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Considerations in underwater vision

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ABSTRACT

A review of the effect of water on vision revealed that all aspects of vision in air are altered in an underwater environment. The advantages and disadvantages of availiable means of correcting ametropia for divers were evaluated. Selection of the optimum system for a diver is dictated by his individual visual requirements and needs. A survey questionaire was sent to dive shops throughout the United States to determine availiability and popularity of each method of optical correction. Ready-made optical masks or lenses bonded to the faceplate were the most common systems used by ametropic divers. The questionaire also disclosed a level of knowledge about vision by dive shop employees which confirms the need for Optometric advice in mask selection. A comprehensive list of underwater vision aids is presented in the appendicies.

INTRODUCTION

The recent trend in our society toward increased awareness of physical fitness has created new challenges and opportunities for the profession of Optometry. To meet the visual requirements of these new sports enthusiasts, it is necessary to acquire knowledge of the specific conditions encountered by the individual in his sport; as well as what products designed for that sport are currently availiable. The problems encountered in the underwater environment by the emmetropic and ametropic diver are unique in vision due to the properties of light in water, and the limitation of designing an optical correction compatible with a comfortable diving mask. There are several different methods availiable to correct ametropic divers, and the decision on the 'best' style must be based on a thorough knowledge of the optics of each mask and the individual divers visual requirements.

BACKGROUND AND LITERATURE REVIEW

Alteration of Vision Underwater

Most marine creatures have evolved elaborate sensory and guidance systems which make their visual system almost an auxillary sense. Man, on the other hand, is often almost completely dependent on vision when underwater.[6] Every aspect of vision which man has become adapted to in air seems to be altered when underwater.[17]

The most obvious alteration of vision when going from air to water is reduced visibility. Under the most ideal conditions visibility is limited to a few hundred feet.[22] In many waters frequented by sport divers, visibility is often limited to 20 or 30 feet. The rapid attenuation of light energy is due to two components.[26] First, there is the effect of scattering of the harmonic waves by collision with particles in the water. This results in reduced contrast between an object and the background. The second cause of attenuation is the absorption of light energy by the water and its contained materials. This phenomenon is quite variable depending on the particular body of water and the wavelength of the incident light. Luria gives an example of attenuation of light with increasing depth.[17] If 90% is transmitted through one meter, 81% is transmitted through two meters, and 37% is transmitted through ten meters. In clear coastal oceanic water, photopic vision (defined as requiring one lux incident light) would be limited to depths of about 150 feet.[6] This range of photopic vision is extended considerably in clear open ocean water.

Visibility can also be reduced where two groups of water varying in temperature or salinity mix because of their slightly different indices of refraction.[12] This phenomenon may appear as a waviness such as is seen when 'heat waves' shimmer over hot asphalt. Heavy rains may reduce visibility near the surface due to rainwater's different index of refraction. Visibility is also affected by surface conditions.[12] Rain, wind, and waves influence the amount of light transmitted into the water by disturbing an otherwise smooth surface. The angle of the sun is also a factor since as the angle of incidence becomes more acute, more light will be reflected instead of penetrating the surface.

When a diver submerges, size and distance estimations are altered by divergence of light passing from water into the air space of the mask. Size estimates underwater are larger, as would be anticipated by an optical model. The resulting magnification is reported by various authors to be 25% to 33%.[7,25] Luria states that the actual magnification depends on the mask vertex distance and is typically 27%.[17] The following diagram demonstrates the magnification effect, as well as the alteration of perceived distance.

