help divers and fishermen identify likely scallop habitats. Indeed, the detection technology could be utilised as a standalone (autonomous) system providing valuable environmental data and survey capabilities for existing fishery activities.

Discussions with scallop divers suggest that they look for a number of visual indicators in order to find scallops. These include general bottom type, depressions in the sand which are likely to be a sign of a buried scallop, edges of scallop shells and movement of the scallop as it closes on the approach of a diver. They also develop a ‘feel’ for areas of general patches of ground and areas within that ground that are likely to contain scallops. Taken together, these factors combine to form an overall intuition in the scallop diver. Indeed, two quite capable divers, but one who is experienced in finding scallops and one who is not, will usually achieve wildly different success rates when diving on the same ground.

Any scallop detection device will ideally need to reproduce these skills, or use other detection methods.

3.2.1 Available technology and possible solutions

The primary methods of locating objects underwater are either visually (e.g. camera) or using active sonar. These are discussed further below.

A number of other methods may also be able to contribute to scallop detection, for example; motion detection, ultra violet illumination, laser imaging and chemical sensors. Further work will be required to examine the feasibility of these methods. However, they are unlikely to be suitable or reliable enough to detect scallops amongst a cluttered seabed. A combination of sensors could be utilised, however this would add to the cost of any vehicle and further complicate the autonomy. The development of any such novel sensors is likely to be time consuming and expensive, but may be considered over the longer term.

3.2.2 Preferred option

Mature imaging sensors such as video camera and sonar are the preferred options at this stage. However, it is recommended that nothing is ruled out and that any future development project looks at alternative sensors and methods for identifying scallops that could be used to support the visual image data.

Detection with either camera or sonar will benefit from installation to a stable platform travelling at a constant height above the seabed, thereby maintaining a consistent field of view. It is likely that a camera will need to be as close to the seabed as possible, especially when used in turbid conditions, which has implications for platform design.

3.2.2.1 Camera

A camera fitted to a Remotely Operated Vehicle (ROV) launched from the waterside facility at QinetiQ Bincleaves was used to look for scallops and determine whether visual detection is feasible. Examining an area where scallops where known to be, it was possible to locate scallops in the camera images including those partially buried at a range of 1-2m depending on the size of the scallop (figure 1). However, it should be noted that the scallops were placed in this environment for the purposes of the experiment and data from scallops in their natural habitat is required for any definitive conclusions to be made.

3.2.2.2 Sonar

It may be possible to detect scallops using high frequency imaging sonars, however this was not tested under the current package of work. The sonar on the ROV used for these trials was too low frequency to detect scallop size objects.

A high frequency sonar could be tested to see to what range scallops can be effectively detected. This is a higher cost option compared to a camera but should offer a higher range and therefore a quicker rate of scallop detection. It also has the advantage of working in all visibility conditions.

3.3 Image Recognition

Assuming that a camera or sonar is adopted, then image recognition software becomes the key to a successful platform. As the system is to be autonomous then it is essential for computer software to be able to identify scallops from their surroundings.

Images of scallops (figure 1) collected by the ROV confirms the difficulty of finding scallops by eye, especially amongst other broken shells and stones. As discussed previously, divers report that considerable experience and some amount of intuition is required for a successful catch. These features need to be incorporated into a computer algorithm and any future development project will require a detailed feasibility study to calculate the probable success and reliability of any such scallop detection software.

An initial survey of QinetiQ expertise indicates that this software would be possible to develop and that current algorithms could be incorporated. A prominent feature of a scallop is its scalloped edge and edge detection filters could be used to aid identification, as illustrated in figure 2. However, where the scallops have been buried the edge becomes increasingly difficult to identify with software and the success of further algorithms, such as a transform that looks for semi-circular shapes, would need to be analysed. The likelihood of false alarms would also need to be assessed.

Further considerations that would drive the effectiveness of the software and also its cost, are related to the speed of analysis of the visual data. The application of real-time processing on the vehicle would need to be considered in the initial feasibility study.

Using this technique it may be possible to select only fully-grown scallops for harvesting. This will help to maintain the population by preventing over fishing of an area.

3.4 Scallop Collection

A further complex issue is how the platform is going to pick up the scallops and subsequently store them so that they can be retrieved. The use of image detection software will provide the location of scallop-like objects in the field of view of the camera or sonar. This is likely to be a maximum of 2 square metres for a camera and possibly up to five for sonar. The speed of the image processing software plus the effectiveness of the collection method will decide the rate of scallop collection and hence the speed of advance of the platform.

3.4.1 Scallop Retrieval

Available Technology and possible solutions

Although an underwater vehicle has not attempted scallop (or other shellfish) retrieval there are many methods of picking up samples underwater and these are considered below. Generally, however, these methods are all manually controlled using an ROV as a platform and so the feasibility of autonomous control needs to be evaluated. Methods including robotic hands, scoops, grabs, suction nozzles, suction containers and suction dredges could all be used for this task. The main factors to consider are environmental impact and speed of retrieval.

Robotic hands were dismissed as being over complicated and difficult to manoeuvre autonomously to successfully pick up a succession of scallops rapidly. The fewer moving parts the device has the easier it will be to control and the cheaper it will be to develop. Scoops and large suction dredges were immediately discounted due to their negative impact on the seabed.

Methods of scallop agitation were considered. It is reported that the shadow of the diver can cause scallops to close. If scallops could be encouraged to move off the seabed then a net could be used to catch them. However, consultation with divers revealed that it was more likely for the scallops to shut and retreat than swim where collection using a net would be possible. Those that do move are likely to be the smaller scallops that are not to be fished; also the net could catch other objects and fish which could cause problems for the vehicle.

The preferred option

It is thought that suction would provide the simplest way to retrieve scallops with the least environmental damage. The suction device would need to know exactly where the scallop was and target that scallop individually, turning on the suction only when it was over the scallop to minimise seabed damage and power consumption. Various suction methods have been considered and need further research to determine their reliability, behaviour and environmental impact when directed autonomously.

There are two main ways that a scallop could be picked up using suction. The first would be hoovering up the entire scallop into a collection crate in a similar way to the NOAA suction container illustrated in figure 3. The scallop could be sucked into a small container and then released into the collection crate. The second method would be to use a suction nozzle that attaches itself onto the scallop, picking up the shellfish and moving to deposit it in the crate. It is not known whether this method would work due to the grooves in the shell but it is thought that with high enough suction it should be feasible. This method would disturb the seabed less but would provide difficulties with the moving parts required to then deposit the shell in the crate plus the added chance of the scallop falling off back into the sea.

It is difficult to envisage how more than one scallop could be collected at any one time without disturbing the seabed but as the speed of advance of the vehicle relies on the collection rate then further methods and possibilities should be considered in any future work.

3.4.2 Scallop storage

Once the scallops have been collected they must be stored by the vehicle and then retrieved back to the sea surface. From our sample data the average scallop weighs around 20g in water and the increasing weight of the vehicle must be accounted for in any platform design. The vehicle collection crate would be gridded so that any accidental objects such as shell debris and stones collected by the suction device would fall back out and not add unnecessary weight and take up additional space in the crate. The size of the gridding will be determined by the minimum fishing size for scallops (10 or 11cm depending on location and assuming Great Scallops) so that any smaller scallops would fall through also. The crate then acts as a sorting system eliminating the need for further sorting on the surface and allowing the scallop population to rejuvenate.

In order for the vehicle to stay below the water for extended periods of time it may be necessary to unload the vehicle throughout its mission. One option is to have large underwater storage crates/nets where the vehicle can deposit its load of scallops once it has collected its capacity. Alternatively the vehicle could rise to the surface every time it has a full load. A radio or acoustic link to a boat would alert the fisherman that there was a vehicle to empty and give its position.

3.5 Autonomy

The platform is to be fully autonomous, this includes the navigation of the platform around the seabed and also the detection and collection of the scallops as discussed above.

The vehicle needs to direct itself along a pre-planned route, preferably avoiding any obstacles and possibly depositing scallops in a crate at intervals. It needs to stay a constant distance from the seabed and this distance must be as small as possible if the camera is to recognise any scallops. This means that normal depth sensors (echo sounders) which ping a signal to the seabed and back providing a distance will not be applicable as the vehicle will need to be below the 2m minimum depth that most of these sensors function at. The vehicle needs to be able to navigate effectively covering an area systematically and not revisit its previous tracks. It also needs to alert a surface vessel of when and where it returns to the surface.

3.5.1 Navigation

Available technology and possible solutions

Autonomous underwater vehicles (AUVs) require a number of advanced sensors in order to navigate accurately. Vehicles currently being trialed by QinetiQ use GPS to gain position fixes and then dead reckon in between fixes. This involves using a combination of a compass, accelerometers, prop revolutions, a doppler velocity log and Inertial navigation systems (INS) to calculate exactly where the vehicle has been since the previous fix and correct its path and bearing as necessary to stay on a pre-programmed trackline.

Other methods of navigation use a long-baseline transponder system. This is simpler and requires the launch of two acoustic transponders at known latitude and longitude. The platform will then receive a ping from these transponders and be able to calculate its position. If there were two underwater crates with radio buoys attached these would act as navigation transponders for the platform and could also track the vehicle if required. A tracking system may be useful if there is more than one platform in the water at any one time. The transponders on the crates could then be used as homing beacons for the vehicle to deposit its scallops when it has reached full capacity or at designated times during the mission when it was closest to the crate. The design of the underwater crate for both launch and retrieval will require consultation with those likely to be working from the surface vessel.

The preferred option

As navigation is not critical to the success of the platform then it may be more cost effective to develop a rudimentary system using just compass and prop/wheel revolutions without any of the more expensive sensors to provide a guide to the vehicle. As long as the vehicle had GPS it could still alert the surface vessel to its location when it emerged regardless of whether it had moved off course during its mission. A detailed cost versus required performance assessment would need to be completed.

3.5.2 Depth Control

Available technology and possible solutions

As it is necessary for the platform to be as close to the ground as possible then the usual depth sensors will not be appropriate. Alternatives to echo sounder depth sensors could include a laser measure at each corner to maintain a mean altitude, new acoustic sensor, dragging weight(s) to offset buoyancy (line length equals altitude), wheels or runners to keep a negatively buoyant vehicle off the bottom.