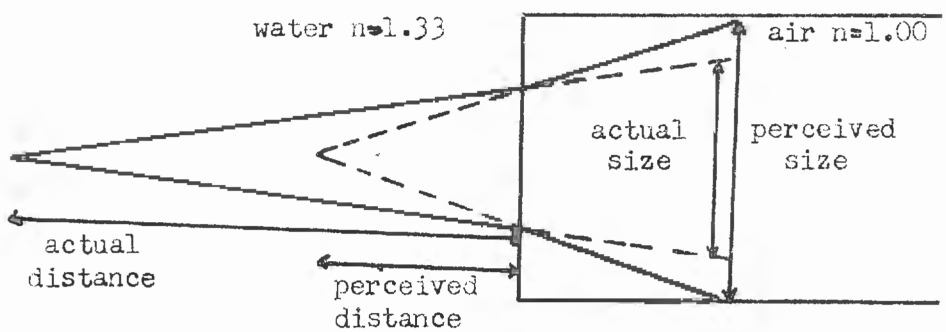

Figure 1 Divergence of Light at Diving Mask Faceplate

As seen in figure 1, refraction at the faceplate predicts an underestimation of distance. The increased retinal image size also suggests an underestimation of distance (size-distance invariance hypothesis). Experimentation, however, has demonstrated that underestimation occurs only for distances within arms length (1.2 meters).[16,26] Beyond this distance, overestimation occurs. This has been largely attributed to light scatter in water. This scattering of light results in a low contrast, diffusely illuminated homogenous field of view, uniform visual stimulation, and lack of distinct visual stimuli for perception of depth.[16] All of these factors have been shown to cause overestimation of distance in air. This estimation error increases turbidity of the water increases.

A study by Ferris investigated motion parallax as a means of improving accuracy of distance estimation.[9] He found that this was useless due to loss of position constancy underwater. In air, a mechanism apparently exists whereby the extent of retinal movement is compared to head, eye, and body movement so the world is perceived as stationary when the head moves. Magnification underwater upsets this relationship, and the visual and proprioceptive information does not match. As the head moves, the underwater world appears to move also. Both position constancy and size-distance perception are highly dependent on strictly visual information, which, in the altered underwater environment, leads to inaccuracies of judgement. There is evidence that long term intermittant exposure to such a distorted environment does not produce adaptation of primary visual processes.

Light is absorbed by water with spectral selectivity. Divers notice a change in ambient spectral composition as they decend. Gregg reports that depending on water conditions and location, no red light penetrates beyond about 25 feet, although occasionally reds are seen at greater depths due to bioluminescence.[12,22] At about 150 feet orange disappears, yellow at 300 feet, blue at 400 feet, and violet at 700 feet. Beyond 1000 feet light seldom reaches. Mertens presents the following graph of attenuation of light in pure filtered water (figure 2). Divers interested in underwater photography should be aware of this color attenuation, and compensate by film selection or use of an artificial light source.[10]