The preferred option

Due to cost, time and complexity considerations, the preferred option at this stage would be to fix wheels to the vehicle effectively turning it into a crawling vehicle. This would easily provide the constant altitude required and means that the increased weight of the vehicle becomes less of an issue. Thrusters would still control the vehicle allowing it to hover above the seabed and move up and down as required. An investigation into any damage wheels would cause to the seabed, plus its forward manoeuvrability and its likelihood to disturb the visibility would need to be assessed.

3.6 Power Considerations

The key to the economical success of the platform is its ability to outperform its competition. It is extremely unlikely that any autonomous platform will ever be able to collect more scallops than a dredger over the same period of time. However, whereas a dredger destroys an area, significantly lowering the chance of being able to successfully fish in subsequent years, the ASHP will cause less environmental damage, leave smaller scallops to grow and allow the possibility for the same patch of seabed to be successfully harvested year after year.

The ASHP is therefore aiming to be more economic than a diver is. A diver will on average only be able to spend 2 hours a day in the water. In order to compete with divers the vehicle must be able to collect more scallops and the simplest method of achieving this is to spend more time collecting. This sets a requirement for mission duration exceeding 2 hours assuming collection rates are comparable. It is likely that human collection rates will be considerably higher, especially in comparison to the earlier versions of the ASHP and so an even higher endurance is likely to be required.

The vehicle will require power for all four of the stages detailed above - the camera or sonar, the processing software, the collection device and the autonomy software and navigation control (thrusters). Of these, the suction and thrusters are likely to consume the most power. A battery comparison will need to be undertaken to see whether the cheaper lead acid batteries are sufficient to provide the power requirements or whether superior lithium ion batteries are required. A further cost versus required performance analysis is recommended once all power requirements from the various stages are known.

Further options such as a modular build so that the batteries can be changed whenever the platform rises to the surface for emptying should also be considered.

As an alternative, the ASHP could be tethered to a mothership (trawler). This would, of course, remove any autonomous capabilities but may, in the shorter term, provide an easier development program (as well as lower cost).

4 Platform Design

4.1 Ideas and Concepts for the platform

The ASHP will be a purpose built vehicle designed to give high stability during transit and seabed survey and minimise power consumption by providing an efficient means of propulsion. Innovative techniques using the pump and suction to propel the vehicle could be considered. The platform will have to be operator friendly i.e. easy to deploy, maintain, and be robust to extend running times and minimise maintenance between services. This lends the design to be based around a ROV (tethered underwater vehicle) which are relatively low-cost, reliable, stable and manoeuvrable.

The platform will carry a camera and/or sonar and image recognition software which will allow it to detect scallops on the seabed. The software will divide the field of view in front of the vehicle into a grid. The grid reference of the scallop is then relayed to the collection device which moves into place so that it can turn the suction on and collect the scallop as the vehicle goes over it.

The scallops are passed into a collection crate which sorts the scallops depending on their size and allows all other debris mistakenly sucked up to fall out. Positioning the crate underneath the thrusters, creating a high vehicle rather than forming a long vehicle by positioning the crate behind the thrusters, means that the load is evenly distributed and the vehicle retains its manoeuvrability.

As it is necessary for the platform to be as close to the ground as possible the usual depth sensors will not be appropriate. Considering the options the platform could feasibly be kept the required distance from the seabed by adding wheels. This will also minimise the requirement to develop sophisticated control systems and ensure platform stability. The platform will then have the capability to be able to swim quickly through the water or land on the seabed and 'crawl' depending on the requirement. It is likely a quick survey of a larger area to detect likely scallop habitats will be required before settling the vehicle on the seabed for the slower collection phase.

The axles will not be driven, the wheels will simply support the platform at a known height off the seabed and are propelled via thrusters which allow it to lift off the sea floor at the end of each leg or when an obstacle is encountered. The likelihood of the wheels digging into the seabed and impeding progress when the vehicle is thrusted forward needs to be assessed. The ability of the vehicle to move at a constant, slow speed as required must also be investigated.

The wheels also mean that the increasing weight of the platform is not a problem until the vehicle wishes to return to the surface. The vertical thrusters should still lift the vehicle to the surface but it is not desirable to have the thrusters working while the fishing vessel locates and retrieves the platform. Therefore ballasting techniques, such as onboard weights (sand) that are released as the vehicle weight increases or a system where water is forced out with the increased weight and replaced with air, must be considered.

Figure 4 shows a possible design which incorporates the features discussed.

5 Discussion

This section describes the stages required to design, develop and test the ASHP. It pulls together all the information detailed in the previous sections and recommends a way forward to the development of a fully autonomous platform.