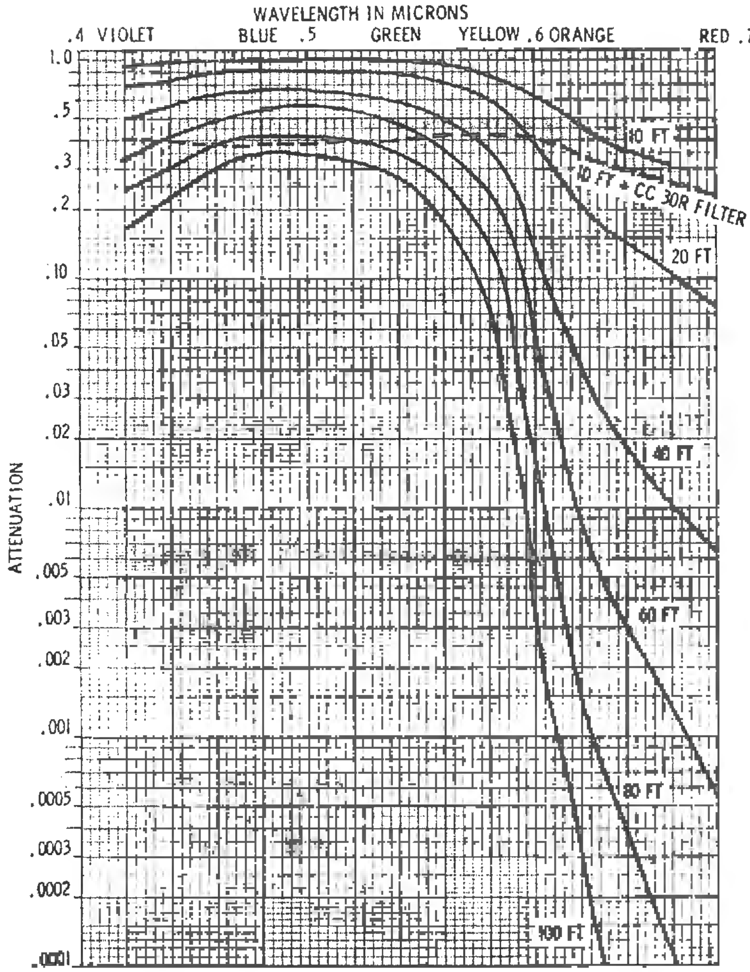

Figure 2 Spectral Attenuation of Light at Various Depths

Yellow'shooting lenses' have been favored by some hunters to improve visibility by enhancing contrast. Their effectiveness has been established only in certain conditions. Luria defines these conditions as longer wavelength targets in a short wavelength background. This is of interest to divers since the dominant wavelength in water will be the shorter wavelengths. Any object whose color is in the longer wavelengths will be enhanced with these lenses. Luria states that the underwater environment would appear to be an excellent situation for the use of filters to improve visibility for divers.[18] Such a lens is being advertised in dive magazines. It is availiable in prescription and is suitable for bonding to faceplates. Their effectiveness would be reduced as the depth of water increases since fewer long wavelength targets would be present.[18]

A facemask is essential for the diver to maintain the dioptric power of the cornea which is lost when the eyes are immersed directly in water. Divers use many criteria in the selection of a mask. Such properties as comfort, ease of clearing the mask of water, vertex distance, and field of view may be considered. Few divers, however, consider that such basic visual processes as acuity or distance estimation can be affected by differences in the configuration of the mask. Stereoacuity will be affected by the field of view through the mask and the visibility of peripheral objects. Size estimates are affected by the 'frame effect' resulting from limitations of the field of view, which in turn influences perception of distance.

In a study by Luria, visual performance using five mask designs was compared.[19] The masks evaluated were: 1)a standard oval mask, 2)a kidney shaped mask, 3)a wraparound, wide-field mask, 4)a goggle type mask, and 5)a compensated mask (with a built-in lens system to restore normal size and distance perception). It was found that there were significant differences amoung the masks for every visual process tested, but no mask was superior in all aspects. The wide-field mask with side ports had the largest field of view and somewhat better stereoacuity. The compensated mask gave improved size and distance estimates and hand-eye coordination, but degraded acuity and stereoacuity. This mask is useful if accurate size and distance estimates are necessary, and the mask's disadvantages are acceptable.

The field of view through any facemask is always compromised compared to the normal binocular visual field in air of 200° horizontal and 130° vertical.[27] These fields are reduced to 97° in any meridian of a single plate facemask due to a critical angle of reflection at the water-glass boundary of 48.5° (figure 3).[27] In some masks this field is further reduced by the rubber sides of the mask. The wrap-around type of mask with two additional temporal viewing ports restores the normal lateral field of view, but image jump is present in the periphery. Restricted peripheral view can be bothersome and potentially dangerous for the diver.[28] Peripheral vision is important for the purposes of orientation, keeping track of diving partners, maneuvering in tight quarters, and spotting sea life.[12]

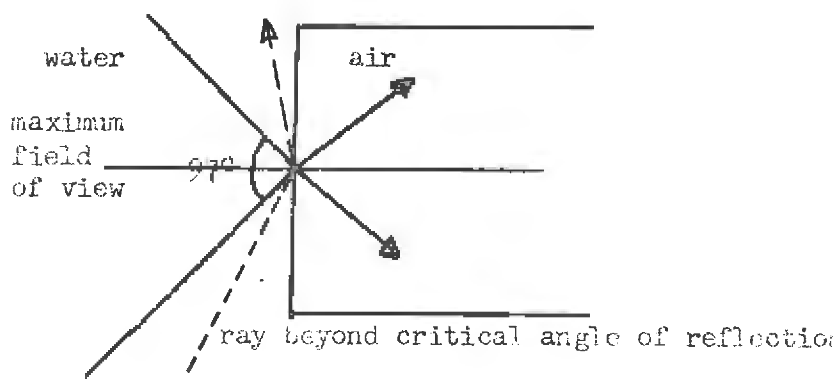

Figure 3 Critical Angle of Reflection at Dive Mask Faceplate

Visual Signs

Visual cues can be important to a divers safety. In waters of limited visibility ascent speed can be difficult to judge. Too rapid an ascent can seriously injure a diver by causing the 'bends' or an air embolism.[13] Fortunately, a visual cue for judging rate of ascent is always present. The diver's largest exhaust bubbles always assume approximately the recommended ascent rate of sixty feet per minute.[13] These exhaust bubbles also indicate the direction of the surface should a diver become totally disoriented due to irrigation of the vestibular organs (as occurs in a ruptured tympanum).