5.1 Development

5.1.1 Stage 1 – Data acquisition trial

The first stage is to identify the most suitable detection sensor – sonar or camera. The project would need to look at the feasibility of a high frequency sonar and compare this with a suitable camera. This would include hiring a commercial COTS forward look sonar such as the Acoustic Barnacle Imaging Sonar which quotes a resolution of 1cm at 3m range. The sonar would need to be commercially available to keep the final costs of the platform to a minimum. The superior range of the sonar, and its ability to work in all visibility conditions would need to be traded off against its higher cost and the presumably reduced clarity of any scallop image. The trial would involve collecting a detailed data set of scallop images from both sonar and camera to be used throughout the proceeding stages.

From the data gathered, an analysis will need to be completed evaluating the overall performance of both sonar and camera. This will include determining the ability of image/signal processing software to successfully pick out scallops from the relevant data and limit false alarms. A decision must be made before proceeding to stage 2.

5.1.2 Stage 2 – Image recognition software feasibility study

Detecting scallops autonomously has not been done before and is key to the success of the platform. The software development stage therefore forms the core of the research proposal and will provide proof of principal and an initial software release. The first part of this development is the feasibility study, which will aim to establish the best development path and provide an idea of performance and reliability. This will include looking at the real time considerations, which are critical in determining the speed of advance of the platform.

5.1.3 Stage 3 – Image recognition software development

The software development will follow the path recommended by the feasibility study and produce code which identifies a scallop, records the position of the scallop in the field of view and relays that information to the collection device software. The deliverable from this stage will be an initial software release and an analysis of the limitations and any advances that could be made with future development.

5.1.4 Stage 4 – Collection device development

This stage involves testing the design concepts detailed in the initial report and building a device that will successfully collect scallops and deposit them in a crate. The crate will act as a sorting device for smaller scallops and debris by being gridded. It is envisaged that a suction device will move from side to side at the back of the vehicle to a position dictated by the image recognition software. When the vehicle is positioned over the scallop the device is turned on and the scallop collected. This minimises the environmental impact and power consumption of a continuous suction pump. An assessment of the device's sensitivity to height above the seabed will also be undertaken to determine how undulations in the seabed will affect the device and illustrate the importance of the platform's altitude control. The possibility of using the pump for propulsion will also be considered.

5.1.5 Stage 5 – Autonomous depth control

The height of the platform above the seabed needs to be kept constant for both the image recognition and the collection device to work to their optimum capability. Several methods of depth control will be tested including wheels, a laser measure at each corner to maintain a mean altitude and dragging weight(s) to offset buoyancy.

5.1.6 Stage 6 – Autonomous mission control

The platform will need to navigate over a pre-determined area without re-covering ground. The most cost-effective way to navigate will be considered, either using large underwater collection crates as transponders or using the platform's thrusters and compass to calculate direction and speed of advance. Video mosaicing techniques can also be used to determine the platform's velocity and distance travelled. This stage will also involve development of the programming software and the man machine interface to direct the platform.

5.1.7 Stage 7 – Platform design and build

An optimum design incorporating all the results from the previous stages will need to be developed and the platform built in conjunction with the software development in stage 8. The final design will incorporate the most efficient means of propulsion and integration of the detection and collection devices as well as ballasting considerations and the most appropriate depth control solution. This stage will also include final calculations on power requirements and the incorporation of lead acid or lithium ion batteries to the vehicle.

5.1.8 Stage 8 – Autonomous control software

This stage takes the request of the user through the programming software and the updates from the navigation and depth control system to command the vehicle's movements via the thrusters. A software requirements document will need to be produced and followed in order to define and implement all the autonomous capability required from the vehicle. Any intelligence features such as collision avoidance will be considered here. This task forms the bulk of the autonomous control technology problem and will require significant software development and testing. However, the basic algorithms for autonomy have already been proven in many autonomous underwater vehicles (AUV's) and QinetiQ's strong history in software development for AUV's significantly lower the risk of this key phase.

5.1.9 Stage 9 – Software integration and platform testing

This final stage will bring together all the software components so that the vehicle is programmed by a human and then controlled completely by its software. The image recognition software needs to direct the collection device to the appropriate position. The platform's speed of advance needs to vary depending on the amount of scallops viewed and being collected. The platform needs to stay on a pre-determined course dictated by its programming and executed by the control system. The control system needs to be updated from the navigation system if the vehicle goes off course. Any other intelligence features also need to be integrated.

The final test of this software will be a series of scallop harvesting missions with a known amount of scallops to determine the platform's success and reliability.

5.2 Cost Estimates

The final cost of the ASHP will be dependent on many factors and will only be definitively confirmed through the development of the above stages. The main costs of the vehicle will be the software development, both image recognition and autonomy, the platform design and build and the batteries. The software development is likely to be the highest cost but will only have to be met once.

The prototype platform build is likely to be in the £75k-£100k region. It is unlikely that all of the development stages listed previously would be fully completed at this level of investment, though distinct advances in scallop/shellfish recognition could be expected along with working prototypes for remote collection systems. Reaching this level of development would enable step changes in shellfish/environmental survey capability, which at present are unavailable to the industry.

As is usual with this type of underwater platform development, the initial R&D costs are high. However, it is anticipated that commercial variants of the technology could be delivered for considerably less.

6 Conclusions

An autonomous scallop harvesting platform has the potential to be a viable shellfish collector causing little or no damage to the seabed.

The key problems that must be solved so that an autonomous platform can meet the requirements stated in section 2 can be divided into the following areas – scallop detection, scallop collection, autonomy and vehicle endurance.

The scallop detection and collection methods are vital to the success of the platform and further development is required to confirm the feasibility of these options and their likely performance. This will also indicate possible collection rates and hence the economic viability of the platform.

Development of the ASHP can be divided into nine stages covering detection, collection, software development, control and depth autonomy, platform design and build and final integration and testing.

The cost of the prototype ASHP cannot be clearly defined at this stage but is likely to be in the region of £70k-£100k. Actual build costs for commercial units would be reduced as it is expected that the prototype would accommodate much of the R&D required.

7 Recommendations

It is recommended that initial development concentrate on Stages 1 to 5 in section 5 to prove the new concepts detailed in this report.

It is possible that on completion of stages 1 –3, the image recognition suite could be used immediately to aid the industry and detect likely areas of scallops by mounting it onto an ROV or AUV.

A comprehensive analysis of performance needs to be undertaken in conjunction with the earlier stages of development detailing power requirements, image processing speed, collection rate and vehicle speed of advance, coverage rates, endurance, scallop capacity and retrieval plus cost considerations and trade-offs.

8 References

[1] DEFRA statistics 2004.

9 Figures

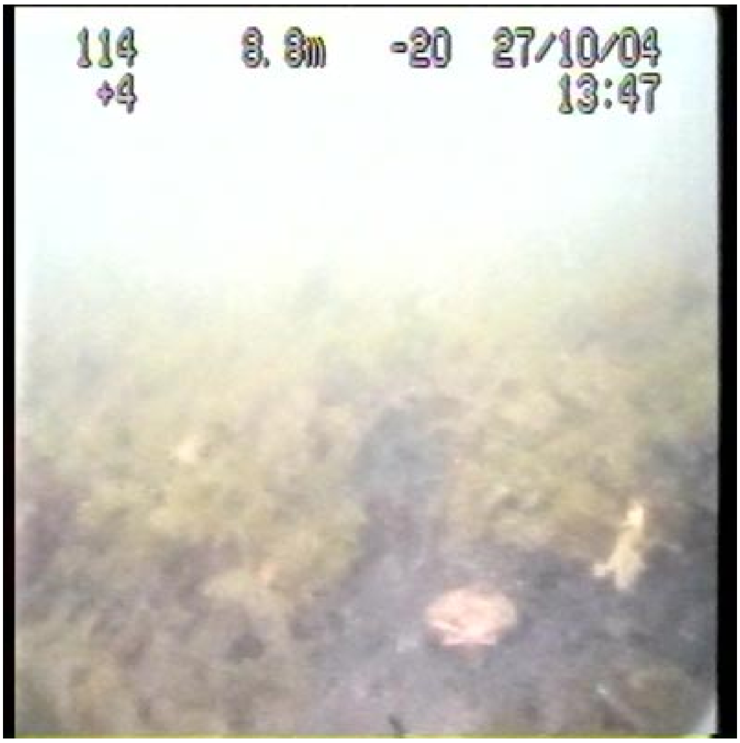

Figure 1a: Exposed Scallop

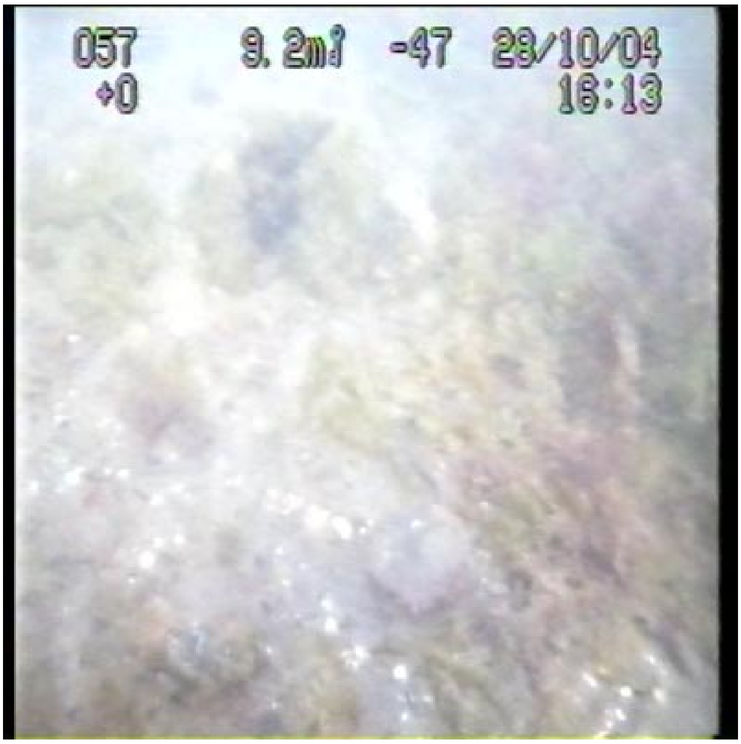

Figure 1b: Buried Scallop 1

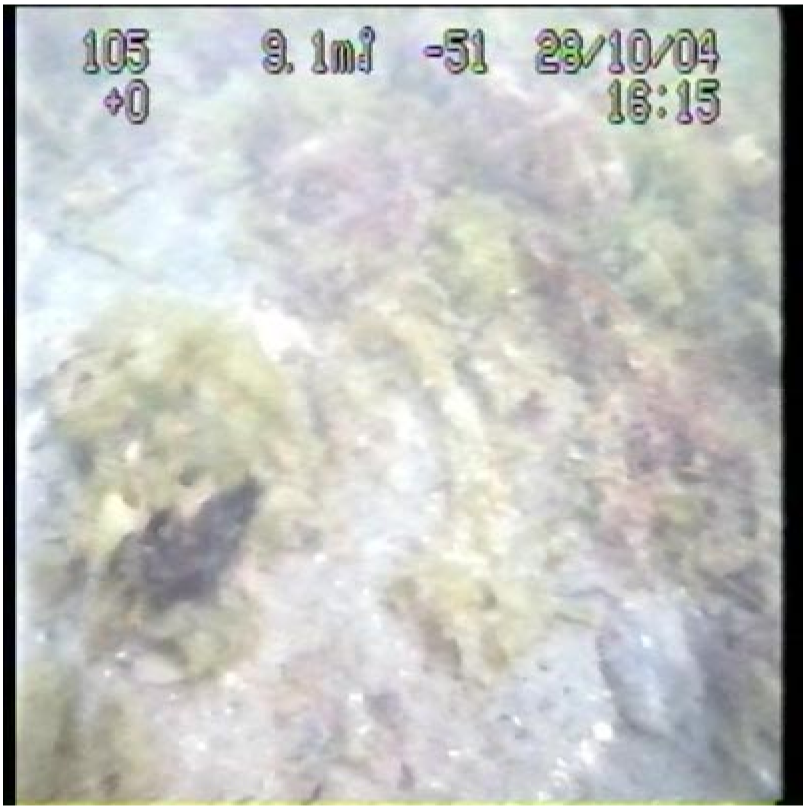

Figure 1c: Buried Scallop 2

Figure 1d: Buried Scallop 3

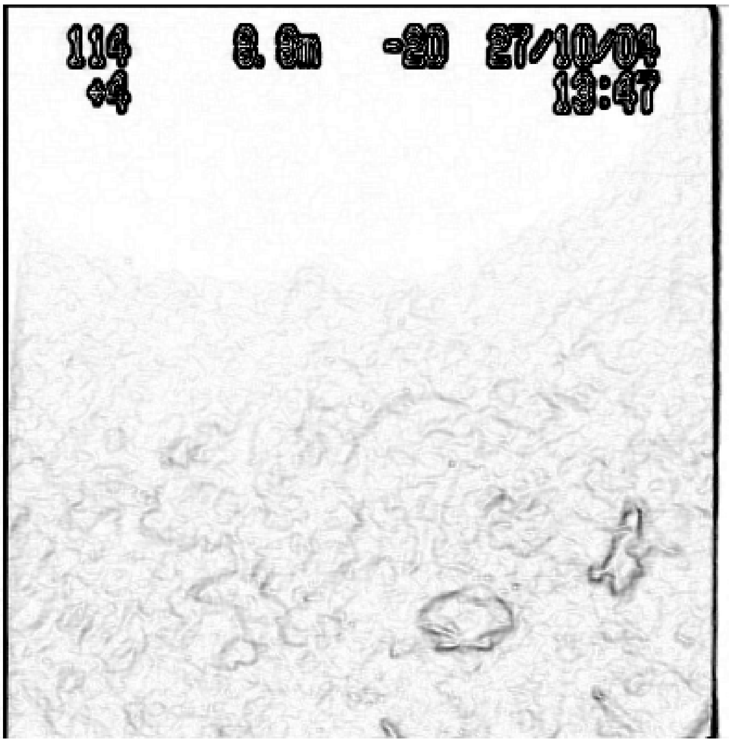

Figure 2a: Exposed Scallop

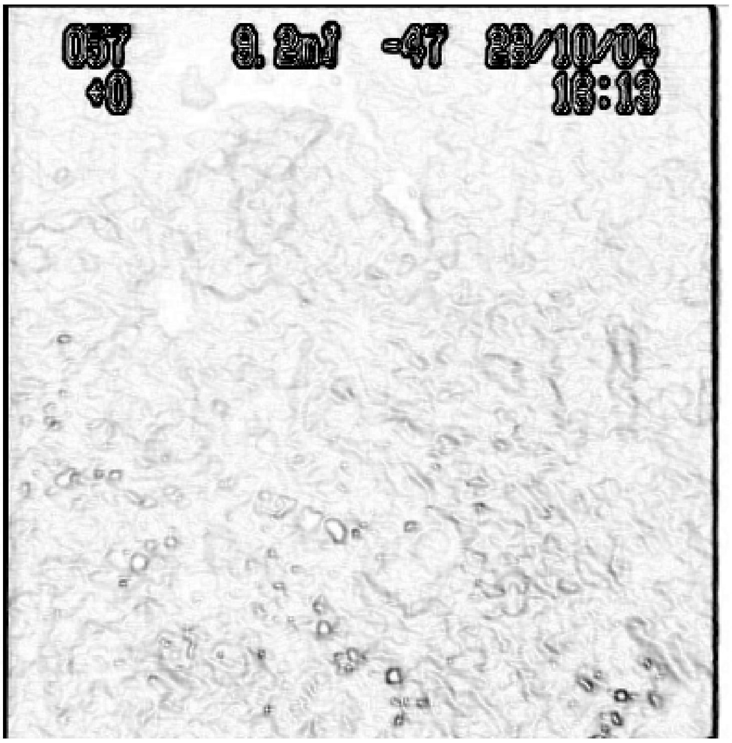

Figure 2b: Buried Scallop 1

Figure 2c: Buried Scallop 2

Figure 2d: Buried Scallop 3

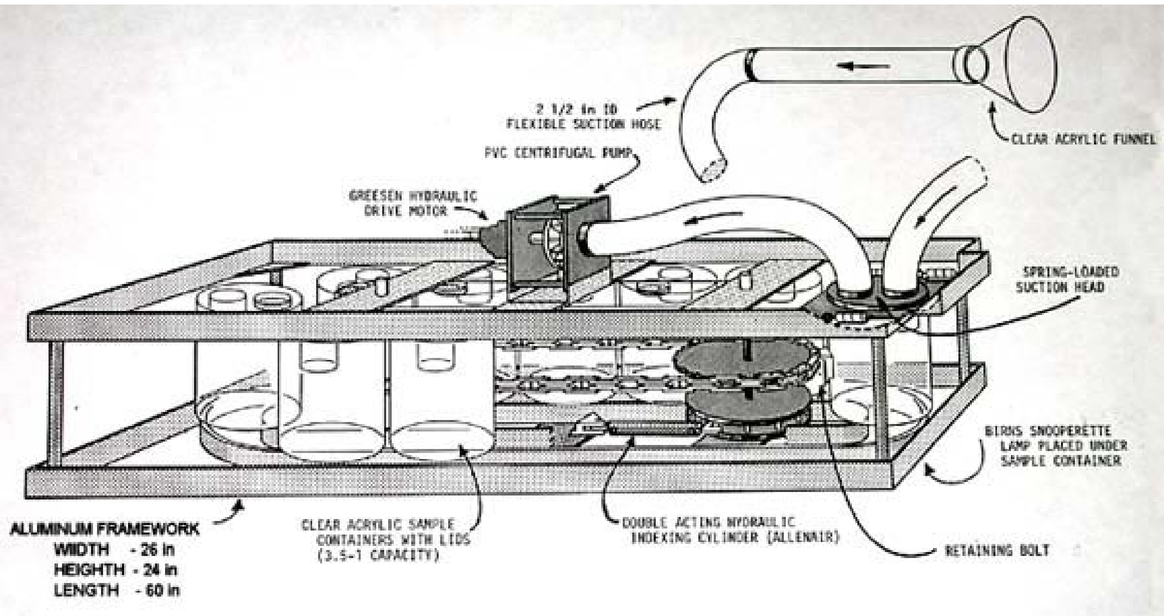

Figure 3: NOAA Suction collecter

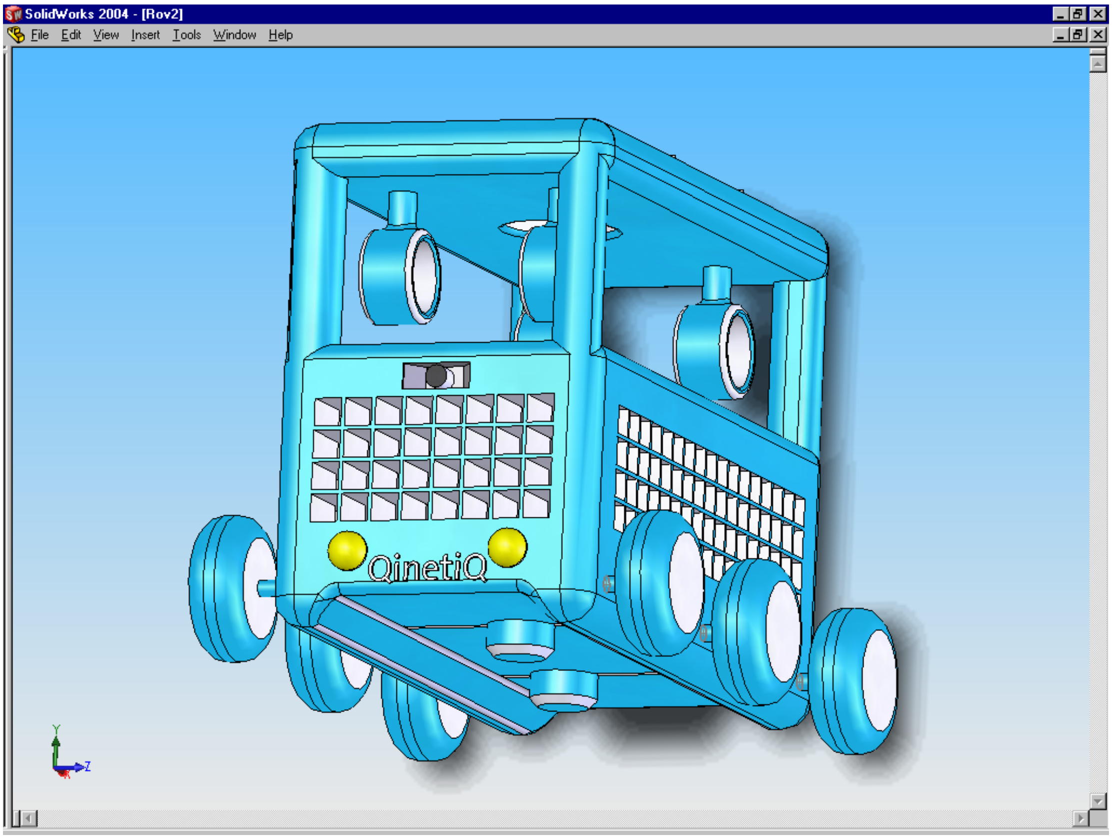

Figure 4a: Design Concept

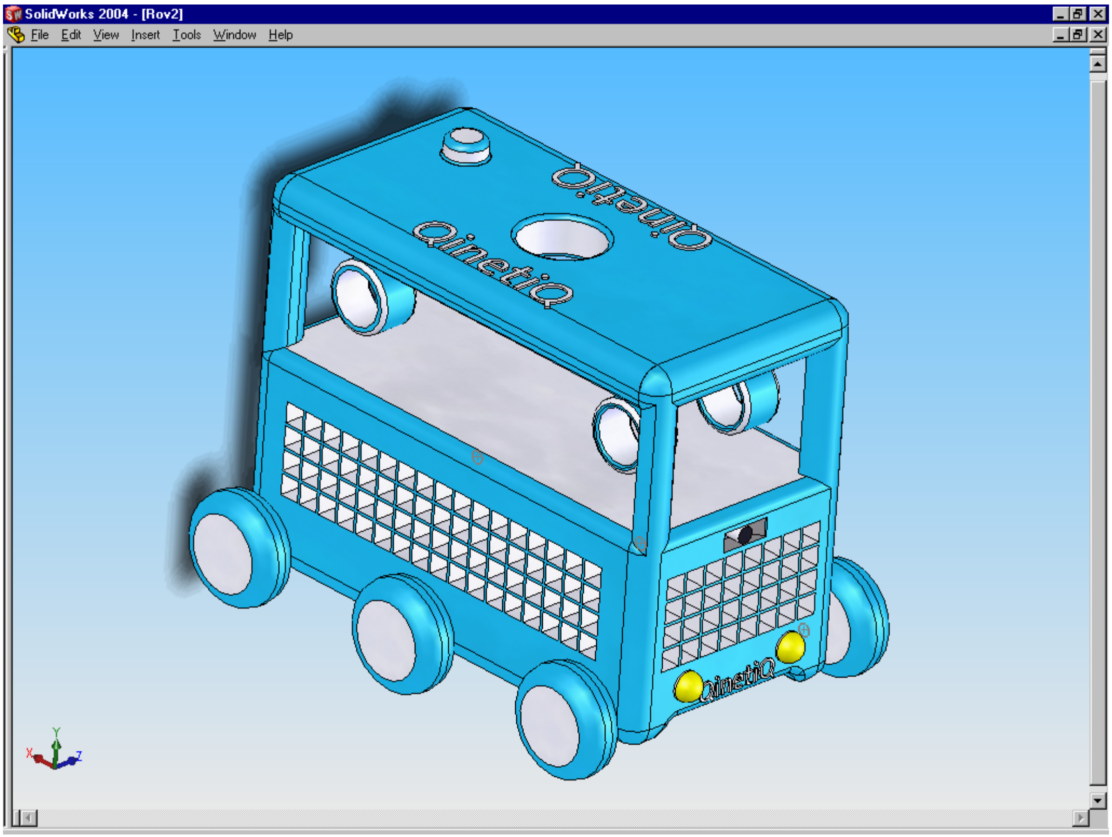

Figure 4b: Design Concept

Initial distribution list

External
Seafish

QinetiQ
Information Resources

Report documentation page

Originator's Report Number	QinetiQ/Seafish 001		
Originator's Name and Location	Alex Duke, Bincleaves		
Customer Contract Number and Period Covered	10413		
Customer Sponsor's Post/Name and Location			
Report Protective Marking and any other markings Enter protective markings in use QinetiQ Proprietary	Date of issue 13/8/04	Pagination Cover + 14	
Report Title: Autonomous shellfish harvesting platform			
Translation / Conference details (if translation give foreign title / if part of conference then give conference particulars) Enter translation or conference details			
Title Protective Marking	QinetiQ Proprietary		
Authors	Anna Bent, Andrew Moody		
Downgrading Statement			
Secondary Release Limitations			
Announcement Limitations			
Keywords / Descriptors	Autonomy, Shellfish, AUV.		
Abstract Enter abstract			
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