Visual imput can also be a danger signal to the diver. Divers affected by nitrogen narcosis often report a "narrowing of the field of vision".[6] Any symptom of nitrogen narcosis should alert the diver to carefully re-evaluate his situation with regards to depth, air supply, and decompression, since judgement can be compromised by this condition.[13]

Narrowing of the field of view followed by coma can result from carbon dioxide poisoning.[13] This can occur from a poorly maintained air compressor. Even with a pure air supply it can afflict a scuba diver subjected to heavy exertion.

Extraocular muscle balance can be affected by tensions, anoxia, and overexertion.[12] Clearness of vision can be influenced by abnormal levels of oxygen intake. Any onset of blurred vision, diplopia, or visual field disturbances should signal the diver to leave the water immediately.

Correction of Ametropia

According to Dr. Brown, mild refractive errors can often be ignored for diving purposes since both myopia and hyperopia are somewhat improved by the magnifying properties of water.* Exactly how a 'mild' refractive error is defined depends largely on the individual diver and on the water conditions encountered by the diver. Dr. Gillilan reports that some divers in the low myope range who have been diving for years with their ametropia uncorrected are very pleased when they finally try a corrective mask system.** It has been the experience of the authors that it is not uncommon to find scuba divers who would not feel comfortable above water without their glasses diving uncorrected. Novice divers often begin diving without a corrective mask and feel that their refractive error is compensated for by the water's magnification; or they may attribute reduced acuity underwater to water conditions rather than refractive error.

Drs. Gillilan,** Williamson, and Ephriam all agree that corrective lenses bonded to the inside of the faceplate is usually the best method to correct refractive error.[7,29] Any high quality mask owned by the diver can be used. Plano fron surface blanks with the required power on the back surface are edged to fit the mask and cemented inside the faceplate. Optically clear epoxy is reported to bond the lenses indefinitely.[29] The lenses can incorporate all aspects of the patients habitual prescription with the exception of habitual base curve. The power of the lenses is adjusted for the increased

* unpublished NAUI newsletter
** personal communication

vertex distance of the mask by applying the following formula:

$$P_2 = \frac{1}{1/P_1 + d}$$

where P_1 is spectacle power
d is the increase in vertex distance
P_2 is lens power at the faceplate

The greater vertex distance results in a larger difference between near and far pupillary distance, and may be a consideration for certain individuals.

Since this method requires a plano front lens surface, considerable peripheral abberations may be induced. Surprisingly few, if any, divers complain of these distortions.[7] Gillilan states that he has had no complaints of distortion underwater from the hundreds of units he has prescribed and assembled for his diving patients.* This may be due to the nature of the typical underwater visual array. Very few straight lines or linear contours are encountered in a natural underwater setting.[22] Dr Gillilan has had complaints of peripheral distortion when the mask was used for above water viewing, befor entering or after leaving the water. One of his patients was so unhappy with this that he designed a unit for her utilizing corrective lenses of her habitual base curve bonded to a ring which held the lenses slightly off the faceplate. This also eliminated all fogging since a thermal-pane effect was achieved.

Clear vision at near is required for inspection of small objects, reading pressure and depth gauges, and checking underwater camera settings. For a presbyopic ametrope, fused plano front bifocal lenses can be bonded to the faceplate. For the emmetropic presbyope, or ametropic presbyope who dislikes bifocals, an add for one eye may be sufficient. It is customarily placed on the left side, the

* personal communication

side on which the scuba diver's gauge console is carried. Small glass planoconvex lenses which glue onto the faceplate are designed specifically for this purpose and availiable from several sources (appendix 1).

Masks are available with an optical correction ground into the face plate. Limitations of this design include the following: (1) available only in .50D increments for myopic, single vision, spherical lenses, (2) no variability of PD, (3) limited mask styles, (4) identical power in each eye. If the mask fits well and the above mentioned limitations are not a handicap for the diver, this type of mask has advantages. The correct power mask may be on hand at the dive shop, eliminating the ten day to two week fabrication period required for the bonded-lens system. Unfortunately, many dive shops stock a very limited number of these masks, and the time required to receive one by special order may exceed three weeks. The cost is generally lower than for the bonded-lens system, unless the diver already owns a non-corrective mask he is otherwise satisfied with. Lenses can be bonded to this mask for a slightly lower price than the cost of a mask with optics built into the faceplate.

One scuba equipment manufacturer supplies a goggle-type two-window mask to dive shops accompanied by a selection of lenses which insert into the mask apertures. The lenses become the water-tight faceplates of the goggles. The advantages of these masks, compared to the masks with optics ground into the faceplate, is that the power before each eye can vary and the correct powers are more likely to be in stock. However, the PD is still fixed and no cylinder or prism can be incorporated. Also, the field of view with a goggle-style mask is reduced by about 25% compared to a conventional mask.

There have been many commercial and improvised attempts to mount a spectacle front inside a divers mask. Probably the most efficient way devised to date is the 'scuba-spec'. This is a patented nylon spectacle front which snaps securely in and out of a mount which is glued to the center of the faceplate (a two-window mask cannot be used). The construction of the frame allows for adjustment of pantoscopic tilt. The diver's customary spectacle prescription is used in a familiar relationship to the eyes. Corrected curve lenses can be used, reducing the distortion of the plano front bonded lenses. This may useful in highly hyperopic corrections. [7] Another advantage is that one spectacle front can be used in several masks by installing a mount in each mask.

Non-commercial methods of installing a spectacle front inside the diver's mask include clear, pliable silicone adhesive, or suction cups. Power changes due to increased vertex distance can result in less than optimal acuity with some prescriptions. Few divers would be aware that moving the frame a few millimeters forward will change the effective power of the lenses. If the frame was mounted with a tilt the result would be further reduction of acuity. If a make-shift method of securing the frame in the mask is attempted a mask should be chosen in which the spectacle front fits snugly to make the system more secure.

Contact lenses have been worn sucessfully by many divers. The contact lens wearing diver's vision closely approximates the emmetropic diver's vision through a facemask. A few precautions must be kept in mind as the underwater environment can create problems. Some divers have found that the small amounts of salt water that inevitably find their way to the eyes makes contact lenses too uncomfortable for them.[12] Some divers are reluctant to wear their lenses for diving because they fear losing them. Hard lenses are easily washed out of the eye if the mask is dislodged or flooded with water and the eyes remain open.[2] The chances of a mask being accidentally flooded are unlikely but far from remote.[2] The consequences of a highly ametropic diver being unable to spot a boat or shoreline are obvious, contraindicating contact lenses for the highly ametropic diver.[2] An optical mask is less likely to be lost.

Williamson reported no losses of hydroget contact lenses in 300 trials of opening his eyes underwater. He also stated that his acuity remained unchanged after five minute immersions of the opened eye with lens in sea water.[30] It may be that the Bionite hydrogels investigated by Williamson are different in their characteristics than some current hydrogel designs. Bennett was of the opinion that hydrogel lenses are just as easily washed from the eye as hard lenses.[2] This has been borne out by one of the investigators who lost three Hydrocurve II lenses in sea water.

Hydration of soft lenses may be affected by diving. Particularly, a training session in a fresh-water pool could result in a hypotonic lens. This introduces the possibility of a denuded corneal epithelium on removal.[30]

Hard contact lens wearing divers often experience discomfort at depths of 120 to 150 feet. Bennett believed this to be related to the increased partial pressure of carbon dioxide and the accumulation of it in the facemask.[2] Following sufficiently deep or long dives bubbles of nitrogen may form in the precorneal fluid between the eye and hard lens, or even within the cornea (a condition erroneously termed 'lens bends'). The cornea may cloud with temporary blurring of vision.*

Scleral lenses with tiny air cells cemented on their front surfaces have been devised to be worn underwater without a facemask. These are known as 'SCAL', skin diver's contact air lens.

In theory SCAL lenses appear to be the ideal method for the correction of ametropic divers.[11] They were first created in the 1950's. The British, American and French navies have experimented with their versions of the SCAL lens. They enable the diver to appreciate binocular lateral field of view of about 140°.[11] Fogging, instability of the mask in turbulent water, and difficulty in pinching the nose to equalize pressure encountered with the conventional facemask are eliminated.

The major limitations of these lenses have been irritation from sea water and expense. The lenses require special care for insertion and removal, and must be custom manufactured and fit to

*unpublished NAUI newsletter

the diver, resulting in a cost of $500 to $1000 per pair in 1980. Also, the protection which a facemask offers is lost and the conventional air regulator must be modified to prevent exhaust bubbles from obscuring vision.[24]

METHOD and MATERIALS

A survey questionaire was sent to dive shops to determine the current level of optical expertise at retail outlets, and the availability of various underwater optical appliances at dive shops. (see appendix II)

56 dive shops were selected from the dive shop directories in Skin Diver and Sport Diver magazines. An attempt was made to choose dive shops representing a cross section of the diving population of the United States. Those shops selected received the questionaire accompanied by an explanatory letter (see appendix II) and an addressed, stamped return envelope.

Current product information was also gathered from recent issues of Skin Diver and Sport Diver. Personal and telephone contact was used to gain knowledge from dive shop owners, managers and employees. Optometrists Dr. Rod Gillilan of Eugene, Oregon, and Dr. Dale Rorabaugh of Pacific Beach, California, were personally contacted concerning their work and expertise in underwater vision.

RESULTS

(refer to survey questionaire, appendix II)

survey question #1:

Of those responding to this question 21% indicated that they personally used an optical correction of some kind in conjunction with their diving activities. 79% indicated that they did not.

survey question #2:

Of those dive shops responding 40% stated that spectacle frames to be suspended inside the mask were available at their shop. 85% of the shops directed customers to a lens bonding service (exclusively or as required by prescription), and 85% carried at least one type of ready made optical mask.

Dive Shop Availability of Various Optical Systems for Correcting Ametropia with a Dive Mask

	suspended spectacles	lens bonding service	ready made optical mask
percentage of dive shops where type of system is available	40%	85%	85%

survey question #2a:

Popularity with divers of three means of correcting ametropia were judged by the responding dive shops. Although 25% indicated no definite preference, 45% stated that ready made optical masks were most popular. 25% reported custom bonding of lenses to be most favored by divers, while 5% of the dive shops indicated suspended spectacle fronts to be most popular.

Dive Shop Evaluation of
Popularity of Various Optical
Systems for Correcting the
Ametropic Scuba Diver

	suspended spectacles	lens bonding to faceplate	ready made optical mask
percentage of dive shops judging this system most popular with divers	5%	25%	45%

survey question #2b:

This question elicited few responses.

survey question #2c:

One-half of those responding to this question indicated that a type of correction was available in their dive shop for use at closer distances by older divers.

survey question #3:

60% of respondents stated that a prescription was always required to determine the proper lens powers for an optical mask.

Some other method was used to arrive at correct lens powers by 25% of dive shops responding. 15% generally required a prescription for lens selection but used an alternate method in some circumstances.

survey question #3a:

Of the dive shops responding to this question 95% considered astigmatism and other factors in arriving at the proper lens requirements.

survey question #3b:

65% indicated that there was an Optometrist or Ophthalmologist in their area specializing in corrective masks for divers.

survey question #4:

Estimates of the percentage of divers who could benefit from a corrective mask system ranged from 5% to 50%. 21% was the average estimate. 30% felt that anyone wearing glasses above water would benefit from an underwater optical correction.

survey question #4a:

Salespersons at the diveshops responding to the questionaire routinely inquired about the diver's possible need for underwater optical correction at 65% of the dive shops.

survey question #5:

Because no corrective mask was mentioned more than 5 times in this section of the questionaire, no detailed analysis of the responses was possible. Widely divergent opinions as to the qualities of the various masks was apparent.

DISCUSSION

100% of the dive shops responding to the survey questionaire had availiable for their customers some type of underwater optical correction. This number may be higher than the actual percentage due to the nature of the questionaire. Dive shops not dealing in corrective masks would perhaps not return the survey since most questions would be unanswerable. Many of the dive shops indicated that they carry three or more styles of ready-made corrective masks to insure good fit and performance for the individual diver. Also, in diving magazines there are many advertisements for corrective masks and bonding of lenses to the faceplate availiable by mail. However, it was noted from the survey that over 30% of salespersons at the dive shops do not routinely ask whether a customer needs an optical correction in their mask, and not all divers read dive magazines. This leaves many novice and recreational divers uninformed as to the options availiable to them. For this reason, the Optometrist should inform his diving patients that corrective optical systems are availiable, and advise them, based on refractive error and diving purpose, as to what method best suits their needs.

According to the survey questionaire, ready made masks are more popular with divers (45%) than are bonded lens systems (25%). The most common reasons stated for this preference were lower cost and immediate availiability. However, if a diver already owns a mask which can be mailed in for bonding, the cost is actually less than many pre-ground masks. Also, due to limited stock, the correct power may not be immediately availiable, and the limitations of this mask design mentioned earlier will limit the performance for many divers. Another reason for the increased popularity of ready made masks is that divers are more aware of this method of correction from advertising and visibility in many dive shops. From a business standpoint, when a dive shop sells a corrective mask the profit is greater than selling a conventional mask, so this might influence the percentage cited here which comes from dive shops, not individual divers. The three most popular ready made masks are those made by White Stag, Mares, and Scuba-Pro. See appendix I for a list of availiable corrective masks.

Although none of the dive shops responding to the survey had facilities for bonding prescription lenses to the faceplate, they all referred those desiring this type of optical system to an individual or lab specializing in this process. Ten days to three weeks are generally required to fill an order for custom bonded lenses, but the additional capabilities mentioned earlier will in many cases offset the waiting period. The diver should insist on high quality work in this area. Reputable lens bonding firms will offer a 60 or 90 day money back guarentee that the customer will be satisfied. The bonding should be waranted for five years against the possibility of lenses and faceplate separating. The firm should also assure the diver that the blanks used will be the largest availiable. Some firms state that they are able to remove the lens for rebonding to a new faceplate. This is advantageous since the mask skirt will often wear out while the lenses are still usable. As a convenience, some firms will supply any mask at regular retail price to eliminate the inconvenience of mailing a mask to them.

The survey indicated that a majority (60%) required a prescription from an Optometrist or Ophthalmologist to determine the appropriate power for a mask. The remaining 40% used their own methods. This is generally by trying a mask on, then reading some type of chart on a wall (distance not specified). The potential errors using this approach are obvious to any Optometrist. Aside from possible over-plusing or over-minusing, the individual trying on the mask may be unaware of his astigmatism or other special aspects of his visual problem, thus leading him to believe that the spherical mask he has just tried is the best possible for him. Once again, the Optometrist can provide valuable information for these patients.

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GLOSSARY OF CORRECTIVE OPTICAL MASKS

APPENDIX I

A) Pre-Ground Optical Masks

Manufacturer/Model Name	Availiable From	Powers Availiable	Cost	Comments
AMF Mares				
Santiago	retail dive shop	-1.5 to -8.5 D 0.5D increments spherical only	$47 to $65	goggle style mask power can vary between eyes
Scuba-Pro				
Optical Corrective	retail dive shop	-1.0 to -10.0D 0.5 D increments	about $60	1 window mask
White Stag				
Superview Optical	retail dive shop	-2.0 to -7.5D 0.5D increments	about $57	2 window mask
Superview Translucent Optical	retail dive shop	minus powers spherical only	about $67	2 window mask clear silicone skirt
Seavision Optical	retail dive shop	minus powers spherical only	about $55	1 window mask
Cressi-Sub				
Superlince Optical	retail dive shop	minus powers spherical only	about $70	2 window mask
Piuma Lux Optical	retail dive shop	minus powers spherical only	about $70	2 window mask
Lince Optical	retail dive shop	minus powers spherical only	about $65	2 window mask

APPENDIX I (CONT)

Manufacturer/Model Name	Available From	Powers Availiable	Cost	Comments
Tabata Splendive Optical	retail dive shop	minus powers spherical only	about $50	2 window mask
Dacor DM 19 Corrective	retail dive shop	plus and minus powers spherical only		only pre-ground mask with plus powers
Scuba-spec Inc. Scuba-spec	retail dive shop or Scuba-spec Inc. PO Box 22356 Savannah, Ga. 31403	as specified to optical lab	about $12	spectacle front with 2 'anchor bars' lenses from most optical labs

B) Near Point Lenses

Manufacturer/Model Name	Available From	Powers Availiable	Cost	Comments
Waterlou Enterprises Microsight	Waterlou Enterprises PO Box 125 Mountainville, NY 10953	power not specified	$3.50	one inch diameter plano-convex lens
Libra Optics	Libra Optics PO Box 871 Redondo Beach, Ca. 90277	power not specified		

C) Lens Bonding to Faceplate

	Lenses Guaranteed			
Bonding Firm	money back guarantee	not to separate	can supply mask	Cost
Aqua Optics 575 West 6th St. San Pedro, Ca. 90731 (213)832-7300	90 days	yes	yes	about $45 bifocals $14 extra
Leonard Maggiore 69-03 Fresh Pond Road Ridgewood, Queens, NY 11227 (212)386-5339	90 days	yes	yes	about $45 bifocals $14 extra
Opti-Sport Dr. Gillilan Eugene, Oregon	60 days	yes	yes	about $45

SURVEY QUESTIONAIRE SENT TO DIVE SHOPS APPENDIX II

PACIFIC UNIVERSITY
COLLEGE OF OPTOMETRY

November 29, 1979

Dear Sir:

We are fourth year students at Pacific University College of Optometry, and are very interested in the area of sports vision, especially underwater vision. We are currently working on a research project concerning the correction of vision problems of divers needing spectacle prescriptions. The questionnaire enclosed will help us determine the most commonly used corrective mask, and compare features of different masks.

It is our hope that the information which we gather will help make other optometrists aware of the options available to their patients who enjoy diving. This will assist the doctor in advising their patients on how, and where, to obtain appropriate dive masks for their specific needs.

Thank you very much for your help and cooperation.

Sincerely,

Thomas Leech

Thomas Leech

Steven Arnquist

Steven Arnquist

Norman Stern, O.D., Ph.D.
Research Advisor

Enclosure

2043 COLLEGE WAY FOREST GROVE, OREGON 97116 TELEPHONE (503) 357-6151

DIRECTIONS: Please answer the following questions. If more space is needed, please attach another sheet of paper.

1. Do you personally wear a corrective mask? Yes No

2. What types of masks do you have available for divers who require spectacle correction, i.e., lenses bonded to the faceplate, prescription ground into faceplate, or lenses suspended inside mask?

____

____

a. If you carry more than one type, which is the most popular with divers, and why?

____

____

b. If you carry no corrective masks or faceplates, what advice do you give customers needing such a correction? ______________________________

____

____

c. Do you have any masks available for older divers who need more power for close distances?

____

____

3. How is the correct mask power determined for a customer in your shop? Please explain.

____

____

____

a. Are such factors as astigmatism correction, difference in power between the two eyes, or prism corrections considered in arriving at the correct prescription?

____

____

b. Are there any optometrists or ophthalmologists in your area who are specializing in fitting corrective masks?

____

____

4. What percentage of divers would you estimate could benefit from some type of lens correction in their diving mask?

____

____

a. Do salesmen at your shop routinely ask whether a diver needs a correction in their mask?

____

5. Please rate the corrective mask which you sell. If you carry more than one type of mask, or have experience with other mask types, please name and rate them also.

Type ______________________ Manufacturer ______________________

	very good	good	average	poor	very poor
comfort	1	2	3	4	5
fogging	1	2	3	4	5
durability	1	2	3	4	5
cost to divers	1	2	3	4	5
visual distortions	1	2	3	4	5
visual acuity	1	2	3	4	5
overall performance	1	2	3	4	5
overall satisfaction	1	2	3	4	5

Type ______________________ Manufacturer ______________________

	very good	good	average	poor	very poor
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visual acuity	1	2	3	4	5
overall performance	1	2	3	4	5
overall satisfaction	1	2	3	4	5

We would welcome any further comments you may have. ______________________